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9. ABSTRACT
Based on two years of research on the effects of pesticides in Central American cotton production, this study identifies management measures which reduce environmental and economic problems associated with pesticide use while maintaining the benefits derived from cotton production. Most of the environmental components examined -- food, forage, water, flora, and fauna -- contained highly residual pesticides. Other findings point out that: aerial application of pesticides under unstable weather conditions is a key event in spreading pesticides through the environment; pesticide drift increases sub-clinical intoxication of humans and the possibilities of poisonings; it contributes to the development of resistance by the malaria vector; and it creates high economic losses because of meat contamination by DDT. Part One of the study presents a systems management program to reduce pesticide use and its environmental and economic consequences. The program, carried out in Guatemala, El Salvador, Honduras and Nicaragua, included integrated pest control. This meant reducing the number of pesticide applications by about 39% while increasing yields; improving soil conservation; using fertilizers more effectively; and discouraging the use of "hard" pesticides. The program also examined the use of a more refined pest economic threshold and the establishment of selected import duties. Part Two discusses the technical issues on which this study focuses, and it includes tables and appendices. The study makes these recommendations: (1) Adopt occupational safety procedures. (2) Improve and expand existing first-aid clinics to promptly treat human poisonings. (3) Implement integrated cotton pest control as an alternative to sole reliance on chemical pesticides. (4) Educate farmers regarding the economic and environmental significance of planting cotton in suitable land and of applying pesticides efficiently.

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AN ENVIRONMENTAL AND ECONOMIC STUDY OF THE CONSEQUENCES OF PESTICIDE USE IN CENTRAL AMERICAN COTTON PRODUCTION

FINAL REPORT

ICAITI 1976

INSTITUTO CENTROAMERICANO DE INVESTIGACION
Y TECNOLOGIA INDUSTRIAL
(ICAITI)
CENTRAL AMERICAN RESEARCH INSTITUTE FOR INDUSTRY

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AN ENVIRONMENTAL AND ECONOMIC STUDY OF THE CONSEQUENCES OF PESTICIDE USE IN CENTRAL AMERICAN COTTON PRODUCTION

(FINAL REPORT)

Guatemala, ICAITI Headquarters
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The Central American Research Institute for Industry (ICAITI) is an independent institution chartered as a nonprofit organization. It was founded in July, 1955, by the governments of the five Central American republics, Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua, with the assistance of the United Nations Technical Assistance Administration who acted upon the need for an applied research institution in Central America. It began operations in Guatemala City in January, 1956.

For more than 20 years ICAITI has made significant contributions to the industrial development of the region and has completed a considerable number of technical-economic studies and applied research on a wide variety of subjects. ICAITI has put technological advances at the disposal of Central America's industry and has assisted the regional authorities and manufacturers in the planning, expansion and development of a broad range of projects.

SUMMARY

Pesticides are at the present time essential for commercial cotton production in Central America. Nevertheless, their use has been found to have consequences on the natural environment and the health of its inhabitants. Some of these consequences represent economic losses outside the cotton activity. The present study discusses pesticide issues with a view to identifying those management measures which would reduce environmental and economic problems while maintaining or increasing the benefits dervied from cotton production.

Most of the components of the Central American environment examined contain highly residual pesticides. DDT contamination ranges from 0.000042 parts per million (ppm) for estuarine water in Guatemala to 117.59 ppm for cow's milk in Nicaragua. It is not possible to determine the implications of insecticide residue accumulation in human and other living organisms in Central America at the present time.

The aerial application of pesticides under unstable weather conditions is a key event in the movement of pesticides through the environment. It was estimated that with the ultra-low volume application system about 75% of the amount applied falls outside the swath of the airplane under conditions of temperatura inversion and moderate winds. If a 20-hectare field is being treated one can expect about 56% of the insecticide to fall outside the target area. Some of the $70 million spent annually for cotton pesticides is lost because of drift.

Pesticide drif increases sub-clinical intoxication and the possibilities for clinical poisonings. It contributes to the contamination of neighboring environmental components and to the development of resistance by the malaria vector (Anopheles albimanus). Sometimes it may create economic problems for other agricultural activities. Beef exporters in the recent past have lost between $1.7 and $2.0 million because of meat contamination by DDT.

The number of reported human clinical poisonings in Central American cotton areas is still substantial. However, total cases diminish every year. Poisoning incidence has dropped from 6,078 cases in 1972 to an estimated 2,074 cases in 1975. During these four years, only a total of 40 people were reported dead from pesticide poisonings. Most poisonings are attibuted to the non-persistent but highly toxic organophosphorous pesticides.

Sub-clinical intoxication leveles are higher in the cotton areas of Central America that in urban centers or in other countries. Average content of DDT in human blood (serum) from general population samples in cotton areas of Guatemala and Nicaragua was 520.6 ppb. The average in urban areas of Central America was 76.16 ppb. General population samples from Dade county, Florida, U.S.A., averaged 46.4 ppb. However, although some studies indicate higher concentrations of DDT in a variety of pathologies, others have found no positive correlation between DDT residues and disease. Thus one cannot conclusively infer the human health implications of the high levels of sub-clinical intoxication found in Central America.

Resistance of *A. albimanus* to chemical control by DDT has been increased in the area. It is particularly high where cotton is grown. Average resistance in Guatemalan cotton areas went from 58% to 86% between 1972 and 1975 (a 48% increase). In El Salvador it has remained above 80% in those years. Malaria Control Agencies in the former country reacted by applying more expensive pesticides more frequently which resulted in a drop in malaria rates in cotton areas (from 6.34 cases/1,000 in 1972 to 2.21 cases/1,000 in 1975). Control in El Salvador has not been as effective and malaria rates have increased. (From 39.2 cases/1,000 to 65.7 cases/1,000 between 1972 and 1974).

Anopheline resistance (significantly higher in cotton areas) results in human health and economic problems. The four countries had increasing costs estimated at $11.95 million because of the use of more expensive, less persistent chemicals for malaria control in 1975. Not all of the resistance can be attributed to pesticide use in cotton. DDT use in malaria control itself may create resistance. Yet the increased expenditures are almost exclusively made in cotton areas. In the absence of alternative explanations one is led to infer that pesticide use in cotton may be the cause for greater expenditures in malaria control. Failure to control adequately may result in greater malaria incidence.

Human intoxication and malaria are intimately related to the inadequate living conditions of the rural population of Central America. Pesticide effects on humans cannot be fully understood in the vacuum of the socio-economic and cultural circumstances of the population affected.

The use of some pesticides is at the present time indispensable for cotton pest control. Yet there are indications that actual use levels are too high for best economic results to the farmer. The demonstration of integrated pest control in the four Central American countries shows that it is possible to increase yields and profits while reducing the number of pesticide applications by about 39%. Statistical analysis of Nicaraguan country data also suggests that the economically optimum level of pesticide use under existing conditions is about 38% below present levels.

Among the available alternatives to lower insecticide use the study examined integrated pest control, the use of more refined pest economic thresholds and the establishment of selective import duties. These were integrated into a systems management program to reduce pesticide use in cotton and its environmental and economic consequences. The program included other management actions as well: adopt educational procedures to reduce worker's exposure to pesticides; improve and expand first-aid field clinics for treatment of intoxicated persons; implement integrated cotton pest control and discourage the use of "hard" pesticides; educate farmers on more efficient pesticide applications techniques and promote compatible crops in cotton areas to reduce external diseconomies, and establish an environmental monitoring program for pesticides in Central America.

The study's recommendations are presented in the pages that follow (Part I), while the findings of the study are given subsequently (Part II).

INTRODUCTION

This report shows the results of two years of research on the effects of pesticides in Central America. It is intended primarily for environmental and economic planners, health agencies, cotton technicians, growers' representatives and technical groups or individuals interested in scientific appraisals of pesticide problems.

The report is divided in two parts. The first (Part I) presents a summary of recommendations under the label of systems management program. The second (Part II) discusses the technical issues on which the study focused in detail, and the appendices complement the data presented in Part II.

The report achieves some degree of compartmentalization: readers interested in human health problems can proceed directly to Chapter 3 and expand from there to the rest of the areas. Readers interested in policy implications are advised to read Part I and refer to the more technical chapters as necessary. Nevertheless, a global understanding of pesticide problems can only be achieved by simultaneously focusing on the issues from different standpoints.

BACKGROUND

Pesticide use in cotton production in Central America is a complex environmental and economic problem (see Summary). Since 1971, a group of scientists from the Central American Research Institute for Industry (ICAITI) and the United States National Academy of Sciences (NAS) became interested in finding solutions to the problem consistent with the Central American economic and socio-political reality. A proposal to study the environmental and economic consequences of pesticide use in cotton production in the countries of El Salvador, Guatemala, Honduras, and Nicaragua was prepared and submitted to the United Nations Environment Programme (UNEP). The project was approved and started in 1974. The results and recommendations of that study are reported herein.

The study was carried out by ICAITI with the assistance of members of NAS. A joint NAS-ICAITI Executive Committee was formed and entrusted with the task of selecting the project's director, the Central American experts in charge of the studies and the advisory board composed of NAS members.

In charge of over-all project supervision was Francisco Aguirre B. (Deputy Director of ICAITI). The project Director was Fernando Mazariegos (Head of the Analysis and Testing Division of ICAITI) who conducted the environmental studies with the support of David Pimentel (Cornell University) and Julia Alicia de Zeissig (ICAITI), Environmental Chemist.

Dr. Pimentel in addition developed the Systems Ecology Area with the assistance of Walter Lynn (Cornell University). Carlos García-Salas (Guatemalan Social Security Institute - IGSS) was responsible for the Human Health studies, with the advice of John Davies (University of Miami).

The Integrated Pest Control Demonstration program was conducted by Alejandro Romero (National Bank of Nicaragua - BNN) with the counsel of Louis Falcon (University of California, Berkeley). The Pesticide Economic studies were carried out by Eduardo Villagrán (ICAITI), jointly with Gerald Carlson (North Carolina State University). Mr. Villagrán also coordinated the preparation of reports. Jay Davenport, of the National Academy of Sciences, acted as Coordinator of the Executive Committee.

The project team benefitted from the support of a Technical Resources Group. The group was composed of individual from the four Central American countries and the United States. They included Wesley Yates (University of California, Davis), pesticide drift expert; Mario Vaughan and Gladys León (National Bank of Nicaragua), entomologists and integrated cotton pest control experts; Ronald Estrada (Universidad de San Carlos de Guatemala), agricultural engineer; Oscar Vigil (Cooperativa Algodonera Salvadoreña), agricultural engineer; Ricardo Romero-Trochez (Cooperativa Agropecuaria Algodonera del Sur - Honduras), agricultural engineer; Santos Quant (Comisión Nacional del Algodón - Nicaragua), economist; Julio Pellecer (ICAITI), mathematician; Alvaro Somarriba, agricultural engineer; Andrew P. Gutierrez (University of California, Davis), cotton systems analyst; Dalila Díaz and Enrique Hernández (ICAITI), environmental analysis;

Jorge López (Renewable Resources Department - El Salvador), marine biologist; Mauricio Ramírez (Renewable Resources Department - El Salvador), marine taxonomist.

Several institutions made the successful completion of the project possible, Chief among them the United Nations Environment Programme who provided financial support. The Central American institutions, whose cooperation is hereby acknowledged, included the Comisión Nacional del Algodón (CONAL, Nicaragua), the Cooperativa Algodonera Salvadoreña, the Cooperativa Agropecuaria Algodonera del Sur (Honduras), the Consejo Nacional del Algodón (CNA, Guatemala), the Instituto Guatemalteco de Seguridad Social (IGSS, Guatemala), the Dirección General de Recursos Naturales Renovables (Honduras), the Banco Nacional de Nicaragua (BNN), the Dirección General de Recursos Naturales Renovables (El Salvador), and Public Health Institution in the four countries.

PART I

A SYSTEMS MANAGEMENT PROGRAM TO REDUCE THE CONSEQUENCES OF PESTICIDE USE IN CENTRAL AMERICA

I. SUMMARY OF RECOMMENDATIONS

The objectives of this research and demonstration project on a systems management program to reduce the consequences of pesticide use in Central America cotton production were:

(i) Reduce human insecticide poisonings
(ii) Increase profits for the cotton economy
(iii) Reduce the social and economic externalities (costs) of insecticide use
(iv) Restore the quality of environment

After completing the research and field work on various dimensions of problem (Part II), the following management actions are recommended to improve the social, economic, health, and environmental aspects of pesticide problem:

(I) Adopt occupational safety procedures that would reduce worker's exposure to pesticides.

(II) Improve and expand existing first-aid field clinics for prompt and effective treatment of human poisonings

(III) Implement integrated cotton pest control as an alternative to the sole reliance on chemical pesticides.

(IV) Educate farmers regarding the economic and evironmental significance of planting cotton in suitable lands, applying insecticide efficiently and practicing soil conservation.

(V) Establish an environmental monitoring program for pesticides in Central America.

The recommendations could be implemented by three types of institutions in each country working in an integrated manner. These would be a cotton growers' organization, a human health or worker security institution, and environmental or resource management agency. Although many of these exist, some are still in the formative process. Their establishment may require legislative action possibly stimulated by increasing public awareness. To that end it will be useful to disseminate in a non-technical style the more important results of this project.

2. A SYSTEMS MANAGEMENT PROGRAM

Single-factor management programs have often created more problems than they solve. For example employing an insecticide to solve one pest problem has in some cases resulted in one or more other pest problems not to mention the other environmental problems that resulted. Another example is the construction of tube wells in the Sahel to water livestock that resulted in overgrazing and desertation of some lands.

In Central America a noted example of management (mismanagement) is the stocking of Lake Atitlan with black bass, a fish that dominated the total fish community.

Management of environmental resources always has multi-faceted effects through the numerous interconnections among the many factors that make up the environment. It is not possible to understand all the interactions nor consider all of them, but sound decision-making relative to environmental management must consider the major interactions and ramifications of any recommended change. This was the goal of this systems management program.

2.1 The Program's Objectives

The systems management program has four objectives: Remedy human health problems caused by pesticide use; improve the economic efficiency of cotton production, particularly in the area of pest management; reduce economic losses emmanating from pesticide use to other economic activities, and protect the environment.

2.2 Recommended Management Actions

The multidisciplinary investigations of the consequences of pesticide use in Central American cotton production suggested five recommended management actions that are needed to improve the social, economic, health, and environmental aspects of the pesticide problem. The recommendations plus explanations for each are listed as follows:

(I) Adopt occupational safety procedures that would reduce workers' exposure to pesticides:

All cotton farm laborers should attend a 1-day training lecture on pesticide safety before starting work. The lecture would be imparted at the farm by worker security staff. It will include explanations on the nature of pesticides, gross detection and identification of pesticides in the air and water, recognition of poisoning symptoms and other warning signals, proper use of protective clothing and hygiene equipment, and a possible demonstration of the toxic actions of insecticides on live rats or mice. Posters encouraging pesticide safety should be placed in strategic places on the farm to remind workers of the need for safety.

The living conditions of cotton workers would have to be improved to reduce worker exposure (P.II, p. 50). This would include walled-in housing for temporary laborers, using metallic cloth, installing showers and running water, and erecting letrines.

Worker security or human health institutions in the four Central American countries producing cotton would require each cotton farm and pesticide application firm to have basic equipment for the protection of workers. The list of requirements should include mechanical loading towers, shower facilities, personnel protection equipment (hats, goggles, masks, cover-alls, gloves, and boots) for workers particularly exposed to pesticides ("flaggers", "scouts", and "loaders").

Worker security or human health personnel would visit every farm and applicator firm before the cotton season begins during April and July. Upon a satisfactory examination of the equipment and facilities a permit to operate would be issued. During the cotton growing season, each farm should be re-visited. Continuous supervision needs to be exerted to guarantee that the equipment is properly used.

Cotton fields treated with highly toxic insecticides should be marked by appropriate warning signs which the workers can understand. The signs placed every 100 meters of the cotton fields perimeter would be left standing for at least 72 hours. Workers would not enter these fields until after 72 hours have passed.

Guatemala already has a worker security system that covers agricultural laborers. A similar system might be used in the other countries. To finance the system cotton farmers pay a set amount based on the number of laborers working each week. Also the workers contribute a proportion of their salaries for their own security.

Cotton growers and workers alike will benefit from the application of these preventive measures. Healthy conditions might attract better workers and result in improved efficiency.

(II) Improve and expand existing first-aid clinics for prompt and effective treatments of human poisonings.

The field clinics should be designed to reduce the severity of human poisoning cases and complement the preventive measures outlined in recommendation I. These clinics would have the necessary equipment and antidotes to be able to give first-aid to insecticide intoxicated persons. The need is for one field clinic for every 3,000 manzanas. These could be constructed by the cotton growers. However, the field clinics would be staffed and operated by the worker security or human health institutions.

As a part of recommendation I, farmers, field workers, and supervisors would be instructed on what to do in case of insecticide poisoning. Important points include recognition of symptoms, location of the nearest field clinic and what to do and what not to do with an intoxicated person.

(III) **Implement integrated cotton pest control as an alternative to the sole reliance on chemical pesticides:**

Lack of sufficient practical knowledge on integrated cotton pest control causes farmers to use excessive amounts of pesticides. Integrated pest control has been proved to be a more efficient pest management strategy than existing methodologies which depend almost exclusively on the application of chemical pesticides. Through large scale demonstrations and training farmers and cotton technicians can be made aware of the benefits that can be derived from this pest management system.

Integrated pest control emphasizes the need to work within the ecological context of a particular ecosystem. It employs all available techniques and methods in the most compatible manner to maintain pest populations below economically harmful levels. It relies heavily on the preservation, introduction, and encouragement of natural control agents such as predators, pathogens, and parasites. Cultural, mechanical, and climatic control are also employed to achieve the aim of producing optimum economic returns while taking into account short-and long-term ecological constraints. When artificial control becomes necessary (an application of pesticides or a liberation of parasites) it is carried out as selectively as possible and only when economically and ecologically justified.

Integrated cotton pest control philosophy and procedures are found in FAO, Manual Integrado de Plagas de Algodón, (Rome: FAO, 1975), and in Part II, page 69 of the present report. The results of demonstrating integrated control in Central América are presented in Part II. Appendix 3 presents a strategy for implementation in the area.

The srrategy followed in the program was control bollweevil before planting, select an adequate planting date and density, optimize fertilization, effect a daily count of pests and beneficials, apply pesticides only after the plantation is about 70 days old, employ economic pest thresholds, use lower insecticide doses and more selective pesticides, liberate parasites (Trichogramma spp.) and harvest promptly.

Pre-planting control of bollweevil results in less need to use methyl parathion. This chemical has caused the greatest number of human poisonings because of its high toxicity to mammals. Integrated bollweevil management reduces the application of Parathion at a small cost to the farmer.

The strategy for bollweevil control is to leave 1-2 % of the field planted with cotton in between seasons by not destroying old stocks and planting small cotton islands early. Since cotton is the favorite host of the bollweevil these islands are constantly infested and allow for a large reduction of colonizing population through the use of small amounts of methyl parathion and the physical destruction of damaged squares. The use of pesticides for bollweevil control during the commercial season can be reduced by 75%-100% with an investment of about $1 per hectare.

Planting date may affect the incidence of pest attacks at a time the plant is particularly susceptible and planting density affects the tolerance of a field to heavy infestations. Fertilizer used in excess promotes the use of pesticides through lengthening the growing season and increasing plant attractiveness for pests.

The backbone of integrated pest control is a day-to-day understanding of the ecological conditions in a particular plot. Fields have to be divided in conveniently-sized scouting units. Most Central American farmers make no systematic effort to observe population trends within existing ecological conditions. A daily **pest and beneficial count is very desirable. The study tried out one scouting method and found it satisfactory (Part II, page 71).**

There exist a number of control criteria for different pests and situations (Part II, page **137**). Some of these tolerable pest levels can be substantially improved. Yet existing thresholds are more likely to result in efficient pest management than the practice of applying pesticides based on the mere presence of pests in a field.

The implementation of integrated pest control will result in a reduction in pesticide applications of about 40% according to demonstration carried out. Studies suggest that this would be economically more efficient in addition to being environmentally desirable. It is recommended that integrated pest control be developed as rapidly as possible through demonstration, extension, education, training, and dissemination programs.

As a complementary step, a system of selective import duties on pesticides could be put into effect. Studies in Nicaragua and El Salvador have shown that a 10% increase in pesticide price is likely to result in a 6-10% reduction in pesticide use per unit of cotton produced (Part II, page **165**). Other studies suggest that moderate changes in pesticide price will have no effect on the volume of cotton activity. Changes in pesticide price will not damage the cotton economy to a significant degree and yet they may lead to more efficient pesticide use levels.

(IV) Educate farmers regarding the economic and environmental significance of planting cotton in suitable lands, applying insecticide efficiently and practicing soil conservation:

Farmers have an economic incentive to solve the problems of beef contamination, excessive pesticide drift and unnecessary pesticide run-off. If they become aware of the potential savings to be made from solving these environmental problems, they might be more receptive to possible solutions and may even take action on their own initiative.

Most of beef contamination occurs because large cattle ranches are established in cotton areas. Cattle are allowed to roam the vicinity of cotton fields. Ecologically, pastures represent a less demanding land use than annual crops such as cotton. Beef producers should be encouraged to devote their lands to more profitable activities by means of showing them comparative farm budgets for alternative crops and cattle.

This would also help reduce the social and economic externalities of cotton production and protect the environment. The uniform distribution of agricultural activities will help reduce human poisoning cases and eliminate the exposure of other crops and livestock to cotton insecticides.

Through agricultural, ecological, and economic analysis by a team of experts the agricultural potential of selected areas for cotton production can be established. Cotton production should be encouraged in those areas that have the greatest ecological and economic potential. In the long run cotton profits will be higher there than anywhere else and resource allocation in general will improve.

A reduction in pesticide drift from aerial applications would serve all of the objectives of the systems management program. It would contribute to eliminate human poisonings, increase cotton profits through a reduction of costs, reduce cotton economic externalities, and protect the environment. A measure to reduce drift would have two major components: aerial application efficiency improvement and substitution of ground spot treatments for general aerial applications.

- Application efficiency

Studies show that under unstable weather conditions a large percentage of the total amount of pesticide applied does not fall where it was intended. Only 25% of the pesticide applied fell within a 14-meter band underneath the airplane in an ultra low volume application. (The figure for a conventional spray was 31%). Only 44% would fall inside a 20-hectare field, so that 56% would be lost from a pest control standpoint (PartII, page 28). Smaller fields would report higher losses but larger fields would not necessarily increase the amount deposited.

High pesticide losses at the time of application are caused by weather conditions, type of application, and equipment calibration. Application timing should be carefully supervised. Optimal hours should be established in each zone considering temperature inversion and wind velocity. Requiring no treatment under inappropriate conditions may result in higher application costs(more planes and more pilots) but the savings to be obtained will probably offset the increased costs.

Most spraying aircrafts pilots are probably unaware of the extent and significance of pesticide drift. A short course could be given stressing the importance of appropriate calibration, optimal flying altitudes, the relationship between weather conditions, time of day and pesticide drift, and the effects of misplaced pesticide on the natural and human environment.

An equipment calibration program could be established, with periodic supervision of airplanes, nozzles, and other elements. Although reducing drift is essentially in the interest of cotton grower's organizations, some support from public agencies might be needed. Publicly-provided tests with specialized equipment and additives could pay off in the form of public health protection, reduction of beef and other economic losses, and greater environmental quality.

Spot treatments:

Often, the treatment of an entire cotton field with pesticides is unnecessary. A reduction in pesticide use and drift could be obtained by treating only those spots heavily infested whenever advisable. Better pest count systems than presently used should be implemented. The adoption of spot treatment technology for cotton pest control appears operationally linked to the development of integrated pest control. It is therefore recommended that this management action be included in the integrated control program for each country.

Last, reducing soil erosion and consequent pesticide movement will limit the contamination of water bodies, especially rivers and estuaries, and protect economically valuable species such as shrimp and fish. Soil conservation also protects the natural environment and contributes to increase cotton profits.

Soil conservation programas should include soil cover, drainage, and wind barriers. One soil protection practice includes leaving the old cotton stocks on the land surface. This also helps the integrated bollweevil management(Recommendation III). The stocks help protect the soils during periods of severe wind and water erosion.

Fields should be appropriately planned and prepared to allow for proper drainage of run-off water.

Dense stands of trees can be arranged systematically across cotton fields to diminish the erosion force of winds. The trees should be spaced so as not to interfere with cultural operations. Some of them can also serve as buffer zones to prevent pesticide drift.

Trees planted in the buffer zones will have soil protection benefits as well. Ministries of agriculture and cotton organizations should publish and distribute pamphlets on soil conservation procedures.

(V) Establish an environmental monitoring program:

The purpose of environmental monitoring is to be able to detect significant changes in the absolute and relative importance of environmental problems. Within the context of the present study, it will also serve to verify the effectiveness of the proposed solutions. As an environmental instrument it will aid directly in locating beef zones free of insecticide drift through milk analysis and by monitoring water run-off from cotton fields.

- Human health monitoring:

Intoxication data by degree of severity should be collected every year. This will allow detection of trends and particularly check the effectiveness of recommended measures. Samples of human biological material will be collected every year from cotton and non-cotton areas to verify levels of sub-clinical intoxications. More investigation of the sub-clinical effects in non-cotton areas is dictated by the fact that a large percent of cotton workers are migratory.

A complement to this program would be the systematic monitoring of mosquito resistance to insecticides. This should be done on a regular basis in cotton and non cotton areas to allow for comparison.

- Cotton agroecosystem management:

Records of yields, costs, pesticide use, planted areas, and average profits should be established and kept in the cotton producing countries on yearly bases. Of special interest is the relationship pesticide use-yields-profits as it will reflect the effectiveness of integrated pest control in this area. Cotton organizations in each country are responsible to collect systematic data on this aspect of the systems management program.

- Contamination level monitoring:

Samples of key environmental components (milk, meat, water and marine species) will be systematically collected and analyzed every year to obtain a measure of pesticide residual levels in the environment. Environmental protection agencies are responsible for executing this measure and reputable chemical laboratories will be involved in the analysis of samples.

It is recommended that while the systems management program goes into effect, the Central American Research Institute for Industry (ICAITI) perform all the environmental monitoring actions outlined above. Upon execution of the program ICAITI could continue as a consultant to Environmental Protection Agencies, Social Security Institutions and Cotton Growers Organizations.

A visual representation of the systems management program will put all the management actions prescribed under a perspective which facilitates their individual and collective comprehension. In figures 1 through 5 the management actions can be seen in relation to the main objective they are intended to pursue. Most actions affect more than one problem. For example, a reduction of drift problems, although primarily intended to reduce economic externalities, has a beneficial effect on intoxication rates.

Table I shows the interactions between the recommended measures and the program's objectives.

FIGURE I

A Systems Management Program: Reducing Human Intoxications and Improving Human Health

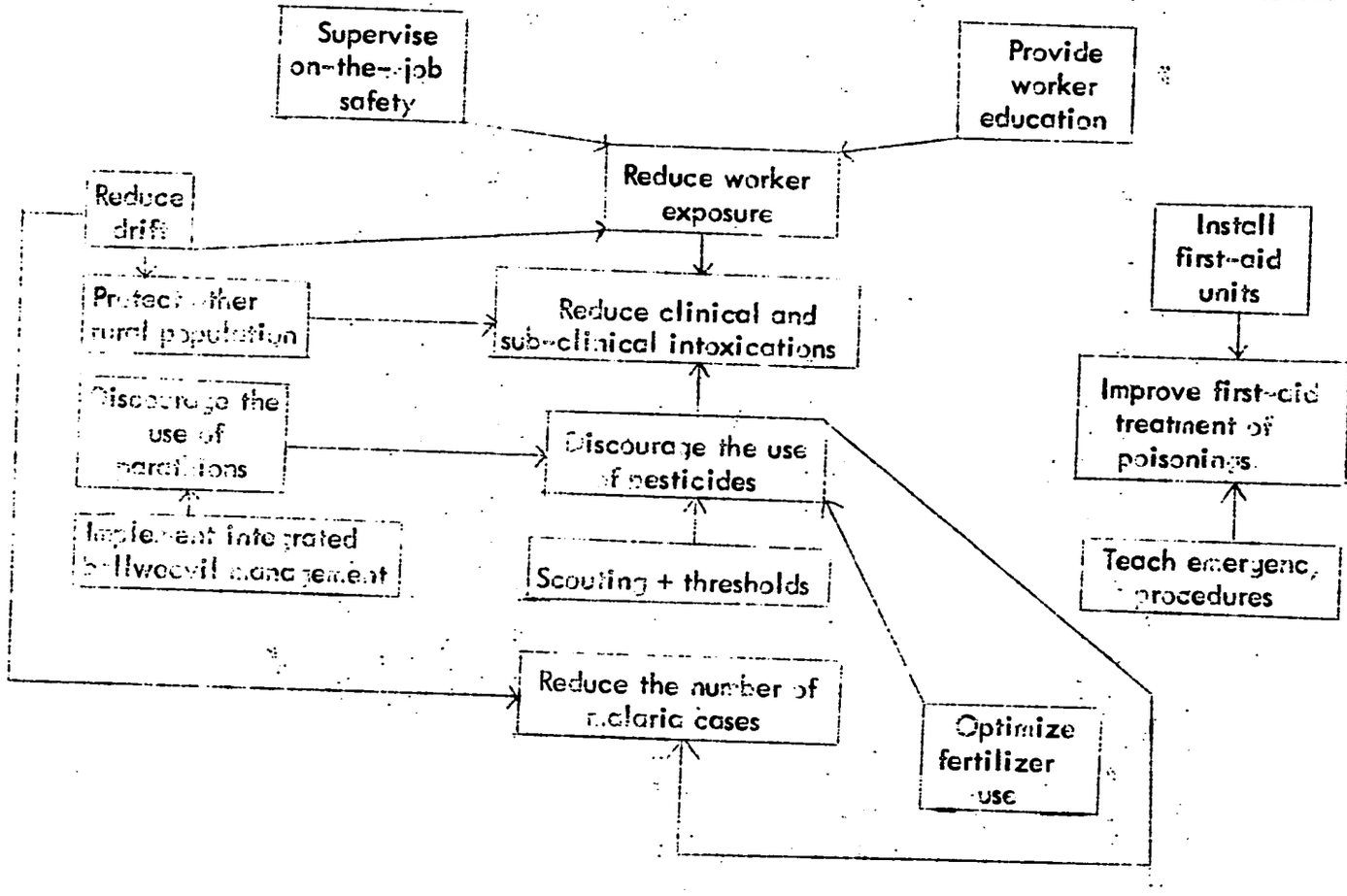


FIGURE 2

A Systems Management Program: Increasing Cotton Profits

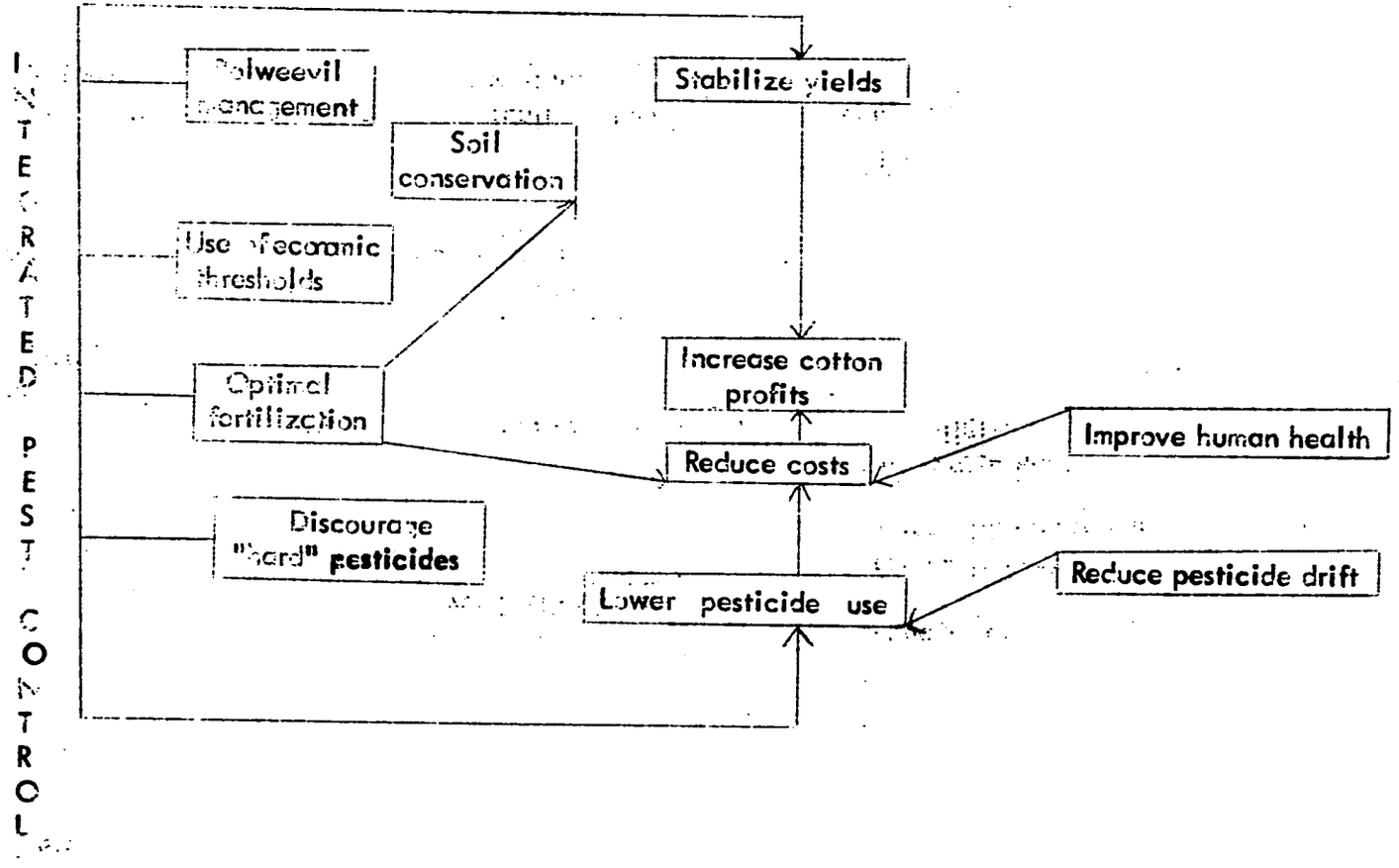


FIGURE 3

A Systems Management Program: Reducing the Economic Esternalities of Pesticide Use

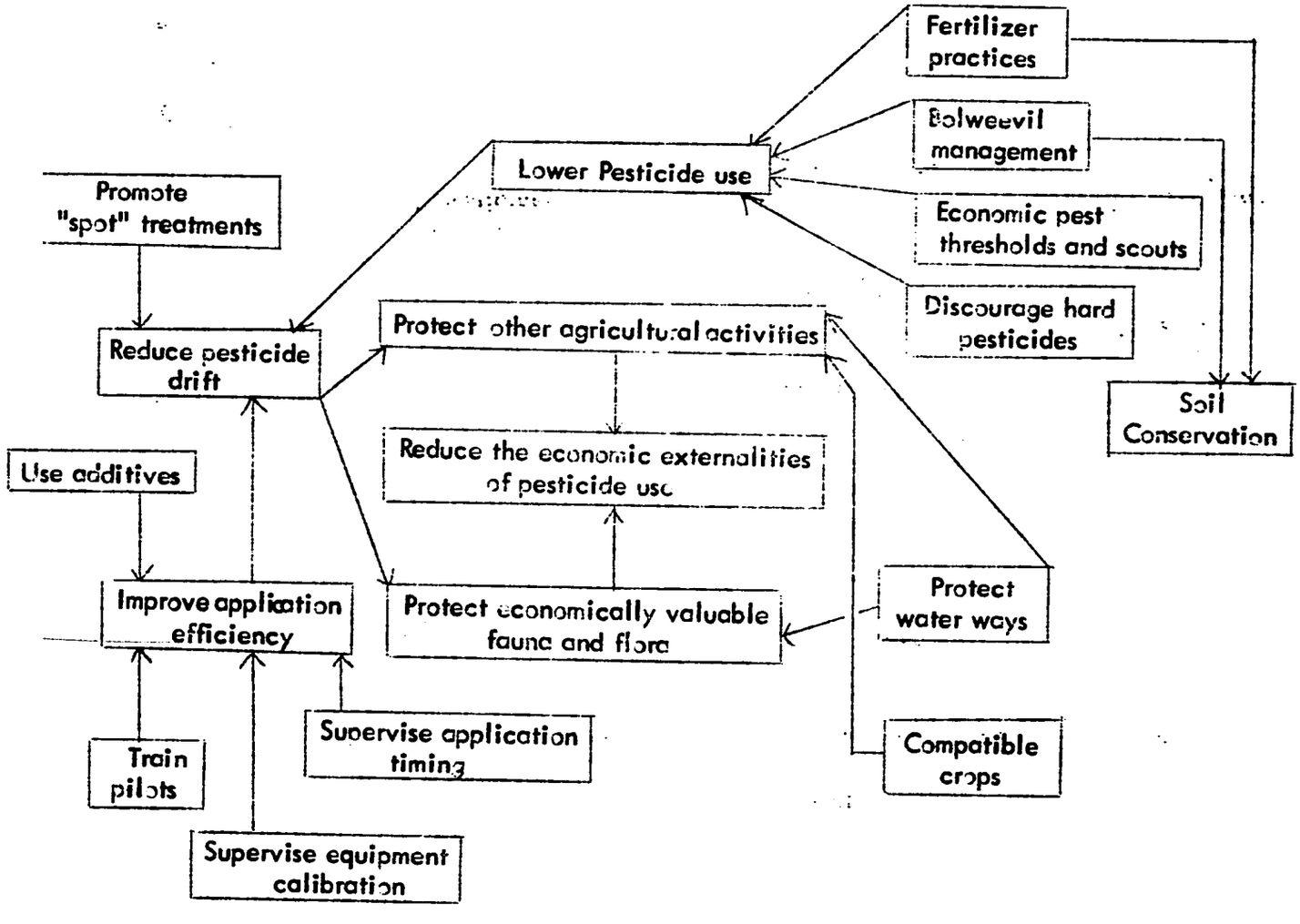


FIGURE 4

A Systems Management Program: Protecting the Environment

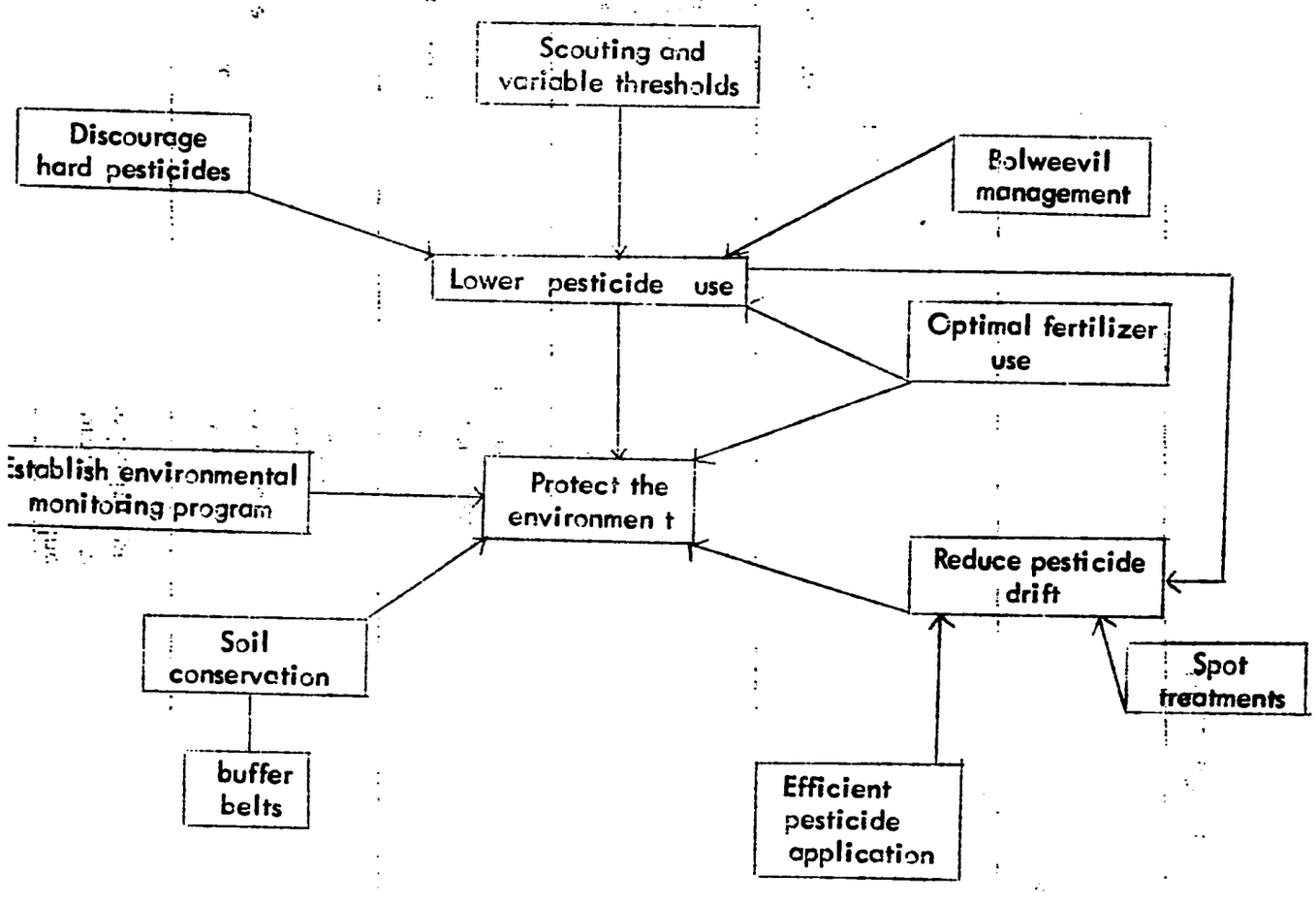


TABLE I

A SYSTEMS MANAGEMENT PROGRAM TO REDUCE THE CONSEQUENCES OF PESTICIDE USE

Management actions	Program's Objectives			
	Improve human health	Increase cotton profits	Reduce economic externalities	Protect the environment
1. Reduce worker exposure	** Effectiveness reduced without 2	*	*	
2. Improve first aid	** Effectiveness improved by 1	*		
3. Implement integrated cotton pest control	**	**	*	*
4. Educate farmers on economic benefits of solving environmental problems	*	*	**	*
5. Establish environmental monitoring program			*	*

* Weak effect
** Strong effect

SOURCE: ICAITI

2.3 The Executing Agencies

In order to implement the systems management program three types of institutions are necessary. First it is indispensable to secure the cooperation of a truly representative, progressive and well-organized cotton growers organization. It is also required to involve a social security or public health institution who covers agricultural workers. Last, it is necessary to engage an environmental resource management agency.

Although many other institutions will eventually become involved, the three mentioned are believed to be the key executing agencies. The integrated pest control program, for instance, will involve universities, schools, and ministries.

Most cotton grower's organizations in Central America are representative, progressive and well-organized. In Guatemala, where there are two organizations representing different sectors of the cotton activity, it might be useful to form a new, truly representative organization which is progressive as well.

Only one of the Central American countries has a social security insitutution which covers agricultural workers. The others are restricted to industrial workers in urban areas. However, the infraestructure is already laid, and the rest of the Central American countries can benefit from the experience of Guatemala in the area of agricultural worker security.

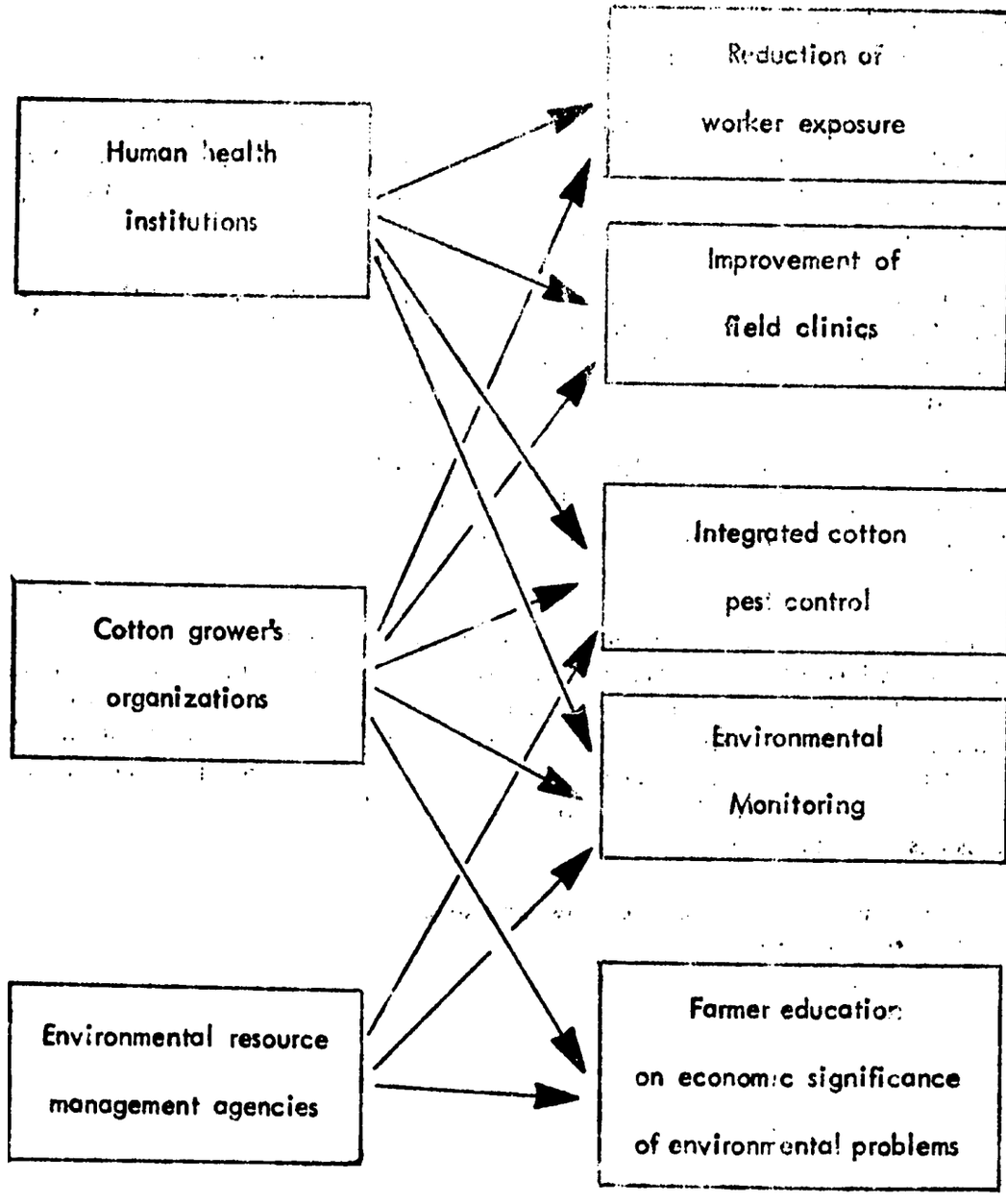
Most countries have either departments of Natual Resources or embryonic institutes for the environment. These should be oriented toward an agency for the protection of the environment. Specific legislation might have to be designed and implemented to meet this end.

It is recommended that appropriate authorities in the four countries promote the creation of the institutional infraestructure necessary to execute the recommendations of this study and to provide for much needed environmental protection at this realtively early stage of Central American economic development. In this manner, Central America can benefit from and avoid the mistakes of more developed nations. The presente project may help achieve this objective by publicizing the results and awakening public conciousness to these problems.

Figure 5 shows the interaction between executing agencies and the management actions they are to implement.

FIGURE 5

SYSTEMS MANAGEMENT PROGRAM:
EXECUTING AGENCIES AND THE MANAGEMENT ACTIONS



PART II

"SOME ENVIRONMENTAL, HUMAN HEALTH, AGRICULTURAL AND ECONOMIC ISSUES OF PESTICIDE USE IN CENTRAL AMERICA"

1. A DESCRIPTION OF CENTRAL AMERICA AND ITS COTTON AREAS

The area under study is described according to location, extension, ecological characteristics, human population, current utilization of agricultural resources and socio-economic characteristics. The cotton agroecosystem is discussed separately in these pages.

1.1 Central America:

It is located in the western hemisphere between 8:00 and 18:00 degrees latitude north. It includes five countries: Costa Rica, El Salvador, Guatemala, Honduras, and Nicaragua. It is north-bounded by México and the Caribbean, and south-limited by Panamá; the Atlantic Ocean provides the East Boundary and the Pacific Ocean the West. Central America covers an area of 411 384 Km.^{2}.

The area under study comprises the four countries situated to the north of Costa Rica and covers 360 484 Km.^{2}. The latter country was not included in the study because its cotton growing area is very small (around 1 000 Ha.).

Ecological characteristics:

This part of the Continent is within the "Tropical Strip". Altitude variations run from 0 to 4 211 m (Volcán Tajumulco in San Marcos, Guatemala). These are wide variations if one considers the small extension and narrowness of the territory. This abrupt topography, the geographical position of the region (bathed by two Oceans), and the narowness of the territory have produced a wide range of climatic conditions.

The living zones comprise all tropical classifications. They run from "very dry tropical zones", where the average annual rainfall varies from 500 to 1 000 mm, to "very wet tropical zones", with average yearly rainfall over 6 000 mm. The annual average temperature varies from 28°C along the Pacific lowlands to less than 6°C in the mountains. (1)

The chemical and physical properties of the soil are also varied. Virtually all countries in the region have fertile soils of volcanic or alluvial origin, and poor soils which sometimes due to excessive runoff are rendered unsuitable for agriculture.

This extreme variability of the environment in topography, climatic conditions, and soils are also reflected in the diversity of flora and fauna.

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(1) Holdrige, L.R., Zonificación Ecológica de Centro América, 1967

Population:

The population of the four countries reached 15 221 215 inhabitants in 1974. It is a young, undernourished, rapidly-increasing population of a race termed indolatin.

The total population was unevenly distributed in the four countries of the area under study. The country with the largest number of inhabitants was Guatemala, with 6 223 940. El Salvador was in second place with 3 937 701. Honduras had 2 879 300 inhabitants and Nicaragua 2 180 274 in 1974.

A large proportion (62.8%) of the total population of the four countries lived in rural areas in 1973. The rural population in Honduras was 71.6 % of its total population. El Salvador had 66.5 %, Guatemala 59.4% and Nicaragua had the lowest rural population, 54.2% of the total.

In 1974, the population density of the whole area was 42.2 inhabitants per square kilometer. This density was different for each country. El Salvador has 186.1 inhabitants per square kilometer; Guatemala had 57.1 ; Honduras 25.6 ; and Nicaragua 18.4.

Almost half the Central American population (46%) was less than 15 years old in 1974. Less than 10% of the population was included in the group over 50 years old.

This population has undergone a rapid growth in recent years as reflected in the birth and death rates (44/1 000 and 10/ 1 000 respectively). In 1940, Central America had 6 400 000 inhabitants. The annual growth rate of the population increased as a result of a drop in the general death rate caused by better sanitary conditions. During the following decade, the population rose by 25% and reached 8 759 000 inhabitants in 1950. From then on the growth rate increased at an even faster pace. The annual average growth rate, 2.5% between 1940-50, was 3.4 percent in the following decade. An annual growth rate of 3.5% is expected for 1965-80.

The Central American population is the result of mixing between an indian race of Mayan extraction and a Spanish European race. The resulting breed is known as indolatin race. The major part of the population belongs to this heterogeneous racial group.

Undernourishment refers to low calory ingestion and a deficient protein diet and it is documented extensively elsewhere (1).

Land use:

Land use in the countries covered by this study is relatively low. In 1970, only 33% of the land was used for agriculture (United States: 47%, France: 64%, Chile : 40%,

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(1) INCAP, Evaluación Nutricional de la Población de Centroamérica y Panamá. (Guatemala; INCAP, 1969) and several other publications.

Holland: 64%, Pakistan: 36%). About 70% of the total agricultural production(in monetary terms) was exported that year. The major part of the land was used in the form of relatively large concerns, while the majority of agricultural families occupied relatively small farms (1).

Of the 35 048 400 hectares in the countries considered in this study, 11 799 000 were used for agriculture during 1970. Thus about 33% of the total land surface was under some type of cultivation. El Salvador had a more intensive land use (77.8%) and Honduras had the lowest land utilization of the four countries (22.0%). (2).

In 1970 approximately 1 781 000 hectares were used for annual cultures. This represented about 15% of the land exploited in farms. Permanent cultures used 960 000 hectares (8%). The major part was dedicated to grazing and totalled 5 100 000 hectares (43%). The remaining 395 800 hectares were not in use (34%). (1) .

The most important agricultural products according to value were: coffee, cattle produce, cotton, corn, bananas, sugar cane, and beans. The first three were major export products. Among the last, corn and beans are the most important staple food for the human population in Central America. It is significant footnote again that the value of the Central American agricultural exports was 70% of the total agricultural production in 1970. Both subsistence and export agriculture are very important for Central America.

Yet the agrarian structure of the region is very unbalanced. About 67% of agricultural land was exploited in units larger than 35 hectares. Only 3% corresponded to exploitations in less than four hectares. (2).

The significance of this fact is that the small farms concentrate a major part of the human population. A 76% of agricultural human population lived in farms of less than four hectares, and 6% of the population occupied 67% of the agricultural land in farms of 140 hectares on the average.

Socio-economic characteristics:

The economically active population of Central America is approximately one third of the total population. About 60% of this active population works in the agricultural sector. This gives an agriculturally active population of 2 866 000 persons, and 4 777 000 in all economic sectors of the countries under study.

In 1970 this active population generated an annual average income of $CA 284 per person ($CA 1 = US $1). This income showed widely separated extremes: 5% of the people had $CA 1 760 per person and absorbed 31% of total income; half the people had an average income of $ CA 74 and shared 13% of the total income.

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(1) Anuario de la Producción 1973, FAO., Roma, 1974.
(2) SIECA, Perspectivas para el desarrollo y la integración de la agricultura en Centro América, (Guatemala: SIECA, 1974)

The average income per capita was $CA 141 among the agricultural population. That is half the national average income.

The landless families and peasants with less than four hectares, which made up 76% of the agricultural population, had an average income of only $CA 49. Families with more than 35 hectares, 6% of the agricultural population, had in 1970 an average income of $CA 952. This figure is 19 times larger than that of the lowest stratum.

1.2 The Cotton Agroecosystem:

The geographical location, extension, characteristics, utilization history, and present situation of the cotton agroecosystem are described in the following sections.

Location and extension:

The Central American cotton growing area runs parallel to the 900 km of the Pacific coastal plain between 12° and 16° latitude north. In 1974 the area cultivated in the four countries under study totalled approximately 393 000 hectares.

Characteristics:

Almost all of the cotton growing area is within the "dry-tropical zone", according to Holdrige's initial ecological zonification. (1).

This area is characterized by a flat topography. Most of the cotton area is no more than 200 meters above sea level, The average rainfall varies from 1 000 to 2 000 mm per year. There is a well defined dry season from November to April and a rainy season from May to October. The annual average temperature is 28°C and has a very narrow variation range. The major part of the soils is of volcanic and alluvial origin.

The cotton plant thrives well in fertile, deep and well drained soils. It requires a minimum rainfall of 650 mm during vegetative growth and blooming stages and absence of rain during maturation and harvesting. The fastest rate of growth occurs between 25° and 30° C and the plant needs more than 50% luminosity. The Pacific coastal plains meet these agro-climatic requirements, which explains why cotton growing is concentrated there.

A substantial part of the human population of the countries under study lives in the Pacific watershed, within or very near the cotton growing zones.

Background:

Cotton growing was initiated in a commercial scale during the first quarter of the

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(1) Holdrige, L.R., Zonificación ecológica de Centro América, 1967.

present century. Central American farmers, lured by the results obtained in the United States and other countries in South America, imported seeds and agricultural techniques from the Southern States of the United States of América.

Cotton cultivation during and before this period may be considered as a stage of subsistence. (1).

In the subsistence phase the use of pesticides was low. Pests were controlled with calcium arsenate, sulphur, or an infusion of tobacco leaves. This was done by "progressive" producers. The majority depended on natural control and manual gathering of insects. At that time the main pests were three: the red boll weevil (Anthonomus grandis Boh.), the leafworm (Alabama argillacea), and desert locust (Schistocerca perenensis Burm.).

At the end of the Second World War, a successful campaign was launched against the desert locust. The important pests for the cotton producer were reduced to two: the red boll weevil and the leafworm.

These two insects, according to some agroecologists, are the only ones that have an ecological potential as cotton pests in Central America. The boll weevil, which is apparently native to this part of the world, has developed parallel to the cotton plant. The cotton plant is his favorite host. The leafworm, because of his migratory character, follows the apparent motion of the sun and his favorite food is the cotton leaf.

According to some old cotton producers, before the use of pesticides there were no "worm" pests in their plantations, and they were only concerned about collecting the boll weevil. This gives an idea of the slight perturbation existing in some agroecosystems, which favored an effective natural protection for the highly exposed species. The system had been disturbed by lumbering, fire and subsistence agriculture before the discovery of America but in sufficiently small areas to allow an "adequate" ecological equilibrium.

Cotton yields per unit of area were not very high. The maximum values were 2 000 kg of cotton per hectare, with averages of about 1550 kg/ha.

Current situation:

During the 1950-60 decade Central America entered what Smith calls the "explcitation phase" of cotton growing. (2). Intensive use of machinery and chemicals started during this phase.

At the beginning of this phase the harmful species which attained pest levels were two: the red boll weevil (Anthonomus grandis) and the leafworm (Alabama argillacea).

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(1) Falcon, L.A. and Smith R.F., Manual de Control Integrado de Plagas del Algodonero, Roma, FAO, 1974.

(2) Smith, R.F., Cited reference.

The introduction of organosynthetic insecticides for control of these pests caused a real revolution. Pest control became easier, more economical, and efficient. Average yields increased from 1 550 kg of cotton with seed per hectare to 2270 kg. This made cotton an attractive venture and planted areas began to increase rapidly.

The most common organosynthetic insecticides used were DDT, BHC, and Toxaphene. These were used pure, mixed with each other, or in some cases with sulphur. The average number of insecticide applications per surface unit was eight per season.

In the middle of the decade the organophosphorous insecticides made their appearance. These showed greater efficiency in pest control.

The increasing use of organosynthetic insecticides apparently brought about an increase in the number of harmful species which reached pest levels. By the middle of the decade three more problem species were added to the existing two: Boll worm (Heliothis spp.) , aphid (Aphis gossypii), and false pink boll worm (Sacadodes pyralis).

In the following decade (1960-1970) a great variety of organosynthetic insecticides appeared in the Central American market, mainly organophosphates and carbamates. Inadequate governmental restrictions concerning the agricultural use of pesticides turned Central America into a sort of experimental grounds for pesticide manufacturing companies. Many pesticides used in cotton production in Central America were not approved for commercial sale in their country of origin.

The inadequate regulation of pesticides and the belief that a mix of several pesticides increased control efficiency lead cotton growers to situations in which they could choose from more than fifty alternatives between products and mixes for the chemical control of one pest.

By that time the applications of pesticides under a calendar system became important based on the apparent need of maintaining certain toxic level in the plantation and to cover new parts of the plant.

The number of pesticide applications per season increased to an average of 28 and the species that reached pest levels varied. Of the five important harmful species existing in the previous decade the false pink boll worm ceased to be important, the aphid became a species of less importance, but four species which did not cause problems, the army worm (Prodenia spp), the white fly (Bemicia tabaci), the cabbage looper (Trichoplusia ni), , and the army worm (Spodoptera spp) reached pest levels. In some parts of the region, one species (Creontiades signatum) attained pest level.

The appearance of new pests and resistance to insecticides compelled cotton growers to use larger amounts of insecticides and make more frequent applications. Pest control expenditures reached 50% of production costs. Unit yields, which had attained a maximum level around the middle of the decade, began to decline.

A price drop of the fiber in the international market prompted the abandonment of marginal lands. Inefficient cotton growers had to withdraw from the activity.

At the beginning of the current decade, the number of harmful species of importance increased to eight when the Creontiades signatum reached the status of important pest.

In the light of the situation some countries launched programs aimed at reducing the number of pesticide applications. El Salvador, with the advice of the Government of Israel, started a technical assistance program which covered a rather extensive physical area. Research was mainly developed by the Cotton Growers Cooperative of El Salvador with the advice of the French Research Institute for Cotton and Exotic Fibers.

Nicaragua, with the advice of the United Nations Food and Agricultural Organization (FAO), initiated an integrated pest control program. This program consists of technical assistance, training, and research. Technical assistance is provided by the Ministry of Agriculture and the National Bank of Nicaragua. Training is conducted by the National University of Nicaragua. Research is carried out by the Cotton Experiment Center with the advice of the French Research Institute for Cotton and Exotic Fibers. There is also an integrated Pest Control Coordinating Committee made up of representatives of all entities involved in cotton production.

In Honduras, the Southern Cotton Growers Cooperative initiated a technical assistance program which covers the whole cotton growing area of that country. Although they have conducted little research of their own, they have utilized to advantage the results of research conducted in Nicaragua.

All these programs have had good results, for the use of pesticides in cotton production has been somewhat reduced. With the exception of Guatemala, which has no organized programme to provide technical assistance, the other countries have achieved some reductions in pesticide applications in comparison with the number of applications effected in the previous decade. Nevertheless, current technology suggests that it is possible to reduce insecticide usage further and restore some of the original ecological balance to the Central American Pacific coastal plain.

2. THE ENVIRONMENT AND PESTICIDE USE

This chapter discusses the contamination levels in Central America, some important events which propitiate pesticide movement and some environmental implications of pesticide use. Special emphasis is given to the results of a pesticide drift test and the contamination of meat and milk in relation to pesticide use in cotton production.

2.1 The presence of pesticides in the Central American Environment

Pesticides are widely disseminated throughout the Central American environment. Most of the samples analyzed in the present study were contaminated with DDT, many with Toxaphene and some with ethyl and methyl Parathion despite the more readily degradable nature of the latter. It is apparent that organosynthetic pesticides have become a part of the natural and human environment.

Although enough evidence of pesticide contamination was gathered by the study, pesticide effects at very low doses were not studied. For the most part the study of envitonmental impact in the case of pesticide continues to be a preliminary nature.

The pesticide load:

In 1974 about 27,300 metric tons of pesticides were consumed in the four countries under study. This amount represented a little over 75 kilograms per square kilometer of surface area and about 2 kilograms per person per year. (See tables 2, 3 and 4).

El Salvador and Guatemala were the highest consumers in absolute terms, followed by Nicaragua, with Honduras a very distant fourth. On a per-surface-area basis this ranking was maintained as well as per capita. This different pesticide load may be reflected in the consequences of pesticide use, for instance number of poisoning cases and sub-clinical intoxication levels. (See pages 57 58 and 67).

TABLE 2

TOTAL PESTICIDE LOAD
IN THE CENTRAL AMERICAN ENVIRONMENT
1972 - 1975 (in kilograms)

COUNTRY	1972	1973	1974	1975
El Salvador	9 014 838	12 530 783	11 068 537	7 293 718
Guatemala	5 292 127	10 264 903	11 208 665	13 471 380
Honduras	-	226 800	158 916	-
Nicaragua	7 123 657	7 809 774	4 859 079	-
Central America	-	30 832 260	27 295 197	-

SOURCE: ICAITI

TABLE 3

CENTRAL AMERICA:
PESTICIDE LOAD PER TOTAL SURFACE AREA OF COUNTRY
1972-1975 (in kg/km^2)

COUNTRY	1972	1973	1974	1975
El Salvador	427.0	593.5	424.2	345.4
Guatemala	48.6	94.4	102.9	123.7
Honduras	--	2.02	1.42	-
Nicaragua	60.2	66.0	41.0	-
Central America	--	85.5	75.7	--

SOURCE: ICAITI

TABLE 4

CENTRAL AMERICA
AVERAGE PESTICIDE USE IN COTTON PRODUCTION
1972/73 - 1974/75 (kg/ha a.i.)

COUNTRY	1972/73	1973/74	1974/75
El Salvador	58.4	72.1	70.0
Guatemala	45.6	75.2	79.9
Honduras	-	27.0	19.3
Nicaragua	51.2	44.1	49.8

SOURCE: ICAITI, CONAL, and, for 1974/75 in Nicaragua, Banco Nacional de Nicaragua.

- Not available

TABLE 5

CENTRAL AMERICA: DDT USE IN COTTON PRODUCTION
1974/75

COUNTRY	POUNDS/MANZANA	Kg/Ha.
El Salvador**	10.28	6.7
Guatemala*	15.77	10.22
Honduras	3.72	2.41
Nicaragua	9.69	6.28

SOURCE: ICAITI
CONAL Nicaragua
ALGOSUR: HONDURAS

** Survey of farms in whole country.
* Survey of farms in La Gomera.

Contamination levels:

The objective of this portion of the study was to document the levels and geographical distribution of pesticide contamination in the area. To this end a number of environmental components were selected for exploratory sampling and analysis. The samples fall in three broad categories. It seemed important to include a large number of human and animal foods and feeds. This relates to the project's concern for human health problems and sub-clinical intoxication levels. A second group was that of economically useful fauna. Pesticide contamination might eventually result in adverse effects for these valuable species which are also human foods. Last, samples of wildlife were obtained to document their contamination with pesticides.

The study relied heavily on the cooperation of other institutions for the obtention of samples. As a result a total of 1,621* samples were collected and analyzed. Nevertheless, this reliance on external sources made it very difficult to follow a systematic sampling pattern on to obtain samples for all components in each country. Although this makes comparisons between countries very limited the results provide a comprehensive picture of contamination in the whole area.

Some difficulties were encountered in the collection of wildlife samples. Arms control is more stringent in Central America than in many other areas. Birds and lizards had to be acquired from third sources when they were available.

The samples collected were labeled, packed, and shipped to the laboratory for analysis. The content of pesticides in parts per million of weight was established through gas chromatography. Except in the cases of milk and meat, contamination was expressed in relation to total weight of the animal or plant. In the cases of meat and milk contamination was determined in the fat and expressed in relation to its weight.

Table 6 presents a summary of the information obtained. Environmental components are grouped in classes and the average found for every country is presented. The table also shows the standard deviation of the average and the number of samples analyzed.

Sample number refers to the number of separate analysis performed on a particular environmental component. For instance a sample number of 7 for cottonseed does not mean that 7 seeds were analyzed but that 7 lots of seed were analyzed. This is true in all cases except a few instances of fishes, reptiles, and birds, when a single individual was analyzed.

Some aspects of table 6 are worth noticing. As in most pesticide contamination studies it is evident that higher concentrations of pesticide are found in the higher trophic levels. Water shows that least contamination of all environmental components. Producers (plants and plant products) follow with noticeably higher contamination levels but still bellow 1 ppm. Animals and animal products appear consistently more contaminated than the rest of the elements of environment.

*** This total does not include 1871 samples of meat that were also analized.**

TABLE 6

Central America: Average DDT Contamination in Selected Environmental Components, in ppm. 1974-76

	Environmental Components	EL SALVADOR			GUATEMALA			HONDURAS			NICARAGUA		
		$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n
Substratum	Ground water	0.0055	0.0076	2	0.00020	0.00038	60	0.00011	0.00016	14	0.000065	0.00012	23
	river water	0.00015	0.00022	21	0.033	0.108	11	0.00099	0.0011	9	0.000054	0.000067	9
	estuarine water	0.000043	0.000033	14	0.0	0.0	1	0.00011	0.000096	6			
Plants and Plants Products	corn	0.0055	0.0081	29	0.0119	0.0075	4	0.019	0.023	14			
	rice	0.88	0.92	2				0.32	0.34	3	0.16	0.16	1
	beans	0.011	0.014	24				0.015	0.018	6			
	sorghum	0.24	0.40	12	0.646	0.528	2	0.033	0.024	7			
	cottonseed				32.15	84.26	7	0.092	0.061	5	0.242	0.179	5
	cottonseed flour				0.162	0.170	6						
	sesame							0.010	0.00502	2			
	animal feed				0.18	0.20	3	0.063	0.063	1	0.126	0.160	2
	edible greens				0.185	0.209	9	0.030	0.024	2			
	pasture				0.72	1.27	42						
	fruit	0.007	0.11	18	0.23	0.46	6						
	tobaco	0.15	0.16	21									
CONSUMERS	earthworm				1.41	1.41	1	0.60	0.60	1			
	frogs				4.035	3.0338	2						
	shrimp	0.40	0.78	57	4.06	5.419	3	0.090	0.056	2	0.42	0.69	14
	other shellfish	0.46	1.40	70	3.070	3.838	5	0.071	0.071	1			
	fish	2.77	4.44	142	8.26	13.59	9	0.63	1.30	20	1.53	1.47	22
	reptiles				0.14	0.16	4	0.021	0.018	3	1.80	2.97	26
	birds				8.57	9.93	2	4.63	4.63	1	35.05	28.56	3
	meat	6.29	11.46	13	4.93	6.60	302						
	cheese	3.06	4.80	20									
	milk	7.29	12.09	49	4.54	5.16	408	2.54	2.84	7	36.05	32.66	32

SOURCE: ICAITI

TABLE 7

EL SALVADOR: PESTICIDE CONTAMINATION IN SELECTED ENVIRONMENTAL COMPONENTS 1974-76 BY DEPARTMENTS

Departments	Area Km2	Manzanas of cotton growing 74-75	% of cotton growing area	SAMPLES	# of samples	Average of residues in parts per million (ppm)					
						DDT + metabolites	Dieldrin	TOX	Methyl parath.	Ethyl parath.	Endrin
La Paz	1224	33699	19.24	beans	2	0.011	0.0003				
				corn	1	0.0041	0.031				
				milk	3	1.72	0.016				
				meat	1	3.09					
Usulutan	2130	44901	14.73	river water	20	0.00207	0.000008		0.0001	0.00004	0.000036
				estuarine water	14	0.000045				0.00074	
				ground water	2	0.0055					
				shrimp	56	0.366	0.0017				
				other shellfish	61	0.502	0.0046	0.609			
				fish	69	3.47	0.012		0.11		
				sorghum	4	0.34	0.52	0.14			
				beans	6	0.0051	0.0001				
				corn	9	0.0028	0.00018				
				fruits	4	0.014	0.00002				
				milk	12	20.06	1.22				
San Miguel	2077	32937	11.08	river water	1	0.00034	0.00006				
				fish	6	10.94		5.24			
				sorghum	3	0.09	0.0009	0.15			
				beans	3	0.023	0.001				
				corn	8	0.0015	0.0002				
				rice	1	0.23	0.006	0.76			
				fruits	3	0.006	0.001	0.13			
				milk	15	[illegible]	[illegible]	0.073			
				cheese	3	[illegible]	[illegible]				
				meat	[illegible]	[illegible]					
San Vicente	1184	12794	7.65	sorghum	1	[illegible]		1.77			
				beans	1	[illegible]					
				rice	[illegible]	[illegible]	0.04				
				tobaco	2	[illegible]		0.13			
				milk		[illegible]	[illegible]				
				cheese	7	[illegible]	0.1[illegible]				
				meat	[illegible]	[illegible]					
Sonsonate	1226	6263	3.57	shrimp	1	[illegible]					
				other shellfish	1	0.2[illegible]					
				fish	9	1.0[illegible]		0.08	1.2[illegible]	0.09	
				beans	2	0.0[illegible]7			0.16	0.10	
				corn	4	0.0[illegible]74	0.0001				
				tobaco	1	0.0[illegible]5					
				milk	2	[illegible]					
				meat	1	0.8[illegible]					
La Unión	2074	5802	1.95	other shellfish	5	0.208					
				fish	32	1.279		0.043	0.028	0.163	
				sorghum	4	0.016	0.0007				
				corn	1	0.006	0.004	0.28			
				milk	1	1.12					
				cheese	4	1.54	0.015				
La Libertad	1653	4236	1.79	other shellfish	3	0.14	0.006		0.03		
				fish	20	1.61		1.37	0.009	0.004	
				beans	7	0.0124					
				corn	3	0.0055	0.0010				
				tobaco	4	0.141	0.0007				
				fruits	11	0.0060	0.0004				
				meat	2	0.93	0.025				
Ahuachapan	1240	2136	1.20	fish	6	0.92			0.93		
				corn	2	0.017	0.0003		0.16	0.08	
Chalatenango	2017	396	0.13	tobaco	1	0.17					
				milk	8	0.94					
				cheese	3	1.32					
				meat	3	2.00	0.016				
Cabañas	1104	40	0.02	beans	2	0.0074					
				tobaco	1	-					
				milk	3	0.49					
				cheese	3	0.92					
San Salvador	886	15	0.01	tobaco	7	0.257		0.428			
				milk	1	0.37					
Cuscatlan	756	-	-	beans	1	0.003					
				corn	1	0.0045	0.001				
				tobaco	5	0.089					

TABLE 8

GUATEMALA: PESTICIDE CONTAMINATION IN SELECTED ENVIRONMENTAL COMPONENTS
1974-76 BY DEPARTMENTS

Departments	Area Km2	Manzanas of cotton growing 74-75	% of cotton growing area	SAMPLES	# of samples	Average of residues in parts per million (ppm)					
						DDT metabolites	Dieldrin	TOX.	Methyl parath.	Ethyl parath.	Endrin
Retalhuleu	1856	44736	16.84	river water	3	0.00043					
				ground water	5	0.00018					
				shrimp	2	5.89		2.35			
				other shellfish	3	4.56		8.66			
				fish	4	10.99		16.27			
				sorghum	1	0.[illegible]		1.83	0.001	0.045	
				corn	[illegible]	0.015				0.008	
				edible greens	1	0.15		0.15	0.003	0.005	
				pasture	8	[illegible]	0.04	3.40		0.026	
				cottonseed	2	0.067					
				reptiles	1	0.[illegible]	0.02			0.016	
				citrus	2	8.57				0.09	
				milk	2	4.74	0.0085				
				meat	99	6.19	0.009	0.021			
Escuintla	4384	78782	12.56	river water	8	0.045					
				ground water	35	0.00010	0.0000039				
				estuarine water	1	-	-	-	-	-	
				shrimp	1	0.403	0.004				
				other shellfish	2	0.205					
				fish	5	5.08	0.02	8.29	0.008	0.054	
				corn	2	0.008					
				edible greens	3	0.35					
				pasture	34	0.52	0.011				
				cottonseed	5	44.90	0.03	50.79			
				fruits	6	0.13			0.001	0.005	
				earthworm	1	1.41					
				frogs	2	4.03					
				reptiles	1	0.048					
				milk	345	5.20	0.046				
				meat	126	5.27	0.001	0.291			
Suchitepequez	2510	19779	5.50	milk	1	3.38					
				meat	27	4.01					
Quezaltenango	1951	5350	1.91	meat	5	3.81					
San Marcos	3791	5780	1.06	meat	3	1.98					
Santa Rosa	2955	4500	1.06	meat	10	2.47		0.23			
Sacatepequez	465	-	-	milk	46	0.3682					
Alta Verapaz	8686	-	-	meat	7	0.66					
Izabal	9038	-	-	meat	6	0.26					
Guatemala	2126	-	-	animal feed	3	0.18					
				cottonseed flour	6	0.16	0.0015				
				milk	6	0.99					
				meat	1	2.24					
Zacapa	2690	-	-	meat	6	0.36					
Jutiapa	3219	-	-	meat	1	0.56					
Sololá	1061	-	-	milk	3	0.30					

TABLE 9

HONDURAS: PESTICIDE CONTAMINATION IN SELECTED ENVIRONMENTAL COMPONENTS
1974-76 BY DEPARTMENTS

Departments	Area Km2	Manzanas of cotton growing 74-75	% of cotton growing area	SAMPLES	# of samples	Average of residues in parts per million (ppm) DDT + metabolites	Dieldrin	TOX	Methyl parath.	Ethyl parath.	Endrin
Valle	1564	2000	0.89	estuarine water	6	0.00011			0.000016	0.000015	
				shrimp	2	0.09					
				fish	13	0.49					
				other shellfish	1	0.071					
				sorghum	4	0.031	0.001				
				corn	3	0.031					
				sesame	1	0.007					
				reptiles	2	0.031					
				milk	4	2.67					
Choluteca	4211	4797	0.79	river water	8	0.0011				0.000003	
				ground water	6	0.00019				0.00001	
				fish	6	1.02					
				corn	7	0.017	0.0010			0.0001	
				sorghum	2	0.027	0.0002				
				beans	1	0.0108	0.0004			0.001	
				sesame	1	0.0142	0.0006				
				birds	1	4.63					
				reptiles	1	0.00					
				milk	1	5.71					
Olancho	24350	4269	0.12	ground water	4	0.00					
				river water	1	0.00					
				fish	1	0.109					
				corn	5	0.0097					
				beans	5	0.0168	0.00008				
				rice	3	0.32					
				cottonseed	4	0.075	0.0012	0.035			
				animal feed	1	0.060					
				edible greens	2	0.0303					
				earthworms	1	0.60					
				milk	1	0.30					
Paraiso	7218	635	0.06	ground water	4	0.00012				0.000045	
Fco. Morazán	7946	74	0.006	milk	1	1.09					

NICARAGUA: PESTICIDE CONTAMINATION IN SELECTED ENVIRONMENTAL COMPONENTS
1974-76 BY DEPARTMENTS

Departments	Area Km2	Manzanas of cotton growing 74-75	% of cotton growing area	SAMPLES	# of samples	Average of residues in parts per million (ppm)					
						DDT + metabolites	Dieldrin	TOX	Methyl parath.	Ethyl parath.	Endrin
León	5234	131474	17.55	river water	9	0.00005	0.0000045		0.000001		
				ground water	16	0.000088	0.0000017	0.000032			
				shrimp	8	0.60	0.0005				
				fish	12	1.[illegible]6	0.036	0.98			
				reptiles	7	0.[illegible]9	0.026	0.99			
				cottonseed	4	0.2[illegible]		0.5		0.0017	
				animal feed	1	0.013					
				rice	1	0.16					
				birds	3	35.[illegible]5	0.026				
				milk	26	32.[illegible]1	0.25				
Chinandega	4662	111766	16.75	ground water	3	0.0[illegible]					
				shrimp	5	0.20					
				fish	7	1.01	0.028	0.15			
				reptiles	6	1.20	[illegible]073	9.09			
				milk	2	11.23	[illegible]095				
Masaya	543	9921	12.77	ground water	3	0.00					
				fish	2	3.39		1.60			
				reptiles	13	2.73	0.02[illegible]	0.25			
				cottonseed	1	0.0064				0.005	
				animal feed	1	0.24					
				milk	4	73.42	0.05				
Managua	3635	18547	3.56	ground water	1	0.000069	0.00001			0.00004	
				shrimp	1	0.088	0.003				
Granada	964	3342	2.42	fish	1	0.00003					

Although meat and milk appear in many cases to contain DDT above tolerances established in some countries, the different dietary habits of Central Americans make any conclusion on human health effects inapplicable. Specific studies would have to be made to create a set of standards adapted to the area. Such studies would appear useful for beans, rice, corn, cottonseed oil, meat, milk , and other popularly consumed products.

Only very limited comparisons between countries can be made because of the nature of the sampling effected. It can be said for instance that Honduras appears to be the least contaminated of the four countries. This makes sense because Honduras has the smallest cotton area and the least insecticide use in relative and absolute terms (tables 2 and 6).

Tables 7 through 10 show detailed information on the presence of DDT and other pesticides in the four Central American countries.

2.2 Pesticide drift from aerial applications in Central America

One of the most important sources of pesticide pollution is drift during an aerial application under less than optimal conditions. The study intended to clarify several points. It seemed relevant to know which proportion of the total insecticide discharged during an aerial application fell within the 14-meter strip underneath the airplane. Technically speaking, everything else falls off target. Second, it seemed practical to be able to estimate total drift from regular sized fields on the premise that cotton growers may not consider it a loss if some areas get more pesticide than others. Third, it was important to find out how far can insecticide from an aerial application travel downwind and possibly contaminate other areas.

The tests performed indicate that about 25 percent of pesticide applied in Ultra Low Volume (ULV) fell on the 14-meter airplane swath and 31 percent of the material applied in the conventional diluted form fell on target. This implies that within a field the sections up wind are getting too little pesticides while the areas downwind get an overdose. It is also apparent that the conventional system is 25% more effective than Ultra Low Volume.

The farmer may be more concerned about the amount that falls outside a particular field being treated. If the field has 20 hectares and is approximately square in shape (has 450 meters per side) one can expect about 43.6 percent to fall inside the field boundaries with ultra low volume and about 45.6 percent with the conventional system.

By the same token, 56.4% and 54.5% respectively falls or drifts outside the 20 - hectare field with ultra-low volume and conventional applications. In the test, it was found that even at 1,600 meters about 0.01 grams of DDT per hectare were still falling on the sampling plates. This implies contamination to surrounding agricultural activities and higher levels of sub-clinical intoxication for rural populations exposed as well as increased resistance build-up of human and other pests.

The study was conducted to evaluate the spray distribution characteristics of two typical methods used for aerial application of insecticides in Central America. The ULV application was a DDT formulation applied without dilution while the diluted spray contained the same amount of DDT formulation but was diluted with four parts water to one part of chemical formulation. The study was designed to measure the deposit in the treated area as well as the drift as far as 1,600 meters downwind from each application. Each test consisted of spraying six consecutive passes over the same spray line for a length of 1,609 m. This technique permits an evaluation of the characteristic deposit versus distance which can be utilized to predict drift for various sizes and shapes of field as indicated in the discussion section. Applications were made over a large block of cotton in Finca "Tolimán", Tiquisate, Escuintla (Guatemala)

Materials and methods:

Table 11 lists the details of the application information. A Piper Pownee aircraft fitted with four Micronair AU 3000 atomizers with a 35° blade setting was used for both applications (figure 6). No drop size data was taken; however, the higher flow rate for the diluted application would reduce the rotational speed of the atomizers which would result in a larger drop size (1). It was estimated that the VMD was 120 m for the ULV application and 135 m for the dilute application.

The sampling line was along a ranch road perpendicular to the spray line and parallel to expected wind direction (figure 7). Each sample plate consisted of a 600 sq. centimeter Mylar film stapled to a plywood board. The sample board was placed on a stake which held it flat and slightly above the crop level. Samples were located at one meter intervals from 10 meters upwind to 50 meters downwind. From 50 m downwind, four replicate samples were taken: two on each side of the 3-meter wide ranch road and one meter apart from one another. The distance from centerline increased logarithmically 50, 100, 200, 400, 800, and 1,600 m. The Mylar samples were removed and placed into separate jars and sealed for transport back to the laboratory for analysis (figure 8). The DDT was stripped off the plates with an appropriate organic solvent and the total amount per plate quantified through gas chromatography.

A portable weather station was set up next to the cotton field about 1,000 m downwind from the application (figure 9). The temperature gradient between 10 and 2.5 m., and the ambient temperature at 2.5 m was measured by two aspirated and shielded thermistor probes connected in bridge circuitry (Hallow Springs Inst. Co.). The full-scale temperature difference was ± 10°F. The wind speed was measured at a height of 5 m with a Cassella sensitive cup anemometer. The wind direction was measured at a height of 5 m with a lightweight vane connected to a potentiometer and the direction recorded on a 6-in. strip chart recorder. Figure 10 shows a rescaled record of the wind direction during the tests. Table 11 shows the record of the temperature, temperature gradient, average wind velocity, relative humidity, and average wind direction during the tests.

(1) Akesson, N.B. and W.E. Yates, 1974. The use of aircraft in agriculture, FAO Agricultural Development Paper No. 94, FAO, Rome.

The Stability Ratio was calculated as follows:

$$S.R. = \frac{(t_{10} - t_{2.5})}{V_5^2} \; 10^5$$

where "t" is the temperature in °C and "V" is the wind velocity in cm/sec. The S.R. is a convenient turbulence parameter that has been useful in relating the micro-weather to drift levels(1).

The ULV application, test 1, was applied from 12:40 to 13:00 on November 25, 1975. The dilute application, test 2, was applied the same day from 15:00 to 15:25.

Results:

The average emission rate for Test 1 was 3.4 grams of DDT per meter per pass and for test 2 was 3.1 grams DDT/m/pass. Because of the slight difference, the residue data from each test was normalized to an equivalent emission of 3.2 grams DDT/m/pass. For a 14 m swath spacing, the normalized application rate was equivalent to 2,270 grams DDT/ha.

Deposits in the target area are principally measured by the samples within the first 15-25 meters of the aircraft. Figures 11 and 12 are plots of the normalized residue data converted to gm/ha/pass versus the downwind location as far as 50 m. The data represents the average of 6 aircraft passes, 3 in each direction. Another useful means of presenting this data is shown in figures 13 and 14. The graphs show the cumulative recovery expressed as percent of total emission as a function of distance downwind. Amount recovered per plate at the different stations is shown in figures 15 and 16 and shows the same spray pattern.

The normalized drift deposit data from 50 m. to 1,600 m are plotted on log-log axis as shown in figure 17. The data was analyzed similar to previous drift studies (1). Briefly, a regression curve was calculated for the following general form:

$$\log D = b_0 + b_1 (\log d) + b_2 (\log d)^2$$

where "D" is the deposit on Mylar in g/ha; "d" is the distance downwind in meters; and "b_0, b_1, and b_2" are regression coefficients. For test 2, the data from the 800 and 1,600 m stations were omitted from the analysis since the wind direction data indicated the particle trajectories missed those stations part of the time.

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(1) Yates, W.E. and N.B. Akesson, 1974. "Criteria for minimizing drift residues on crops downwind from aerial applications". Trans. of the ASAE, 17 (4), pp. 627-632.

TABLE 11

Application Data for Pesticide Drift Tests

Tolimán, Guatemala, November 25, 1975.
Piper Pawnee, 160 km/hr., 1.5 m. wheel height
1609 m length of spray pass, four Micronaire AU 3000 atomizers, 276 kPA (40 psi) pressure, 35° blade setting.
Area treated: 2.25 hectares

	Test I ULV	Test II Diluted
Time of Application	12:40 - 13:00	15:00-15:25
Type of Application		
Application rate with a 14 m swath, liters/ha.	6.17	28.4
Number of passes	6	6
Spray Mixture		
(a) DDT Formulation (392 g DDT/l) applied, liters	53.3	76.8
(b) Dilution water, liters	0	307.0
DDT emission rate, grams DDT/m/pass	3.4	3.1
Normalized emission rate, grams DDT/m/pass	3.2	3.2
Normalized application, grams DDT/ha (14 m/swath)	2270	2270
Weather		
Ambient temperature, °C (2.5m)	28.9	28.3
Temp. difference (temperature (10 m) - temperature (2.5 m), °C	-0.833	-0.389
Wind velocity , cm./sec (5m)	223.5	304.0
Stability Ratio	-1.67	- 0.42
Relative Humidity	89%	67%
Average Angle of wind deviation from sampling line:	8° East	24° East

SOURCE: ICAITI

Table 12 shows the regression coefficients obtained for the ULV and dilute application tests. Also shown is the simple correlation coefficient for the two tests. Correlation between deposit and distance was excellent in both cases.

TABLE 12

DDT DEPOSIT AS A FUNCTION OF DISTANCE TO APPLICATION LINE:

REGRESSION AND CORRELATION COEFFICIENTS
CALCULATED FOR EACH TEST

TEST	b_o	b_1	b_2	r
ULV	6.5438	-2.6942	0.0156	0.9938
Dilute	2.0323	1.5242	1.0407	0.9919

SOURCE: W.E. Yates and ICAITI

The above values were used to calculate the cumulative deposit data at one meter intervals from 50 m out to 1,600 m. The values again were expressed as percent of the total emission. A few values of cumulative recoveries from 10 m to 1,600 m are given in Table **12 A.**

- Discussion:

The micro-weather data, table 11, indicated a very unstable or turbulent condition for the ULV application, S.R. = 1.67 compared to a slightly unstable condition, S.R. = 0.42, for the dilute application. The very turbulent conditions would tend to diffuse the spray vertically and cause a more rapid reduction in deposits with distance as compared to the conditions during the dilute application (1).

(1) Yates, W. E., N.E. Akesson, and H.H. Coutts, 1966. "Evaluation of drift residues from aerial applications" Trans. of the ASAE, 9 (3), pp. 389-393, 397.

TABLE 12 A

Estimated Cumulative Downwind Recovery for

Pesticide Drift Tests, % *

Distance Downwind Meters

	10	25	50	100	400	1600
Test:						
Test 1	30.7	43.0	50.9	57.8	60.6	60.9
Test 2	38.5	47.9	51.9	55.0	56.3	--

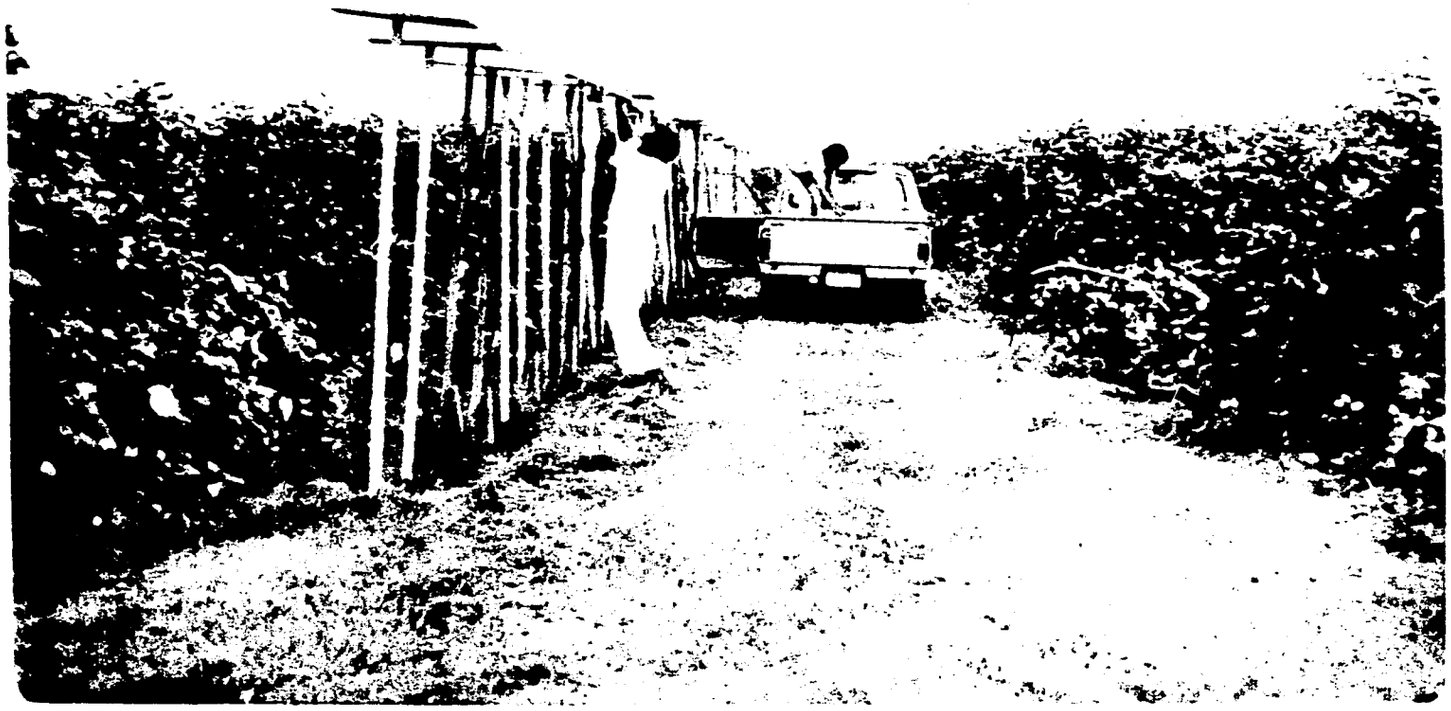
SOURCE: ICAITI

* From equations shown in table 12.

FIGURE 6

A Pawne 235 prepares to leave the ground to effect the first drift test.

FIGURE 7



Mylar sheet being mounted on wooden poles near the application line.

FIGURE 8

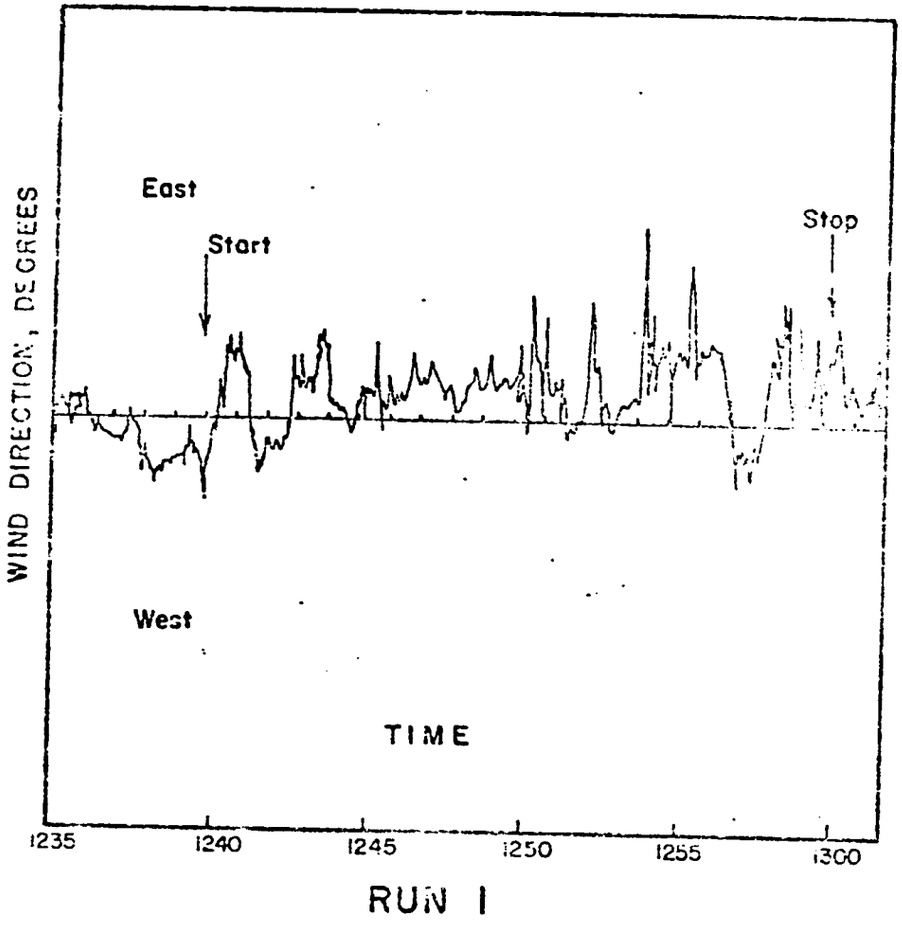
Mylar sheets being picked up, rolled and placed in glass jars for transport to the laboratory.

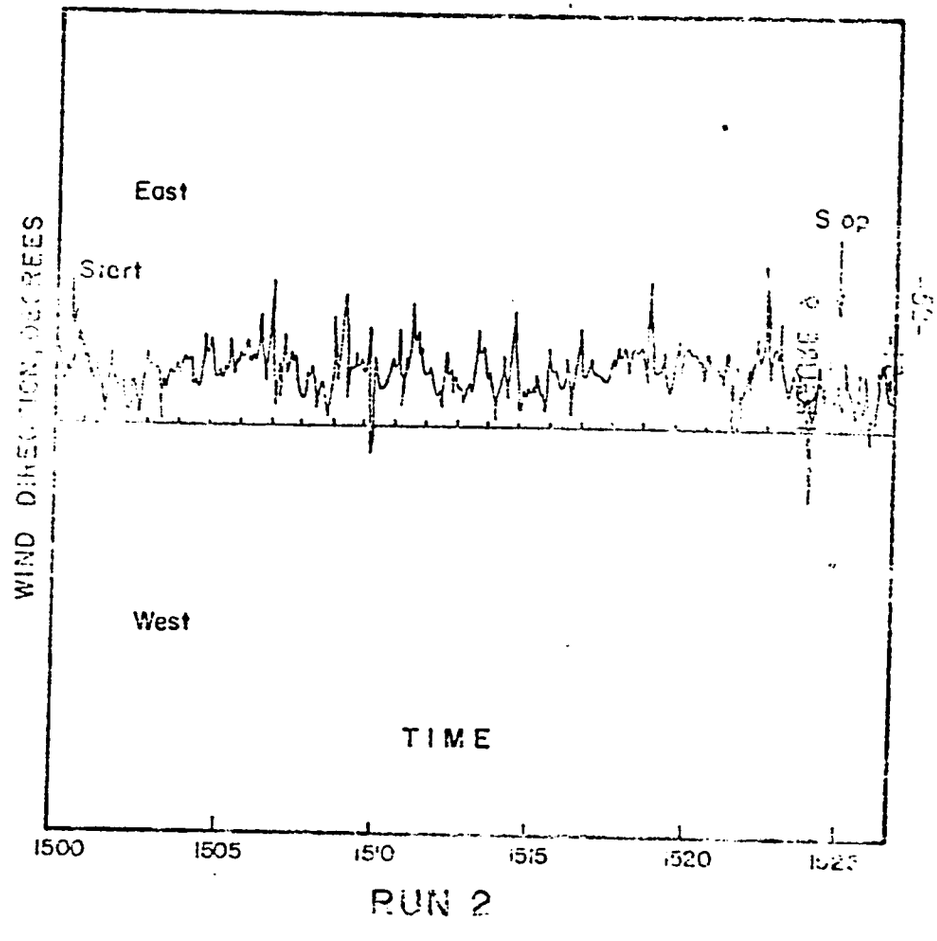
FIGURE 9

Weather station used for monitoring climatic conditions during the drift test.

FIGURE 10

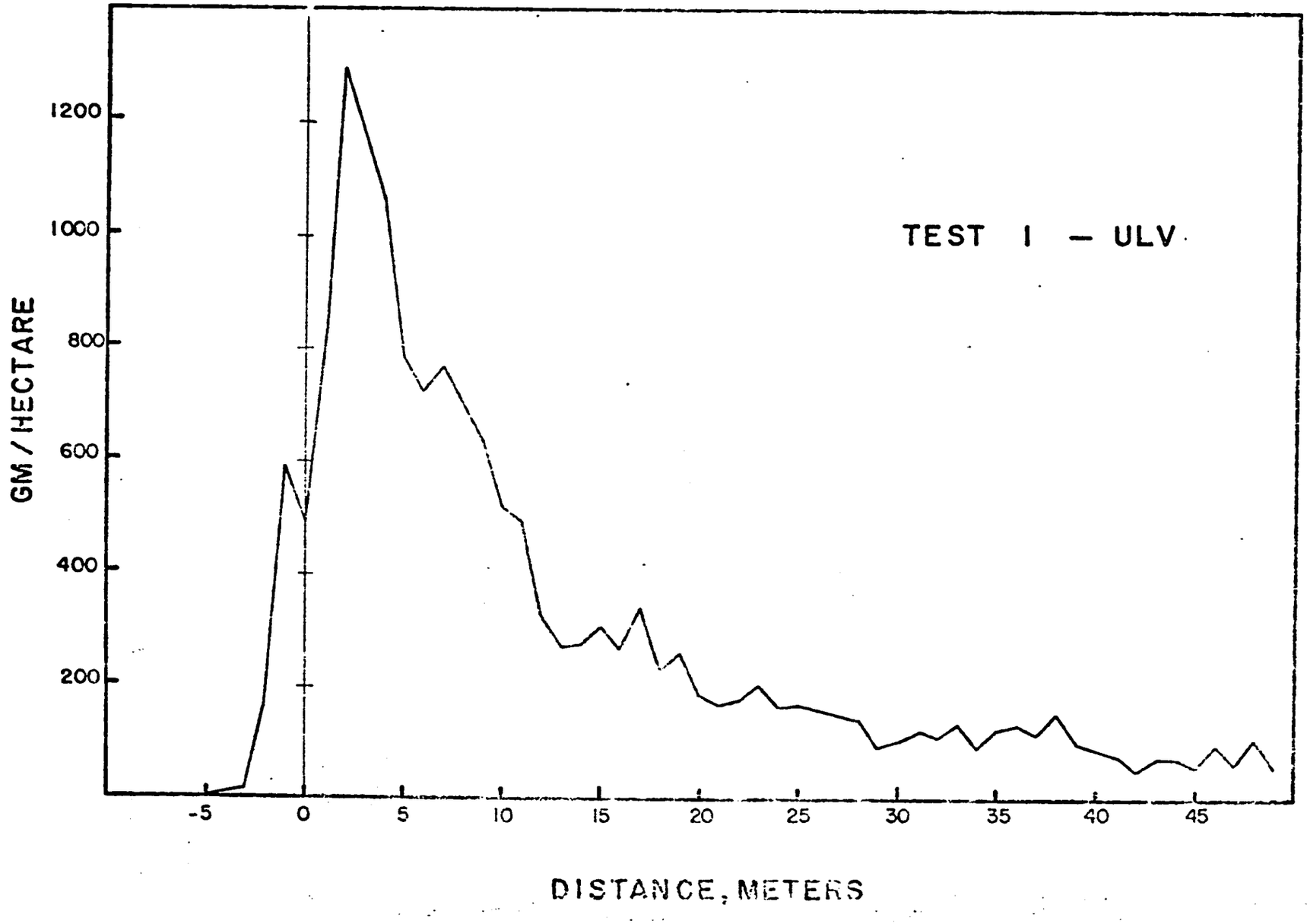
WIND DIRECTION DURING THE DRIFT TESTS





SOURCE: ICAITI

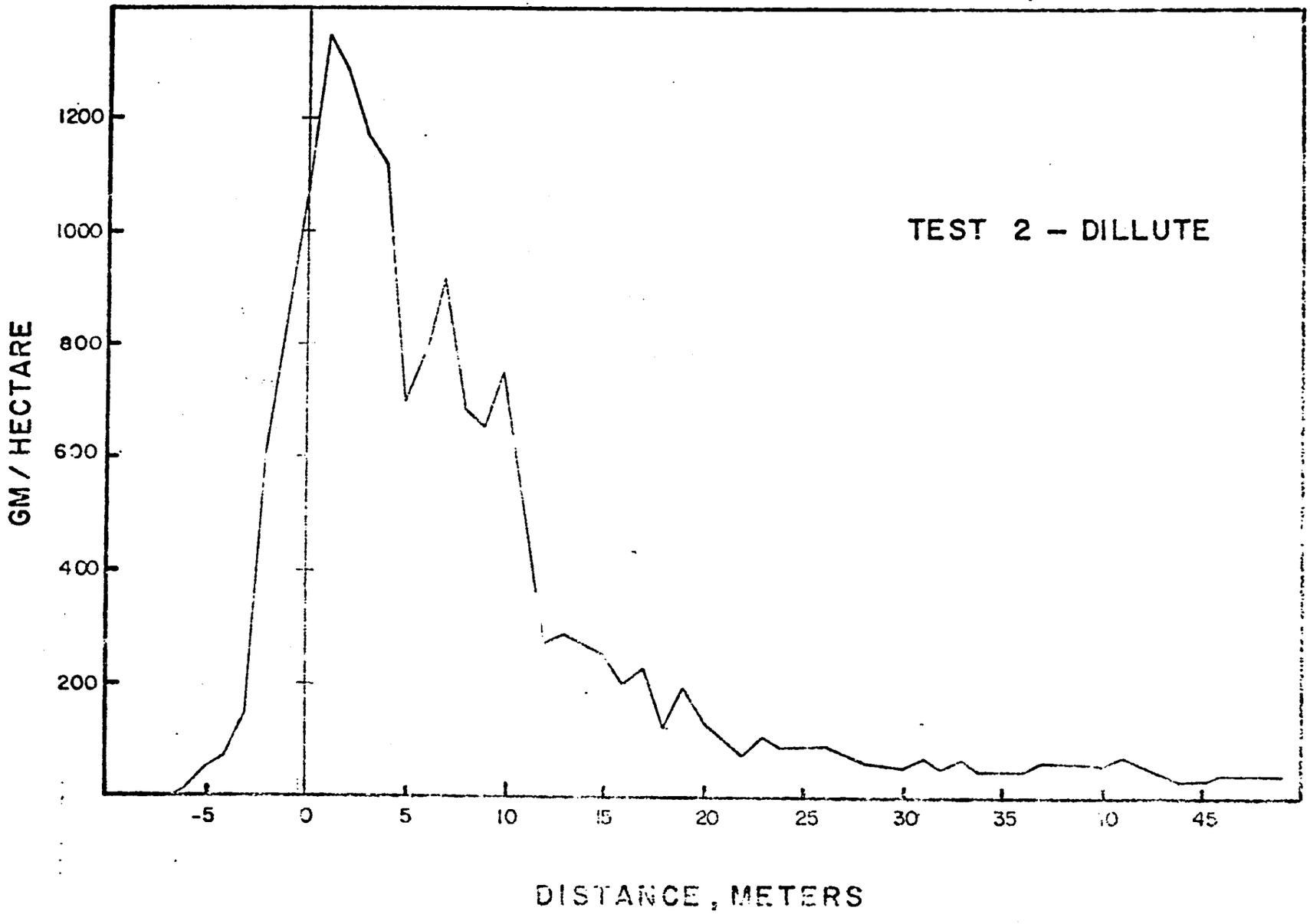
DOWN WIND DDT RECOVERY FROM ULTRA LOW VOLUMEN APPLICATION GR/her



SOURCE: ICAITI

FIGURE 12

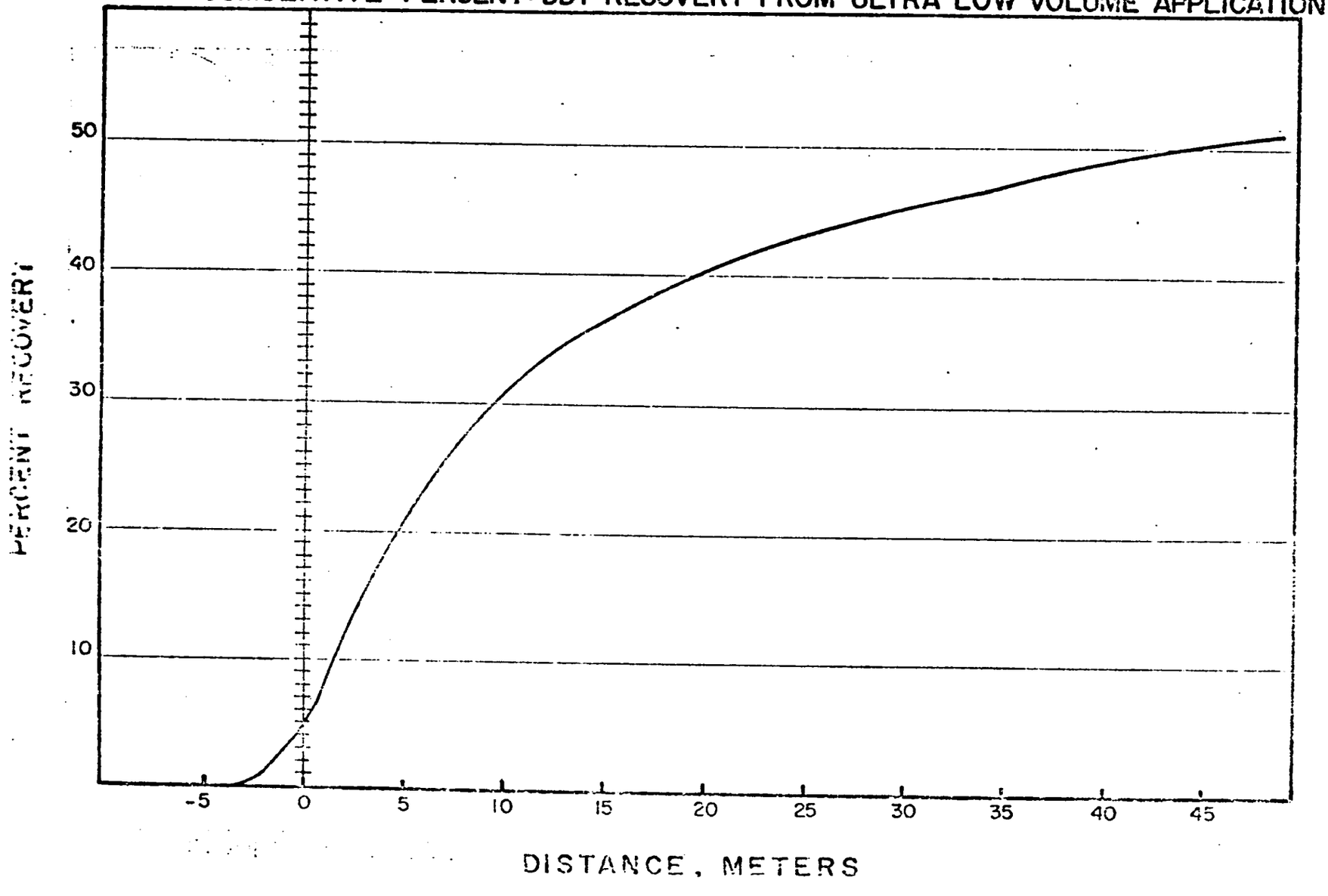
DOWN WIND DDT RECOVERY FOR CONVENTIONAL APPLICATION, G./he.



SOURCE: ICAITI

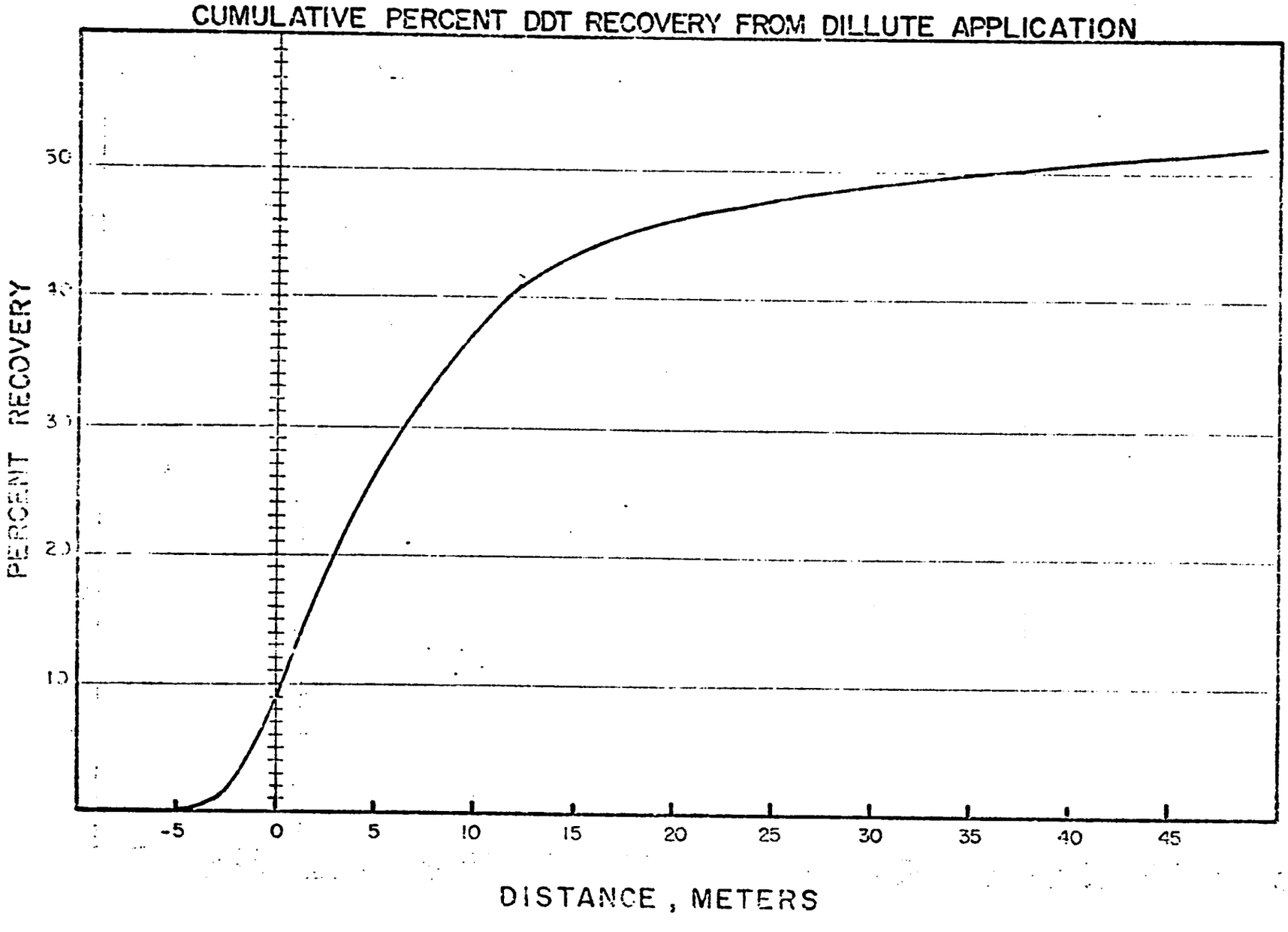
FIGURE 13

CUMULATIVE PERCENT DDT RECOVERY FROM ULTRA LOW VOLUME APPLICATION



SOURCE: [illegible]

FIGURE 14



SOURCE: ICAITI

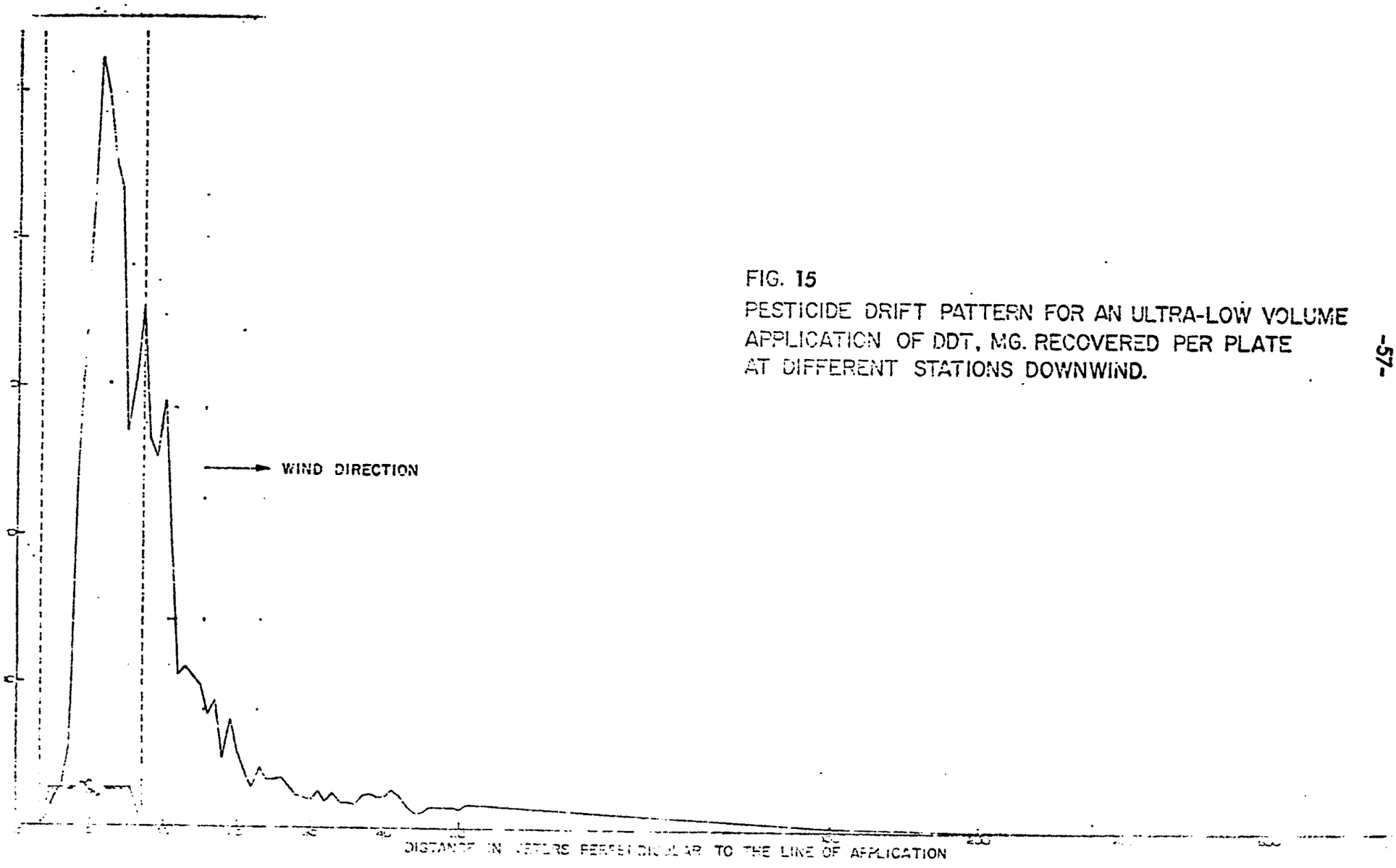


FIG. 15

PESTICIDE DRIFT PATTERN FOR AN ULTRA-LOW VOLUME APPLICATION OF DDT, MG. RECOVERED PER PLATE AT DIFFERENT STATIONS DOWNWIND.

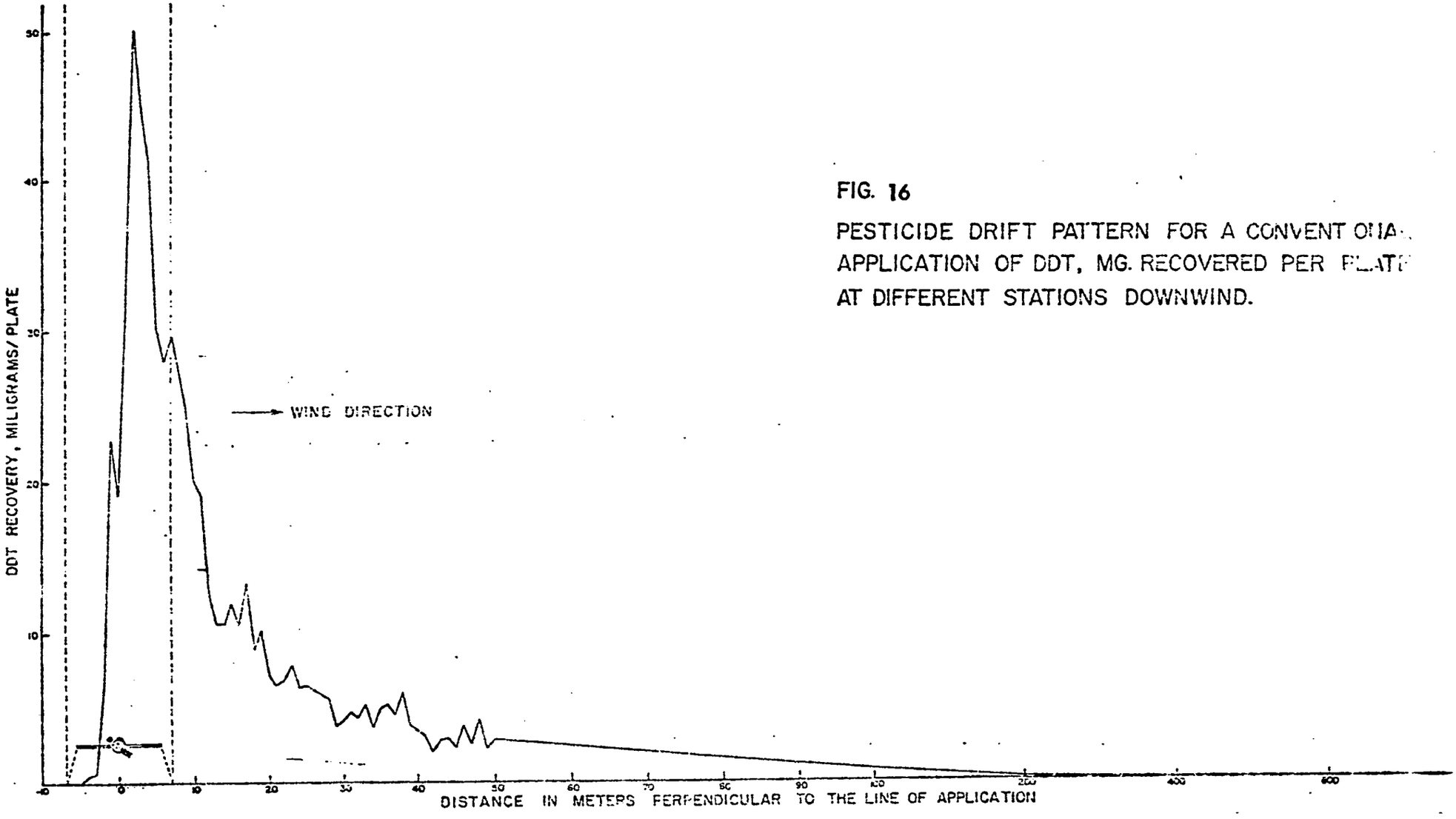
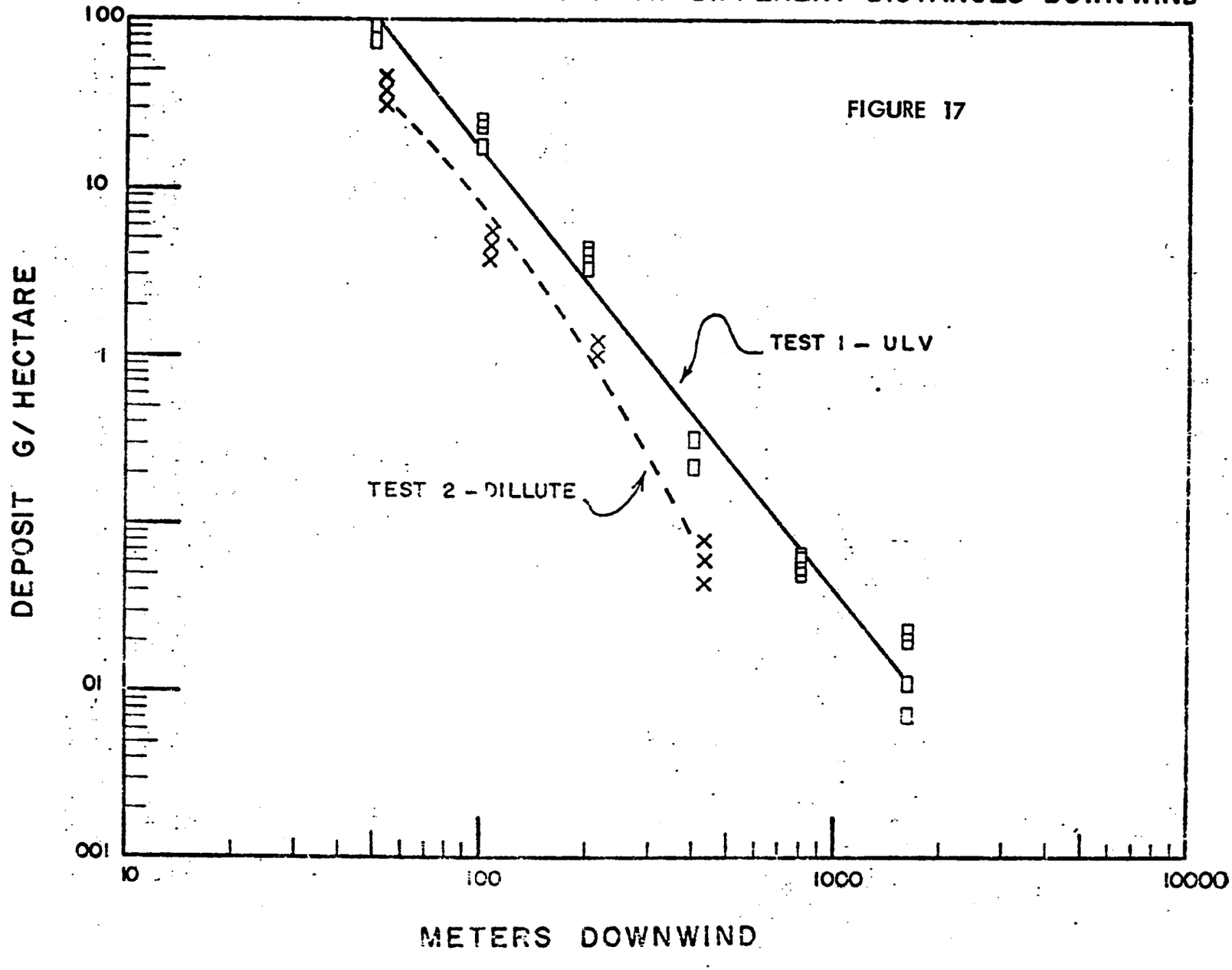


FIG. 16

PESTICIDE DRIFT PATTERN FOR A CONVENTIONAL APPLICATION OF DDT, MG. RECOVERED PER PLATE AT DIFFERENT STATIONS DOWNWIND.

RATE OF PESTICIDE DEFORIT AT DIFFERENT DISTANCES DOWNWIND



SOURCE: ICAITI

The distribution patterns, figures 11 and 12 show the Dilute application had slightly higher deposits under the aircraft and less fallout from 15 m. on downwind. The differences would probably be even greater under similar weather conditions. The above observations are further verified by reference to table 11. The cumulative deposit for the dilute application is much higher at both 10 and 25 m downwind then reverses and the ULV produces a higher fallout at the more distant stations. For instance, from 50 to 100 m the ULV application deposited 9.7% of the spray compared to 4.4 % from the Dilute application. The differences are attributed to the finer atomization obtained at the lower flow rate for the ULV application and the lower evaporation rate of the ULV formulation.

The total recovery from tests 1 and 2 were 60.9 and 56.3 % respectively. A very limited amount of data is available on the total recoveries from this type of application. Previous studies in California with larger droplet spectrums and more stable conditions produced recoveries of 100% (1). Studies by Courshee and Coutts (2) indicate about 70% recoveries for ULV applications with a Micronair ser at a 35% pitch angle. G. Ware et al (3) have also reported recoveries in the target area of 57% for dillute aerial applications with flat fan nozzles at 28.1/ha. Hinden et al (4) reported DDT recoveries on glass plates of 30% and 22% from aerial applications.

Thus, the recoveries reported in these tests appear reasonable. The losses are attri - buted to (a) losses remaining in the air due to fine atomization and turbulent weather conditions and (b) possible volatility and photodecomposition of the DDT on the Mylar sheets.

The basic drift data and regression curves of fallout from 50 m and greater are shown in figure 17. The levels indicate approximately 2 times as much fallout from the ULV ap - plication as the Dillute application.

Prediction of drift hazards ffom above type of treatments:

The regression curves were used to calculate the cumulative fallout that would likely result from two different sizes of simulated applications. The field lengths were assumed to run perpendicular to the wind direction and were 1,609 m long. The amount of drift

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(1) Yates, W.E. , P. Christensen and N.B. Akesson, 1972. "Residues and air pollution hazards related to aerial applications. Proceedings of the International Conference on Tropical and Subtropical Agriculture, Hawaii, ASAE pg. 317-320.

(2) Courshee, R.J. and H.H. Coutts, 1974 "Patterns of ULV spraying". Proceedings of Pesticide Application by ULV Methods, British Crop Protection Council Monograph, No. 11 , pg. 67-72.

(3) Ware, G.W., W.P. Cahill and B.J. Estesen, 1975" Pesticide drift: aerial applications comparing conventional flooding vs. raindrop nozzles. J. Econ. Entomol. . 68:329, 330.

(4) Hinden, E., D.S. May and G.H. Dunstan, 1966. "Distribution of insecticides sprayed by airline on an irrigated corn plot." Organic Pesticides in the Environment, Advances in Chemistry Series 60, R.F. Gould Editor, American Chemical Society, Chapter 11, pp. 132 - 145,

concentration downwind would thus be a function of the number of passes or field width. One simulated treatment was for a field 196 m wide, which required 14 passes with a 14 m swath spacing. The other was for a field 1,400 m wide which required 100 passes with a 14 m swath spacing. Cumulative fallout values for different distances downwind are shown in table 13. All of the calculated values were within the distance of the actual sample locations. Blanks are left in part of the table to avoid extrapolation of the data.

Previous studies in California determined a direct correlation between deposits on Mylar sheets and the residue of green alfalfa in ppm (1). It was found that the residue of DDT in alfalfa could be estimated from DDT deposit rate according to the following equation (R^2 = .99):

$$\text{Log } P = -2.4544 + 1.00 \log C$$

where "p" is ppm in green alfalfa and "C" is micrograms/ft^2 on Mylar sheets.

The above correlation was used to convert the fallout values in g/ha to residues on alfalfa in ppm. Table 14 indicates the predicted drift in terms of ppm on green alfalfa. All of the alfalfa samples were taken just prior the harvest and represented a yield of about 2.4 tons/acre. If the forage crop is smaller and if the crop is cut and allowed to dry, the ppm would be greater than the above estimates. It should be remembered that the above tests were applied in the middle of the day during unstable weather conditions. Aplications during early morning or late evening would likely be during more stable conditions and could produce higher residues. Values during very stable conditions have been reported as high as 10 times as much as during neutral conditions (1).

Table 14 illustrates the estimated contamination outside the treated area for a ULV application would be about 2 times as much as a dilute application. Also for a ULV treatment of a small field the contamination 204 m downwind would be over 0.5 ppm and for a large area treatment the contamination would be over 0.8 ppm.

Summary:

In comparison to the ULV application, the dilute application produced somewhat higher deposits within the treated area (14 m swath) and lower fallout downwind of the treated area. From 50 to 400 m downwind the deposits from the ULV treatment were about 2 times as much as the dilute treatment. Fallout 204 m downwind from a 14 swath ULV application would likely deposit 15.1 g/ha compared to 4.6 g/ha for a dilute application. Higher recoveries both in treatment area and downwind areas would likely acurr during more stable atmospheric conditions.

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(1) Yates, W.E. and N.B. Akesson, 1974. "Criteria for minimizing drift residues on crops downwind from aerial applications". Trans. of the ASAE, 17 (4), pp. 627-632.

TABLE 13

PREDICTED FALLOUT ON MYLAR
FOR VARIOUS TYPES OF PESTICIDE APPLICATIONS

(Wind perpendicular to length of field)
(Fallout measured downwind from edge of treated field)

SIMULATED APPLICATION	Test 1 - ULV		Test 2 - Dilute
Field Length	1 609 m	1 609 m	1 609 m
Field Width	196 m	1 400 m	196 m
DISTANCE FROM EDGE OF FIELD (meters)		Fallout (g/ha)	
50	205	220.5	94.5
106	53.7	65.0	23.9
204	15.1	22.1	4.8
400	3.7	-	-
806	0.7	-	-
1408	0.2	-	-

SOURCE: ICAITI

TABLE 14

PREDICTED RESIDUE ON GREEN ALFALFA FOR VARIOUS TYPES OF APPLICATIONS

(Wind perpendicular to length of field)
(Residues on alfalfa downwind from edge of treated field)

SIMULATED APPLICATION	Test 1 - ULV		Test 2 - Dilute
Field Length	1 609 m	1 609 m	1 609 m
Field Width	196 m	1 400 m	196 m
DISTANCE FROM EDGE OF FIELD (meters)	Residue on Green Alfalfa (ppm)		
50	6.68	7.20	3.08
106	1.75	2.12	0.78
204	0.49	0.72	0.16
400	0.12	-	-
806	0.02	-	-
1 408	0.01	-	-

SOURCE: ICAITI

TABLE 15

DDT RECOVERY FOR DRIFT TEST WITH ULTRA-LOW-VOLUME APPLICATION. MILIGRAMS/PLATE

Sample			Sample		
-10	=	0.0005	24	=	3.44
- 9	=	0.0005	25	=	3.47
- 8	=	0.0010	26	=	3.54
- 7	=	0.0005	27	=	2.97
- 6	=	0.59	28	=	2.38
- 5	=	2.04	29	=	2.18
- 4	=	2.85	30	=	2.04
- 3	=	5.60	31	=	2.66
- 2	=	23.52	32	=	1.94
- 1	=	32.23	33	=	2.56
0	=	41.40	34	=	1.84
1	=	52.24	35	=	1.85
2	=	49.85	36	=	1.76
3	=	45.34	37	=	2.37
4	=	43.39	38	=	2.48
5	=	27.02	39	=	2.29
6	=	30.40	40	=	2.24
7	=	35.54	41	=	2.75
8	=	26.50	42	=	2.22
9	=	25.26	43	=	1.59
10	=	29.07	44	=	1.17
11	=	21.27	45	=	1.17
12	=	10.54	46	=	1.59
13	=	11.17	47	=	1.52
14	=	10.47	48	=	1.52
15	=	9.83	49	=	1.50
16	=	7.78	50	=	1.44
17	=	8.84	51	=	1.72
18	=	4.84	100	=	0.1781
19	=	7.56	200	=	0.0441
20	=	5.25	400	=	0.0026
21	=	3.98	800	=	0.0002
22	=	2.90	1600	=	0.0006
23	=	4.12			

TABLE 16

DDT RECOVERY FOR DRIFT TEST WITH DILUTE APPLICATION
MILIGRAMS/PLATE

Sample			Sample		
-10	=	0.0007	24	=	6.43
- 9	=	0.0006	25	=	6.55
- 8	=	0.0005	26	=	6.16
- 7	=	0.0007	27	=	5.84
- 6	=	0.0007	28	=	5.63
- 5	=	0.0007	29	=	3.71
- 4	=	0.50	30	=	4.10
- 3	=	0.67	31	=	4.76
- 2	=	6.53	32	=	4.36
- 1	=	22.88	33	=	5.25
0	=	19.13	34	=	3.69
1	=	31.57	35	=	4.91
2	=	50.18	36	=	5.23
3	=	44.77	37	=	4.56
4	=	41.24	38	=	6.0
5	=	30.36	39	=	3.89
6	=	28.03	40	=	3.43
7	=	29.77	41	=	3.11
8	=	27.30	42	=	2.04
9	=	24.65	43	=	2.88
10	=	20.14	44	=	2.93
11	=	19.17	45	=	2.30
12	=	12.74	46	=	3.96
13	=	10.67	47	=	2.51
14	=	10.77	48	=	4.28
15	=	12.02	49	=	2.24
16	=	10.51	50	=	2.88
17	=	13.31	51	=	2.80
18	=	8.98	100	=	0.79
19	=	10.23	200	=	0.14
20	=	7.19	400	=	0.01
21	=	6.54	800	=	0.02
22	=	6.94	1600	=	0.001
23	=	7.99			

2.3 Monitoring pesticides levels through milk analysis

The systematic analysis of milk samples from the same herd and the same cow was found useful for detecting changes in pesticide levels through time and between different areas. It is apparent that cow's milk can be used as a reliable indicator of relative contamination in different regions. Continuing analysis in one region can detect significant changes in the level of contamination and reflect the pesticide load in the environment. Considering that milk is inexpensive and easy to obtain these findings suggest that milk can be a valuable environmental monitor for pesticides.

The study of milk contamination in Central America had four objectives. First it seemed desirable to find out whether the levels of DDT residues in milk varied according to the cotton growing season when pesticide use is more intensive. It was also desirable to see whether milk reflected significantly different levels of contamination between cotton-growing areas and other agricultural regions. It also seemes important to correlate milk contamination with the observed pesticide use in one area to find out exactly with what precision milk residue levels reflect pesticide use. Last, it was thought advisable to obtain a good idea of the levels of contamination in milk since it is a widely-consumed food for infants as well as an industrial input.

Methodology:

Three dairy farms of similar herd composition were chosen, one in the midst of the cotton-growing area, one eight kilometers from the nearest cotton farm, and one removed about 45 kilometers from the cotton area. Sampling from farms under different conditions of pesticide use would allow for comparisons between the levels of milk contamination and the behavior of these levels through time in the different zones. Samples of one liter were taken from the whole herd in the three farms at least once a week. Sampling in the farm within cotton areas was effected 2-3 times a week to obtain a more precise measure of the fluctuations through the season. Separate samples from one control animal were obtained in the first two farms. These samples were refrigerated and shipped to the laboratory. Occasional samples of water, pasture and animal feed were taken in the three farms.

The samples were analyzed through gas chromatography upon arrival. Records were kept of the residue levels of BHC, Aldrin, DDT plus metabolites, Dieldrin, Toxaphene, and Azodrin. Only DDT is considered in the present analysis although all of the others appeared on occasion. DDT was chosen as tracer because of its high persistance and widespread use.

To fulfill the second objective the mean contamination in each zone was compared statistically with the rest of the zones through analysis of variance. The purpose was to see how significant were the differences in contamination between zones with different intensity of cotton cultivation.

In addition 9 cotton farms near the dairy farm closest to cotton were visited every week to obtain pesticide (DDT) use prior to taking the samples. The average amount of DDT active ingredient used per hectare was correlated statistically with the contamination of the sample for that week. This was done to accomplish the third objective of the study.

In order to find out whether milk reflects pesticide use changes throughout the cotton season, analysis of samples was effected for a whole year from planting to planting. Visual inspection of graphs was able to clearly show the behavior of milk contamination throughout the cotton season.

Results

Figure 18 shows the behavior of milk contamination in three Guatemalan dairy farms from May 1975 to May 1976. The values presented are monthly averages of the results obtained for every sample (see tables 17-19 for actual values obtained). Cotton is normally planted in early July and pesticide treatments begin in August. Notice the steep increase in residue levels in the milk from the farm within the cotton area. In the farm near (but not within) the cotton area it is possible to notice a definite but less significant increase. In the farm away from cotton no significant trend can be discerned.

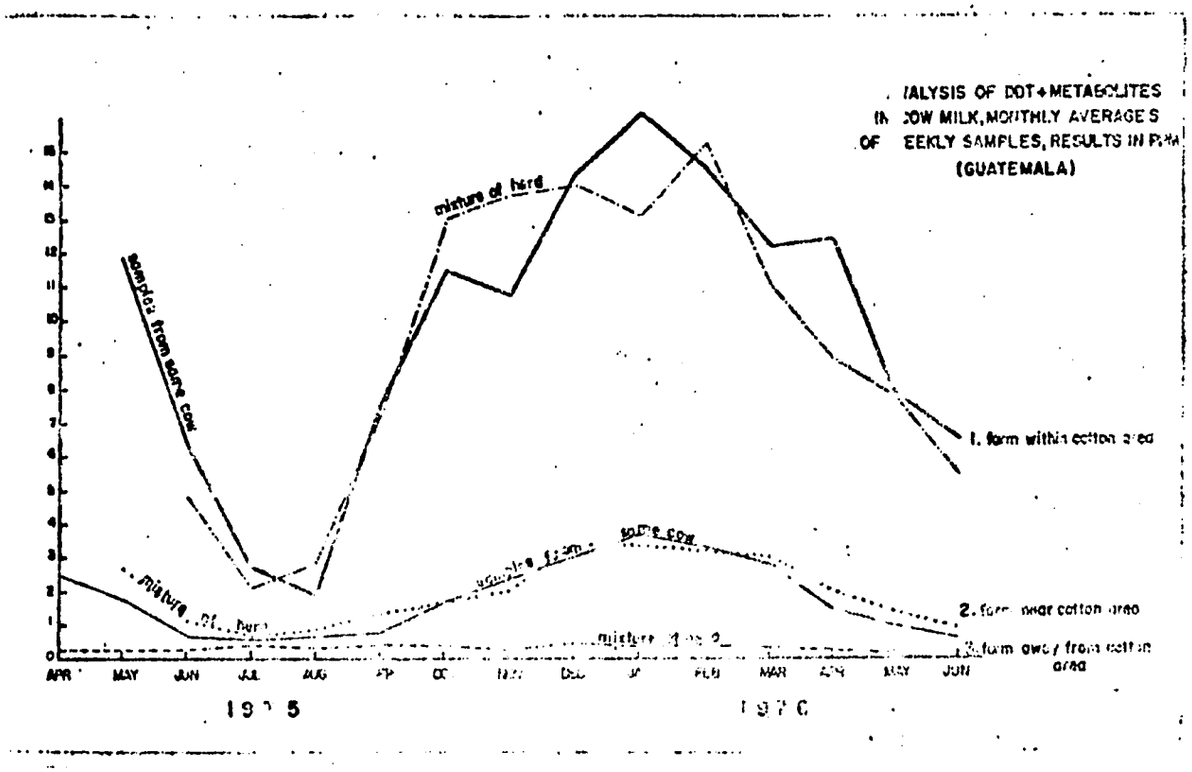
Within the cotton area, contamination reaches a peak in December-January. As insecticide use begins to decline, contamination levels return to practically the same amount as before the season begun. Thus it is apparent that short-term environmental contamination is directly linked to pesticide use in cotton production.

Average contamination in the farm within the cotton area was 9.46 ppm of DDT in the fat of cow's milk (144 samples). In the farm near cotton the average was 1.84 ppm (195 samples). In the farm 45 kilometers away the average was 0.3682 ppm (46 samples). The differences between these means are highly significant according to the analysis of variance performed ($\alpha = .01$). Sample size varies because of the necessity to sample more often in the areas where wider fluctuations were observed and, conversely, the reduced need for intensive sampling where contamination levels appeared more stable.

Judiciously performed, milk analysis adequately reflects the relative contamination in areas under different pesticide loads. This can be useful when trying to establish the severity of environmental contamination by pesticide in different countries. Of course, there has to be a sampling methodology which guarantees comparability between samples.

Accumulated DDT use in cotton farms correlated significantly with DDT presence in milk in neighboring farms (table 59-A, Appendix 1). As the total amount of DDT used per hectare increases through the season the levels of milk contamination also climb.

FIGURE 18



SOURCE: ICAITI

TABLE 17

Milk Contamination in a Dairy Farm Located Inside the Cotton Area of Guatemala, 1975/76. – DDT + Metabolites in ppm

Samples from the Same Animal						Samples from the Whole Heard			
4 may	13.85	2 oct	7.90	31 jan	16.39	3 jun	7.75	19 feb	19.12
11 may	11.58	4 oct	10.70	19 feb	15.32	12 jun	4.80	26 feb	11.34
25 may	10.31	9 oct	14.30	21 feb	14.81	19 jun	3.76	4 mar	14.00
1 jun	8.69	11 oct	9.99	26 feb	15.44	26 jun	2.91	11 mar	9.88
8 jun	8.62	16 oct	7.43	28 feb	12.54	2 jul	3.31	18 mar	9.32
12 jun	7.40	18 oct	11.41	4 mar	12.03	17 jul	1.01	31 mar	10.96
15 jun	6.64	23 oct	11.39	6 mar	11.09	24 jul	2.54	7 apr	9.19
19 jun	4.87	25 oct	10.59	11 mar	13.12	31 jul	1.69	22 apr	8.48
22 jun	4.26	30 oct	19.69	13 mar	11.16	7 aug	3.49	23 apr	8.35
26 jun	4.15	31 oct	11.58	18 mar	10.38	14 aug	2.14	29 apr	7.94
6 jul	5.45	6 nov	12.68	20 mar	13.83	21 aug	3.16	6 may	8.44
13 jul	4.64	13 nov	10.35	27 mar	12.20	28 aug	2.79	13 may	6.93
17 jul	2.57	15 nov	9.18	31 mar	12.55	4 spt	4.08	20 may	8.75
20 jul	1.39	20 nov	10.13	7 apr	10.52	11 spt	9.35	27 may	5.93
24 jul	1.46	22 nov	10.09	10 apr	10.54	18 spt	6.22	3 jun	5.23
27 jul	2.19	27 nov	10.66	22 apr	10.09	25 spt	9.00		
31 jul	1.73	29 nov	12.18	23 apr	9.80	2 oct	11.34		
2 aug	2.02	4 dec	15.03	24 apr	9.25	9 oct	15.77		
7 aug	2.19	6 dec	12.56	26 apr	12.53	16 oct	14.54		
9 aug	1.83	11 dec	17.78	29 apr	8.70	23 oct	10.67		
14 aug	1.80	13 dec	17.73	1 may	9.62	6 nov	12.74		
16 aug	1.73	18 dec	12.41	6 may	8.60	13 nov	16.88		
21 aug	1.78	20 dec	12.72	8 may	9.01	20 nov	13.04		
23 aug	1.90	23 dec	14.02	13 may	8.70	27 nov	12.34		
28 aug	1.56	27 dec	10.05	15 may	6.94	4 dec	14.34		
30 aug	2.45	31 dec	17.10	20 may	6.12	11 dec	18.36		
4 spt	3.22	8 jan	14.70	22 may	6.36	18 dec	12.04		
6 spt	2.85	10 jan	13.78	27 may	5.42	23 dec	13.11		
11 spt	8.78	15 jan	15.17	29 may	8.06	31 dec	12.17		
18 spt	4.70	17 jan	16.16	3 jun	6.35	8 jan	13.46		
20 spt	7.38	22 jan	17.24			15 jan	11.14		
25 spt	12.64	24 jan	16.98			22 jan	13.68		
27 spt	13.83	29 jan	20.24			29 jan	14.20		

TABLE 18

Milk Contamination in a Dairy Farm Located Near the Guatemalan Cotton Area 1975/76. - DDT + Metabolites in ppm

Samples from the Same Animal

30 apr	2.84	12 aug	0.67	4 nov	2.05	29 jan	3.01	21 may	2.69	22 jan	3.62
2 may	2.90	14 aug	0.61	6 nov	2.20	30 jan	3.67	3 jun	1.92	29 jan	3.73
6 may	3.01	15 aug	0.64	7 nov	2.60	3 feb	3.57	12 jun	1.03	19 feb	3.37
23 may	1.19	19 aug	0.63	11 nov	2.70	19 feb	3.00	19 jun	0.56	26 feb	3.00
27 may	1.10	21 aug	0.90	13 nov	2.52	20 feb	3.07	26 jun	1.10	4 mar	3.25
30 may	0.79	22 aug	0.78	15 nov	1.79	24 feb	3.16	2 jul	0.93	11 mar	3.84
3 jun	0.74	26 aug	0.97	18 nov	2.70	26 feb	3.17	17 jul	0.75	18 mar	2.83
6 jun	0.66	28 aug	0.71	20 nov	2.48	28 feb	3.87	24 jul	0.23	24 mar	2.55
12 jun	0.67	29 aug	0.66	21 nov	2.41	2 mar	3.12	31 jul	0.94	31 mar	2.84
13 jun	0.65	2 spt	1.28	25 nov	2.94	4 mar	3.00	7 aug	1.02	8 apr	2.42
15 jun	0.62	4 spt	0.59	27 nov	2.18	5 mar	3.03	14 aug	1.13	22 apr	2.36
17 jun	0.85	5 spt	0.68	28 nov	2.40	9 mar	3.14	21 aug	0.74	27 apr	1.93
19 jun	1.25	9 spt	0.61	2 dec	2.67	11 mar	3.00	28 aug	0.77	29 apr	1.56
20 jun	0.68	11 spt	0.58	4 dec	3.16	9 mar	3.48	4 spt	0.89	30 apr	1.34
24 jun	0.51	12 spt	0.61	5 dec	2.66	12 mar	2.87	11 spt	0.70	4 may	1.60
26 jun	0.66	16 spt	1.53	9 dec	3.57	18 mar	2.35	18 spt	2.09	6 may	2.21
27 jun	0.46	18 spt	0.25	11 dec	2.92	19 mar	2.29	25 spt	1.75	7 may	1.52
1 jul	0.56	19 spt	0.74	18 dec	2.69	23 mar	2.21	2 oct	1.31	11 may	1.28
2 jul	0.45	23 spt	0.67	16 dec	2.49	24 mar	2.30	9 oct	1.75	13 may	1.66
4 jul	0.40	25 spt	0.76	23 dec	3.63	31 mar	2.23	16 oct	1.45	20 may	1.17
8 jul	0.52	26 spt	1.07	12 dec	2.62	8 apr	2.35	23 oct	2.29	27 may	1.14
11 jul	0.39	30 spt	0.98	30 dec	3.86	16 apr	1.69	30 oct	1.80	3 jun	0.94
15 jul	0.51	2 oct	0.33	31 dec	3.79	22 apr	1.48	6 nov	1.48		
17 jul	0.78	3 oct	1.11	19 dec	3.07	23 apr	1.68	13 nov	2.28		
22 jul	1.18	7 oct	1.06	3 jan	2.89	27 apr	1.38	20 nov	1.92		
24 jul	0.55	10 oct	2.17	9 jan	4.05	29 apr	1.36	27 nov	2.30		
25 jul	0.68	13 oct	2.71	13 jan	4.17	30 apr	1.21	4 dec	3.43		
29 jul	0.90	16 oct	1.97	15 jan	3.34	4 may	1.63	11 dec	3.42		
31 jul	0.34	17 oct	2.09	16 jan	4.10	6 may	1.26	18 dec	3.09		
1 aug	0.43	23 oct	1.29	20 jan	3.80	7 may	1.50	23 dec	3.60		
5 aug	0.61	24 oct	1.94	22 jan	3.79	11 may	1.22	31 dec	3.28		
7 aug	0.74	30 oct	2.25	23 jan	3.77	13 may	1.16	8 jan	2.91		
8 aug	0.68	31 oct	2.06	27 jan	3.98	14 may	1.42	15 jan	3.23		

Samples from the Whole Heard

TABLE 19

MILK CONTAMINATION IN A DAIRY FARM REMOVED FROM THE GUATEMALAN COTTON AREA 1975/76. DDT + METABOLITES IN PPM

21 apr	0.27	1 nov	0.27
22 apr	0.31	6 nov	0.21
		13 nov	0.30
8 may	0.34	18 nov	0.41
12 may	0.31	26 nov	0.31
15 may	0.32		
29 may	0.35	4 dec	0.49
		10 dec	0.48
6 jun	0.22		
12 jun	0.44	15 jan	0.74
19 jun	0.31	22 jan	0.30
26 jun	0.34	29 jan	0.12
3 jul	0.23	21 feb	0.39
28 jul	0.29	26 feb	0.46
31 jul	0.81		
		3 mar	0.31
19 ago	0.38	12 mar	0.67
28 ago	0.37	18 mar	0.25
		24 mar	0.28
4 spt	0.30		
11 spt	0.38	4 apr	0.31
19 spt	0.57	7 apr	0.59
24 spt	0.52	22 apr	0.25
		28 apr	0.23
2 oct	0.52		
13 oct	0.64	12 may	0.22
16 oct	0.27	20 may	0.30
24 oct	0.32	27 may	0.24

The statistical analysis gave a relationship of the form:

$$Y = 10.99\ X^{.1242} \qquad \text{----------(1)}$$

where: Y = DDT in parts per million in cow's milk (whole herd)

X = Average DD use in 9 cotton farms accumulated up to the week when milk sample was taken, in kg/ha, active ingredient.

The number 10.99 is a constant and 0.1242 is the change in the rate of pesticide acumulation in cow's milk for different levels of pesticide use (a 10% increase in DDT use is likely to cause a 1.24 % increase in milk contamination by DDT). Simple correlation for equation (1) was r = 0.8 , a value significantly different from zero.

Figure 19 shows a graph of relationship (1)

From figure 19 it is apparent that pesticide use reflects itself rather rapidly in the cow's milk of nearby farms. This would suggest that even a low level of DDT use would contaminate milk in farms inside cotton areas. Thus it is possible that in order to eliminate the presence of DDT in milk it would be necessary to separate the production of milk from the production of cotton, at least while the environment remains in the present contaminated conditions.

Conclusion:

Milk analysis clearly reflects the effects of the intensive pesticide use season on the level of contamination. It is clear that pesticide use in cotton is responsible for short-term milk contamination (and probably long-term as well). Milk contamination can thus be considered an economic externality of cotton production.

The analysis for milk samples can detect significant differences in the environmental pesticide load of different regions. It can be used to establish preliminary differences in the degree of environmental contamination in these regions or countries. Although it can be a valuable first insight into the pollution problems of a country, it should be complemented by more widespread analysis to achieve any degree of certainty.

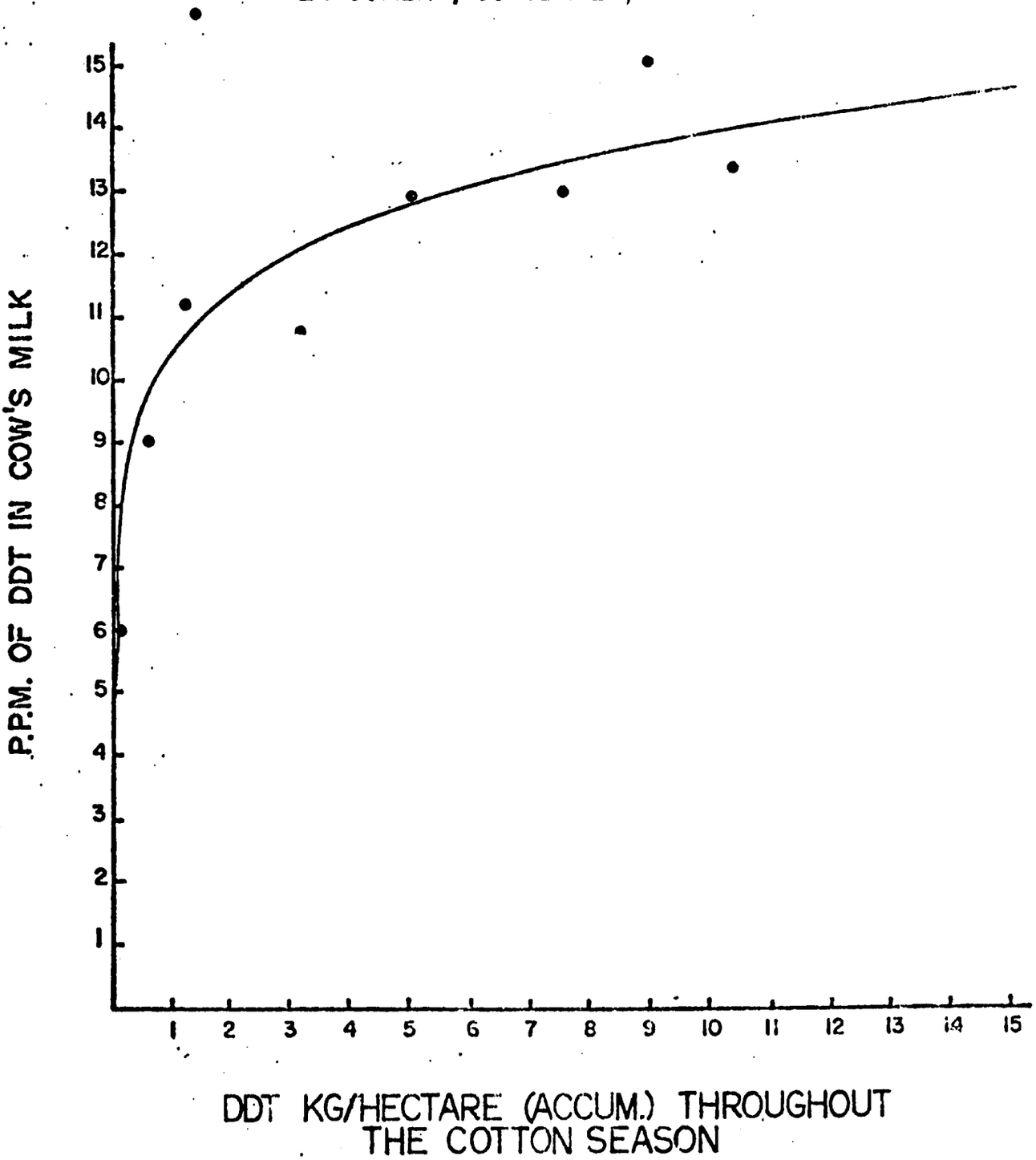
The average contamination of milk in Guatemala was high: 4.52 ppm of DDT. This is very high compared to United States standards, which set a limit of 0.05 ppm for that product. Average contamination in Guatemala is 90 times higher.

Last, it is apparent that other management measures should be explored jointly with a pesticide use reduction to eliminate milk contamination. These include, for example, drift avoidance, promoting compatible crops in cotton zones and buffer belts. Present crops patterns lead inevitably to milk and cattle contamination (figure 20). The solution to even this relatively small environmental problem already implies the necessity to use a multiple-focused , systems approach to environmental management.

FIGURE 19

GUATEMALA. RELATIONSHIP BETWEEN DDT USE IN COTTON AND COW'S MILK CONTAMINATION

LA GOMERA, GUATEMALA, 1975-1976



SOURCE: ICAITI

FIGURE 20

Cotton and cows coexist in Central America which results in milk and beef contamination.

2.4 Meat contamination as an environmental and economic problem

Meat contamination arises from the coexistence of cattle ranches and cotton farms. Contaminated meat is either exported or consumed locally. In the latter case it contributes to pesticide build up in human tissues in areas removed from cotton zones. If the beef is exported and its DDT content is above established tolerances in the country of destination the beef can be rejected. This causes economic losses in the form of increased transportation, storage, and marketing costs.

After the first few rejections occurred in the early 70's the meat-packers reacted by analyzing suspicious samples prior the shipment. Some costs were avoided but chemical analysis is expensive. Meat packers began punishing contaminated cattle and this started an adjustment trend which will contribute to separate cows from cotton.

Most samples above the established tolerances in the principal market came from cotton areas. The United States buys most of the beef Central America exports. Its sanitary inspectors may reject shipments whose fat sample contains more than 5 ppm of DDT. The average contamination in samples from 320 beef lots from cotton areas in Guatemala was 5.70 ppm between 1973 and 1976. By contrast, 39 samples from non-cotton areas contained an average of 1.14 ppm, whereas 33 samples from a farm 20 kilometers away from cotton averaged 3.67 ppm. These differences are highly significant. (See tables 20, 21, and 22).

Beef contamination in cotton areas was higher during the 6 months of more intensive pesticide use. In Guatemala and El Salvador, the highest contamination levels occurred most often in September, October, November, December, January, and February (see tables 23 and 24 and figures 21 and 22).

Cattle from cotton areas is contaminated through eating pasture which has received insecticide drift, drinking water with pesticide runoff and eating cotton stalks. Cows near cotton areas take in pesticides from contaminated pasture and forages for the most part (figure 20). Beef away from cotton gets contaminated through feeds and forages which contain pesticides.

A substantial proportion of the samples analyzed contained DDT above the tolerances established in the main importing country at the time of the analysis. Out of 2,199 samples analyzed in Guatemala and El Salvador between 1973 and 1976, 277 were above the tolerances, 12.6 % of the total. Assuming average sample size and cattle weights, 277 samples imply 2,150 metric tons of meat and an economic loss of $1.02 million if one also includes costs of chemical analysis of $35 per sample.

Total losses for the beef industry in the four Central American countries are estimated between $1.7 million and $2.0 million in the recent past. This is the increased cost caused by pesticide use in cotton production. (See Chapter on the Economics of pesticide use).

TABLE 20

GUATEMALA: BEEF CONTAMINATION IN COTTON AREAS, DDT IN PPM

COUNTY	Samples #	Samples above 5 ppm #	Samples above 5 ppm %	Samples below 5 ppm #	Samples below 5 ppm %	Average contamination ppm	Minimum levels ppm	Maximum levels ppm
Coatepeque	4	1	25	3	75	3.23	1.59	5.74
Chiquimulilla	17	1	5.88	16	94.11	2.66	0.43	8.86
Champerico	3	3	100	0		14.07	6.00	26.56
La Gomera	31	21	67.7	10	32.2	9.78	1.50	34.78
Mes agua	32	3	9.37	29	90.62	2.15	0.18	8.83
Retalhuleu	72	30	41.6	42	58.3	5.97	1.02	29.44
San Andrés V.S.	24	6	25	18	75	6.70	0.30	74.04
Santo Domingo S.	18	4	22.2	14	77.7	4.03	0.53	21.75
Tiquisate	27	13	48.14	14	51.8	6.20	0.81	18.11
Mazatenango	2	2	100	0	0.0	10.51	6.34	14.69
TOTALS	230					5.76		

SOURCE: ICAITI

TABLE 21

GUATEMALA: Beef Contamination Near Cotton Zones, [illegible]

COUNTY	# of samples	Samples above 5 ppm #	Samples above 5 ppm %	Samples below 5 ppm #	Samples below 5 ppm %	Average contamination ppm	Minimum levels ppm	Maximum levels ppm
Democracia	24	6	25	18	75	3.92	1.13	13.70
Escuintla	7	1	14.2	6	85.7	2.80	0.35	9.15
Génova	1	1	100	0	0.0	6.15	6.15	6.15
Pto San José	1	0	0	1	100	1.44	1.44	1.44
TOTAL	33					3.67		

SOURCE: ICAITI

TABLE 22

GUATEMALA: BEEF CONTAMINATION IN COUNTIES REMOVED FROM COTTON AREAS, PPM OF DDT

COUNTY	# of Samples	Samples above 5 ppm #	Samples above 5 ppm %	Samples below 5 ppm #	Samples below 5 ppm %	Average Contamination PPM	Minumum levels PPM	Maximum levels PPM
Cobán	1	0	0	1	100	1.30	1.30	1.30
Cuyotenango	4	0	0	4	100	1.71	1.34	2.25
Chisec	8	0	0	8	100	0.58	0.26	1.42
Gualán	6	0	0	6	100	0.36	0.11	0.86
Los Amates	3	0	0	3	100	0.36	0.20	0.61
Livingston	2	0	0	2	100	0.20	0.09	0.32
Mariscos	1	0	0	1	100	0.23	0.23	0.23
Pajapita	3	0	0	3	100	1.98	1.02	3.07
Pasaco	1	0	0	1	100	0.56	0.56	0.56
Santa Bárbara	3	0	0	3	100	2.65	2.19	3.44
Sta Lucía Cotz.	4	0	0	4	100	2.32	0.93	4.96
San José Pinula	1	0	0	1	100	2.24	2.24	2.24
Taxisco	2	0	0	2	100	0.93	0.61	1.25
TOTAL	39					1.14		

SOURCE: ICAITI

TABLE 23

GUATEMALA: BEEF CONTAMINATION BY MONTH

DDT IN PPM (1973 / 75)

MONTH	1973 MAX	1973 MIN	1973 AVE	1974 MAX	1974 MIN	1974 AVE	1975 MAX	1975 MIN	1975 AVE
*January				17.81	0.[illegible]	5.20	102.59	.17	6.64
*February				22.11	[illegible].10	5.49	65.39	0.16	6.37
March				14.01	1.91	4.87	11.32	0.02	3.05
April				0.0	0.0	0.0	10153	.15	9.39
May				2.34	1.77	2.06	17.65	0.09	3.54
June				-	-	-	16.16	.12	5.69
July				.87	.86	.86	14.69	.90	4.24
August				13.90	13.90	13.90	9.15	0.26	1.90
* September	15.75	0.69	7.11	18.85	.10	4.53	6.96	0.85	2.80
* October	7.01	0.17	1.92	18.52	0.05	3.11	15.21	.18	2.56
* November	27.22	0.60	4.84	73.03	.17	5.12	9.92	0.72	3.22
* December	21.03	0.18	4.69	57.02	.41	6.19			

* Intensive pesticide use season.

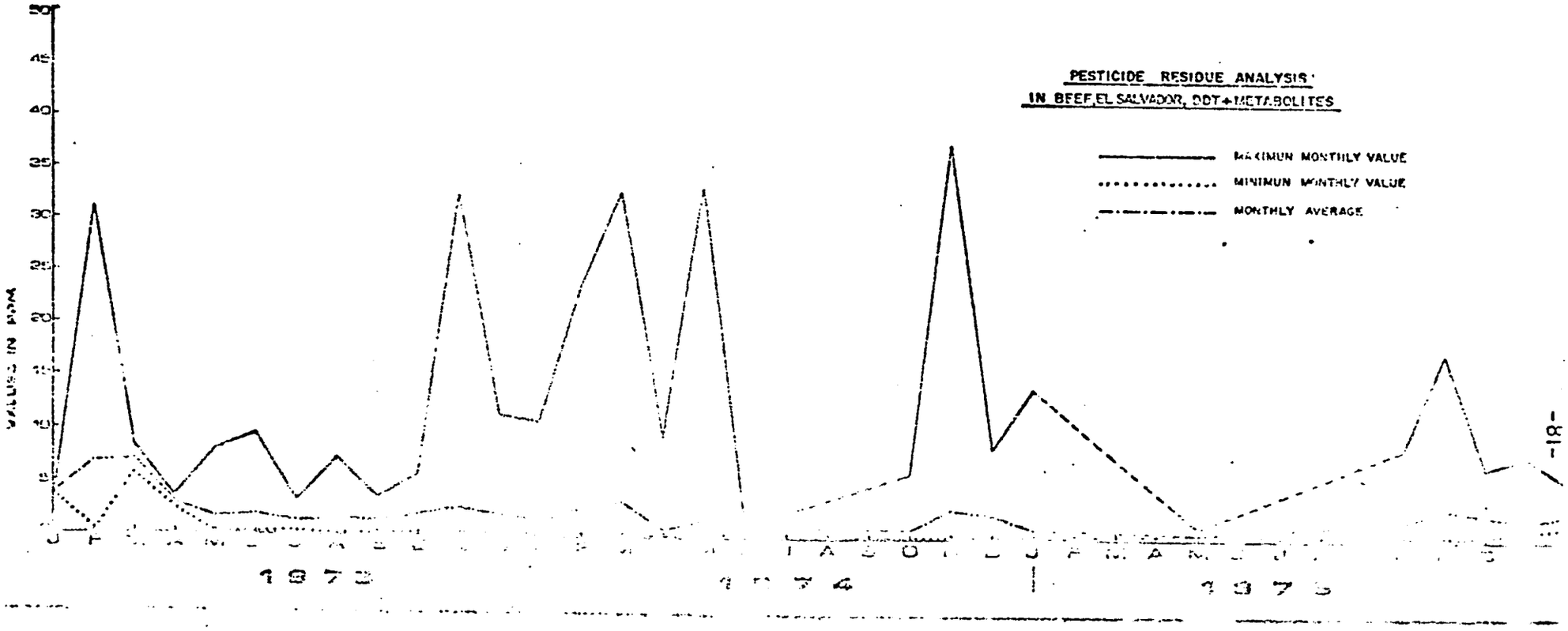
TABLE 24

EL SALVADOR: BEEF CONTAMINATION BY MONTH, DDT IN PARTS PER MILLION (1973 - 76)

MONTH	1973			1974			1975			1976		
	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE
*January	3.71	3.71	3.71	11.02	0.03	1.59	14.46	0.18	1.16	8.28	1.02	2.00
* February	31.10	0.31	6.95	23.64	0.00	2.83	-	-	-	5.58	1.39	2.73
March	8.44	5.84	7.19	33.04	0.00	3.48	-	-	-	1.79	0.43	0.92
April	3.85	2.46	3.11	9.84	0.19	0.86	-	-	-	1.23	0.76	0.97
May	8.19	0.13	1.74	33.60	0.04	1.81	1.26	0.23	0.54	106.27	0.63	21.46
June	9.87	0.27	2.07	1.35	0.64	1.13	-	-	-	-	-	-
July	3.31	0.30	1.33	-	-	-	-	-	-	-	-	-
August	7.33	0.19	1.67	-	-	-	-	-	-	-	-	-
* September	3.80	0.18	1.45	-	-	-	-	-	-	-	-	-
* October	6.03	0.25	2.19	6.32	0.15	1.05	8.81	0.32	1.96	-	-	-
* November	32.46	0.28	2.80	37.91	0.19	2.94	17.85	0.49	3.18	-	-	-
* December	11.63	0.16	2.16	8.77	0.23	2.39	7.08	0.47	2.67	-	-	-

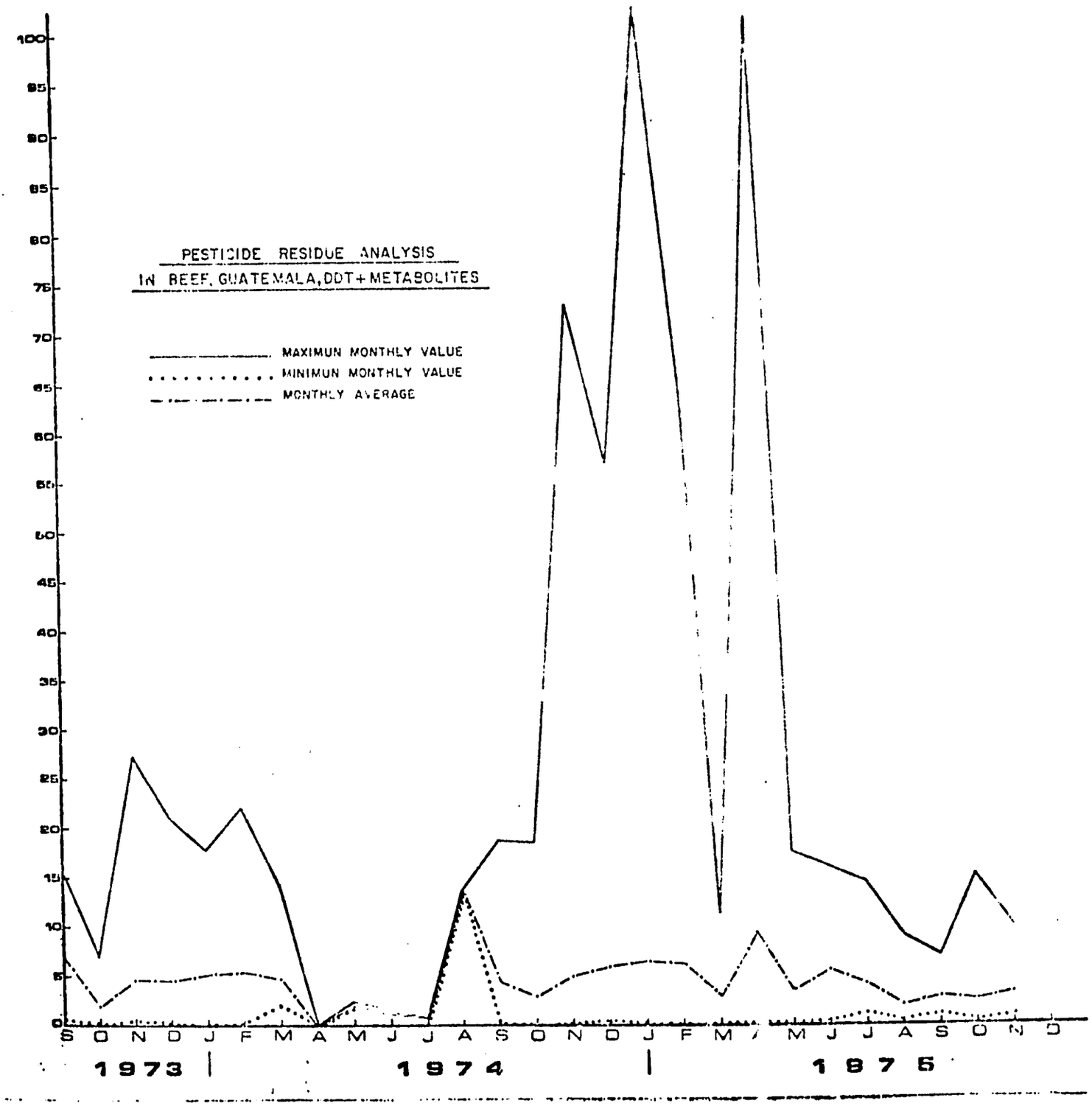
* Intensive Pesticide use season.

FIGURE 21



SOURCE: ICAITI

FIGURE 22



SOURCE: ICAITI

According to beef exporters meat contamination is a commercial problem. Supposedly, the importing countries intensify sampling when the supply of beef is plentiful and let more contaminated meat into the country when supply is low. Besides they argue that present tolerances are arbitrary in the sence that nobody knows the effect of continuously eating beef with more than the tolerable amount of DDT.

Contamination of beef was higher in Guatemala than in El Salvador. About 26% of 685 samples were above tolerances compared to only 6.5% in 1514 samples from El Salvador. This may reflect a higher proportion of chlorinated hydrocarbons used in Guatemala (see table 54) and less separation between cotton and cattle areas.

Under a certain light beef contamination appears to be an agroeconomic problem. Cattle raising in Central America represents an extensive use of land resources. All cotton lands are located in areas of agricultural potential for annual, intensive crops such as cotton, corn, sorghum and cowpeas. Cattle raising in or near cotton zones implies underutilization of land resources. Thus, it would seem to be economically desirable to separate cows from cotton and promote compatible crops in cotton areas. This would also eliminate meat commercialization problems and contribute to reduce sub-clinical intoxication in Central Americans.

2.5 The need for evaluating the effects of contamination on the marine environment

One of the first sources of popular concern over the consequences of pesticide use in Central America was occasional fish kills. As of yet there has been no systematic effort to evaluate these environmental and economic loses. The necessity to investigate pesticide effects on the marine environment is all the more important since the oceans eventually receive all the contaminants washed into rivers.

The initial objective of this portion of the study was to detect possible differences in catches of shrimp and fish per unit of fishing effort in ocean waters with and without drainage from cotton lands. It was hoped that large enough differences in pesticide load would reflect themselves in different catches per unit of effort. The shrimp (Peneaus spp) fishery was selected because is one of the most modern and systematic operations at a commercial scale in Central American fishing.

The study took place in Salvadorean waters for reasons of topography. From the Guatemalan border to the Port of La Libertad the shoreline is abrupt and there is no cotton upland. The coastline between La Libertad and Jiquilisco Bay is flat, sandy and cotton is grown almost at all points. There is a clear potential for differences in pesticide load in the two portions of the ocean.

Permission was obtained to sample from commercial shrimp trawlers with the intention of comparing catches in zones with and without heavy pesticide drainage. For obvious reasons the shrimp producers were very interested in the study and their cooperation was a valuable asset. In actual practice the study encountered a series of logistic and methodological problems which limited the information that was obtained.

The first difficulty arose from the actual manner in which shrimp trawlers do their fishing. They endeavor to find sizable shrimp banks and once they do stay on them for as long as they can. This limits the area to be covered and biases the sampling procedure.

Second, shrimp tend to be gregarious. They cluster in dense patches and any survivors from allegedly contaminated estuaries would soon be lost among the rest.

Third, fishing does not proceed uniformly and uninterfered. Vessels frequently cross the path of one another. Since there is some evidence of overfishing the activities of one boat may result in a diminished catch for the next regardless of the presence of cotton in the mainland.

Partly to overcome the first difficulty it was decided to analyze water samples from the surface and the botton of the ocean. It was expected that the degree of pesticide contamination could help distinguish areas with insecticide drainage. During the sampling trip records were kept of the location, depth, shrimp and fish catches per hour of trawling and samples of water, fish and shrimp were taken from each time the net was recovered.

No significant relationships between catches and contamination could be derived by analyzing the results obtained. Aside from the difficulties mentioned above it is possible that better results could have been obtained if the average size of individual shrimp had been measured. Ecological disturbances often affect the age structure of the populations involved. Table 25 shows the data collected and the results of analyzing shrimp, fish, and water samples.

TABLE 25

CONTAMINATION OF MARINE SAMPLES AND FISHING CATCHES, PER UNIT OF EFFORT, EL SALVADOR 1975

	(PPM) DDT Contamination			Catches (lbs/hr)		
Casting	Water	Shrimp	Fish	Shrimp	Fish	TOTAL
1	.00003	n.a.	0.08	.63	15.77	16.4
2	.00004	.083	.086	3.33	26.67	30
3	.00006	.022	.398	16.28	34.88	51.16
4	.00012	.168	-	6.55	32.75	39.3
5	.00006	.067	.04	11.99	21.58	33.57
6	.00005	.045	.28	1.77	10.6	12.37
7	.000025	.003	.11	15.81	15.81	31.62
8	.000045	.0108	.19	14.55	7.27	21.82
10	.0000735	.03	.10	6.32	10.53	16.84

SOURCE: ICAITI

FIGURE 23

A marine taxonomist identifies the species to be sampled.

FIGURE 24

A member of the project's team marking each sample prior to storage.

3. HUMAN HEALTH

This chapter gives a picture of the impact of pesticide use on the human population of Central America. The universe affected is first described, followed by an account of the most obvious consequence of pesticide use on humans, intoxication. A discussion is then presented on the relationship between pesticide use and the sub-clinical presence of pesticides in humans. Last, the effects of pesticide use on malaria and its control are highlighted.

3.1 The inhabitants of central america's cotton areas:

About 1680000 people live in rural areas with at least 1% of the county's surface planted with cotton. This figure, around 10% of the total population of the 4 countries, represents the group most affected by pesticide use. By country, the cotton area residents of El Salvador totaled 742800; those of Nicaragua were 377000; the Guatemalans were 364000; and those of Honduras only 196200, in 1975.

The inhabitants of prime cotton lands, or highest pesticide risk areas, were about 700000 in 1975. Tables 29 to 43 show the population by county over the last 4 years.

This population group is growing at fast rates. The annual increment by country was 3.3% for Guatemala, 3.5% for El Salvador, the same for Honduras and 3.3% for Nicaragua in 1975.

Perhaps the easiest way to describe the people from cotton areas is to talk about their living conditions. From a public health standpoint (and rather subjectively) they can only be termed deplorable. Follows a more objective summary extracted from a survey of cotton farms in Guatemala, 1974 (**Table N° 26 and Figures 25 and 26**).

Over 75% of the people interviewed were illiterate. This is translated as an incapacity to read warning signs pesticide use instructions, reports on the effects of pesticides, and instructions on the use of protection equipment. It also reflects a low level of modernism, which implies ignorance of the nature and activity of pesticides.

Most of the buildings where these people lived had no floors. The difficulty to keep a mud floor clean should not be stressed. About 30% though had floors made of wood.

The majority of walls were also made of wood, mostly plancks with spaces between them. They provide little protection against insects such as mosquitoes, fleas and ticks. Housing for temporary workers has normally no walls and thus provides no protection against insecticide drift.

FIGURE 25

Young child standing next to cotton fields near his house.

FIGURE 26

Peasant-built cuts along a road which crosses cotton fields.

About 60% of the "houses" surveyed had no toilet. This means that their inhabitants must do per force elsewhere. Aside from other unsanitary implications, the risk of pesticide intoxication increases through direct contact and through the habit to use surrounding vegetation including cotton leaves for hygienic purposes.

Many of the buildings had no running water; only 25% did. Some (20%) used what is labeled a "sanitary" well, but a 37% had an unsanitary water supply. 80% of all living structures had no drainage of any kind.

During the survey, over 80% of the houses were found to have insect and rodent pests inside them. None of them had any facilities for the disposal of garbage. Less than 25% had bathrooms with shower facilities. This increases the difficulties of bathing after being exposed to pesticides.

All of these contribute to increase the potential hazards of pesticide use. They also reflect a social and economic reality from which the consequences of pesticide use cannot abstract (see table 26).

3.2 Human intoxication.

This section deals with the most obvious effect of pesticide use on humans. Number of poisoning cases and rates per country are given for several years. Also presented are the results of an epidemiological study which delves somewhat into the circumstances which most often lead to intoxication.

Number of **pesticide** poisonings:

At the outset, it is useful to distinguish between an intoxication and a death. There were 2284 human poisonings reported in cotton growing areas in 1975, and only 10 of these people passed away, less than .5%. The intoxications reported include mild, moderate and serious cases as well as deaths. Tables 27 and 28 give a summary of pesticide poisonings, while tables 29 through 44 give a detailed account of poisoning cases and other related factors.

El Salvador has consistently reported the highest number of poisonings. There were 1280 cases in 1974, of which 6 resulted in the death of the person. The poisoning rate was 5.16 cases per thousand rural inhabitants of prime cotton zones.

From this perspective, the most significant point to be made is that El Salvador uses the highest proportion of organophosphates (parathions) among the main producing countries, 48% (see table 53 These pesticides have the highest toxicity for mammals of those used in cotton production. Ethyl parathion has an LD 50 of about 10 mg/kg, compared to an LD50 of 600 for DDT, so that it would take 60 times more DDT to kill 50% of a population than would be required if ethyl parathion is used.

TABLE 26

GUATEMALA: POPULATION, EDUCATION, HOUSING, AND SANITARY CONDITIONS IN COTTON FARMS IN THE DEPARTMENTS OF ESCUINTLA AND SANTA ROSA, 1974.

	No.	%
I. POPULATION		
Age Group:		
Less than one year	124	2.60
From 1 to 4 years	349	7.06
From 5 to 6 years	213	4.44
From 7 to 15 years	522	10.88
Over 15 years	3589	75.02
TOTAL	4797	100.00
Education:		
Literate from 7 to 15 years	119	2.89
Illiterate from 7 to 15 years	403	9.80
Literate adults	445	10.55
Illiterate adults	3144	76.76
TOTAL	4111	100.00
II. HOUSING		
Ownership Conditions:		
Owners	77	2.73
Tenants	252	97.27
Buildings not examined	0	0.00
Total buildings	259	100.00
Building use:		
Exclusively for living	240	91.67
For food handling	10	3.86
Commercial	5	1.93
Other uses	4	1.54
Buildings not examined	0	0.00
Total buildings	259	100.00

TABLE 26(Cont.)

	No.	%
Floor Material		
Cement tiles	78	30.10
Clay tiles	1	0.38
Wooden floors	56	21.61
Earth floors	124	47.91
Buildings not examined	0	0.00
Total buildings	259	100.00
Wall Materials:		
Masonry walls	18	6.94
Wooden walls	149	58.55
Wooden walls and others	45	16.37
Buildings not examined	0	0.00
Total buildings	259	100.00
Ceiling Materials		
Wooden ceilings	12	4.63
Blanket ceilings	[illegible]	0.00
Other ceilings	3	1.15
Without ceiling	244	94.22
Buildings not examined	0	0.00
Total buildings	259	100.00
Roof Materials		
Concrete roofs	0	0.00
Zinc sheet roofs	219	84.56
Clay tile roofs	0	0.00
Straw roofs and others	40	15.44
Buildings not examined	0	0.00
Total buildings	259	100.00
General Conditions of buildings:		
In good conditions	29	11.19
In regular conditions	148	57.16
In poor conditions	82	31.65
Buildings not examined	0	0.00
Total buildings	259	100.00
Total number of bed-rooms	289	

TABLE 26(cont.)

	No.	%
Kitchens:		
Buildings with independent kitchen	201	77.58
Building without independent kitchen	54	20.88
Building without kitchen	4	1.54
Buildings not examined	0	0.00
Total buildings	259	100.00
Bathrooms:		
Buildings with bathrooms	60	23.96
Buildings without bathrooms	199	76.04
Buildings not examined	0	0.00
Total buildings	259	100.00
III. BASIC SANITATION		
Water Supply:		
Buildings with running water	69	25.63
Buildings with sanitary well	52	20.07
Buildings with unsanitary well	93	36.95
Buildings supplied with municipal water	4	1.54
Buildings supplied with spring water	28	10.80
Buildings supplied by other waters	13	5.01
Buildings not examined	0	0.00
Total buildings	259	100.00
Excretion Disposal:		
Buildings with toilet	19	7.33
Buildings with flushing toilet	36	13.89
Buildings with septic toilets	5	1.93
Buildings with non septic toilets	50	19.30
Buildings without excretion disposal	149	57.55
Buildings not examined	0	0.00
Total buildings	259	100.00
Drainages:		
Buildings without drainages	204	79.77
Buildings with drainages in public network	10	3.86

TABLE 26 (cont.)

	No.	%
Buildings with cesspool drainage of F.S.	45	16.37
Buildings not examined	0	0.00
Total buildings	259	100.00
Garbages:		
Buildings with sanitary deposits	0	0.00
Buildings with unsanitary deposits	1	0.38
Buildings without deposits for garbage	258	99.62
Buildings with garbage collection	0	0.00
Buildings not examined	0	0.00
Buildings with free disposal	259	100.00
Total buildings	259	100.00
Animals:		
Buildings with animals	214	82.60
Buildings with rodents	222	85.69
Buildings with pigs	17	5.56
Buildings with cows and horses	11	4.24
Buildings with dogs	71	27.40
IV TYPE OF ESTABLISHMENTS		
1. General and grocery stores	13	5.01
2. Restaurants, eating places, cafeterias	4	1.54
3. Bars	0	
4. Butcher shops	0	
5. Foodstuffs, beverages, factories	0	
6. Candies, stores, factories	0	
7. Ice, icecreams, factories	0	
8. Hotels, boardings houses, rooming houses		
9. Dairy shops	0	
10. Corn cooking and cereal meals	2	0.77
11. Bread stores, cake shops, pastry shops	0	
12. Small and large slaughter houses	0	
13. Fowl slaughter houses	0	
14. Tortilla shops	1	0.38

TABLE 26 (cont.)

		No.	%
Business:			
1.	Barber shops and beauty parlors	0	
2.	Warehouses	0	
3.	Movie houses and theaters	0	
4.	Companies	0	
5.	Hardware stores	0	
6.	Haberdasheries	0	
7.	Workshops	0	
8.	Funeral parlors	0	
Agricultural Industries:			
1.	Pigsties	0	
2.	Hencoops	0	
3.	Vegetables	0	
Public Offices:			
1.	Post Offices	0	
2.	**School (La Montañeza)**	1	0.38
3.	Churches	0	
4.	Municipal Buildings	0	
5.	National Buildings (specify)	0	

SUMMARY

Total number of inhabitants	4797
Total number of buildings examined	259
Total number of buildings not examined	0
Total number of buildings	259
Total number of empty lots	0

TABLE 27

CENTRAL AMERICA: MORBIDITY BY PESTICIDES BY COUNTRY, 1972/75

COUNTRY	1972	1973	1974	1975
Guatemala	2 313	1 621	946	804
El Salvador	3 163	1 703	1 274	1 083 *
Honduras	30	48	37	21
Nicaragua	557	243	136	159
TOTAL	6 063	3 615	2 393	2 067

* Projected

SOURCE: ICAITI, based on investigations in the four countries under study.

TABLE 23

CENTRAL AMERICA: MORTALITY BY PESTICIDES BY COUNTRY, 1972/75.

COUNTRY	1972	1973	1974	1975
Guatemala	2	0	2	1
El Salvador	5	5	6	1*
Honduras	4	6	0	0
Nicaragua	4	4	0	0
TOTAL	15	15	8	2*

* Projected

SOURCE: ICAITI, based on investigations in the four countries under study.

TABLE 29

EL SALVADOR: INTOXICATIONS, MALARIA, COTTON AREAS AND HUMAN POPULATION BY COUNTY, 1972

artment	COUNTY	total area Km2	cotton area Km2	%	POPULATION Urban	Rural	population Density	Intoxications by department	Total intox. rate for (1000)	Rural intox. rate for (1000)	MALARIA cases	% resistence to DDT	OMS	total malar. rate x (1000)	Rural malar. rate (1
a Ana	Texistepeque	177.60	0.70	0.39	1838	15144	95.62	52	0.13	0.23	1411	-	-	3.70	6.
	Metapán	643.76	0.70	0.11	5435	40906	71.98	-	0.0	0.0	-	42		00.0	00.
ichapán	St. Lorenzo	40.00	0.53	1.32	581	4911	137.30	1	-	-	801	-	-	4.29	5.
	S Fco Menénd.	219.20	15.77	7.19	968	18808	94.76	-	-	-	-	-	44	-	-
	Guaymango	52.99	0.70	1.32	1071	10423	216.31	-	-	-	-	-	-	-	-
	Jujutla	297.75	2.25	0.75	1048	14797	52.91	-	-	-	-	-	41	-	-
	Atiquizaya	62.84	0.35	0.56	8393	17[illegible]9	411.07	-	-	-	-	-	-	-	-
onate	Sonsonate	214.82	35.09	16.32	36415	15757	242.91	389	1.59	2.51	1420	70	88	5.82	9.1
	Nahuilingo	35.13	3.42	9.73	1599	3200	136.[illegible]	-	-	-	-	-	-	-	-
	Acajutla	123.83	6.15	4.97	6080	18136	195.[illegible]	-	-	-	-	-	12	-	-
	Armenia	66.00	4.46	6.76	9467	11[illegible]7	[illegible]	-	-	-	-	-	-	-	-
	Ishuatán	77.00	0.03	0.04	828	6098	[illegible]	-	-	-	-	52.	82	-	-
ibertad	La Libertad	146.84	22.22	15.13	7908	129[illegible]0	[illegible]4	3	0.02	0.03	5187	-	-	17.41	26.8
	Los Moras	-	1.76	-	-	-			-	-	-	-	-	-	-
atenango	Chalatenango	145.16	1.32	0.91	7939	14[illegible]55	15[illegible].03	0	-	-	2564			13.59	18.0
	Nva Concepc.	254.00	0.35	0.14	[illegible]319	17355	[illegible].63	-	-	-	-	67	-	-	-
Salvador	Guazapa	[illegible]	0.03	0.03	3024	7768	1[illegible].03	1	-	-	1760	-	-	2.34	11.0
	Panchimalco	104.00	0.21	0.20	3609	15120	180.08	-	-	-	-	-	-	-	-
ntas	Tejutepeque	54.94	0.10	0.18	2036	5279	138.14	0	-	-	747	-	-	5.26	6.2
Vicente	San Vicente	268.13	7.29	2.72	21546	28305	185.92	92	0.56	0.80	3916	-	-	23.98	34.3
	Tecoluca	312.10	68.25	21.87	2862	23179	83.50	-	-	-	-	-	-	-	-

TABLE 29 (CNTD.)

Department	COUNTY	total area Km2	cotton area Km2	%	POPULATION Urban	POPULATION Rural	population Density	Intoxications by department	Total Intox. rate for (1000)	Rural Intox. rate for (1000)	MALARIA cases	% resistence to DDT	% resistence to OMS	Total malar. rate x (1000)	Rural malaria rate x (1000)
La Paz	Zacatecoluca	407.87	65.47	16.05	17325	43767	149.78	1351	6.82	9.92	4202	-	82	21.21	30.87
	San Nonualco	125.92	35.83	28.49	4965	22079	214.76	-	-	-	-	95	0	-	-
	S J Nonualco	62.16	6.74	9.74	5109	11062	234.11	-	-	-	-	-	-	-	-
	S Rel Obrajelo	10.94	3.58	32.72	1907	4037	543.33	-	-	-	-	-	-	-	-
	Olocuilta	82.18	8.95	10.89	4078	7977	146.69	-	-	-	-	-	-	-	-
	S Luis Talpa	64.03	37.27	58.21	1521	3443	74.87	-	-	-	-	-	-	-	-
	S Pedro Masah.	138.52	41.14	29.70	2737	10366	94.59	-	-	-	-	-	-	-	-
	Rosario La Paz	43.49	22.35	48.07	3443	3524	146.03	-	-	-	-	-	-	-	-
	S Juan Talpa	35.00	5.45	15.14	2464	1336	101.11	-	-	-	-	-	-	-	-
Usulután	Usulután	158.86	34.16	2[illegible].50	[illegible]	2[illegible]019	293.49	1227	3.95	5.52	5712	-	-	18.49	25.73
	San Dona	50.92	7.[illegible]	15.04	[illegible]3	1[illegible]17	372.56	-	-	-	-	-	-	-	-
	Jiquilisco	400.00	15[illegible].14	[illegible]	[illegible]	34724	[illegible].70	-	-	-	-	98	4[illegible]	-	-
	San Dionicio	70.51	18.[illegible]	2[illegible]	[illegible]	2[illegible]73	[illegible].91	-	-	-	-	98	60	-	-
	Jucuarán	210.33	8.70	[illegible].14	[illegible]	17357	[illegible].17	-	-	-	-	-	-	-	-
	Ereguayquín	16.[illegible]	7.[illegible]	[illegible]	[illegible]	[illegible]790	334.81	-	-	-	-	-	-	-	-
	Ozatlán	46.16	7.[illegible]	1[illegible]	[illegible]	[illegible]	2[illegible].78	-	-	-	-	-	-	-	-
	Conc. Patres	99.45	39.70	[illegible]	[illegible]	[illegible]80	111.93	-	-	-	-	94	17	-	
	Sta María	12.80	7.43	[illegible]	[illegible]	[illegible]20	379.37	-	-	-	-	-	-	-	-
	Jucuapa	45.72	[illegible]	[illegible]	[illegible]	[illegible]	323.36	-	-	-	-	-	-	-	-
	Pto El Triunfo	90.00	7.69	[illegible]	[illegible]	[illegible]	71.08	-	-	-	-	-	-	-	
	Estanzuelas	115.72	3.[illegible]3	[illegible]	[illegible]	[illegible]	93.54	-	-	-	-	-	-	-	-
	Nva Granada	52.72	4.62	8.77	1668	[illegible]	125.30	-	-	-	-	-	-	-	-
	Berlín	92.97	3.56	[illegible]	6566	18536	200.76	-	-	-	-	-	-	-	-
	San Agustín	109.48	6.09	[illegible]	[illegible]	16299	166.86	-	-	-	-	-	-	-	-
	Merc. Umaña	83.91	4.24	5.07	[illegible]	8186	119.94	-	-	-	-	-	-	-	-
	S Fco Javier	29.48	6.[illegible]	21.[illegible]	[illegible]	[illegible]	281.17	-	-	-	-	-	-	-	-
	El Triunfo	27.00	0.72	2.67	2322	2670	184.89	-	-	-	-	-	-	-	-
	S Marcos Lempa	-	0.03	-	-	-	-	-	-	-	-	-	-	-	-
	Tecapán	50.00	0.08	0.16	1731	5881	152.24	-	-	-	-	-	-	-	-
	Stgo de María	43.00	0.35	0.81	9511	7146	387.37	-	-	-	-	-	-	-	-
	San Buenaventura	22.00	0.56	2.54	1170	4659	264.95	-	-	-	-	-	-	-	-

TABLE 29 (CNTD.)

partment	COUNTY	total area Km2	cotton area Km2	%	POPULATION Urban	POPULATION Rural	population Density	intoxications by department	Total intox. rate for (1000)	Rural intox. rate for (1000)	MALARIA cases	MALARIA % resistence to DDT	MALARIA % resistence to OMS	Total malar. rate x (1000)	Rur malar rate (
Miguel	San Miguel	620.00	115.79	18.67	55017	63126	190.55	4	0.01	0.01	4020	91	56	11.70	17
	Moncagua	112.80	3.47	3.08	1289	14216	137.45	-	-	-	-	-	-	-	-
	Ulyazapa	41.48	1.95	4.70	1398	2903	103.69	-	-	-	-	-	-	-	-
	Chapeltique	104.80	9.12	8.70	1792	9027	103.23	-	-	-	-	-	-	-	-
	Chirilagua	211.20	12.93	6.12	5582	15859	101.52	-	-	-	-	100	98	-	-
	Quelepa	21.66	6.80	31.39	1211	3433	214.40	-	-	-	-	-	-	-	-
	Comacarán	36.00	0.65	1.80	809	3807	128.22	-	-	-	-	-	-	-	-
	Chinameca	75.04	0.02	0.03	7455	18047	339.84	-	-	-	-	-	-	-	-
	Nva Guadalupe	18.08	0.14	0.77	3191	2237	300.22	-	-	-	-	-	-	-	-
	S Rafael Orient.	47.68	4.17	8.74	6845	7149	293.92	-	-	-	-	-	-	-	-
	El Trámito	49.96	26.63	53.30	7248	10297	351.18	-	-	-	-	-	-	-	-
	Lolotique	104.00	1.94	1.86	3366	11071	138.82	-	-	-	-	-	-	-	-
	Sn Jorge	40.00	0.14	0.35	4734	6385	277.97	-	-	-	-	-	-	-	-
	Sesori	253.92	0.09	0.03	1643	16444	71.23	-	-	-	-	-	-	-	-
azán	Sn Fco Gotera	110.00	0.75	0.68	5019	5692	97.37	36	0.20	0.25	802	-	-	4.62	5
	Sn Carlos	36.00	1.45	4.03	432	2132	[illegible]	-	-	-	-	-	-	-	-
Unión	La Unión	110.36	10.57	9.58	18799	[illegible]	[illegible]	2	-	0.02	4645	96	-	19.90	26
	Sn Alejo	185.28	2.92	1.57	4434	[illegible]	[illegible]	-	-	-	-	91	43	-	-
	Yucuaiquín	56.96	0.14	0.24	3415	[illegible]	[illegible]	-	-	-	-	-	-	-	-
	Yuyantique	67.93	0.69	1.01	1253	4175	[illegible]	-	-	-	-	-	-	-	-
	Bolivar	94.24	0.03	0.03	1101	[illegible]	[illegible]	-	-	-	-	-	-	-	-
	El Carmen	123.71	3.34	2.70	1895	[illegible]	[illegible]	-	-	-	-	-	-	-	-
	Conchagua	204.49	96.69	47.28	2646	9008	[illegible]	-	-	-	-	-	-	-	-
	Intipucá	158.08	3.45	2.18	4489	[illegible]	[illegible]	-	-	-	-	-	-	-	-
	Sn Jose La F.	12.48	0.06	0.48	1484	2688	334.39	-	-	-	-	-	-	-	-
	Sta Rosa Lima	122.40	3.75	3.06	7130	17544	202.07	-	-	-	-	-	-	-	-
	Pasaquina	301.60	4.82	1.60	2395	18233	60.39	-	-	-	-	-	-	-	-
	El Sauce	82.83	0.59	0.72	1274	9667	132.25	-	-	-	-	-	-	-	-
	Polorós	116.32	0.13	0.11	877	9908	92.72	-	-	-	-	-	-	-	-
	TOTAL	9775.88	1036.42	10.60	413453	947796	131.25	3162	2.32	39.2	37187	82.8	55.6	27.32	39.2

SOURCE: ICAITI

TABLE 30

EL SALVADOR: INTOXICATIONS, MALARIA, COTTON AREAS AND HUMAN POPULATION BY COUNTY, 1973

artment	COUNTY	total area Km2	cotton area Km2	%	POPULATION Urbana	POPULATION Rural	population Density	Intoxications by department	Total intox. rate for (1000)	Rural intox. rate for (1000)	MALARIA cases	MALARIA % resistence to DDT	MALARIA % resistence to OMS	Total malar. rate x (1000)	Rural malar rate (1
ta Ana	Texistepeque	177.60	1.76	0.99	1818	15647	98.34	82	0.23	0.40	1966	-	-	5.51	9.5
	Metapán	643.76	0.49	0.08	8180	34947	66.99	-	-	-	-	-	-	-	-
achapán	Ahuachapán	245.33	0.10	0.04	19257	39310	238.43	17	0.08	0.11	335	-	-	1.73	2.7
	S Fco Menénd.	219.20	8.68	3.96	785	23874	112.49	-	-	-	-	-	-	-	-
	Guaymango	52.99	1.16	2.19	951	10993	225.40	-	-	-	-	-	-	-	-
	Jujutla	297.75	2.29	0.77	468	17063	58.88	-	-	-	-	-	-	-	-
	Atiquizaya	62.84	0.35	0.56	7795	17876	407.75	-	-	-	-	-	-	-	-
sonate	Sonsonate	214.82	29.46	13.71	38238	16269	253.73	216	0.86	1.36	1043	-	-	4.17	6.5
	Nahuilingo	35.13	1.41	4.01	1643	3358	142.36	-	-	-	-	-	-	-	-
	Acajutla	123.83	13.54	10.93	9766	18987	232.20	-	-	-	-	55	-	-	-
	Armenia	66.00	0.07	0.11	79[illegible]0	125[illegible]2	310.64	-	-	-	-	-	-	-	-
.ibertad	La libertad	146.84	26.42	17.99	8814	106[illegible]9	[illegible]	2	-	0.01	5744	-	-	18.96	28.8
	Chiltupiún	103.88	0.06	0.06	1471	59[illegible]9	[illegible].43	-	-	-	-	-	-	-	-
lotenango	Chalatenango	145.16	2.65	1.82	8017	14[illegible]18	[illegible]	8	0.04	0.05	2218	-	-	12.00	16.4
	Sta Rita	49.93	0.42	0.84	891	29[illegible]4	[illegible]	-	-	-	-	-	-	-	-
Salvador	San Martín	52.70	0.08	0.15	5099	9[illegible]37	285.31	24	0.03	0.13	1977	-	-	2.52	10.7
años	Tejutepeque	54.94	0.10	0.18	1895	4[illegible]	115.14	2	0.01	0.01	384	-	-	2.77	3.3
Vicente	San Vicente	263.13	10.03	3.74	27379	[illegible]	194.4[illegible]	85	0.50	0.70	2080	-	-	14.40	17.2
	Tecoluca	312.10	69.90	22.39	3093	25260	90.81	-	-	-	-	-	-	-	-
	Sn. Lorenzo	17.45	0.70	4.01	1685	3680	306.30	-	-	-	-	-	-	-	-
	Sn Ildefonso	123.00	0.10	0.08	1384	8810	32.88	-	-	-	-	-	-	-	-

TABLE 30 (CNTD.)

artment	COUNTY	total area Km2	cotton area Km2	%	POPULATION Urbana	Rural	population Density	Intoxications by department	Total Intox. rate for (1000)	Rural Intox. rate for (1000)	MALARIA cases	% resistence to DDT	OMS	malar. rate x (1000)	malaria rate x (100
az	Zacatecoluca	407.87	59.02	14.47	16818	43303	147.40	616	3.17	4.45	7660	-	-	39.42	55.3
	Stgo Nonualco	125.92	39.47	31.34	4247	22301	210.83	-	-	-	-	-	-	-	-
	S Juan Nonual.	69.16	16.52	23.89	3192	42059	220.52	-	-	-	-	-	-	-	-
	S Rafael Obraj.	10.94	0.89	8.13	1967	4059	550.46	-	-	-	-	-	-	-	-
	Olocuilta	82.18	6.34	7.71	3522	8197	142.60	-	-	-	-	-	-	-	-
	S Luis Talpa	64.03	33.60	52.47	1437	3514	77.32	-	-	-	-	-	-	-	-
	S Pedro Masah.	138.52	49.95	36.06	2246	10868	94.67	-	-	-	-	-	-	-	-
	Rosario L Paz	46.49	12.41	26.69	2903	3157	130.35	-	-	-	-	-	-	-	-
után	Usulután	158.66	32.15	14.57	20262	29361	312.37	237	0.75	1.01	7597	-	-	24.20	32.6
	Sta Elena	50.92	5.46	10.72	4299	11898	306.06	-	-	-	-	-	-	-	-
	Jiquilisco	480.00	153.02	31.88	5159	37244	88.34	-	-	-	-	89	-	-	-
	Sn Dionicio	70.51	11.89	16.86	390	2937	47.18	-	-	-	-	-	-	-	-
	Jucuarán	210.33	9.90	4.71	1487	18914	96.99	-	-	-	-	80	-	-	-
	Ereguayquín	18.30	6.39	34.92	1235	5105	346.45	-	-	-	-	-	-	-	-
	Ozatlán	46.16	4.29	9.29	3290	8510	255.63	-	-	-	-	-	-	-	-
	Conc Betres	99.45	40.48	40.70	1665	11298	130.35	-	-	-	-	-	-	-	-
	Sta María	12.80	7.37	57.58	959	3562	353.20	-	-	-	-	-	-	-	-
	Pto El Triunfo	90.27	8.03	8.89	4403	3193	84.15	-	-	-	-	-	-	-	-
	Jucuapa	45.72	0.29	0.63	6361	8736	330.20	-	-	-	-	-	-	-	-
	Estanzuelas	115.72	5.70	2.92	2632	7161	84.63	-	-	-	-	-	-	-	-
	Nva. Granada	52.72	3.25	6.16	1438	4776	117.87	-	-	-	-	-	-	-	-
	Berlín	92.97	4.87	5.24	5581	19402	268.72	-	-	-	-	-	-	-	-
	Sn Agustín	109.48	4.83	4.41	1853	16132	164.28	-	-	-	-	-	-	-	-
	Merc. Umaña	88.91	4.10	4.61	2429	8117	118.61	-	-	-	-	-	-	-	-
	S Fco Javier	29.48	1.34	4.54	1211	7420	292.77	-	-	-	-	-	-	-	-
Miguel	San Miguel	620.00	154.25	24.88	67439	61401	207.81	397	1.14	1.74	1714	99	-	4.95	7.5
	Moncagua	112.80	5.44	4.82	1376	14323	139.17	-	-	-	-	-	-	-	-
	Ulucazapa	41.48	2.24	5.40	1472	2574	97.54	-	-	-	-	-	-	-	-
	Chapeltique	104.80	10.46	9.98	1755	9068	103.27	-	-	-	-	-	-	-	-

TABLE 30 (CNTD.)

ment	COUNTY	total area Km2	cotton area Km2	%	POPULATION Urbana	Rural	population Density	Intoxications by department	Total intox. rate for (1000)	Rural intox. rate for (1000)	MALARIA cases	% resistence to DDT	OMS	Total malar. rate x (1000)	Rural malaria rate x (1000)
iguel	Chirilagua	211.20	13.15	6.23	5017	17286	105.10	-	-	-	-	96	-	-	-
nuación)	Quelepa	21.66	0.72	3.32	783	3193	183.56	-	-	-	-	-	-	-	-
	Comacarán	36.00	0.45	1.25	735	3553	119.11	-	-	-	-	-	-	-	-
	Chinameca	75.04	0.16	0.21	7164	13390	340.54	-	-	-	-	-	-	-	-
	Nva Guadalupe	18.08	0.10	0.55	3807	1364	313.66	-	-	-	-	-	-	-	-
	Sn Rafael Ori.	47.68	2.66	5.58	5160	7058	256.73	-	-	-	-	-	-	-	-
	El Tránsito	49.96	27.31	54.66	6630	9636	325.98	-	-	-	-	-	-	-	-
	Lolotique	104.00	0.42	0.40	3001	10330	132.99	-	-	-	-	-	-	-	-
	Sn Jorge	29.71	0.42	1.41	[illegible]	5471	325.98	-	-	-	-	-	-	-	-
	Sesori	253.92	1.30	0.51	1436	[illegible]	68.36	-	-	-	-	-	-	-	-
ón	Yamabal	89.00	0.08	0.09	486	3570	45.59	1	-	-	460	-	-	2.72	3.33
	Torola	42.72	0.03	0.07	843	514,	147.24	-	-	-	-	-	-	-	-
ón	La Unión	110.36	7.48	6.78	1598	17626	323.62	1	-	-	1277	-	-	5.42	7.03
	Sn Alejo	185.23	3.40	1.83	[illegible]	16731	123.34	-	-	-	-	-	-	-	-
	Yucuayquín	56.96	0.34	0.60	7051	4537	133.18	-	-	-	-	-	-	-	-
	Yayantique	67.93	0.97	1.43	1745	4037	78.04	-	-	-	-	-	-	-	-
	Bolivar	94.24	0.04	0.04	1150	4539	58.24	-	-	-	-	-	-	-	-
	El Carmen	123.71	2.55	2.06	7706	11440	106.26	-	-	-	-	100	-	-	-
	Conchagua	204.49	7.71	3.77	2760	19196	105.41	-	-	-	-	-	-	-	-
	Intipucá	158.08	3.98	2.52	3645	3658	46.19	-	-	-	-	85	-	-	-
	S José L Fuente	12.48	0.17	1.36	1042	2445	279.41	-	-	-	-	-	-	-	-
	Sta Rosa lima	122.40	3.08	2.52	5999	16806	186.31	-	-	-	-	-	-	-	-
	Pasacuina	301.60	8.61	2.85	2203	17634	65.77	-	-	-	-	-	-	-	-
	El Sauce	82.88	0.67	0.80	1220	9264	126.50	-	-	-	-	-	-	-	-
	Nva. Esparta	75.68	0.02	0.03	1490	9206	141.33	-	-	-	-	-	-	-	-
	Polorós	116.32	0.18	0.15	940	8837	84.05	-	-	-	-	-	-	-	-
	TOTAL	9701.35	949.52	9.79	417155	1006505	146.75	1689	1.19	1.68	34455	86.3	0	24.20	34.23

SOURCE: ICAITI

TABLE 31

EL SALVADOR: INTOXICATIONS, MALARIA, COTTON AREAS AND HUMAN POPULATION BY COUNTY, 1974

artment	COUNTY	total area Km2	cotton area Km2	%	POPULATION Urbana	Rural	population Density	Intoxications by department	Total intox. rate for (1000)	Rural intox. rate for (1000)	MALARIA cases	% resistence to DDT	OMS	Total malar. rate x (1.00)	Rural malaria rate x (10
a Ana	Texistepeque	177.60	1.85	1.04	1881	16188	101.74	-	-	-	5516	-	-	14.95	26.0
achapán	Sn Lorenzo	40.00	1.06	2.65	728	5052	144.50	-	-	-	798	-	-	4.00	5.1
	Ahuachapán	245.33	0.18	0.07	19973	40679	246.98	-	-	-	-	-	20	-	-
	S Fco Menend.	217.20	7.18	3.28	812	24899	116.35	-	-	-	-	-	-	-	-
	Jujutla	297.75	6.63	2.23	404	17653	60.91	-	-	-	-	-	-	-	-
ionate	Sonsonate	214.82	28.34	[illegible]	[illegible]	16831	262.50	-	-	-	2338	-	59	9.03	14.2
	Nahuilingo	35.13	2.11	6.01	1700	[illegible]	147.28	-	-	-	-	-	56	-	-
	Acajutla	123.83	13.65	11.02	10103	19644	240.22	-	-	-	-	-	-	-	-
ibertad	La Libertad	146.84	29.83	20.31	[illegible]	11027	137.20	-	-	-	8676	-	-	27.69	42.0
latenango	Chalatenango	145.16	1.25	[illegible]	[illegible]	15330	162.74	-	-	-	4079	-	-	25.29	35.[illegible]
	Sta Rita	49.93	1.54	3.08	[illegible]	3035	79.03	-	-	-	-	-	-	-	-
Salvador	Panchimalco	104.00	0.10	0.10	2793	18677	206.44	-	-	-	4148	-	-	[illegible]	22.0
ños	Ilobasco	234.00	0.28	[illegible]	7775	34453	179.18	-	-	-	692	-	-	4.84	5.3
Vicente	San Vicente	268.13	11.68	4.36	20891	31661	195.99	-	-	-	4873	-	-	28.09	39.1
	Tecoluca	312.10	77.42	24.81	[illegible]	26133	137.60	-		-	-	-	87	-	-
	Sn Ildefonso	123.00	1.00	0.81	1402	9114	85.74	-	-	-	-	-	-	-	-
Paz	Zacatecoluca	407.87	60.37	14.8	17399	44801	152.52	-	-	-	11417	-	-	56.79	79.7
	Stgo Nonualc.	125.92	36.27	28.8	4394	23072	218.12	-	-	-	-	-	-	-	-
	Sn Juan Non.	69.16	9.21	13.32	3302	12476	228.14	-	-	-	-	-	-	-	-
	Sn Rafael Obr.	10.94	0.87	7.95	2035	4195	569.47	-	-	-	-	-	-	-	-
	Olocuilta	82.18	8.45	10.28	3644	8480	147.53	-	-	-	-	-	-	-	-
	Sn Luis Talpa	64.03	37.09	57.93	1487	3635	79.99	-	-	-	-	-	-	-	-
	Sn Pedro Masah	138.52	62.17	44.88	2324	11243	97.54	-	-	-	-	-	-	-	-

TABLE 31 (CNTD.)

ent	COUNTY	total area Km2	cotton area Km2	%	POPULATION Urbana	Rural	population Density	Intoxications by department	Total Intox. rate for (1000)	Rural Intox. rate for (1000)	MALARIA cases	% resistence to DDT	OMS	Total malar. rate x (1000)	Rural malaria rate x (1000)
	Rosario I. Paz	46.49	22.30	47.97	3003	3766	134.85	-	-	-	-	-	-	-	-
uadalán)	S Juan Talpa	36.00	0.58	1.61	2626	4026	184.61	-	-	-	-	-	-	-	-
n	Usulután	158.66	30.82	19.4	20962	60377	323.17	-	-	-	14378	-	84	44.27	5[illegible].74
	Sta Elena	50.92	4.86	9.54	4448	17209	342.08	-	-	-	-	-	-	-	-
	Jiquilisco	480.00	166.11	34.61	5327	38102	91.39	-	-	-	-	-	-	-	-
	San Dionicio	70.51	12.24	17.36	433	3009	48.61	-	-	-	-	-	-	-	-
	Jucuarán	210.32	10.81	5.14	1536	19213	100.35	-	-	-	-	-	-	-	-
	Eregueyquín	18.30	5.96	32.57	1278	5781	356.41	-	-	-	-	-	-	-	-
	Ozatlán	46.16	5.59	12.11	3404	8604	234.47	-	-	-	-	-	-	-	-
	Cone Betres	99.45	46.75	47.01	1723	11268	134.85	-	-	-	-	-	-	-	-
	Sta María	12.80	6.56	51.23	996	3485	[illegible]	-	-	-	-	-	-	-	-
	Pto El Triunfo	90.27	3.36	3.72	4545	3973	[illegible]	-	-	-	-	-	-	-	-
	Jucuapa	45.72	0.27	0.59	6581	1035	[illegible]	-	-	-	-	-	-	-	-
	Estanzuelas	115.72	4.68	4.04	3723	7409	[illegible]	-	-	-	-	-	-	-	-
	Nva. Granada	52.72	3.62	6.87	1498	4741	[illegible]	-	-	-	-	-	-	-	-
	Berlín	92.97	6.49	6.98	5774	[illegible]	[illegible]	-	-	-	-	-	-	-	-
	San Agustín	109.48	2.57	2.35	1917	[illegible]	[illegible]	-	-	-	-	-	-	-	-
	Mercd. Umaña	88.91	3.53	3.97	2513	[illegible]	[illegible]	-	-	-	-	-	-	-	-
	S Fco Javier	29.48	1.05	0.03	1953	[illegible]	[illegible]	-	-	-	-	-	-	-	-
	El Triunfo	27.00	0.86	3.18	1850	[illegible]	[illegible]	-	-	-	-	-	-	-	-
	Tecapán	50.00	0.07	0.001	164	[illegible]	[illegible]	-	-	-	-	-	-	-	-
guel	San Miguel	620.00	154.00	24.84	69770	63924	216.09	-	-	-	3933	-	76	10.69	16.73
	Moncagua	112.80	9.68	0.03	1424	[illegible]	113.99	-	-	-	-	-	-	-	-
	Uluazapa	41.48	3.22	0.03	1523	2663	103.92	-	-	-	-	-	-	-	-
	Chapeltique	104.80	8.48	8.09	1816	9381	105.84	-	-	-	-	-	-	-	-
	Chirilagua	211.20	13.87	6.57	5190	17885	109.95	-	-	-	-	-	-	-	-
	Quelepa	21.66	7.34	33.88	810	3304	189.93	-	-	-	-	-	-	-	-
	Comacarán	36.00	0.07	0.19	760	3476	123.22	-	-	-	-	-	-	-	-
	Chinameca	75.04	1.15	1.53	7411	19023	352.30	-	-	-	-	-	-	-	-

Department	COUNTY	total area Km2	cotton area Km2	%	POPULATION Urban	POPULATION Rural	population Density	Intoxications by department	Total Intox. rate for (1000)	Rural Intox. rate for (1000)	MALARIA cases	% resistence to DDT	% resistence to OMS	Total malar. rate x (1000)	Rural malaria rate x (1000)
La Paz	Zacatecoluca	407.87	65.47	16.05	17325	43767	149.78	1351	6.82	9.92	4202	-	82	21.21	30.57
	Snt Nonualco	125.92	35.88	28.49	4965	22078	214.76	-	-	-	-	95	0	-	-
	S J Nonualco	69.16	6.74	9.74	5109	11082	234.11	-	-	-	-	-	-	-	-
	S Rel Cibrajalo	10.94	3.58	32.72	1907	[illegible]	543.33	-	-	-	-	-	-	-	-
	Olocuilta	82.18	8.95	10.89	4078	7977	146.69	-	-	-	-	-	-	-	-
	S Luis Talpa	64.03	37.27	58.21	1331	3463	74.87	-	-	-	-	-	-	-	-
	S Pedro Masah.	138.52	41.14	29.70	2737	10366	94.59	-	-	-	-	-	-	-	-
	Rosario La Paz	46.49	22.35	48.07	3465	3324	146.03	-	-	-	-	-	-	-	-
	S Juan Talpa	36.00	5.45	15.14	2464	3336	161.11	-	-	-	-	-	-	-	-
Usulután	Usulután	150.86	34.16	21.50	20805	26619	293.49	1227	3.95	5.52	5712	-	-	18.41	25.73
	Sta Elena	50.92	7.66	15.04	5108	[illegible]	322.66	-	-	-	-	-	-	-	-
	Jiquilisco	480.00	156.14	32.53	7374	[illegible]	87.70	-	-	-	-	98	44	-	-
	Sn Dionicio	70.51	18.77	26.72	505	[illegible]	47.91	-	-	-	-	98	60	-	-
	Jucuarán	210.33	8.70	4.14	1820	[illegible]	91.17	-	-	-	-	-	-	-	-
	Eregueyquín	18.20	7.16	39.12	1337	[illegible]	334.61	-	-	-	-	-	-	-	-
	Ozatlán	46.16	7.82	16.94	4072	[illegible]	251.78	-	-	-	-	-	-	-	-
	Conc. Patres	97.45	39.73	39.95	2049	[illegible]	[illegible]	-	-	-	-	94	17	-	-
	Sta María	12.80	7.43	58.05	1036	[illegible]	[illegible]	-	-	-	-	-	-	-	-
	Jucumpa	45.72	0.07	0.15	6341	[illegible]	[illegible]	-	-	-	-	-	-	-	-
	Pto El Triunfo	90.00	7.39	8.21	3454	[illegible]	[illegible]	-	-	-	-	-	-	-	-
	Estanzuelas	115.72	3.23	2.83	3022	[illegible]	[illegible]	-	-	-	-	-	-	-	-
	Nva Granada	52.72	4.52	8.57	1638	[illegible]	[illegible]	-	-	-	-	-	-	-	-
	Berlín	92.97	3.56	3.83	6546	[illegible]	[illegible]	-	-	-	-	-	-	-	-
	Sn Agustín	109.42	6.05	5.53	1989	[illegible]	[illegible]	-	-	-	-	-	-	-	-
	Merc. Umaña	88.91	4.24	4.77	2478	[illegible]	[illegible]	-	-	-	-	-	-	-	-
	S Fco Javier	29.48	6.22	21.10	1264	[illegible]	[illegible]	-	-	-	-	-	-	-	-
	El [illegible]	[illegible]	0.72	2.47	2522	[illegible]	[illegible]	-	-	-	-	-	-	-	-
	S Marcos Lempa	-	0.03	-	-	-	-	-	-	-	-	-	-	-	-
	Tecapán	50.00	0.08	0.16	1731	[illegible]	159.24	-	-	-	-	-	-	-	-
	Stgo de María	43.00	0.35	0.81	9511	[illegible]	387.37	-	-	-	-	-	-	-	-
	Sn Buenaventura	22.00	0.56	2.54	1170	4559	264.55	-	-	-	-	-	-	-	-

TABLE 31 (CNTD.)

artment	COUNTY	total area Km2	cotton area Km2	%	POPULATION Urbana	POPULATION Rural	population Density	Intoxications by department	Total Intox. rate for (1000)	Rural intox. rate for (1000)	MALARIA cases	MALARIA % resistence to DDT	MALARIA % resistence to OMS	Total malar. rate x (1000)	Rural malari rate x (1000)
Miguel	Sn Rafael Ori.	47.68	3.24	0.07	5362	7302	265.60	-	-	-	-	-	-	-	-
ntinuación)	El Tránsito	49.96	27.20	54.44	6859	9990	337.25	-	-	-	-	-	80	-	-
	Lolotique	104.00	1.75	1.68	3105	11204	137.59	-	-	-	-	-	-	-	-
	Sn Jorge	40.00	1.14	2.85	4356	5661	250.42	-	-	-	-	-	-	-	-
	Sesori	253.92	0.52	0.20	1485	16463	70.72	-	-	-	-	-	-	-	-
azán	Sn Feo Gotera	110.00	1.15	1.04	5150	5836	99.87	-	-	-	1064	-	-	6.08	7.4
	Sn Carlos	36.00	0.01	0.03	637	1759	66.55	-	-	-	-	-	-	-	-
	Jocoro	126.00	0.15	0.12	2974	8572	91.63	-	-	-	-	-	-	-	-
Inión	La Unión	110.36	8.72	7.90	18714	18236	334.81	-	-	-	2409	-	36	9.88	12.8
	Sn Alejo	185.28	2.20	1.19	4263	19879	107.60	-	-	-	-	-	-	-	-
	Yucuaiquín	56.96	0.07	0.12	3156	4692	13[illegible].78	-	-	-	-	-	-	-	-
	Yayantique	67.93	0.48	0.71	1313	4171	[illegible]	-	-	-	-	-	-	-	-
	El Carmen	123.71	2.53	2.04	1764	11836	[illegible]	-	-	-	-	-	80	-	-
	Conchagua	204.49	10.53	5.15	2442	19859	[illegible]	-	-	-	-	-	-	-	-
	Intipucá	158.08	5.53	3.50	3771	3785	[illegible]	-	-	-	-	-	-	-	-
	Sn Jose Fuente	12.48	0.14	1.12	1078	2590	[illegible]	-	-	-	-	-	-	-	-
	Sta Rosa Lima	122.40	1.83	1.49	6206	17397	[illegible]	-	-	-	-	-	-	-	-
	Pasaquina	301.60	7.50	2.49	2280	18243	68.05	-	-	-	-	-	-	-	-
	El Sauce	82.88	0.41	0.49	1262	9534	[illegible]	-	-	-	-	-	-	-	-
	Polorós	116.32	0.77	0.66	972	9142	96.95	-	-	-	-	-	-	-	-
	Cons Oriente	116.00	0.09	0.08	3397	8136	106.32	-	-	-	-	-	-	-	-
	Anamorós	91.00	0.04	0.04	1122	15062	177.85	-	-	-	-	-	-	-	-
	TOTAL	9307.36	1011.42	10.87	410062	990914	150.52	1280	0.91	1.29	65121	n.a.	64	45.48	65.72

SOURCE: ICAITI

TABLE 32

GUATEMALA: INTOXICATIONS, MALARIA, COTTON AREAS AND HUMAN POPULATION BY COUNTY, 1972

					POPULATION			INTOXICATIONS							MALARIA				
		total area	cotton area				population		Mode-				Total Intox rate x	Rural Intox rate x		% resistence to		Total malar. rate x	Rural malari rate x
rtment	COUNTY	Km2	Km2	%	Urbana	Rural	Density	Mild	rate	severe	Fatal	Total	(1000)	(1000)	cases	DDT	OMS	(1000)	(10
Marcos	Ayutla	204	21.31	10.45	3796	8677	61.14	50	26	1	0	77	6.17	8.87	35	-	-	2.80	4.0
	Ocós	205	16.35	7.97	740	9018	47.60	4	14	1	0	19	1.95	2.11	203	69	2	20.80	22.5
zaltenango	Coatepeque	372	25.02	6.72	17948	36083	145.24	24	16	15	0	55	1.02	1.52	57	-	-	1.05	1.5
ihuleu	Retaihuleu	795	115.93	14.56	19211	30062	61.90	29	19	10	0	58	1.18	1.93	136	-	-	2.76	4.5
	Champerico	416	133.54	32.10	5141	10299	37.11	171	23	4	0	198	12.82	19.22	243	57	6	15.74	23.5
	S.A. Villa S.	256	9.47	3.70	1125	25373	103.50	10	0	0	0	10	0.38	0.39	446	60	0	16.83	17.5
itepéquez	Mazatenango	355	9.78	2.75	23928	16473	113.48	10	0	0	0	10	0.25	0.60	46	-	-	1.14	2.7
	Sto. Domingo S	242	102.40	42.31	2684	17772	84.53	102	39	5	0	146	7.14	8.21	139	-	-	6.79	7.8
intla	Tiquisate	892	207.98	23.32	15437	91769	120.23	477	198	24	2	701	6.53	7.64	110	-	-	1.02	1.2
	La Gomera	640	220.52	34.46	2076	40821	67.03	427	557	32	0	1016	23.68	24.89	63	60	0	1.53	1.6
	La Democrac.	320	1.71	0.53	2650	16146	54.74	0	0	0	0	0	0.0	0.0	33	49		1.91	2.0
	Masagua	448	6.61	1.47	1653	22621	54.16	6	0	0	0	6	0.24	0.26	91	-	-	3.75	4.0
a Rosa	Chiquimulilla	499	-	-	4238	30237	69.09	3	5	8	0	16	0.46	0.53	65	50	-	1.82	2.1
	Guazacapán	172	2.44	1.42	1350	9687	64.17	1	0	0	0	1	0.08	0.10	2	64	-	0.18	0.2
	TOTAL	5818	873.06	15.01	101977	365038	80.27	1314	897	100	2	2313	4.75	5.34	1674	53.4	4.0	3.58	4.5

SOURCE: ICAITI

TABLE 33

GUATEMALA: INTOXICATIONS, MALARIA, COTTON AREAS AND HUMAN POPULATION BY COUNTY, 1973

					POPULATION			INTOXICATIONS							MALARIA				
partment	COUNTY	total area Km2	cotton area Km2	%	Urbana	Rural	population density	Mild	Mode-rate	Severe	Fatal	Total	Total intox. rate x (1000)	Rural intox. rate x (1000)	cases	% resistence to DDT	OMS	Total malar. rate x (1000)	Rural malari rate x (10
n Marcos	Ayutla	204	25.86	12.68	3909	8930	62.94	28	32	0	0	60	4.67	6.72	4	-	-	0.31	0.44
	Ocós	205	15.44	7.53	780	9283	49.09	8	9	0	0	17	1.69	1.83	27	60	5	2.68	2.91
ezaltanango	Coatepeque	372	38.79	10.43	18478	37150	149.54	45	29	9	0	83	1.49	2.23	10	-	-	0.18	0.27
talhuleu	Retalhuleu	796	127.65	16.04	19977	31272	64.38	41	16	1	0	58	1.13	1.85	60	-	-	1.17	1.92
	Champerico	416	146.54	35.22	5345	10700	38.56	444	31	4	1	80	4.98	7.47	76	24	0	4.74	7.10
	S.A. Villa S	256	10.74	4.19	1178	26353	107.54	3	1	1	0	5	0.18	0.19	124	86	0	4.50	4.70
chitepéquez	Mazatenango	356	22.08	6.20	24625	[illegible]	115.80	17	3	1	0	21	0.50	1.24	21	-	-	0.50	1.24
	Sto Domingo S	242	116.68	48.21	2770	[illegible]	87.10	44	35	6	0	85	4.03	4.64	38	-	-	1.80	2.07
uintla	Tiquisate	892	224.74	25.19	14285	[illegible]	126.29	218	51	2	0	271	2.40	2.80	39	-	100	0.34	[illegible]
	La Gomera	640	266.82	41.69	[illegible]	[illegible]	70.73	382	154	7	1	494	10.91	11.46	34	0	-	0.75	[illegible]
	La Democrac.	320	4.89	1.53	[illegible]	[illegible]	14.97	0	0	0	0	0	0.0	0.0	12	-	-	0.60	[illegible]
	Masagua	448	6.64	1.48	1747	[illegible]	[illegible]	2	0	0	0	2	0.07	0.08	46	-	-	1.79	[illegible]
nta Rosa	Chiquimulilla	499	21.17	4.24	[illegible]	31086	71.03	2	37	6	0	45	1.26	1.45	22	-	1	0.62	[illegible]
	Guazacapán	172	3.52	2.05	[illegible]	[illegible]	66.04	0	0	0	0	0	0.0	0.0	2	-	-	0.17	0.20
	TOTAL	5818	1031.56	17.73	[illegible]	360545	83.42	1184	398	37	2	1221	2.51	3.21	515	56.3	53.0	[illegible]	1.35

SOURCE: ICAITI

TABLE 3

GUATEMALA: INTOXICATIONS, MALARIA, COTTON AREAS AND HUMAN POPULATION BY COUNTY, 1974

rtment	COUNTY	total area Km2	cotton area Km2	%	POPULATION Urbana	Rural	population density	INTOXICATIONS Mild	Mode-rate	Severe	Fatal	Total	Total intox. rate x (1000)	Rural intox. rate x (1000)	MALARIA cases	% resistence to DDT	DDT	Total malaria rate x (1000)	Rural malaria rate x (1000)
Marcos	Ayutla	204	22.55	11.05	4025	9192	64.79	12	4	0	1	17	1.29	1.85	1	43	-	0.07	0.11
	Ocós	205	16.84	8.21	821	9554	50.61	1	2	0	0	3	0.29	0.31	38	69	88	3.66	3.98
altenango	Coatepeque	372	37.39	10.05	19021	38257	153.97	25	27	6	1	59	1.03	1.54	2	91	6	0.03	0.05
huleu	Retalhuleu	796	120.08	15.08	20872	32519	67.07	91	0	0	0	91	1.70	2.80	37	77	11	0.69	1.14
	Champerico	416	179.79	43.21	5556	11118	40.08	69	0	0	0	69	4.14	6.21	98	92	98	5.88	8.81
	S.A. Villa S.	256	12.82	5.01	1235	27378	111.77	1	1	0	0	2	0.06	0.07	50	87	98	1.82	1.90
itepéquez	Mazatenango	356	19.99	5.61	25345	17450	120.21	34	47	0	0	81	1.87	4.64	34	81	96	0.79	1.95
	Sto Domingo S	242	118.22	48.85	2861	19866	93.91	20	4	0	0	24	1.06	1.21	26	67	-	1.01	1.16
intla	Tiquisate	892	229.61	25.74	17180	103310	135.00	71	109	33	0	213	1.77	2.06	33	88	100	0.27	0.32
	La Gomera	640	307.35	48.02	2323	45449	74.64	284	87	2	0	373	7.80	8.21	90	96	100	1.95	2.05
	La Democracia	320	4.27	1.33	2952	17978	65.40	0	0	0	0	0	0.0	0.0	18	91	-	0.86	1.00
	Masagua	448	9.43	2.10	1845	25177	60.32	0	0	0	0	0	0.0	0.0	36	87	41	1.33	1.43
a Rosa	Chiquimulilla	499	28.30	28.30	4485	31960	73.03	8	3	3	0	14	0.38	0.44	20	56	55	0.55	0.62
	Guazacapán	172	3.14	1.82	1451	10237	67.95	0	0	0	0	0	0.0	0.0	4	36	33	0.34	0.39
	TOTAL	5818	1109.78	19.07	109972	399445	87.56	616	284	44	2	946	1.85	2.37	459	76.7	64.2	0.96	7.22

SOURCE: ICAITI

TABLE 35

GUATEMALA: INTOXICATIONS, MALARIA, COTTON AREAS AND HUMAN POPULATION BY COUNTY, 1975

					POPULATION			INTOXICATIONS							MALARIA				
		total area	cotton area				Population		Mode-				Total intox. rate x	Rural intox. rate x		% resistence to		Total malar. rate x	Rural malari rate x
ortment	COUNTY	Km2	Km2	%	Urbana	Rural	density	Mild	rate	Severe	Fatal	Total	(1000)	(1000)	cases	DDT	OMS	(1000)	(1
Marcos	Ayutla	204	18.31	8.97	4143	9460	66.38	15	1	2	0	18	1.32	1.90	3	66	29	0.22	0.32
	Ocós	205	13.03	6.36	861	9836	52.18	0	0	0	0	0	2.24	4.60	24	96	53	2.24	3.44
zaltenango	Coatepeque	372	25.53	6.78	19585	39385	158.52	6	3	1	0	10	0.17	0.25	30	-	42	0.51	0.76
lhuleu	Retalhuleu	796	103.98	13.06	21679	33828	69.63	14	9	1	0	22	0.40	0.65	124	93	46	2.23	3.65
	Champerico	416	89.00	21.39	5773	11552	41.65	42	6	2	0	50	2.88	4.32	223	80	88	12.87	19.30
	S.A. Villa S	256	5.28	2.06	1294	28448	116.18	1	0	0	0	1	0.03	0.04	141	-	55	4.74	4.96
itepéquez	Mazatenango	356	96.38	27.07	26084	17961	123.72	16	0	0	0	16	0.36	0.89	48	-	62	1.09	2.67
	Sto Domingo S	242	9.15	3.78	2957	19445	92.57	21	9	0	0	30	1.34	1.54	109	-	-	4.86	5.60
intla	Tiquisate	892	225.21	25.25	18127	109024	142.57	99	120	24	0	243	1.96	2.28	142	93	100	1.12	1.30
	La Gomera	640	243.37	38.03	2453	47965	78.7[illegible]	396	[illegible]	10	1	413	8.19	8.61	163	-	45	3.23	3.40
	Masagua	448	6.02	1.34	1951	26567	63.6[illegible]	[illegible]	0	0	0	0	0.0	0.0	198	-	34	6.94	7.45
a Rosa	Guazacapán	172	2.99	1.74	1503	10522	69.9	0	0	0	0	0	0.0	0.0	2	-	-	0.17	0.19
	TOTAL	6637	838.25	12.63	106910	363993	70.8[illegible]	520	244	40	1	805	1.71	2.21	1207	86.6	55.[illegible]	2.57	3.32

SOURCE: ICAITI

TABLE 36

HONDURAS: INTOXICATIONS, MALARIA, COTTON AREAS AND HUMAN POPULATION BY COUNTY, 1972

ment	COUNTY	total area Km2	cotton area Km2	cotton area %	POPULATION Urbana	POPULATION Rural	Population density	INTOXICATIONS Mild	INTOXICATIONS Mode-rate	INTOXICATIONS Severe	INTOXICATIONS Fatal	INTOXICATIONS Total	Total intox. rate x (1000)	Rural intox. rate x (1000)	MALARIA cases	MALARIA % resistence to DDT	MALARIA % resistence to OMS	Total malar. rate x (1000)	Rural malaria rate x (1000)
eca	Marcovia	364	-	-	922	14685	42.87	-	-	-	-	24	-	-	2398	-	61	153.64	163.29
	El Triunfo	518	-	-	2713	11947	28.80	-	-	-	-	-	-	-	737	99	-	50.27	61.68
	Namasigüe	322	-	-	759	7845	26.72	-	-	-	-	-	-	-	305	-	6	35.44	38.87
	Apasilagua	145	-	-	960	6428	50.95	-	-	-	-	-	-	-	71	-	-	9.61	11.04
	S Ant de Flo.	137	-	-	283	3240	25.71	-	-	-	-	-	-	-	18	-	-	5.10	5.55
	Yusguare	41	-	-	948	2758	90.41	-	-	-	-	-	-	-	132	-	-	35.60	47.86
	Choluteca	975	-	-	23392	21933	46.49	-	-	-	-	-	0.52	1.09	1427	-	-	31.48	65.06
no	Catacamas	6438	-	-	8456	14135	3.51	-	-	-	-	2	-	-	13	-	-	0.57	0.91
	S Fco Becerra	743	-	-	1333	2075	4.61	-	-	-	-	-	-	-	27	-	-	7.87	13.01
	Juticalpa	479	-	-	9401	26076	74.06	-	-	-	-	-	0.05	0.07	96	-	-	2.70	3.68
	Nacaome	464	-	-	5488	21394	57.94	-	-	-	-	-	-	-	1577	-	3	58.66	73.71
	Sn Lorenzo	228	-	-	8624	3380	52.65	-	-	-	-	-	-	-	278	-	-	23.15	82.24
iíso	Moroceli	665	-	-	1347	3606	7.44	-	-	-	-	-	-	-	18	-	-	3.63	4.99
	Danlí	3390	-	-	10587	37157	14.08	-	-	-	-	-	-	-	830	-	57	17.38	22.33
orazán	El Porvenir	320	-	-	2201	6497	27.18	-	-	-	-	-	-	-	18	-	-	2.06	2.77
	Sn Ignacio	208	-	-	2052	3774	28.01	-	-	-	-	-	-	-	2	-	-	0.34	0.52
	TOTAL	15437	0	0	79466	186930	17.26	0	0	0	0	26	0.10	0.14	7947	99.0	31.7	29.83	42.51

SOURCE: ICAITI

TABLE 37

HONDURAS: INTOXICATIONS, MALARIA, COTTON AREAS AND HUMAN POPULATION BY COUNTY, 1973

ent	COUNTY	total area Km2	cotton area Km2	cotton area %	POPULATION Urbana	POPULATION Rural	Population density	INTOXICATIONS Mild	INTOXICATIONS Mode-rate	INTOXICATIONS Severe	INTOXICATIONS Fatal	INTOXICATIONS Total	Total intox. rate x (1000)	Rural intox. rate x (1000)	MALARIA cases	MALARIA % resistence to DDT	MALARIA % resistence to OMS	Total malar. rate x (1000)	Rural malari rate x (10
a	Marcovia	364	1.07	0.29	955	15218	44.43	0	0	0	0	0	0	0	273	-	99	16.87	17.93
	El Triunfo	518	10.52	2.03	2811	12380	29.33	0	0	0	0	0	0	0	100	-	17	6.58	8.07
	Namasigüe	322	1.34	0.42	787	8130	27.69	0	0	0	0	0	0	0	37	-	13	4.14	4.55
	Apacilagua	145	-	-	995	6661	52.80	-	-	-	-	-	-	-	4	-	-	0.52	0.60
	S Ant de Flor	137	-	-	293	3358	26.65	-	-	-	-	-	-	-	3	-	-	0.82	0.89
	Yusguare	41	0.25	0.61	983	2859	93.51	0	0	0	0	0	0	0	13	-	-	2.38	4.54
	Choluteca	975	3.25	0.33	24241	22729	48.17	5	2	2	0	9	0.19	0.39	229	-	13	4.87	10.07
	Catacamas	6438	18.48	0.29	8763	14648	3.64	0	0	1	1	2	0.08	0.13	79	-	-	3.37	5.35
	Sn Fco Becerra	743	0.06	0.008	1382	2151	4.78	1	1	0	0	2	0.56	0.92	30	-	-	8.49	13.94
	Juticalpa	479	10.93	2.28	9742	27022	76.75	6	2	1	3	12	0.32	0.44	76	-	-	2.06	2.81
	Nacaome	464	8.66	1.87	5688	22170	60.04	0	0	0	0	0	0	0	119	-	31	1.11	1.39
	Sn Lorenzo	228	5.40	2.37	8937	3503	54.56	0	0	0	0	0	0	0	36	-	18	1.94	5.13
)	Moroceli	665	-	-	1396	3734	7.71	0	0	0	0	0	0	0	3	-	-	0.58	0.80
	Danlí	3390	4.74	0.14	10971	38505	14.69	0	0	0	0	0	0	0	118	-	-	2.38	3.06
zán	El Porvenir	320	-	-	2281	6733	28.17	0	0	0	0	0	0	0	13	-	-	1.44	1.93
	Sn Ignacio	208	0.05	0.02	2127	3911	29.03	0	0	0	0	0	0	0	1	-	-	0.16	0.25
	TOTAL	15437	64.75	0.42	82352	193712	17.98	12	5	4	4	25	0.09	0.13	1134	n.a.	31.9	4.11	5.85

SOURCE: ICAITI

TABLE 38

HONDURAS: INTOXICATIONS, MALARIA, COTTON AREAS AND HUMAN POPULATION BY COUNTY, 1974

					POPULATION			INTOXICATIONS							MALARIA				
		total area	cotton area				Population		Mode-				Total intox. rate x	Rural intox. rate x		% resistence to		Total malar. rate x	Rural malar rate
artment	COUNTY	Km2	Km2	%	Urbana	Rural	density	Mild	rate	Severe	Fatal	Total	(1000)	(1000)	cases	DDT	OMS	(1000)	(1
luteca	Marcovia	364	8.97	2.46	989	15769	46.04	3	0	0	0	3	0.18	0.19	121	-	27	7.22	7.67
	El Triunfo	518	12.98	2.51	2913	12829	30.39	0	1	0	0	0	0	1	382	99	20	25.15	29.78
	Namasigüe	322	8.38	2.60	815	8424	28.69	0	0	0	0	0	0	0	175		55	19.62	20.77
	Apacilagua	145	1.41	0.97	1031	6902	54.71	0	0	0	0	0	0	0	14		-	1.83	2.03
	S Ant de Flor	137	0.14	0.10	304	3474	27.58	0	0	0	0	0	0	0	8		-	2.19	2.30
	Yusguare	41	0.42	1.02	1019	2963	97.12	0	0	0	0	0	0	0	29		-	7.55	9.79
	Choluteca	975	0.58	0.06	25120	23553	53.19	1	2	0	0	3	0.06	0.13	184		13	0.28	0.55
ncho	Catacamas	6438	8.92	0.14	9081	15179	3.77	1	0	0	0	0	0	0	231		-	9.87	15.22
	S Fco Becerra	743	0.60	0.08	1432	2229	4.93	0	0	0	0	0	0	0	15		-	4.24	7.73
	Juticalpa	479	13.88	2.90	10095	28002	79.53	4	2	4	0	10	0.26	0.36	168		-	4.57	6.00
e	Nacaome	464	14.95	3.22	5894	22974	62.15	0	0	0	0	0	0	0	42		18	0.65	0.78
	Sn Lorenzo	228	0.60	0.26	9261	3638	56.57	0	0	0	0	0	0	0	19	-	-	1.53	5.22
raíso	Moroceli	665	2.18	0.33	1447	3869	7.99	0	0	0	0	0	0	0	1	-	-	0.19	0.26
	Danlí	3390	5.76	0.17	11369	39901	15.12	0	0	0	0	0	0	0	76	-	-	1.54	1.90
	TOTAL	14909	79.77	0.54	80770	189706	18.14	9	3	4	0	18	0.07	0.09	1465	99.0	26.6	5.42	7.72

SOURCE: ICAITI

TABLE 39

HONDURAS: INTOXICATIONS, MALARIA, COTTON AREAS AND HUMAN POPULATION BY COUNTY, 1975

artment	COUNTY	total area Km2	cotton area Km2	%	POPULATION Urbana	Rural	Population density	INTOXICATIONS Mild	Mode-rate	Severe	Fatal	Total	Total intox. rate x (1000)	Rural intox. rate x (1000)	MALARIA cases	% resistence to DDT	OMS	Total malar. rate x (1000)	Rural mala rate
luteca	Marcovia	364	4.00	1.10	1023	16320	48.64	0	1	1	0	2	0.11	0.12	1771	-	37	102.11	108.
	El Triunfo	518	3.64	0.70	3015	13278	31.45	1	0	0	0	1	0.06	0.08	1522	-	-	93.41	114.
	Namasigüe	322	6.80	2.11	1067	7143	29.69	0	2	1	0	3	0.03	0.04	877	-	-	91.72	122.
	Apacilagua	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S Ant de flor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Yusguare	41	0.24	0.58	1055	3067	100.53	0	0	0	0	0	-	-	146	-	-	35.4	47.
	Choluteca	975	1.20	0.12	25999	24377	51.66	3	2	1	0	6	0.10	0.25	1263	57	23	25.07	51.
ncho	Catacamas	6438	2.71	0.04	9399	15610	3.88	0	0	0	0	0	-	-	589	-	-	23.55	37.
	S Fco Becerra	743	1.13	0.15	1432	2307	5.09	0	0	0	0	0	-	-	22	-	-	5.81	9.
	Juticalpa	479	5.99	1.25	10448	28982	82.31	0	0	0	0	8	0.20	0.27	419	-	-	10.65	14.
le	Nacaome	464	8.44	1.82	6100	23778	64.39	0	1	0	0	1	0.03	0.04	338	-	-	11.31	14.
	Sn Lorenzo	228	0.50	0.22	9585	3765	58.55	0	0	0	0	0	-	-	138	-	-	10.34	36.
araíso	Morocelí	665	0.92	0.14	1498	3994	8.26	0	0	0	0	0	-	-	13	-	-	2.37	3.
	Danlí	3390	2.78	0.08	11667	41297	15.63	0	0	0	0	0	-	-	745	-	-	14.07	18.
Morazán	El Porvenir	320	-	-	2425	7221	30.14	1	0	0	0	0	0.10	0.14	4	-	-	0.41	0.
	Sn Ignacio	208	-	-	2281	4193	31.12	0	0	0	0	0	-	-	0	-	-	-	-
	TOTAL	15437	38.35	0.25	87044	195332	18.29	5	6	3	0	21	0.07	0.11	7847	57	30.0	27.79	40.

SOURCE: ICAITI

TABLE 40

NICARAGUA: INTOXICATIONS, MALARIA, COTTON AREAS AND HUMAN POPULATION BY COUNTY, 1972

Department	COUNTY	total area Km2	cotton area Km2	%	POPULATION Urbana	Rural	Population density	INTOXICATIONS Mild	Moderate	Severe	Fatal	Total	Total intox. rate x (1000)	Rural intox. rate x (1000)	MALARIA cases	% resistence to DDT	OMS	Total malar. rate x (1000)	Rural malaric rate x (1000)
Chinandega	Chinandega	625	174.66	27.94	36700	15882	84.13	139	109	88	0	336	6.39	21.16	-	-	-	-	-
	El Viejo	1271	229.54	18.06	9803	16047	20.34	-	-	-	-	-	0.0	0.0	-	-	-	-	-
	Posoltega	144	39.36	27.33	1333	6285	52.89	1	0	0	0	1	0.13	0.16	-	-	-	-	-
	Chichigalpa	253	36.66	14.49	16344	8415	97.86	0	1	0	0	1	0.04	0.12	-	-	-	-	-
	El Realejo	100	26.86	26.86	600	1665	22.6	0	0	0	0	0	0.0	0.0	-	-	-		-
	Morazán	224	26.96	12.03	2016	4442	19.17	0	0	0	0	0	0.0	0.0	-	-	-	-	-
	Somotillo	928	14.84	1.60	2130	10291	13.3[illegible]	0	0	0	0	0	0.0	0.0	-	-	-	-	-
	Villanueva	794	4.87	0.61	1487	7558	11.39	0	0	0	0	0	0.0	0.0	-	-	-	-	-
	Sn Francisco	144	0.53	0.37	518	4603	35.5[illegible]	0	0	0	0	0	0.0	0.0	-	-	-	-	-
	Corinto	10	0.04	0.004	14091	818	1490.9[illegible]	1	1	0	0	2			-	-	-	-	-
	Sto Tomás	34	0.09	0.26	861	2533	99.7[illegible]	0	0	0	0	0	0.0	0.0	-	-	-	-	-
León	León	852	203.85	23.93	64607	22963	102.73	36	[illegible]	46	1	86	0.98	3.74	-	-	-	-	-
	Larreynaga	834	133.46	16.00	6275	11714	21.57	0	1	0	0	1	0.05	0.08	-	-	-	-	-
	Telica	364	124.48	34.20	2413	8973	31.23	2	0	0	0	2	0.17	0.22	-	-	-	-	-
	Quezalguaque	48	48.15	103.00	374	3340	53.0[illegible]	1	0	0	0	1	0.27	0.30	-	-	-	-	-
	La Paz Centro	872	98.17	11.26	6903	7151	16.1[illegible]	[illegible]	1	0	0	3	0.21	0.42	-	-	-	-	-
	Nagarote	602	11.34	1.88	8055	5703	22.85	0	0	0	0	0	0.0	0.0	-	-	-	-	-
	El Sauce	700	25.45	3.63	3625	10473	19.0[illegible]	0	0	0	0	0	0.0	0.0	-	-	-	-	-
	El Jicaral	206	4.53	2.20	464	2861	16.14	0	0	0	0	0	0.0	0.0	-	-	-	-	-
	Achuapa	342	1.02	0.47	1417	2738	29.69	0	0	0	0	0	0.0	0.0	-	-	-	-	
	Sta Rosa	204	0.26	0.13	543	4089	22.71	0	0	0	0	0	0.0	0.0	-	-	-	-	-
Managua	Managua	816	64.50	7.90	342512	53774	485.64	11	2	0	2	15	0.04	0.28	-	-	-	-	-
	Tipitapa	1000	67.96	6.80	8150	15568	23.72	2	0	2	0	4	0.17	0.26	-	-	-	-	-
	Sn Rafael S.	386	13.70	3.55	3876	17694	55.88	0	0	0	0	0	0.0	0.0	-	-	-	-	-
	Mateare	248	4.15	1.67	1587	3873	22.02	0	0	0	0	0	0.0	0.0	-	-	-	-	-
	S Fco Carnic.	771	8.68	1.12	992	7786	11.38	0	0	0	0	0	0.0	0.0	-	-	-	-	-
	El Carmen	414	7.06	1.70	967	9502	25.29	0	0	0	0	0	0.0	0.0	-	-	-	-	-

TABLE 40 (CNTD.)

Department	COUNTY	total area Km2	cotton area Km2	cotton area %	POPULATION Urbana	POPULATION Rural	Population density	INTOXICATIONS Mild	INTOXICATIONS Mode-rate	INTOXICATIONS Severe	INTOXICATIONS Fatal	INTOXICATIONS Total	Total intox. rate x (1000)	Rural intox. rate x (1000)	MALARIA cases	MALARIA % resistence to DDT	MALARIA % resistence to OMS	Total malar. rate x (1000)	Rural malaria rate x (1000)
Masaya	Masaya	160	0.57	0.36	39860	14521	339.88	9	11	3	1	24	0.44	1.65	-	-	-	-	-
	Nindirí	121	22.17	18.32	2543	6119	71.59	5	1	1	0	7	0.81	1.15	-	-	-	-	-
	Tisma	73	47.91	65.63	2561	649	42.25	3	5	1	0	9	2.79	13.86	-	-	-	-	-
Granada	Granada	509	14.27	2.80	45206	9651	107.77	0	0	0	0	0	0.0	0.0	-	-	-	-	-
	Nandaime	385	5.67	1.47	6689	9581	42.26	0	0	0	0	0	0.0	0.0	-	-	-	-	-
Matagalpa	San Isidro	192	9.39	4.89	2697	4164	35.73	0	0	0	0	0	0.0	0.0	-	-	-	-	-
	Ciudad Darío	736	3.69	0.50	6005	17057	31.33	0	0	0	0	0	0.0	0.0	-	-	-	-	-
	Sébaco	317	3.09	0.97	3596	6073	30.52	0	0	0	0	0	0.0	0.0	-	-	-	-	-
Carazo	Diriamba	341	6.35	1.86	12271	17086	88.14	0	0	0	0	0	0.0	0.0	-	-	-	-	-
	San Marcos	113	0.06	0.05	4153	6695	96.00	0	0	0	0	0	0.0	0.0	-	-	-	-	-
Boaco	Teustepe	585	0.06	0.01	1271	11584	21.98	0	0	0	0	0	0.0	0.0	-	-	-	-	-
Estelí	Pueblo Nuevo	176	0.23	0.13	1631	9155	61.76	0	0	0	0	0	0.0	0.0	-	-	-	-	-
	TOTAL	16694	1485.22	8.79	667843	385081	62.13	212	156	120	4	492	0.47	1.28	n.a.	n.a.	n.a.	n.a.	n.a.

SOURCE: ICAITI

TABLE 41

NICARAGUA: INTOXICATIONS, MALARIA, COTTON AREAS AND HUMAN POPULATION BY COUNTY, 1973

Department	COUNTY	total area Km2	cotton area Km2	cotton area %	POPULATION Urbana	POPULATION Rural	Population density	INTOXICATIONS Mild	INTOXICATIONS Moderate	INTOXICATIONS Severe	INTOXICATIONS Fatal	INTOXICATIONS Total	Total intox. rate x (1000)	Rural intox. rate x (1000)	MALARIA cases	MALARIA % resistence to DDT	MALARIA % resistence to OMS	Total malar. rate x (1000)	Rural malaria rate x (1000)
Chinandega	Chinandega	625	-	-	37952	16424	87.00	79	29	12	2	122	2.24	7.42	9	-	-	0.16	0.54
	El Viejo	1271	-	-	10138	16595	21.03	1	1	0	0	2	0.07	0.12	82	-	-	3.06	4.94
	Posoltega	144	-	-	1378	6499	54.70	0	0	0	0	0	0.0	0.0	2	-	-	0.25	0.30
	Chichigalpa	253	-	-	16902	8702	101.20	1	1	1	0	3	0.11	0.34	70	-	-	2.72	8.04
León	León	852		-	66812	23747	103.29	31	10	1	1	43	0.47	1.81	36	-	-	0.39	1.51
	Larreynaga	834	-	-	6489	12114	22.30	0	1	0	0	1	0.05	0.08	79	-	-	4.24	6.52
	Telica	364	-	-	2495	9279	[illegible].35	2	0	0	0	2	0.16	0.21	69	-	-	5.86	7.43
	Quezalguaque	48	-	-	387	3434	80.02	4	0	0	0	4	1.04	1.15	11	-	-	2.86	3.18
	La Paz Centro	872	-	-	7139	7395	16.67	8	0	0	0	8	0.55	1.08	26	-	-	1.78	3.51
Managua	Managua	816	-	-	354201	55609	50[illegible].22	0	1	0	0	1	0.0	0.01	159	0	12	0.38	2.85
	Tipitapa	1000	-	-	8428	16099	[illegible]	[illegible]	0	0	0	3	0.12	0.18	53	-	-	2.16	3.29
	S Rafael Sur	386	-	-	4008	16298	[illegible].79	0	0	1	0	1	0.04	0.05	17	-	-	0.76	0.92
	S Fco Carnic.	771	-	-	1026	8052	[illegible].77	[illegible]	[illegible]	1	0	2	0.22	0.24	19	-	32	2.09	2.35
	El Carmen	414	-	-	1000	9826	[illegible]	0	0	0	0	0	0.0	0.0	20	-	-	1.84	2.03
Masaya	Masaya	160	-	-	41220	15017	[illegible]	25	1	[illegible]	0	29	0.51	1.93	5	-	-	0.08	0.33
	Nindirí	121	-	-	2630	6328	[illegible]	2	0	[illegible]	0	2	0.22	0.31	1			0.11	0.15
	Tisma	73	-	-	2629	671	[illegible]	[illegible]	[illegible]	0	0	12	3.59	17.88	1			0.29	1.49
Matagalpa	Matagalpa	1880	-	-	24730	49968	[illegible]	5	3	[illegible]	1	10	0.14	0.22	40			0.58	0.90
	TOTAL	10884	n.a.	n.a.	589564	278077	[illegible]	172	[illegible]	20	4	245	0.28	0.88	699	n.a.	22.0	0.81	2.51

SOURCE: ICAITI

TABLE 42

NICARAGUA: INTOXICATIONS, MALARIA, COTTON AREAS AND HUMAN POPULATION BY COUNTY, 1974

Department	COUNTY	total area Km2	cotton area Km2	cotton area %	POPULATION Urbana	POPULATION Rural	Population density	INTOXICATIONS Mild	INTOXICATIONS Moderate	INTOXICATIONS Severe	INTOXICATIONS Fatal	INTOXICATIONS Total	Total intox. rate x (1000)	Rural intox. rate x (1000)	MALARIA cases	MALARIA % resistence to DDT	MALARIA % resistence to OMS	Total malar. rate x (1000)	Rural malaria rate x (1000)
Chinandega	Chinandega	625	223.76	35.80	39247	16984	39.97	16	21	9	0	46	0.81	2.70	96	-	-	1.70	5.65
	El Viejo	1271	334.69	26.33	10484	17161	21.75	2	2	1	0	5	0.18	0.29	1042	-	-	37.69	60.71
	Posoltega	144	53.28	37.00	1425	6721	56.57	2	1	0	0	3	0.36	0.44	16	-	-	1.96	2.38
	Chichigalpa	253	51.37	20.30	17479	8929	104.65	7	4	0	0	11	0.41	1.22	543	-	-	20.50	60.34
	El Realejo	100	35.62	35.62	641	1781	24.22	0	0	0	0	0	0.0	0.0	42	-	-	17.34	23.58
	Morazán	224	38.92	17.37	2156	2437	20.51	0	0	0	0	0	0.0	0.0	31	-	-	6.74	12.72
	Somotillo	928	24.22	2.61	2278	11005	14.31	0	0	0	0	0	0.0	0.0	302	-	-	22.73	27.44
	Villanueva	794	23.41	2.95	1590	8068	12.18	0	0	0	0	0	0.0	0.0	340	-	-	35.74	42.06
	Sn Francisco	144	0.46	0.32	954	4072	33.00	0	0	0	0	0	0.0	0.0	14	-	-	2.55	2.84
	Sto Tomás N.	34	0.02	0.06	920	2708	106.73	0	0	1	0	1	0.27	0.36	36	-	-	9.92	13.29
León	León	852	341.00	40.02	69092	8083	109.92	17	6	1	0	24	0.25	2.96	137	-	-	1.46	16.94
	Larreynaga	834	152.39	18.27	6710	12527	23.07	0	0	0	0	0	0.0	0.0	139	-	-	7.02	11.09
	Telica	364	140.45	38.56	2560	9596	33.45	0	0	0	0	0	0.0	0.0	89	-	-	7.30	9.27
	Quezalguaque	48*	63.10*	131.46	400	3340	82.75	2	0	0	0	2	0.50	0.59	42	-	-	10.37	12.57
	La Paz Centro	872	144.88	16.61	7385	7607	17.24	1	0	0	0	1	0.06	0.13	97	-	-	6.15	12.63
	Nagarote	602	27.90	4.62	3514	6099	24.41	0	0	0	0	0	0.0	0.0	33	-	-	2.24	5.41
	El Sauce	700	50.53	7.22	3877	11200	21.24	0	0	0	0	0	0.0	0.0	95	-	26	6.38	8.48
	El Jicaral	206	5.45	2.64	476	3560	17.26	0	1	0	0	1	0.28	0.32	170	-	-	47.38	55.55
	Achuapa	342	0.28	00.08	1515	5344	31.75	0	0	0	0	0	0.0	0.0	20	-	-	1.34	2.14
Managua	Managua	816	38.87	4.76	366787	82999	519.36	2	2	2	0	6	0.01	0.07	2061	-	-	4.36	24.80
	Tipitapa	1000	74.90	0.07	8710	16648	25.36	0	0	0	0	0	0.0	0.0	297	-	60	11.70	17.89
	S Rafael Sur	386	6.95	1.80	4145	18922	59.76	1	0	0	0	1	0.04	0.05	46	-		1.99	2.43
	El Carmen	414	9.90	2.39	1034	10161	27.04	0	0	0	0	0	0.0	0.0	23	-	-	2.05	2.26
Masaya	Masaya	160	15.81	9.88	42627	15529	363.47	6	2	2	0	10	0.17	0.64	15	-	-	0.25	0.96
	Nindirí	121	15.94	13.17	2720	6544	76.55	1	1	1	0	3	0.32	0.45	6	-	-	0.69	0.98
	Tisma	73	38.11	52.20	2760	694	47.31	1	0	1	0	2	0.57	2.88	3	-	27	0.86	4.32

TABLE 42 (CNTD.)

Department	COUNTY	total area Km2	cotton area Km2	%	POPULATION Urbana	Rural	Population Density	INTOXICATIONS Mild	Mode-rate	Severe	Fatal	Total	Total intox. rate x (1000)	Rural intox. rate x (1000)	MALARIA cases	% resistence to DDT	OMS	Total malar. rate x (1000)	Rural malaria rate x (1000)
Granada	Granada	509	18.51	3.64	48344	10321	115.25	6	0	2	0	8	0.13	0.77	6	-	-	0.10	0.58
	Mandaime	385	5.03	1.30	7153	10246	45.19	1	6	3	0	10	0.31	0.97	193	-	-	11.09	18.83
Matagalpa	Sn Isidro	102	3.15	1.64	2864	4453	38.21	0	0	0	0	0	0.0	0.0	163	-	13	22.21	36.60
Carazo	Diriamba	341	1.94	0.57	13872	18272	94.26	2	0	0	0	2	0.06	0.10	361	-	-	11.23	19.75
Zelaya	Ciudad Rama	7728	0.03	0.0004	2175	34189	7.70	0	0	0	0	0	0.0	0.0	557	-	-	15.31	16.29
	TOTAL	21372	1940.77	9.08	680160	360675	49.64	47	46	23	0	136	0.13	0.35	7013	0	52.0	6.61	18.43

SOURCE: ICAITI

TABLE 43

NICARAGUA: INTOXICATIONS, MALARIA, COTTON AREAS AND HUMAN POPULATION BY COUNTY, 1975

Department	COUNTY	total area Km2	cotton area Km2	%	POPULATION Urbana	Rural	Population density	INTOXICATIONS Mild	Mode-rate	Severe	Fatal	Total	Total intox. rate x (000)	Rural intox. rate x (000)	MALARIA cases	% resistence to DDT	OMS	Total malar. rate x (000)	Rural malaria rate x (000)
Chinandega	Chinandega	625	159.5	25.5	40386	17564	93.04	24	6	11	0	41	0.70	2.33	470	97	74	8.06	26.76
	El Viejo	1271	283.9	22.3	10842	17747	22.49	1	0	1	0	2	0.07	0.11	1577	-	92	55.16	88.85
	Posoltega	144	31.3	21.7	1474	6950	58.50	0	0	0	0	0	0.0	0.0	157	-	-	18.63	22.59
	Chichigalpa	253	37.2	14.7	18075	9306	108.22	7	4	2	0	13	0.47	1.40	2477	100	97	90.46	266.17
	El Realejo	100	22.9	22.9	663	1842	25.05	0	0	0	0	0	0.0	0.0	76	-	-	30.34	41.26
	Morazán	224	25.5	11.3	2230	2521	21.20	0	0	0	0	0	0.0	0.0	230	-	-	48.42	91.23
	Somotillo	928	11.5	1.2	2356	11381	14.80	0	0	0	0	0	0.0	0.0	575	-	-	41.85	50.52
	Villanueva	794	14.5	1.8	1645	8359	12.60	0	0	0	0	0	0.0	0.0	172	-	-	12.19	20.58
León	León	852	40.9	4.8	71450	25395	113.67	17	2	0	0	19	0.20	0.75	579	-	-	5.98	22.80
	Larreynaga	834	104.2	12.5	6939	12955	23.05	0	0	0	0	0	0.0	0.0	434	-	87	21.81	33.50
	Telica	364	151.7	41.6	2668	9923	34.59	1	0	0	0	1	0.08	0.10	225	-	-	17.87	24.47
	Quezalguaque	48	69.5	100.0	414	3464	85.58	0	0	0	0	0	0.0	0.0	33	-	-	8.03	9.55
	La Paz Centro	872	98.1	11.2	7635	7908	17.82	0	0	1	0	1	0.06	0.13	448	83	87	28.82	56.65
	Nagarote	602	5.5	0.9	8908	6307	25.27	0	0	0	0	0	0.0	0.0	127	-	-	8.35	20.13
	El Sauce	700	33.1	4.7	4009	11582	21.97	0	0	0	0	0	0.0	0.0	235	-	-	15.28	20.29
	El Jicaral	206	16.2	7.8	513	3164	17.85	0	0	0	0	0	0.0	0.0	160	-	-	45.50	50.57
	Achuapa	342	0.3	0.08	1567	9663	54.51	0	0	0	0	0	0.0	0.0	86			7.57	8.79
Managua	Managua	816	29.1	3.5	373789	85631	537.06	12	5	0	0	17	0.04	0.20	5744	-	98	13.11	66.92
	Tipitapa	1000	56.0	5.6	9013	17217	26.23	1	0	0	0	1	0.04	0.06	937	-	91	35.72	54.42
	S Rafael Sur	386	4.7	1.2	4286	19560	61.90	0	0	0	0	0	0.0	0.0	1236	-	84	51.81	63.16
	S Fco Comic.	771	0.4	0.05	1097	8611	12.59	0	0	0	0	0	0.0	0.0	38	88	82	3.91	4.41
	El Crucero	404	16.3	4.0	1039	10508	27.97	0	0	0	0	0	0.0	0.0	105	-	-	9.07	9.99
Masaya	Masaya	160	9.9	6.1	44081	16059	375.88	10	5	4	0	19	0.31	1.18	122	-	-	2.03	7.60
	Nindirí	121	1.1	0.9	2813	6767	79.17	0	0	0	0	0	0.0	0.0	31	-	-	3.23	4.58
	Tisma	73	31.5	43.1	2854	718	48.93	0	0	0	0	0	0.0	0.0	17	-	93	4.76	23.68

TABLE 43 (CNTD.)

Department	COUNTY	total area Km2	cotton area Km2	%	POPULATION Urbana	Rural	Population density	INTOXICATIONS Mild	Mode-rate	Severe	Fatal	Total	Total intox. rate x (1000)	Rural intox. rate x (1000)	MALARIA cases	% resistence to DDT	OMS	Total malar. rate x (1000)	Rural malaria rate x (1000)
Granada	Granada	509	16.4	3.2	49994	10673	119.19	10	6	7	0	23	0.33	2.15	327	80	92	5.3[illegible]	30.64
	Mandaime	385	1.6	41.5	7397	10596	46.73	14	5	2	0	21	1.17	1.98	764	69	98	42.46	72.10
	Diriomo	40	0.7	1.7	4943	5625	269.15	0	0	0	0	0	0.0	0.0	52	-	-	1.82	9.24
Carazo	Diriamba	341	3.1	0.9	14345	18896	97.48	0	1	0	0	1	0.03	0.03	460	-	-	13.54	23.81
	TOTAL	14175	1276.9	9.01	702660	377099	76.17	97	34	28	0	159	0.15	0.42	17363	66.0	98.5	15.56	47.42

SOURCE: ICAITI

During the year of 1975 Guatemala reported a total of 803 poisoning cases, of which only 2 were fatal, less than 25%. The poisoning rate for the principal cotton growing counties was 3.64 cases per 1000 heads. Guatemala, with second place in poisonings, used a proportion of phosphates of about 27%.

Nicaragua reported 159 poisoning cases in 1975. There were no deaths in official records. The poisoning rate per 1000 population was 1.14 . Only 24% of all pesticides used were organophosphates. There appears to be a logical relationship between the two.

In Honduras, pesticide poisoning is not a serious problem yet. Only 21 cases were reported in 1975, which gives a rate of .28 per thousand people. Honduras used 66% phosphates in that year. Its average level of use, however, is by far the lowest (see table 54) and, in absolute terms, 66% smaller than any of the other countries.

Factor and circumstances associated to intoxications :

From epidemiological studies it is apparent that the greatest number of poisonings is caused by organophosphorous pesticides(one study reported over 90%). The most affected group was young adult males between the ages of 16 and 35, the majority of them temporary day laborers engaged in cotton harvesting. The greatest number of cases invariably occured during the months of October, November and December, the season of most intensive pesticide use in cotton.

For a more detailed description of the studies, see Final Report, phase 1 of this same endeavor, P. 79-91.

Most of the cases occured because the workers entered treated fields before 72 hours had elapsed, because workers ate, drank and smoked in recently-treated fields, because of bathing in contaminated drainage ditches and because of direct contact with the cotton plant.

Intoxications result from a combination of unsafe working conditions and unsafe acts on the part of uneducated peasants who ignore the nature and activity of pesticides.

Most of the poisonings occur in cotton-growing areas(in Guatemala, 93%). Furthermore, there is a direct relationship between the number of planted hectares and poisoning rates. This resulted from the analysis of 4 years of county data for Guatemala and Nicaragua.

In Guatemala, a 10% increase in the number of hectares planted with cotton appears to result in a 4.5% increase in the poisoning rate (e= .45). This elasticity was derived from a regression coefficient of 0.02029 significant at α=0.05. As an example of the meaning of this elasticity, if planted area in Tiquisate(presently 22500 ha.)went up in 7500 hectares, a 33% increase, an observer could expect the present poisoning rate of 1.3 cases per 1000 population to go up to 1.5 cases / 1000. This is interesting

from the standpoint of public health and preventive medicine planning, as it allows for channeling more resources to expanding cotton areas before the pesticide spraying season begins, and may allow for the prevention of intoxications.

The same relationship can be observed in Nicaragua, although not with the same strength. Here the elasticity was 0.34, so that a 10% increase in planted area may be expected to result in a 3.4% increase in the poisoning rate of a particular municipality. The coefficient obtained was significant at $\alpha = 0.10$.

The lower influence of cotton area on poisoning rates may be another reflection of the smaller use of phosphates in Nicaragua.

Statistical analysis in both countries also showed a possitive association between poisoning rates and cotton area as a percent of the municipality's total area. The elasticities were 0.41 and 0.32 for Guatemala and Nicaragua, respectively. The significance of this value was $\alpha=0.10$ in both cases.

A simple correlation between cotton pesticide use per hectare and poisoning rates by country showed that a 10% increase in the former causes poisoning rates to increase by 20% ($\alpha=0.10$). The analysis covered only 3 years in 4 countries and an expanded data base would serve to ascertain this relationship.

The implications of pesticide intoxications:

Broadly, these can be separated into "social" and "economic". Except for the economic, most are intangible in that they cannot be measured accurately. They are similar to most other human illnesses in that sense.

Even slight intoxications can produce vomits, dizziness, general tremours, blurred vission, diarhea, cramps, salivation and general distress. If there are medical facilities nearby and if the person recognizes the symptoms he may go and receive adequate treatment. In that case his disconfort and ill-being may be short-lived. Otherwise he may go on sick for days, and even become exposed to pesticides on additional occasions.

The efficiency of a working person will diminish and he might become unable to continue to work either of his own accord or at his employer's suggestion. Only one Central American Country has social security programs which cover agricultural workers, Guatemala. Elsewhere the worker would have to bear the economic consequences of his illness by himself. Paradoxically a cotton grower might diminish an inefficient worker unaware that his malaise is caused by pesticide poisoning.

Treating intoxicated persons is expensive. Although there is no indication of the proportions of poisoned people who do not receive assistance, those who do cause expenses of about $32 per case on the average. Human health institutions spent an estimated $73000 because of 2284 pesticide poisonings in cotton areas in 1975. The figure for 1974 was $76500 with 2393 poisoning cases. For 1973 there were 3630 cases which cost $116160. Although small and by no means a measure of the social impact of poisonings, this amount has to be paid every year in addition to the disconfort and ill-being which poisonings provoke.

For instance, over the next five years this amounts to over half-a-million US dollars. Preventive medicine programs costing up to this amount could be justified if they effectively eliminate all poisonings. The figure can be considered as a measure of the cost incurred by not taking preventive measures in the area of human health today.

3.3 Effects of pesticide use on malaria

There exists evidence that the sustained use of pesticides increases the resistance of the malaria vector (Anopheles albimanus) to DDT in cotton areas. This forces malaria control agencies to switch to more expensive pesticides or to accept higher malaria rates. The result is higher malaria control costs and/or potential for greater human health problems because of malaria.

Resistance of Anopheles albimanus to DDT was found to be substantially and significantly higher in cotton-growing counties than in counties where no cotton is grown. After being exposed to DDT at a concentration of 4% during one hour 80% of the mosquitos in cotton areas survived. By comparison only 50% of the mosquitos from non-cotton areas were found to be resistant. This difference was significant at $\alpha = 0.01$.

Resistance of A. Albimanus to DDT has been increasing in Central American cotton areas. Average resistance in Guatemala's cotton counties went from 58% to 86% between 1972 and 1975. In El Salvador resistance went from 30% to 86% during the same period. No consistent information is available for the other two countries.

Higher resistance may lead to higher malaria rates. A statistical analysis of four years of county data in Guatemala suggests that a 10% increase in resistance in a county can be expected to result in a 7.5% increase in malaria rates. The regression coefficient from which this ratio is derived was found significant at $\alpha = 0.05$.

The effect of resistance on malaria rates is counteracted by the efforts of malaria agencies to control Anopheles albimanus with more efficient insecticides. In Central America there has been a partial substitution of the use of OMS-33 (Propoxur, Baygon) for the use of DDT. OMS-33 had a notable impact when its use began in the early 70's but there are already clear signs that Anopheline populations are developing resistance to OMS-33 (Tables 29 through 43).

Between 1972 and 1974 rural malaria rates in cotton areas of El Salvador have gone from 35/1,000 to 65/1,000. This suggests that in the face of increasing resistance malaria control has not become more effective. Nevertheless malaria authorities report having sprayed over 77,000 dwellings with Propoxur at an estimated extra cost of $3.8 million in 1975.

Malaria rates in cotton areas of Guatemala were 4.6/1,000 in 1972; 1.4/1,000 in 1973; 7.2/1,000 in 1974, and 3.32/1,000 in 1975. Thus they have remained at the same level. In the meantime malaria control agencies were spraying over 32,000 houses per year with Propoxur in 1975 at an estimated increased cost of $1.6 million. Malaria is less of a problem in Guatemala's cotton areas.

In Honduras rural malaria rates have fluctuated widely. They stood at 42.5/1,000 in 1972, dropped to 5.8/1,000 in 1973, rose to 7.7/1,000 in 1974, and jumped back to 40.2/1,000 in 1975. By that time malaria agencies report spraying almost 100,000 houses with Propoxur at an estimated extra cost of $5.4 million.

The malaria situation in Nicaragua seems to be getting more serious. Rural malaria rates per thousand population in cotton counties were 2.51 in 1973; 18.4 in 1974, and 47.4 in 1975. Increased malaria control expenditures caused by the use of Propoxur were $1.05 million (the smallest in the four countries) and a total of 21,[illegible]00 dwellings were treated with this material.

Most of the houses that had to be treated with Propoxur in Guatemala because of the ineffectiveness of DDT were located in cotton-producing counties. About 90% of all the houses sprayed with Propoxur in Guatemala were located in the cotton areas. No information is available for the rest of the countries but there are reasons to believe that the situation is similar.

An effort was made to relate malaria rates with cotton acreage, resistance and malaria control expenditures in 15 cotton-growing counties of Guatemala during the past four years. The results indicate that malaria rates are strongly associated with resistance and clearly related to the percent of the surface of a county that is planted with cotton. The effects of malaria control efforts are obscured because even though they result in lower incidence it is precisely in the more problematic counties where the greatest efforts are made.

The analysis indicated that an increase of 1% in the resistance of Anopheles to DDT results in an increase in rural malaria rates of 0.185 cases per thousand population. The regression coefficient of resistance (in percent) as an explanatory variable for rural malaria rate was found to be 0.185 and significant at $\alpha = 0.05$. In percent terms this can be stated to mean that a 10% increase in resistance is likely to result in malaria rates 6.4% higher in a particular county.

Likewise increases in the proportion of a county's surface area devoted to cotton appear to be associated with higher malaria rates. A change of 1% in the area of a county planted with cotton in relation to total planted area may result in an increase of 0.136 cases of malaria per thousand population (regression coefficient = 0.136 significant at $\alpha = 0.05$). However, malaria rates did not appear to correlate with total cotton planted acreage in a given county.

One explanation for this inconsistency may be that the malaria rates reported relate to the rural population of the whole county. In larger counties a large cotton area in comparison to other ocunties may not be sufficient to affect malaria rates in the whole county. This effect is accounted for when one considers cotton area as a percent of total area as the explanatory variable.

Another qualification to the above analysis is that there may be factors affecting the development of resistance other than cotton pesticides. It is obvious that the use of DDT in malaria control itself may eventually result in high resistance. In this sense cotton pesticides may have only catalyzed the process and cause problems before they were due to occur.

The fact that resistance is higher in cotton areas and that malaria control authorities are forced to spend more in cotton counties suggests in the absence of alternative explanations that indeed there are actual and potential malaria effects of pesticide use in cotton. The economic consequences are discussed in the chapter "The economics of pesticide use". From a human health standpoint it can be said that a slackening in the malaria control efforts may prove to be a danger for the population of cotton areas.

There is a need to develop alternative methods for Anopheles control. Resistance to Propoxur is already high in many cotton growing counties of Central America. Other pesticides are already being tested in substitution for Propoxur. Integrated Anopheles control may be one possibility to stop this never-ending circle of innovation and resistance.

3.4 Sub-clinical intoxication levels in Central America

One of the main sources of concern over pesticides is their accumulation in human tissue. This is particularly true in the case of organo-chlorinated pesticides whose build up is enhanced by their high pasistance . Although we know of no study relating DDT accumulation levels to physical ills, it seemed important for comparative purposes to determine the levels of pesticide residues in members of the Central American urban and rural population. A further motivation was to explore the most important factors associated with pesticide build up.

A total of 135 individuals were requested to donate blood samples for analysis in two Central American countries. Of these, 15 came from urban areas and the remaining 120 came from cotton areas in Nicaragua and Guatemala in equal proportion. The samples taken were refrigerated and shipped to laboratory facilities; at the time of sampling the donor was requested to provide information such as age, occupation, previous illnesses, previous poisonings and, in cotton areas, time of residence. Subsequently the serum was extracted and the samples analyzed through gas chromatography.

The levels of sub-clinical intoxication turned out to be substantially higher in cotton areas as was expected. Average levels were 520.6 parts per billion (PPB) for cotton areas in both countries(Guatemala and Nicaragua), a figure 6.8 times higher than the average levels in urban areas. Here the presence of DDT in blood was 76.16 parts per billion. The difference reflects drastically the increased exposures of workers in cotton areas of intensive pesticide use.

The presence of DDT residues is much higher in Central American areas than in countries like the United States. An analysis of 462 samples of various races and socioeconomic conditions in Dade county, Florida, gave an average contamination of 46.4 ppb in blood serum. This figure is 11 times smaller than the average human contamination in Central American cotton areas and 1.6 times smaller than the figure for Central American urban areas. (1) The figure for cotton areas in Central America is only comparable to residue levels in DDT manufacturing workers, 590.5 ppb in 35 samples from California . (1)

By world standards, Central American cotton workers are among the populations most highly exposed to pesticides. To the extent that pesticide accumulation is harmful to humans, a potential cause of health problems underlies the Central American population.

Sub-clinical intoxication was significantly higher in Guatemala than it was in Nicaragua. The average for 68 Nicaraguan cotton workers was 394.7 ppb (r=185.4) a figure 1.6 times smaller than the average for 67 Guatemalan cotton laborers, 646.5 ppb (r = 753.9). This difference should be interpreted with caution as all samples came from two farms in each country and there is some room for distortions caused by different insecticide use levels and mix in the particular farms involved. However average use of chlorinated pesticides was higher in Guatemala in absolute terms. In 1974/75 Guatemalan cotton growers used an average of 51.3 kg/ha of organochlorines, whereas Nicaraguan farmers used 37.9 kg/ha, a figure 1.4 times smaller, and it is sensible to expect higher DDT contamination where more of this material is used.

A statistical analysis was performed to correlate DDT residues in blood with the age of the donor, his time of residence in cotton areas, occupation, past and present illnesses and previous clinical intoxications. This was done in order to understand better the factors affecting sub-clinical intoxication. A linear model was fitted to the data from Nicaragua, the country with the more complete information base.

Time of residence: It was hypothesized that the longer a person lived in cotton areas, the higher DDT residues in his blood would be. This was statistically confirmed. There appeared to be a relationship between the number of years of residence and the level of sub-clinical intoxication by DDT in parts per billion. The analysis suggested that each year of residence in cotton areas increased the DDT level in 15.6 parts per billion. The regression coefficient was significant at α = 0.01. In percent terms the elasticity of sub-clinical intoxication was 0.36 In other words, one could expect that a person with 11 years of living in cotton areas would have 3.6% more DDT in his blood than his comparison with 10 years.

When a study is done relating sub-clinical poisoning levels to disease or a threshold for DDT levels in blood is designed, the above information will be valuable for adopting retirement or re-locating procedures for over-exposed workers.

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(1) Davis, John, et.al., in Press, 1971.

Other variables: Neither age, occupation, previous illnesses or the occurance of previous intoxications appeared to be significantly associated with sub-clinical intoxication levels. The reason might lie in the manner in which this information was collected. A very short interview cannot provide good quantitative information on occupation (we did not know how many years the worker had been in that position), or previous illnesses for which there are no clinical records. Age and exposure may be interrelated in that older people might avoid unnecessary exposure. The incidence of previous intoxication was too low to provide a strong explanation for DDT residue variability.

The studies performed show that sub-clinical intoxication levels in Central America cotton areas are very high. This reflects intensive exposure to residual pesticides. A necessary complement to studies of this type is to relate residue levels to human illness. For although "some reports have indicated higher concentrations of DDT and its metabolites in a variety of pathologies including cancer, hypertension and disease of the liver, other have found no positive correlation between fat residues of DDT and disease"(1)

In order to further explore sub-clinical intoxication and to provide with bases for comparison with other areas, a study of DDT residue levels in human fat tissue was also performed. A total of 46 samples of abdominal fat were obtained from cotton and non cotton areas in the four countries. They were analyzed through gas chromatography.

Average DDT content in human fat [illegible] per billion ppb. In cotton areas the average was 40.32 ([illegible] samples), [illegible] the average in non-cotton (urban) areas, 26.28 ppb in 27 samples. [illegible] however, did not turned out to be statistically significant, probably because of widely separated values obtained within the same category.

Salvadorians showed the highest level of contamination. The average in cotton areas was 55.02 ppb. There were no samples from urban areas available in this country.

Samples from Guatemala had second highest contamination levels. They were 40.9 ppb for cotton areas and 22.96 for non-cotton areas. Nicaragua followed, with averages of 35.9 and 18.2 for cotton and non-cotton areas, respectively.

Honduras had the lowest content of DDT in fatty tissues, 22.3 ppb and 15.0 ppb for cotton and non-cotton areas, respectively.

Table 44 summarizes DDT presence in human fat in the four countries.

As with other environmental data, the only way to prevent future ills is to study the present situation and its associated factors. For instance, cotton workers could be made aware of the fact that each year that passes increases the levels of toxic substances (DDT) in their bodies in 15.3 ppb or its equivalent in the local jargon. This and the relationship between cotton production and human poisonings might help increase their conciousness of personal risk and lead them to prefer those farms where occupational conditions are healthiest.

(1) Davies, John, "Monitoring Residues in Man", Seminario de Plaguicidas, San Salvador El Salvador, Dec 1973, p. 2

The consequences of pesticide use are only one of the many ills that affect the Central American rural working population, with the difference that their cause can be easily traced to pesticide use in cotton. It is therefore possible to work concretely on the reduction of pesticide hazards at the farm level through adequate preventive measures.

TABLE 44

DDT RESIDUES IN HUMAN FAT IN FOUR CENTRAL AMERICAN COUNTRIES

1975/76 (ppb) *

COUNTRY	DDT Residues, ppb Cotton Areas	Non-Cotton Areas
El Salvador	55.02	N.A.
Guatemala	40.90	22.96
Honduras	22.28	15.02
Nicaragua	35.92	18.16
Central America	40.32	20.38

N.A. : Not Available SOUCE: ICAITI

* Parts per billion units of weight.

4. INTEGRATED COTTON PEST CONTROL FOR CENTRAL AMERICA

Since its inception this project has advocated the use of alternative cotton pest management procedures as a major solution to pesticide problems. Specifically the project has emphasized the development of integrated cotton pest control as a technically feasible and economically profitable way to promote a more rational use of pesticides. What makes integrated pest control particularly desirable in the present case is its potential to reduce pesticide consequences while making cotton production more profitable thus promoting this important economic activity.

Integrated pest control is a comprehensive ecological approach to pest management which works within the context of a particular ecosystem employing all available techniques in the most compatible manner to maintain pest populations below economically harmful levels. The approach is based on a day-to-day understanding of ecological conditions within and around the fields. It relies heavily on the preservation and encouragement of natural control agents such as parasites, pathogens and predators. Cultural, mechanical and climatic factors are used to advantage in order to achieve the aim of producing maximum profits while taking into account short and long term ecological constraints. When artificial control becomes necessary it is carried out as selectively as possible and only when economically and ecologically justified.

Although integrated cotton pest control has been thoroughly tested in one country most Central American farmers presently ignore the exact nature of its methodology and economic implications. Likewise many farmers are not acquainted with this technology even though it would help solve many of their pest management problems. Furthermore, the methodology had previously been tested rigorously only in one country and although ecological conditions are very similar farmers tend to believe only what they see happening in their own zone. Aside from this there is the obvious consideration of refining integrated pest control to suit particular ecological conditions in the four cotton producing countries.

Thus it seemed that the best course of action in order to develop integrated cotton pest control was to stage demonstration areas in all countries under the supervision of the project. Demonstration, refinement, divulgation, and some amount of training could be effected simultaneously using each country's experience. Although the program met with institutional difficulties and delays and suffered from natural events such as hurricanes, volcanic eruptions, and earthquakes, the results are highly satisfactory. These are presented below with the aim of informing interested Central American farmers, officials, and other interested parties in both agriculture and ecology on the program's methodology and results.

4.1 Objectives

The objectives of the integrated pest control demonstration program were as follows:

i) Demonstrate the methodology of integrated pest control and the results of its application in comparison to specifically selected check plots and national averages of pesticide use and cotton yields.

ii) Transfer integrated pest control technology to a number of cotton technicians and auxiliary personnel which would be in charge of managing the demonstration areas.

iii) Publicize the integrated cotton pest control experience in order to generate interest in more extended programs.

4.2 Methodology

A central feature of the methodology employed was the selection, establishment management, and monitoring of demonstration "plots" in each Central American country. The official cotton grower organizations in each country were contacted and requested to provide suitable demonstration areas in commercial or experimental cotton farms. The cotton organizations also provided the agronomists necessary for the management of the demonstration plots. Those growers who volunteered their lands also paid for all expenses incurred and bore the risks inherent in the testing of any new technology. The project provided technical assistance and supervision through an integrated pest control expert. This expert was assisted by a local technical resources group as well as by internationally-known experts in integrated pest control.

A basic cotton pest control strategy was designed for the Central American cotton area. This strategy relied heavily on experience obtained in one of the countries (Nicaragua) since the late 1960's(1). However, the project is responsible for a number of adjustments to the methodology and for the particular form in which it was applied.

Before presenting an outline of the strategy designed and implemented it is well to note an important condition which affected the program's development. The philosophy of the demonstration program was to incorporate more efficient pest management and agronomic techniques while working within the constraints of the farmer's particular conditions and attitudes. Thus the strategy designed provided a valuable point of reference but its actual execution had to be adapted to particular circumstances as they arose. This is probably a feature of most demonstration programs in commercial farms and indeed of most technical assistance programs in agriculture.

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(1) Proyecto Algodonero de Asistencia Técnica(PAAT), Banco Nacional de Nicaragua and Comité de Control Integrado de Plagas del Algodonero, an inter-institutional technical group.

The pest management strategy can be divided in four stages: Pre-planting (or between seasons); plant establishement (from planting to appearance of the first floral button); crop formation (from first floral button to first open boll), and maturation of the crop. Recommended management actions are different for each of these stages. This makes their separate consideration necessary.

(1) Pre-planting:

Cotton pest control begins immediately after the previous year's crop has been harvested. Pre-planting activities have as objectives to encourage the development of beneficial species, protect the soil against wind erosion (a serious problem in some areas of Central America), propitiate genetical diversity in pest populations and confine a major part of the colonizing populations of bollweevil (Anthonomous grandis Boh) from both the previous season as well as new infestations.

Old cotton stocks are left standing in the field until about May 1st. when most but the greenest areas are destroyed. Those green areas (called "cotton islands") are four rows in width and about 50 meters long and cover 1-2% of total surface planted.

Immediately after these cotton islands are formed the careful monitoring of arthropod populations begins. The main objective of these arthropod counts is to be able to perciave significant increases in bollweeevil populations. Counts are made using specifically designed tally sheets (table 45). Daily results are entered into a graph which shows the evolution of weevil populations.

Weevil control becomes necessary when considerable and persistent increases in its populations occur. Control in this stage consists of collecting adult weevils manually in so far as possible. When this is not possible one can resort to chemical control using methyl parathion in doses of about 0.4 kilograms of active ingredient per hectare (0.7 liters of the commercial formulation at 48%).

Cotton islands help concentrate and control bollweevils remaining from the previous season. They are left standing until one week after the first rains which mark the beginning of the next season. At that point "trap crops" substitute for cotton islands.

Trap crops are small plots of cotton planted with sufficient anticipation to concentrate those weevil populations which invade cotton from the surrounding vegetation. These small plots are also four rows wide and 50 meters long. They are planted immediately after the first rains in those spots which experience has shown to be preferential entries for bollweevil.

(In most cotton plantations bollweevil first appears in certain areas of the field. These areas are called bollweevil entries. In fields to be planted for the first time one should consider the existence of rivers, alternative weevil hosts such as sugar cane and plantations and predominant wind direction during the day to establish the trap crops. Obviously no cotton islands can be where no cotton has existed previously therefore the importance of the trap crops is enhanced)

TABLE 45

TALLY SHEET FOR RECORDING PLANT DEVELOPMENT AND ARTHROPOD POPULATIONS

PROYECTO ICAITI-NAS-UNEP
HOJA DE RECUENTO

Finca _____ Lote No. _____
Fecha _____ Revisó _____

Estaciones	1	2	3	4	5	Total
Picudos R.						
Picudos N.						
Bellot. HB.						
Bellot. HR.						
Bellot L.P.						
Bellot L.G.						
Proden. M.H.						
Proden. L.P.						
Proden. L.G.						
L. Medi. H.						
L. Medid. L.						
Chupadores						
Otros						
No. Plantas						
Plts. Poda.						
Alt. Prom.						
Daños Hojas						
No. Chuspas						
Daños P./B.						
No. Flores						
Bellot. peq.						
Daños P./B.						
Bellot gds.						
Bellot. podr.						
Motas						
Cicatrices						

Trap crops are planted on the edges of the fields so as not to interfere with other operations. Non-certified seed can be used but fertilization, weeding and thinning must be effected with the same care as in the rest of the farm.

Weevil control in trap crops differs slightly from control in cotton islands. The strategy here is to collect adult weevils plus weevil-damaged floral buttons from both the ground and the plant itself. As the plant grows, manual control becomes increasingly difficult and chemical control has to be employed.

Trap crops are managed similarly throughout the rest of the cotton growing season.

2) Plant establishment:

The first step is to divide the fields in plots of about 14 hectares to be managed independently from a pest management standpoint. Soil pest counts are made one month and one week before planting begins. The fields are kept free of weeds to reduce pest populations through eliminating their hosts.

Planting date is estimated with a view to reducing pest incidence during the most intensive period of fruit formation which occurs when the plant is between 70 and 110 days old. It has been established that a full moon in a clear night inhibits the activity of adults of the noctuidae family to which bollworm (Heliotis zea B. belongs. It order to maximize the potential advantage of this natural control effect the planting date is set 70 days before the September new moon.

Planting density is relatively high since about 32 kg of seed are employed per hectare. The idea is to obtain a high initial plant population of 430,000 to 570,000 individuals per hectare which provides enough buffer in case the plantation is affected by an early infestation of defoliators. This plant population is reduced to between 22,000-43,000 individuals/ha after 25 days.

Final density depends on soil quality and expected rainfall. Loosely speaking, better soils with adequate precipitation suggest smaller plant populations and viceversa.

Fertilization depends on existing soil fertility and the physical and chemical properties of the soil. The integrated control strategy is to recommend between 65 and 150 kilograms of nitrogen per hectare (active ingredient) and between 0 and 39 kg/ha (a.i.) of both phosphorous and potassium. These two elements are added prior to or during planting. The addition of nitrogen is accomplished in three equal portions, one before or during planting, the other to coincide with the apparition of the first floral button and the third with the apparition of the first flower.

Fertilization affects pest incidence and therefore is an instrument of pest control. Excessive fertilization makes the plant appear lush and hence more attractive for pests. It is not recommendable to add nitrogen after the plant is 60 days old unless there is a deficit (evidenced through chemical analysis of leaves or by leaves turning yellow) or the plant has suffered severe physical damage and it is necessary to induce additional vegetative growth.

Weed management is also very important for integrated pest control. Weeds are the habitat of pests and beneficial organisms. This includes weeds within the cotton field and around its edges. The strategy recommended is to treat weeds so as to obtain a maximum benefit from their destruction. For instance if the number of pests in weeds exceeds the number of beneficials it might be wise to keep the weeds a little longer so as not to induce migration to the cotton.

Weed management implies systematic population counts. Indeed, population counts are the backbone of the integrated pest control strategy. They include data on plant development, beneficial population as well as pest counts and are carried out every day (table 45). Emphasis is placed on obtaining a comprehensive appraisal of the agroecosystem which includes the effects of pest on the plants and the factors affecting pest populations as well as the capacity of the plant to absorb damage.

During the plant establishment period (from planting to the appearance of the first floral button or about 30 days) pest management is directed towards leaf-eaters, leaf-suckers, shoot pruners, and bollweevil. The cotton plant during this period can withstand up to 50% damage to its leaf surface and this allows the tolerance of fairly large populations of leaf-eaters. The proportion of small larvae (less than 1.27 cm) to large larvae is important because it allows an estimate of the efficiency of beneficials and other factors in effecting natural pest control. Other factors affecting population trends include the phase of the moon and the climate and they should be taken into account. If damage begins to approach 50% natural control can be supplemented with liberations of Trichogramma. In cases of attacks by Alabama argillacea with damage above 50% it is recommended to apply triclorfon 95% in a dosis of 215 grams/hectare(1).

Damage to the plant by shoot pruners (Creontiades spp) can be circumvented by delayed thinnings to eliminate damaged plants preferentially. If thinning does not solve the problem and pest populations remain high with little possibilities for natural control localized applications of triclorfon (290-430 g/ha) can be made.

In case of suckers (Aphids and leaf hoppers) management must take into account the capacity of the plant to tolerate foliar damage much in the same manner as in the case of leaf-eaters. Selective and differential control is emphasized here too.

Bollweevil management in this stage depends for its success on the prompt detection of infestation points. Control is manual as far as possible and if necessary chemical but localized, employing about 4 kg/ha of methyl parathion (active ingredient). Control in this stage is very important because bollweevil will develop very rapidly once fruit begin to appear.

(1) For other pests see Comité de Control Integrado de Plagas del Algodonero, Guía de Control Integrado de Plagas del Algodonero para 1975 -1976(Managua: Banco Nacional de Nicaragua, 1975), p.41-42.

3) **Fruit formation:**

Damage to the leaf surface during this period can only be tolerated up to 25%. All other recommendations regarding leaf-eaters are the same as those given for the period of plant establishment. The same goes for leaf-suckers except for white fly (Bemisia spp), whose control is effected through weed management and localized applications of systemic pesticides such as monocrotofos in a dosis of .8 -1.6 kg/ha, a.i.

The most important pests during this stage are those which attack the fruit. They include bollweevil and bollworm (Heliotis spp) and their influence in the agroecosystem is crucial in determining cotton yields. Follows an outline of the management strategy recommended for the integrated control plan.

Bollworm activity in this stage is influenced by planting date(see p.137), fertilization (p.138), and beneficial insect management. Beneficial populations are encouraged through selective control of leaf-eaters and adequate weed management(p.138). As the season advances it becomes increasingly difficult for the beneficial fauna to maintain bollworm population in check. At that point parasite liberations can be the most effective Factors such as rain can aid in the natural control of bollworm populations too.

As time elapses daily population counts become more important. It is estimated that one bollworm larva damages about one fruit part per day during the 14-day period between hatching and pupating. Thus for pest management purposes one larva means the loss of one fruit part in that day.

One of the most important factors in the control of bollworm is derived from the plant fruiting habits. Cotton belongs to the group of the indeterminates so that fruiting normally exceeds the capacity of the plant to support all fruit until maturity. As a consequence fruit shedding occurs naturally and the loss of a considerable number of fruit parts has no implications on final yields.

The strategy recommended was to effect chemical control when the number of small larva (less than 1.27 cm) exceeded 8,600 per hectare but in reality the population trend had great importance in deciding an application of pesticides. As the season advanced the economic threshold was allowed to go up in light of evidence that natural fruit shedding rates also increase with time. Besides with present cotton and pesticides prices bollworm populations have to go above 5,000 larvae/ha before it becomes economical to apply. In implementing the strategy however one must take into consideration the farmer's risk aversion preferences(1).

The strategy recommended was to use chlordimeform 500 in a dosis of .215-.360 kg/ha (a.i.) (2). An alternative is to use toxaphene - DDT (5 -2.5) ULV in a dosis of 4.25 liters/hectare. These measures are applied only when economically and ecologically justified.

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(1) For a more detailed discussion of bollworm economic thresholds see chapter on the economics of pesticide use.

(2) After the 1975-76 season had ended the principal manufacters of chlordimeform temporarily retired its product from the market on grounds of potential human health hazards.

If an appropriate management strategy has been followed before planting and during plant establishment bollweevil may not be a problem in this stage. Manual collection of damaged and fallen floral buttons continues. Chemical control using methyl parathion in a dosis of 0.8 to 1.6 kg/ha (a.i.)is restricted to heavily infested spots or plots.

4) Crop maturation:

As in the stage of plant establishment the strategy is to tolerate up to 50% leaf damage once the first open boll appears. Bollworm and bollweevil management is the same as in the previous stage except that greater populations can be tolerated.

Whitefly control is most important during this stage as whitefly produces Fumagina, a sticky substance which interferes with cotton processing (and lowers cotton prices) and promotes the development of fungy. Crop maturation status is very important in whitefly control. If only a small proportion of the crop is open, chemical control can become necessary when there are five or more adults per plant and more than 80 nymphs. The recommendation is to use metamidophos in dose of .43 to .64 kg/ha (a.i.).

Once 50% of the expected crop (large bolls+open bolls) is already open the strategy is to defoliate selectively up to 50% of the foliar surface. All control is suspended when only a small percent at the crop is in the form of soft large bolls (unopened). A prompt harvest may be the best way to avoid whitefly problems late in the season. The use of any chemicals during harvest must take into account the increased possibilities of human poisonings and emphasize low toxicity products.

The methodology outlined was complemented with: 1) the selection of a check plot and the monitoring of activities and expenses in all plots the first year; 2) a careful monitoring of all agricultural activities the second year with a view to establishing the acceptance of the strategy suggested, and 3) statistical comparisons of economic and organic variables in both years as applicable.

RESULTS

Table 46 shows the demonstration plots in every country in both years and their total extension. Differences in size and number are attributed to grower willingness and ecological differences in each country. The second year a total of 1,357 hectares were supervised, which represents a little more than 0.3% of the total surface planted with cotton in the region.

Table 47 shows a comparison between integrated control demonstration plots and neighbouring plots under the conventional system with respect to number of insecticide treatments and costs, yields and profits per hectare for 1974-75. Integrated control plots made an average of 6.7 pesticide treatments less than the neighbors under the conventional system. This difference (a reduction of 32% in the number of treatments) was statistically significant ($\alpha = 0.05$) when comparing all twelve plots.

Although yields were 211 kg/ha higher in the integrated control plots(a difference of 8%) they were not significantly higher. This is probably attributable to Guatemala's experience and the variation it introduces into the analysis. Obviously there is no tendency toward lower yields in the integrated pest control plots.

Total costs and pest control costs were smaller in the integrated control demonstration plots. Total costs per hectare were $95.1 higher in the conventional check plots and this difference was significant at $\alpha = 0.05$. Pest control costs per hectare were $70.6 lower in the intregrated control plots and this difference was also significant at $\alpha=0.01$. The same is true for pest control costs per kilogram of cotton produced. Here the difference was of $0.028 kilogram (table 47).

As a result of the above differences total and relative profits were higher in the integrated control plots. Statistical analysis showed the differences in profitability significant at $\alpha = 0.05$. Absolute profits per hectare were $162.29 higher in the integrated control plots and relative profits (total profit - total cost) were three times as high.

In all cases an increased cost of $14.3/ha was assigned to the integrated control costs in order to account for more expensive technical assistance and scouting. Still, integrated control produces significantly higher profits while reducing (also significantly) the number of pesticide application by 32% in the first year of the demonstration. Tables 74 to 79 in the appendix show the agroeconomic comparisons in slightly greater detail and expressed in local units (manzanas). Also shown in the appendix is a partial table which gives detailed insecticide use information on three of the demonstration plots and their respective check plots (Table 80).

The results for the second year show essentially the same facts. Largely because of institutional difficulties careful monitoring of the check plots was not effected. However a great deal more agronomic and economic data concerning the demonstration plots was obtained. Table 48 shows cotton yields/hectare and number of pesticide applications for the two years and table 49 a summary of all the relevant agricultural operations performed in the integrated control plots in 1975-1976.

In 1975-1976, the reduction in the number of pesticide application is more marked than in the previous year while the difference in cotton yields remained constant. This shows the effects of experience and confidence on the parts of the growers who experienced the demonstration in their own lands.

The two-year average yield for the whole region (integrated control) was 3,359 kilograms of seedcotton per hectare with 15.25 applications on the average. Its comparison (traditional control) had yields of 3,038 kg/ha and made about 25 applications. Integrated control obtained yields 11% higher and made 39% less pesticide applications.

Table 49 gives a detailed picture of the agricultural activities and results in the demonstration plots during the 1975-1976 season. From the table it is possible to determine the degree to which recommendations are accepted by the farmer. This is important because technical assistance is not compulsory and depends on the interaction between the technician and the grower. It was not possible to obtain analogous information for the check plots because no such records were kept in these farms. However the activities discussed will be refered to aggregate practices whenever possible.

Pre-planting bollweevil management was tried in Guatemala for the first time. It generated considerable interest. The surface of the cotton islands was less than 1 % of planted area in Guatemala as well as in the other two demonstration plots which engaged in this activity. Total insecticide use was 1.4 kg (a.i.) of methyl parathion in each plot during the whole pre-planting stage. Average cost for pre-planting bollweevil control was less than $1 per planted hectare.

Final plant population density is within the recommended limits in most cases. Guatemala and Nicaragua II are exception. The farmer's lower density is caused by specially moist soil conditions in Tiquisate (Guatemala) while the case of Nicaragua II is the exact opposite. Leon is located in a Zone frequently affected by drought.

Except for the use of potassium most fertilization schedules were within the recommended dosis. There is a marked tendency in Central America to use excessive fertilizer. The average for the counties where the demonstration took place in two of the countries is around 165 kg/ha (a.i.), whereas the average for the plots was 142 kg/ha.

In the majority of the demonstration plots pest counts were carried out every day. Where this was not possible counts were spaced two days apart.

The first application of pesticides in the demonstration plots was made on average of 67 days after planting (range: 60-87 days). Most Central American farmers begin treating around day 40. Delaying the first application helps preserve the ecological balance within the agro-ecosystem by not destroying beneficials. Bollweevil did not cause the first application in any of the demonstration plots. The only plot with serious bollweevil problems was the Honduras plot. No trap crops were set up in the demonstration farm there.

Average pesticide use in the demonstration plots was lower than the average use in the four Central American countries. The situation varied from country to country. Guatemala reported the highest reduction since the value in the integrated control plot was 33.1 kg/ha (a.i.), and the national average was 79.9 kg/ha (a.i.) (a reduction of almost 60%).

Savings were second highest in El Salvador: Integrated Control = 53 kg/ha., country average=70.0 kg/ha. In Nicaragua and Honduras the integrated control plots were actually slightly higher than the national average: Nicaragua's average use was 20 kg/ha whereas in the demonstration 30 kg/ha were used. On the average, the demonstration plots used 50.5 kg/ha and the Central American average was 62.5 kg/ha.

Several factors explain why pesticide use in demonstration plots in Nicaragua and Honduras were slightly higher. The most important is that the national average is biased downwards by a large number of marginal growers in both countries. The integrated control plots were located in prime cotton lands where insecticide use was higher. For instance insecticide use in Chinandega (Nicaragua) was 99 kg/ha and in León (Nicaragua II), 82 kg/ha.

In Honduras the small size of the cotton sector and the abundance of low technology growers maintains over all insectide use low. It is different to compare pesticide use in demonstration areas with pesticide use in check plots them to compare it with national values.

In the final analysis the success of a demonstration program is measured by the impact it has on the growers themselves. One way to measure this impact is to find out their willingness to continue and expand the demonstration to large areas. This was done in the present case and the results are highly encouraging

On the basis of two-year of results arrangements had been made in El Salvador to stage a large scale demonstration effort this year. The program would cover 3,500 hectares in the main cotton area of that country. Institutional difficulties and delays caused to plan to be filed away but the option remains for future programs.

The Guatemalan grower on whose farm the 35-hectare demonstration plot was operated was willing to extend the demonstration area to 700 hectares. The interuption of the program meant a cancellation of those plans. Nevertheless he personally hired the project's technician in charge of that plot in order to continue the integrated pest control experience on his own.

In Honduras the demonstration area was going to be extended to cover 600 hectares this year. With the interruption of the program this idea also had to wait. Again, the farmer sought an integrated pest control technician on his own and continues to work in this direction.

The Nicaragua program already covers a large number of farms and influences a considerable percentage of total planted area. The program however is suffering some financial difficulties and it will take continuing effort to maintain its original momentum.

It can be safely stated that this project has made a headstart toward integrated pest control in the four Central American countries that grow cotton.

DISCUSSION

The potential benefits of integrated pest control in Central American cotton production are substantial. Every year about $70 million are spent for cotton pesticides. If control costs per hectare can be reduced by 23% through integrated pest control the potential annual savings are about $15 million.

Integrated pest control results in significantly lower use of insecticides. There are potential environmental benefits to be derived from this reduction. The emphasis on low - toxicity products will have immediate benefits for the human health of the Central Ame - rican population.

Integrated pest control requires an investment in human technical resources as well as further demonstration and dissemination of results and methodology. The committee for the professionalization of integrated pest control in Nicaragua estimates a cost of $1 million annually for the training of technicians alone (1). Further demonstration and dissemination costs have been estimated at about $0.2 million for one year (2).

The adoption of integrated control represents a way to provide environmental protection while encouraging an important economic activity. One of the main atractives of integrated control is its economic benefits. Farmers would be helping solve environmental problems while pursuing their own self-interest.

In order to expand integrated control it will be necessary to devote considerable effort to increased demonstrations and dissemination of existing results. The present project has only begun to scratch the surface of the real problem, which is to change pest management practices in Central America. Dissemination of results in the form of conference and informed talks has been meager so far and it should be undertaken seriously if the project is to have any significant impact in the Central American environment and economy. As an optimist put it "the operation may have been a success but the patient has not yet been cured".

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(1) León, G., M. Vargas and M. Vaughan, Project for the Developmentoof a Teaching Program in Integrated Pest Control for Middle America in Nicaragua, FAO/UNEP Consultation on Pest Management Systems for the Control of Pests of Cotton 13-16 October 1975, Karachi, Pakistan.

(2) Central American Research Institute for Industry (ICAITI), A Systems Management Program to Reduce the Environmental Consequences of Pesticide Use in Central American Cotton Production (A Proposal for Extension), Guatemala:ICAITI, 1976.

TABLE 46

CENTRAL AMERICA: INTEGRATED COTTON PEST CONTROL PLOTS PROVIDED BY COMMERCIAL GROWERS FOR DEMONSTRATION PURPOSES, 1974-75 and 1975-76, HA.

Country	1974-75 ha.	1975-76 ha.
El Salvador	44	210
Guatemala (I)	37	35
Guatemala (II)	25	- *
Honduras	130	145
Nicaragua (I)	260	267
Nicaragua (II)	14	700

SOURCE: ICAITI

* The second Guatemala plot had to be dropped in 1975-76. Increases in El Salvador and Nicaragua reflect more interest and expansion of the methodology.

TABLE 47

CENTRAL AMERICA: RESULTS OF INTEGRATED PEST CONTROL DEMONSTRATION, 1974/75

COUNTRY	Size of Plot (ha)	Number of treatments	Yields (kg of seedcotton)	Control/cost ($/ha)	Control/cost per kg.	Total costs ($/ha)	Profits ($/ha)	Relative profits (profit/cost)(%)
EL SALVADOR								
Integrated control	47.6	19	3500	266.74	0.076	663.73	497.57	75.3
Conventional plot	42.0	21	3020	304.13	0.100	691.55	308.02	44.5
GUATEMALA								
Integrated control	36.7	10	2594	194.36	0.075	687.94	170. 06	25.0
Conventional plot	58.1	27	3567	410.55	0.1151	946.33	233.42	25.0
Integrated control	25.2	12	1628	183.68	0.1129	632.73	-94.34	-14.9
Conventional plot	37.7	19	1680	261.29	0.1552	741.56	-185.57	-25.0
HONDURAS								
Integrated control	130.2	21.4	3385	304.72	0.090	724.07	396.05	54.7
Conventional plot	329.0	24.0	2140	261.00	0.103	755.04	-47.19	-6.00
NICARAGUA								
Integrated control	14.0	11	2983	180.39	0.060	829.61	157.09	18.90
Conventional plot	14.0	17	2933	229.20	0.073	878.42	108.28	12.30
Integrated control	260.4	12.4	3761	260.14	0.073	868.21	375.89	43.00
Conventional plot	245.0	18.0	3243	347.06	0.107	960.87	111.62	16.60
AVERAGE CENTRAL AMERICA								
Integrated control	85.6	14.3	2975	231.67	0.081	733.88	250.39	33.67
Conventional plot	121.0	21.0	2764	302.29	0.109	828.96	88.10	11.23

NOTE: To estimate profits, seedcotton prices of US$0.33 per kg. were assigned.
SOURCE: ICAITI

TABLE 48

CENTRAL AMERICA: YIELDS AND PESTICIDE APPLICATIONS IN INTEGRATED CONTROL PLOTS AND CHECK PLOTS IN TWO SUCCESIVE YEARS, 1974/1975 and 1975/1976

COUNTRY	1974/75 Kg/ha seedcotton Yield	1974/75 Pesticide applications	1975/76 Kg/ha seedcotton Yield	1975/76 Pesticide applications
EL SALVADOR				
Integrated control	3502	19	2727	14
Traditional comparison	3022	21	2856	24
GUATEMALA				
Integrated control	2594	10	3895	13
Traditional comparison	3567	27	3895	35
HONDURAS				
Integrated control	3385	21.4	3376	16
Traditional comparison	2140	24	2337	24
NICARAGUA				
Integrated control	3761	12.4	3636	16
Traditional comparison	3243	18	2246	27
CENTRAL AMERICA				
Integrated control	3310.5	15.7	3408	14.8
Traditional comparison	2993	22.5	3048	27.5

SOURCE: ICAITI

TABLE 49

CENTRAL AMERICA: AGRICULTURAL AND ECONOMIC INFORMATION ON THE INTEGRATED PEST CONTROL DEMONSTRATION PLOTS, 1975/1976.

ACTIVITY	El Salvador	Guatemala	Honduras	Nicaragua I	Nicaragua II
Size of weevil trap crops(ha)	0	.16	0	.22	.7
Scouting frequency in traps.	-	daily	-	twice a week	every 2 days
Use of methyl parathion(kg/ha)	-	7.9	-	5.9	2.4
Planting date	July 21	June 21	July 10	July 11	July 23
Surface planted (ha).	210	35	145	267	700
Plant population per hectare	24310	10580	30000	30000	45760
Nitrogen addition(kg/ha a.i.)	80.3	86.1	76.8	89.5	121.7
Phosphorous addition(kg/ha a.i.)	62.9	0	58.4	58.4	51.9
Potassium addition (kg/ha a.i.)	0	0	19.4	0	6.5
Scouting frequency	daily	daily	every 2 days	three times a week	daily
Days before first insecticide application	60	84	65	67	60
Target Pest.	Bollworm	Bollworm	Whitefly	Alabama	Bollworm
Toxaphene used (kg/ha a.i.)	19.0	11.5	1.5	16.6	6.4
Chlordimeform used(kg/ha a.i.)	2.3	3.2	1.5	0.3	3.9
DDT used (kg/ha a.i.)	9.5	5.7	0.8	0.6	0.2
Formation used(kg/ha a.i.)	-	-	-	0.6	-
Monocrotophos used (kg/ha a.i.)	-	-	3.7	.2	.7
Metalkamato used (kg/ha a.i.)	2.4	-	-	-	.2
Metamidophos used (kg/ha a.i.)	-	1.5	2.7	0.8	1.1
Ethyl parathion used (kg/ha a.i.)	10.0	7.8	1.5	0.8	25.0
Methyl parathion used(kg/ha a.i.)	9.7	1.7	18.3	19.7	21.4
Trichlorphon used (kg/ha a.i.)	-	-		-	0.4
Leptophos used (kg/ha a.i.)	-	1.2	-	-	-
Gramoxone used(kg/ha a.i.)	.1	-	-	-	-
Dicrotophos used(kg/ha a.i.)	-	.2	-	-	-
Endrine used (kg/ha a.i.)	-	.8	-	-	-
Triazapenta used(kg/ha a.i.)	-	-	-	-	.1
Total insecticide used(kg/ha a.i.)	53.0	33.1	30.0	39.6	59.04
Insecticide expenditures $/ha	170.00	143.05	225.90	163.40	180.00
Trichogramma liberated/ha	81000	-	-	200000	14000
Trichogramma cost $/ha.	3.00	-	-	7.00	.50
Plant age at the beginning of harvest	20	159	143	151	180
Seedcotton yield kg/ha.	2724.0	4020.9	3469.0	3671.0	3307.0
Average cost/hectare	808.5	743	945.2	623.1	705.0
Price of cotton $/kg.	.467	.404	.386	.502	.360
Income $/hectare	1272.1	1625.3	1339.0	1842.8	1190.5
Gross profit $/hectare	463.6	882.3	393.8	1219.7	485.5

SOURCE: E. Deshon, O. Vigil, R. Estrada, P. Vestrini, M. Molina, G. León, R. Castillo.

5. THE ECONOMICS OF PESTICIDE USE

This chapter evaluates cotton within the Central American economy and the role of pesticide use in the production of cotton. It discusses the relationship between pesticides and other inputs, addresses the question of how much pesticides seem necessary for cotton production and explores possible ways to move pesticide use towards an economically desirable level. Among the many possible alternatives, technical assistance, economic thresholds, scouting, fertilizer use and preferential import duties are examined for their potential benefits and costs.

5.1 Cotton Activity in the Central American Economy:

Cotton contributes significantly to the economy of the four Central American countries where it is grown. Its relative contribution is nevertheless below that of other agricultural activities. Cotton gives employment to half a million agricultural laborers for a total of 36 million man-days. Pesticide use in cotton production causes external diseconomies (damages to other economic activities) which qualify these benefits.

Value-added:

The yearly contribution of cotton production to the gross international product (GIP) of the four countries under study ranges between 82 and 117 million dollars in 1974 and 1975 (current prices). This amount (roughly one hundred million per year) represents payments to the three large factors of economic activity, land, labor and capital. It includes salaries, wages, profits, land rentals and payments for services. It is, in absolute terms, large; and second only to coffee and bananas.

Most other agricultural activities yield a higher proportion of their production value to the gross internal product. This proportion (expressed as value-added divided by total value of production) is .8 for the whole agricultural sector and only .4 for cotton. It reflects the extent to which cotton production relies on imported pesticides, fertilizers and machinery.

Nevertheless cotton is an important economic activity. Its value added represents about 10% of that portion of the GIP generated by the agricultural sector and near to 3% of the total GIP of the four countries under study. In discussing the consequences of pesticide use in cotton it will be valuable to remember that there are strong economic interests behind this activity.

Employment Benefits:

Central America cotton production is labor-intensive. The largest share of production costs goes to labor, especially that employed for harvest. Cotton gives occupation (mostly temporary) to a half million agricultural laborers.

Even though salaries are comparatively low, the large number of workers employed results in a large absolute contribution to rural incomes. Daily wages for Central American agricultural laborers range between one and two dollars. The total number of work-days paid by cotton is around 36 million. If average salaries are $1.50. the annual payment of cotton to labor is about 54 million, a sizeable sum by Central American standards.

For the most part cotton payments to Central American labor are a small but necessary complement to other agricultural activities. The average laborer works in the cotton fields about 72 days. The small cash sum they earn is particularly important since the rest of the time the peasant might be devoted to self-sufficient agriculture with no other source of income.

Economic Externalities:

Pesticide use in cotton production causes economic losses to other activities. Very few of these can be quantified in monetary terms. Among the most obvious ones are increased cost of malaria control, beef contamination and the clinical treatment of intoxications.

Perhaps the most significant economic consequence of pesticide use in cotton is the increase in the cost of malaria control caused by the development of resistance of Anopheles albimanus populations to chemical control. It is apparent that high resistance only develops in cotton areas (see chapter on public health). This forces malaria control agencies to switch to OMS-33, a product several times more expensive.

It cost about $16 to spray one house one time with OMS-33 and only $7 to spray it with DDT in 1975.

A total of 96,430 houses received two complete treatments with DDT in Guatemala in 1975. Most of these houses were located in non-cotton growing counties. Around $1.35 million were spent in malaria control with DDT in that country. An average of 32,695 houses in or near cotton areas were sprayed four times with OMS-33 for a cost of $2.1 million. Thus malaria agencies had to spend $1.6 million more because of resistance induced by pesticide use.

Pesticide and application costs for malaria control being about the same throughout Central America makes it possible to estimate similar increased costs for other countries. In El Salvador an average of 77,990 houses had to be sprayed four times with OMS-33 and resulted in extra expenditures of $3.9 million in 1975. In Nicaragua 21,088 houses received special treatment for an increased cost of $1.05 million in malaria control. The figures for Honduras were 99,974 houses and $5.4 million extra. The total for the four countries was $11.95 million. This is the cost of increased resistance that must be paid every year by malaria control organizations.

One important qualification to the above analysis is the fact that malaria control itself induces some resistance. In non-cotton counties tested in Guatemala, average resistance to DDT at the usual mosquito control dosis (4%) was 53% in 1974 and 33% in 1975. Thus one may argue that at least part of the resistance (and therefore part of the increased cost) is not solely attributable to pesticide use in cotton production.

The contamination of export beef with pesticides(of which cotton is by far the largest user) has increased the costs of meat packers and cattle raisers. Over the last 15 years the beef industry in the four countries has had increased costs of over $1.7 million because of pesticide contamination. A contaminated beef lot can be rejected causing losses in storage, transportation, marketing, and insurance as well as forcing the exporter to sell in alternative markets at a lower price. Avoiding rejections implies chemical analysis of samples using expensive equipment and techniques.

Aside from physical and other damages, the intoxication of human beings results in increased economic costs for public health agencies. It is estimated that about $150,000 are spent every year in the treatment and compensation payments for intoxicated persons. Although it is relatively small this amount will represent a payment every year in which intoxication levels remain the way they presently are. For instance, the actualized cost of poisoning treatments over the next five years is estimated at over half a million dollars.

The socio-economic benefits of cotton production are diminished by the conse - quences of pesticide use. The economically quantifiable social costs alone amount to $13.8 million, $11.95 million of which have to be paid every year for malaria control. Even if a conservative stand is taken and only 47% of the cost of increased resistance is attributed to pesticide use in cotton one is left with a sizable sum of over $8 million (100 % -53% national resistance level= 47% attributable to pesticide use in cotton. This assumes that if malaria control agencies have to make the switch to a different pesticide resistance is 100% for practical purposes). Systems management programs to reduce the consequences of pesticide use in cotton are thus an economic necessity from a social standpoint.

5.2 Factors affecting cotton supply

Studying the factors which determine cotton supply facilities the search for solutions to pesticide problems which are potentially beneficial to cotton as an economic activity. By knowing what makes planted area increase from one year to the next one can find policy tools which will help the cotton sector maintain its profitability and growth. This is consistent with the philosophy of the present study which is to solve environmental and economic problems without creating new ones.

Cotton supply is a product of planted area and yields per hectare(Table 50). This section examines the effects of prices, yields, and technical assistance on the number of hectares planted in a given season. The factors affecting cotton yields per hectare are presented in the next section in the context of pesticides as an economic input for cotton production.

Price: A priori, the prices for cotton and important inputs may affect planted area. As planting time nears the farmer considers past and present prices to help in his decision of how many hectares to plant. Higher prices imply greater incentives. Contrariwise high prices for pesticides and fertilizers would seem to discourage a farmer from planting.

Yields: Prevailing ecological and technological conditions reflect themselves in physical yields which may encourage or discourage farmers. A string of good years will tend to make them confident and optimistic while bad years have a negative effect.

Technical assistance: This factor has two effects: increases yields and reduces risk by reducing the fluctuation in yield from one year to the next. The effect of technical assistance on pesticide use levels also makes it desirable to examine its effects on cotton supply.

METHODOLOGY

In order to examine the effects of these factors statistically, a series of nine years of data for the four countries was developed. The variables observed were average price per bale of cotton, average cotton yields per hectare, ratio of pesticide prices to cotton prices, planted hectares, and information on technical assistance. Since 1970 Nicaragua has been developing an integrated pest control program and therefore a variable was included since that year to reflect the influence of number of hectares covered by technical assistance on planted area.

RESULTS

The data points were linearly related through a multiple regression. Total multiple correlation was high, $R^2 = 0.97$ and most of the variables were found to be significant. Table 51 shows the variables, their regression coefficient, significance, and the elasticity when this is applicable.

DISCUSSION

In table 51 the intercept (28.7) shows the number of hectares (in thousands) which would be planted in Nicaragua if all other variables were zero. The dummy variable for Guatemala, El Salvador, and Honduras shift the intercept by - 42.21, -53.63, and -111.8, respectively. For instance, to estimate yields in Guatemala, one would have to shift the Nicaragua intercept downwards in 42,210 hectares to reflect the former country's smaller planted area.

The regression coefficient for price of cotton in dollars per bale shows the influence of cotton prices on planted area. A one-dollar increase in the price per bale makes the number of planted hectares go up in 0.046 thousand. In percent terms a 10% increase in prices would be likely to result in a 4.7% increase in the area planted to cotton(elasticity= 0.47). The variable was evaluated as the average price in the past two years to reflect the time it takes to adjust to price changes.

TABLE 50

CENTRAL AMERICA: PLANTED AREA, COTTON YIELDS AND COTTON SUPPLY, 1974/75.

COUNTRY	Planted area(ha)	Seedcotton yields(kg/ha)	Seedcotton production(kg)	Cotton fiber production(kg)
El Salvador	100470	2059.5	206921	75806
Guatemala	111138	2719.0	302185	105105
Honduras	8234	1766.7	14547	5129
Nicaragua	177880	2039.2	362740	121089

SOURCE: ICAITI

For previous years see Appendix four, tables 88 and 89.

TABLE 51

FACTOR AFFECTING COTTON SUPPLY IN CENTRAL AMERICA

(hectares planted)

VARIABLE	Regression coefficient	Significance (t value)	Elasticity
Intercept	28.7	--	--
Price of cotton (X_1)	.046	2.33 *	0.47
Yield (X_2)	19.07	4.12 **	0.49
Technical Assistance (X_3)	64.0	3.62 **	0.64
Guatemala Dummy (X_4)	- 42.21	6.07 **	--
El Salvador Dummy (X_5)	- 53.63	8.39 **	--
Honduras Dummy (X_6)	-- 111.8	3.63 **	--
Pesticide price (X_7)	3.0	not significant	

* Significant at the five percent level.

** Significant at the one percent level.

SOURCE: ICAITI

Yields also have a positive effect on planted area. An increase of one bale per hectare would result in an increase in planted area of 1,070 hectares. As in the case of prices, yield was included as an average of the two previous years. Its elasticity of 0.49 shows the percentual response of acreage to a one unit increase in yields.

A most interesting result of the analysis was the effect of technical assistance on planted area. As mentioned above technical assistance was included as number of hectares covered by the Nicaraguan integrated pest control program PAAT (Programa Algodonero de Asistencia Técnica). According to the analysis, for each additional thousand hectares to which the program was extended total cotton area in the country increased by 640 hectares the following year. Thus one can expect a 0.4% increase in acreage for each 10% rise in the number of hectares covered by the integrated pest control technical assistance program (elasticity = .04).

Pesticide price evaluated as the ratio of pesticide prices to cotton prices was not found significant in the analysis. This means that although prices may affect pesticide use (and therefore yields) within one season the effect between seasons is obscured by more important factors such as cotton prices, yields and technical assistance. Interestingly, it suggests that moderate increases in the price of pesticides may not have an effect on cotton activity and cotton supply if all the other factors are favorable.

Technical assistance may promote cotton production mainly through reducing variance and risk, thereby making farmers more confident. Besides there is the obvious effect of increasing profits mentioned in the previous chapter. If integrated control assistance also contributes significantly to reducing pesticide use, one policy tool apparently works simultaneously toward the objectives of protecting the environment and increasing the benefits of cotton production.

5.3 The kinds and levels of pesticide use which appear economically desirable for cotton production.

Pesticide use in Central American cotton production appears to be above those levels which under present conditions would be economically efficient. Furthermore, there are indications that too much pesticides of the wrong kind (economically speaking) are being used. The standard for comparison is a theoretical and experimental level and mix at which profits to the farmer are at a maximum.

The standard was developed in two ways: 1) through the results of experiencing integrated cotton pest control and 2) through the statistical analysis of existing farm and county data. The results of integrated pest control are presented in a separate chapter. The results of statistical analysis related to optimum insecticide use levels and mix are discussed here.

Present pesticide use in cotton:

Table 52 shows amounts of pesticide (active ingredient) used in Central American cotton production. The variation in use levels between countries stands out. This reflects different ecological and technological conditions. Honduras is beginning to recover from a period of low production and pest control technology is **deficient** in spite of efforts to the contrary. Pesticide use may be economically too low there. Guatemala is the highest user and suffers from almost no research or extension in cotton pest control technology. A combination of cheap labor and good lands helps maintain yields high and discourages technological development.

Pesticide use has been recently increasing in countries like Guatemala and El Salvador and it has tended to decrease in Nicaragua since 1972. As mentioned earlier this country has been developing an integrated pest control extension program since 1970. No other convincing explanation is found for the fact that between 1972 and 1974 pesticide use in Guatemala and El Salvador went up by 75% and 20%, respectively, while Nicaragua's average even decreased slightly. Table 53 shows pesticide use per unit of cotton produced.

Table 53 shows interesting facts: Salvadoreans are having to invest more in pesticides per unit of cotton produced than other countries. Guatemala, highest user in a per area basis, slips to a second place thanks to high yields. The differences between Nicaragua and the other countries persist, but less markedly. There is an apparent relationship between pesticide use, yields, and returns.

On the average Central American cotton producing countries use two kilograms of chlorinated pesticides (mainly Toxaphene and DDT) for each kilo of organophosphates. Nicaragua, the most advanced country in cotton technology, uses the smallest proportion of phosphates; Honduras and El Salvador the largest. The significance of pesticide mix will be discussed in the following section although the implications of high phosphate use on human health are already known (see chapter on human health, p. **124**).

Table 54 shows total amounts used and the average mix in every country. Notice the wide variations between countries. It is not superfluous to repeat that Nicaragua, the smallest user of organophosphates, also has reported the lowest rates of human intoxication and the highest levels of DDT residues in milk. There is a trade-off apparent between human health and environmental quality. An optimum mix will be affected by economic, human health, and environmental considerations.

It is well to mention the variability of present levels between countries, the reduction shown by Nicaragua in the recent past and the differences observed in pesticide mix.

TABLE 52

CENTRAL AMERICA: AVERAGE PESTICIDE USE IN COTTON PRODUCTION 1972/73-1974/75 (kg/ha, a.i.)

COUNTRY	1972/73	1973/74	1974/75
El Salvador	58.4	72.1	70.0
Guatemala	45.6	75.2	79.9
Honduras	--	27.0	19.3
Nicaragua	51.2	44.1	49.8

SOURCE: IC/ITI, CONAL and, for 1974/75 in Nicaragua, Mario Vaughan (75).

-- not available.

TABLE 53

CENTRAL AMERICA: PESTICIDE USE PER METRIC TON OF COTTON PRODUCED, 1974/75

COUNTRY	kg/a.i. 1972/73	kg/a.i. 1973/74	kg/a/i. 1974/75
El Salvador	81.1	96.5	90.5
Guatemala	46.6	64.8	83.5
Honduras	-	55.0	34.2
Nicaragua	74.4	55.9	73.2

SOURCE: ICAITI.

TABLE 54

CENTRAL AMERICAN PESTICIDE USE IN COTTON BY MAIN TYPES, 1974/75

COUNTRY	Chlorinated pesticides Amount (metric tons)	%	Phosphorous pesticides Amount	%	TOTAL Amount (metric tons)	%
El Salvador	3767.2	52. *	32,92.0	48.[illegible]*	6864.0	100.0
Guatemala	5696.2	34.9 *	2378.7	27.1*	8776.9	100.0
Honduras	58.5	33.3	117.1	66.7	175.6	100.0
Nicaragua	6750.1	76.2	2108.3	23.8	8858.4	100.0
TOTAL	16,372.0	67.0	7896.9	33.[illegible]	23968.9	100.0

SOURCE: ICAITI

* Based on a sample of 10% - 15% of planted area. All other figures relate to the total universe.

Optimum use levels:

The analysis was performed for Nicaragua only. With certain limitations pesticide use appears to be high in many important regions of that country. The Central American cotton area can be considered an ecological homologue and some tentative conclusions can be made about pesticide use in the other countries too.

Methodology:

The analysis was divided in two stages. First it seemed necessary to establish with some degree of accuracy the contribution of different factors of production to cotton yields. In other words how fertilizer, pesticides, and farm sizes affect yields. Once this is done it becomes possible to estimate optimum levels of use for some of these inputs.

The procedure was to obtain two years of data on cotton production inputs and yields for all cotton producing counties in Nicaragua (National Cotton Commission, CONAL). The data were converted to appropriate units and related statistically through a multiple regression. A quadratic form was selected to reflect possible diminishing returns and it resulted in the highest multiple correlation (R^2 = .83). Other functional forms tried were linear, logarithmic, power curve, and square root.

The quadratic form has been successfully used in estimating cotton yield responses to pesticide in previous studies(1)

Results:

A preliminaty production function was obtained. Yields depended to a large extent on the use of pesticides. Since it was a multiple-variable equation which included fertilizer use and size of farme these variables were fixed to their average values to obtain an input-output relationship for yield and pesticides. This was done by multiplying the average value of each variable times its regression coefficient and adding the total to the intercept. The preliminary input-output relationship obtained in this manner was:

$$Y = 23.57 + 0.3412 X - 0.00142X^2$$

where: Y = seedcotton yields, in hundred pounds per manzana (1 manzana = 0.7 hectares)

X = pesticide use, in pounds of active ingredient per manzana.

The above equation was used for estimating the marginal physical product of pesticides (MPP). The MPP is the contribution of the last unit of an input to total yields. It is defined by the first derivative of a production function with respect to the input being analyzed. For the above function the MPP is:

$$MPP = 0.3412 - 0.00284 X$$

(1) J. Gwyn Sutherland, G.A. Carlson, and D.M. Hoover, Cost of Producing Cotton in the Southeast 1966, Economics information report No. 25, Dept. of Economics, North Carolina State University (Raleigh: 1971), p.40.

It is interpreted as the increase in cotton yields attributable to the last pound of pesticides applied. This contribution decreases as the level of use goes up.

The optimum theoretical level of pesticide use is that level at which the last unit applied just pays for itself. The marginal physical product valued at the current price of a hundred weight of cotton just equals the cost one pound of pesticides applied at this point.

With current (1974) prices of pesticides of $1.86 per pound (applied) and $13.00 per hundred weight of seedcotton one can estimate an optimum pesticide use level of 69.7 lbs/mz, or 45.2 kg/hectare. This is because

$MPP * Pc = P_p$, where Pc = cotton price and P_p = pesticide price, so that

$$(0.3412 - 0.00284X)\,13 = 1.86$$

$$-0.00284X = \frac{1.86}{13} - 0.3412$$

$$-.00284X = 0.19787$$

$$X = 69.7 \text{ lbs/mz, or}$$

$$45.2 \text{ kg/ha.}$$

Pesticide use levels for Nicaragua stand at about 50 kg/ha in 1974/75, and average 48.4 kg/ha over the last three years. They are **slightly above the economic** optimum estimated. However, these are national averages. There are a number of important municipalities where pesticide use is much higher. For instance, Chinandega, Posoltega, Morazán, León, Quezalguaque, and La Paz Centro averaged 89 kg/ha in 1973/74 and accounted for 31% of total planted area that year. Low national averages reflect use in marginal zones. In most important cotton areas pesticide use is well above the estimated optimum.

If Nicaraguan optima are valid for the rest of the Central American Pacific Coastal plain, then pesticide use is too high in the area. In 1974/75, an average of 62.4 kg/ha were used in the four countries, 38% above the estimated optimum. The integrated pest control experience of the past 3 years further shows that it is possible to produce higher profits with 40% less applications of pesticide. These two criteria suggest that present pesticide use levels are indeed too high and that profits to the farmer could be increased through a rational reduction in pesticide use.

Optimum pesticide mix:

There are indications that too much pesticides of the wrong type are presently being used. Main pesticides used now are the chlorinated hydrocarbons (Toxaphene and DDT) the organophosphorous ethyl, and methyl parathion, and the carbamates. The former two are by far the most significant for cotton pest control; the carbamates have become important for malaria mosquito abatement. Statistical and economic analysis sugests that, possibly, too much organophosphorous pesticides are being used for efficient cotton production in Central America.

Methodology:

The analysis was an extension of the previous one. It had as objectives to separate the contribution of chlorinated and phosphorous pesticides and to quantify the contribution of additional production factors, most importantly rainfall, technical assistance, land quality, and labor. Additional data permitted evaluating these variables statistically. As before, a quadratic functional form was used.

Results:

Table 55 shows the regression coefficients obtained for the most significant variables.

Several important points stand out. Phosphorous pesticides apparently have negative effects on cotton production. This is reflected by the negative sign and high significance of variable X2. Land value as a proxy for land quality has a large positive coefficient and so does rainfall (tens of milimeters recorded during September, October, and the first ten days of November). Technical assistance, measured as number of manzanas covered by the "Proyecto Algodonero de Asistencia Técnica" (PAAT), also has a siginificant positive influence on cotton yields. This is an interesting finding in the context of the present study.

As regards pesticide mix an analysis similar to the one performed in the previous section suggests an optimum level of 38.6 kg/ha of chlorinated pesticides and no phosphorous pesticides at all. However, the phosphates (especially methyl parathion) are essential for chemical control of bollweevil (Antonomus grandis). This is an agricultural fact, and even integrated bollweevil management requires small amounts of methyl parathion. Therefore, it seems reasonable to postulate an optimum mix of 39 kilograms per hectare of chlorinated hydrocarbons and the smallest amount of phosphates necessary for bollweevil control. The presente balance of two kilos of chlorines for each kilo of phosphates implies that excessive pesticide use refers mostly to the phosphates and that it seems desirable from an economic standpoint to reduce as much as possible the levels of organophosphates used in Central America (See table 54).

TABLE 55

FACTORS AFFECTING COTTON YIELDS IN NICARAGUA, 1972/74

Variable	Regression coefficient	(t value) significance
Intercept (qq/mz) X0	7.49	1.51
Chlorinated pesticides (lbs/mz) X1	0.37	4.54 **
(Chlorinated pesticides)^2 (lbs/mz) X1^2	- 0.002	- 3.07 **
Phosphorous pesticides (lbs/mz) X2	- 0.423	- 2.73 **
(Phosphorous pesticides)^2 (lbs/mz) X2^2	0.0036	2.11 *
Land value ($/mz) X3	0.4	3.03 **
Rainfall (10 mm) X4	0.22	3.71 **
Farm size (mz) X5	- 0.025	2.34 *
Fertilizer (10 lbs/mz) X6	0.23	1.03
Technical Assistance (mz) X7	0.02	2.17 *

SOURCE: ICAITI

* Significant at the five percent level.
** Significant at the one percent level.

Discussion:

Several agro-ecological factors contribute to explain why phosphates can have negative effects on yields. Their higher toxicity and wide spectrum combine with disastrous results for beneficial fauna. A secondary effect of the parathions is to increase the infra-red emission of the cotton plant, thereby increasing its attractiveness to potentially undesirable insects.* Last, they may have direct negative consequences on the plant itself. These facts may be reflected in the negative sign confered to phosphorous pesticides in the statistical analysis.

The human health factors against the use of parathions are also strong. These toxic substances account for over 8[illegible]% of all poisonings. Furthermore, their use may have contributed to the development of cross-resistance in Anopheline populations to OMS-33 in cotton areas. This cross resistance may result in greater malaria problems.

There seems to be ample evidence which testifies to the desirability of cutting back the use of parathions for cotton pest control in Central America. How far back they can go depends on how successfully can alternatives for bollweevil control be developed and adopted, notably integrated bollweevil management.

Technical assistance: In a given Nicaraguan municipality, increasing the acreage covered by technical assistance in 1[illegible] manzanas results in twenty pounds of cotton per manzana more. This underlines again the positive effects of technical assistance on cotton activity and cotton supply. Investing in technical assistance is one possible way to estimulate higher yields and higher supply.

Since its inception this study has straighforwardly advocated integrated pest control technical assistance as a measure to decrease excessive pesticide use. Demonstration and experimentation in the last two years have shown that this is quite possible. Now, it has been statistically confirmed that technical assistance of this type results in higher yields at an aggregate level.

5.4 How to Encourage a More Economical Use of Pesticides in Cotton Production:

It was possible to clarify the influence of key variables on pesticide use. The study was complementary to integrated cotton pest control research, itself an efficient way to bring about a more rational pattern of pesticide use. The over-all philosophy was to find those factors which would enhance and support the adoption of integrated pest control.

Methodology:

The objective of this portion of the study was to find out which agro-economic variables affect pesticide use and by how much. A preliminary model was conceived, and a survey designed to obtain the necessary data. The data gathered were tabulated and processed statistically to relate them to pesticide use.

* Falcon, L.A., Personal communication, 1976.

The working model stated that pesticide use was a function of prices, scouting, sales efforts by pesticide firms, agro ecological information, technical assistance, fertilizer use and size of farm. It seemed obvious that higher prices would discourage use, as would technical assistance, ecological information and scouting. On the contrary, sales efforts, fertilizer use and size of farm would tend to promote higher use levels.

Since all of this information was unavailable a survey was designed in Nicaragua and El Salvador. About 8[illegible] farms were visited in each country. Copies of the questionnaire are found in Appendix [illegible]. This information was then related statistically through a multiple regression.

The influence of price on pesticide consumption:

Statistical analysis of the data obtained showed two important facts: 1) price is the most consistently significant factor affecting pesticide use, and 2) the influence of price is conditioned by the existence of pest control alternatives. These findings are discussed below.

El Salvador:

Price has a clearly strong negative influence on pesticide consumption at the farm level. An increase in the price of one pound of pesticides may result in a decrease in pesticide use. A 10% rise in prices will probably diminish quantity consumed by between five and eight percent in El Salvador. (Price elasticity of demand estimated between -.5 and -.8).

In a policy context, if a 40% duty is levied on pesticides imported into El Salvador, one could expect present use levels to drop from [illegible] kg/ha to about 45 kg/ha, the estimated economic optimum for Nicaragua. One could also stimulate pesticide use by reducing duties in the same proportion. This is not just an attempt to seem objective. Pesticides with particular environmental or human health advantages could be subsidized to encourage their use.

Nicaragua:

Here the effect of price changes on pesticide use per hectare appears to be more marked. The price elasticity of demand for Nicaragua was estimated between -.8 and -.12, which means that a 10% change in prices will probably result in a 10% change in use in the opposite direction.

The price elasticity of pesticide demand is greater (more elastic) in Nicaragua than El Salvador. Two factors may account for this fact. The general price level of pesticides is higher in Nicaragua. Farmers may be more sensitive to changes in pesticide prices as they porcentually "mean" more. Second, Nicaragua has practically developed integrated pest control as an alternative to pesticide use. If pesticides go up in price farmers can choose to delay the first application, to use higher pest population thresholds to lower pesticides dose or to rely on natural enemies. The options are also available to farmers elsewhere in Central America but they are not aware enough, trained enough not do they have reliable technical backing and advice on their decisions.

Price changes are a feasible alternative to promote more economical pesticide use levels and mix. As shown in an earlier section (p. 155) pesticide price increases or decreases appear to have no significant effect on planted area within a certain range. Yet their effect on pesticide use levels is notable. This is especially so where an alternative exists. For Guatemala and Honduras one would tend to expect a reaction similar to that of Salvadoran farmers; relatively more inelastic in the face of price changes because of the unavailability of alternatives. The effectiveness of price changes as a policy tool depends to a degree on the availability of substitute methods for pest control.

Pesticide substitutes in addition to technical assistance could be advice on economic thresholds, use of trap crops, resistant varieties and other strategies.

Other variables affecting pesticide use:

Although less consistently than price, other variables appeared related to pesticide use. These range from field numbers to the number of scouting looks per season per plot and include season's length, fertilizer use, farm size, yields, scout training and technical assistance visits. Follows a discussion of these variables in the countries where they were found to be significant.

El Salvador:

Factors positively associated with pesticide use were the percentage of scouts trained and the total number of technical assistance visits. They had elaticities of 0.03 and 0.027 , respectively. This suggests that the type of technical assistance and training presently effected in that country encourages pesticide use.

Two variables appeared to affect pesticide use negatively. These are farm yields and scout's experience, with elasticities of -0.27 and -0.32 . High yielding farms reported lower levels of insecticide use presumably because of more professional management. Also, more experienced scouts resulted in less pesticides used per hectare.

In a separate analysis, technical assistance and percentage of scouts trained appeared to decrease the share of organophosphorous pesticides and increase the proportion of chlorines. Elasticities for these variables were -0.022 and 0.27, respectively. All of the variables were significant at $0.05 \leq \alpha \leq .10$.

Nicaragua:

Apparently the effects of technical assistance are difficult to detect when examining farm data. Technical assistance variables were not found significant probably because of how they were quantified. The number of extension visits may result in lower pesticide use, but it may also reflect increased extension efforts in particularly unreceptive farms.

Three factors seemed to increase pesticide use: season's length, field numbers and fertilizer use. The elasticities for these variables were 0.668, 0.1 and 0.55, respectively. The longer cotton is kept on the ground, the more yield a farmer can get and the more pesticides he ends up using. The number of fields per farm may increase pesticide use by increasing the possibility of fringe infestations. Fertilizer use maintains the cotton plant lush and attractive for pests. It may result in higher use of phosphorous pesticides in Nicaragua. Promoting optimum fertilizer use may yield as a side effect a sizable (e = .55) reduction in the use of phosphates. A 10% decrease in the use of fertilizer may cause a 5.5 % decrease in the use of phosphates (parathions).

Factors decreasing pesticide use in Nicaragua are farm size, yields, scouting looks and scouts years of training. The elasticities for these variables were - 0.168, -0.112, -0.077 and -0.09, respectively. Farm size and yields reflect better management; the significance of scouting training and intensity reflects the emphasis on pesticide substitution in Nicaragua.

Selective price changes perhaps through import duties, appear to be the quickest and most effective way to modify pesticide use. Other variables, notably fertilizer use, scouting and technical assistance can play an important role. The effectiveness of price on pesticides appears to be related to the existence of viable alternatives to chemical pest control. Alternatives include integrated pest control and its components, trap crops, economic thresholds for pests, dosage reduction, scouting, optimal fertilization, etc.

Price increases of 10% would appear to cause reductions in pesticide use of between 6 % and 10%, depending on whether or not there are alternatives available.

5.5 Natural fruit shedding and economic pest thresholds for cotton.

This section discusses the potential for developing and using more appropriate economic pest thresholds for cotton fruit pests. Fruit pests (especially bollweevil and bollworm) are economically important. They cause the majority of insecticide applications in Central America. The dicussion that follows will deal exclusively with the bollworm (Heliothis zea) partly because its fruit consumption habits are better known. With regards to bollweevil it is felt that future innovations will be the application and refinement of integrated weevil management (see previous chapter).

5.5.1. Background:

In a strict economic sense a pest threshold is the population number whose potential economic damage to the crop is exactly equal to the cost of avoiding that damage. It is the point at which the marginal cost of controling equals the marginal benefit of control expressed by the value of the cotton saved. It can be understood by saying that a pest control measure has to pay for itself in order to be justified. So one lets the pest eat and grow until the damages it is about to cause are exactly equal to what it would cost to destroy it.

It is doubtful that farmers regard pest control in such a precise manner. They seldom have a precise idea of the potential economic damage of a pest like bollworm at every stage of crop development. Furthermore there is a tendency to employ pesticide applications as a kind of risk insurance against possible crop losses. Too, some farmers strive to obtain maximum yields without due regard to costs.

The objective of this section is to give an idea of the potential economic damage of bollworm at different crop stages. This is approached by discussing the capacity of the cotton plant to withstand fruit losses. This capacity and other economic considerations may serve as a point of reference for developing more refined economic thresholds for bollworm.

The use of more refined economic thresholds may lead to a more rational use of pesticides in cotton production in a strict micro-economic sense. It may also lead to a reduction in the use of pesticides which might bring about the environmental and human health benefits of a lower pesticide load.

5.5.2. Fruit shedding:

The cotton plant produces many more fruit than it has capacity to nurture and support until they become open bolls of cotton. Whenever the demand for plant energy by these fruit and other plant processes becomes greater than the available supply of energy the plant may drop a sufficient number of young fruit to balance the energy equation. This can also occur in response to environmental stress. This behaviour (called natural shedding) becomes more intensive as the cotton growing season advances.

Natural shedding is a genetic characteristic which results from the "indeterminate mode of reproduction of the cultivated cottons" (1). This reproductive mode is called "opportunistic" and it means that the plant is constantly producing new fruit (although at different rates) in the hopes that some of them will encounter favorable environmental conditions. This behavior is believed to be a left-over of the times when cotton grew wild in desertic climates many years ago (1).

Natural shedding still confuses many Central American farmers. They feel that every floral button and boll should be defended from pest attacks even though they know that only a portion of these fruit will ever become cotton bolls. They ignore when or why natural shedding occur. Pesticide salesman may often share and enhance their well-intentioned over protectiveness.

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(1) Davison, A.; Computerized plant Growth Analysis of the interactions of Arthropod pests and other factors with the cotton plant; (Unpublished Ph. D. dissertation) (Berkeley: University of California, 1973) p. 3.

Some aspects of natural shedding make its understanding difficult. Natural shedding supposedly occurs as a response to a gap between energy supply and demand. The supply of energy is affected by photosynthetic rates and foliar surface. Photosynthetic rates depend on solar luminosity, chlorophyll concentration, temperature, chemical composition of the air, moisture, etc. Chlorophyll concentration in term is dependent on available nutrients, and so on. The demand for energy depends on the rate at which vegetative grown proceeds, the number and age structure of the fruit parts, respiration and so forth.

There is at present no model available which relates all of these factors to explain the occurance and intensity of natural fruit shedding.[1]

Another source of difficulty stems from the fact that shedding may also be induced by pest attacks. Although pest-induced shedding may (an indeed does) substitute for natural shedding to a large extent it is believed by many that the two do not coincide. A farmer or technician who counts the scars left on plants when fruit fall has no straightforward way of telling which ones represent natural shedding and which ones are caused by pest attacks.

Two characteristics of natural shedding deserve to be discussed further. First, it is apparent that as the cotton season advances shedding rates increase. This has been observed by many before.[1,2,3,4] The second can be stated as hypothesis, and is that pest-induced shedding offsets natural shedding to a fairly large extent.

That shedding rates increase as the season advances can be explained through the energy balance model of the plant.[5] Fruit demand a large amount of energy when they are going from small bolls to large bolls. As more bolls begin to grow the plant must somehow meet the increased energy demand. It does so by shedding a number of young fruit. In Central America this high energy demand period occurs after 60 days from planting have elapsed.

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1. However, the work of cotton plant analysts such as Andrew P. Gutierrez at the University of California, Davis, and others is leading in this direction.

1. Vaughan, M., and G. Leon, Personal communication, 1975.
2. Falcon, L., Personal communication, 1975.
3. Gutierrez, A., Personal communication 1975, 1976.
4. Davison, A., Op. Cit. P. 7, 157-8.
5. Gutierrez, A.P., Personal communication, 1976.

The intersection of natural and pest-induced shedding can also be explained by energy supply and demand. By eliminating some of the fruit parts pests effectively reduce the demand for energy. This will reduce the necessity for the plant to shed fruit parts on its own initiative.

Direct observation and analysis seem to support the aseverations made above. The data base consisted of plant fruiting information on two Nicaraguan plots during the season 1974-75.[6] A total of 10 plants were monitored in each plot. Frequent counts were made of the number of scars as well as other parameters of growth such as leaves, mainstem nodes, squares, flowers, bolls and plant height. One of the plots received no insecticide treatments and the other was thoroughly defended Thus it is possible to see whether shedding rates differ greatly where pest-induced shedding is large as opposed to where natural shedding predominates.

The following equation gave best fit in expressing total shedding as a function of time for the unprotected plot in (El Ojoche) Nicaragua (R = .95) (see table 95, appendix 4).

$$Su = (1.135*10^{-6}) \quad D^{3.7} \qquad \text{----------(1)}$$

Where Su = Total shedding in one plant in the unprotected plot.
D = Days after planting (in Central America one calendar day equals one day degree)*

From equation (1) the shedding rate can be derived:

$$\frac{dSu}{dD} = (4.2 \quad * \quad 10^{-6}) \quad D^{2.7} \qquad \text{----------(2)}$$

It is apparent that as the number of days (D) increases expected daily sheddihg becomes larger. The exponent 2.7 gives the change in the rate of shedding for that equation.

For the protected plot the following equation was calculated (R = .95) (table 96, appendix 4).

$$Sp = (3.33*10^{-11}) \quad D^{5.782} \qquad \text{----------(3)}$$

Where Sp = total shedding in one plant in the protected plot.
D = days after planting.

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6. Data tables were provided by Dr. Rainier Daxl and are shown in appendix 4.

* Daxl, Rainier, Personal communication, 1976.

Again, the shedding rate is given by the first derivative of equation (3).

$$\frac{dSp}{dD} = (1.92*10^{-10})\ D^{4.782} \qquad \text{----------(4)}$$

Here again the shedding rate increases as time elapses. Comparing equations (2) and (4) gives an idea of the magnitude of the intersection between "natural" and pest-induced shedding in this particular case. Figure 27 shows a graph of equations (2) and (4) superimposed. The increase of shedding rates with the passage of time is clear. Also evident is a certain correspondence between shedding rates in the protected and unprotected plots.

Although shedding rates are higher in the unprotected plot in the beginning (presumably because of pest attacks) they do not appear to increase as rapidly as the rates in the protected plot. In figure 27 the two curves actually intersect at about day 120. It is possible that the energy savings caused by the destruction of fruit by pests early in the season helps curtail natural shedding in latter stages.

If all of the shedding were induced by pests the curve for the untreated plot would be a flat straight line at about 5 thousand scars. This is because the usual threshold for a plot of 1 manzana with 20,000 plants is about 5,000 larvae and one larva consumes about one fruit-part per day.

Natural shedding exists separate from pest-induced shedding and the two substitute for each other. Otherwise the two curves in figure 27 would never cross.

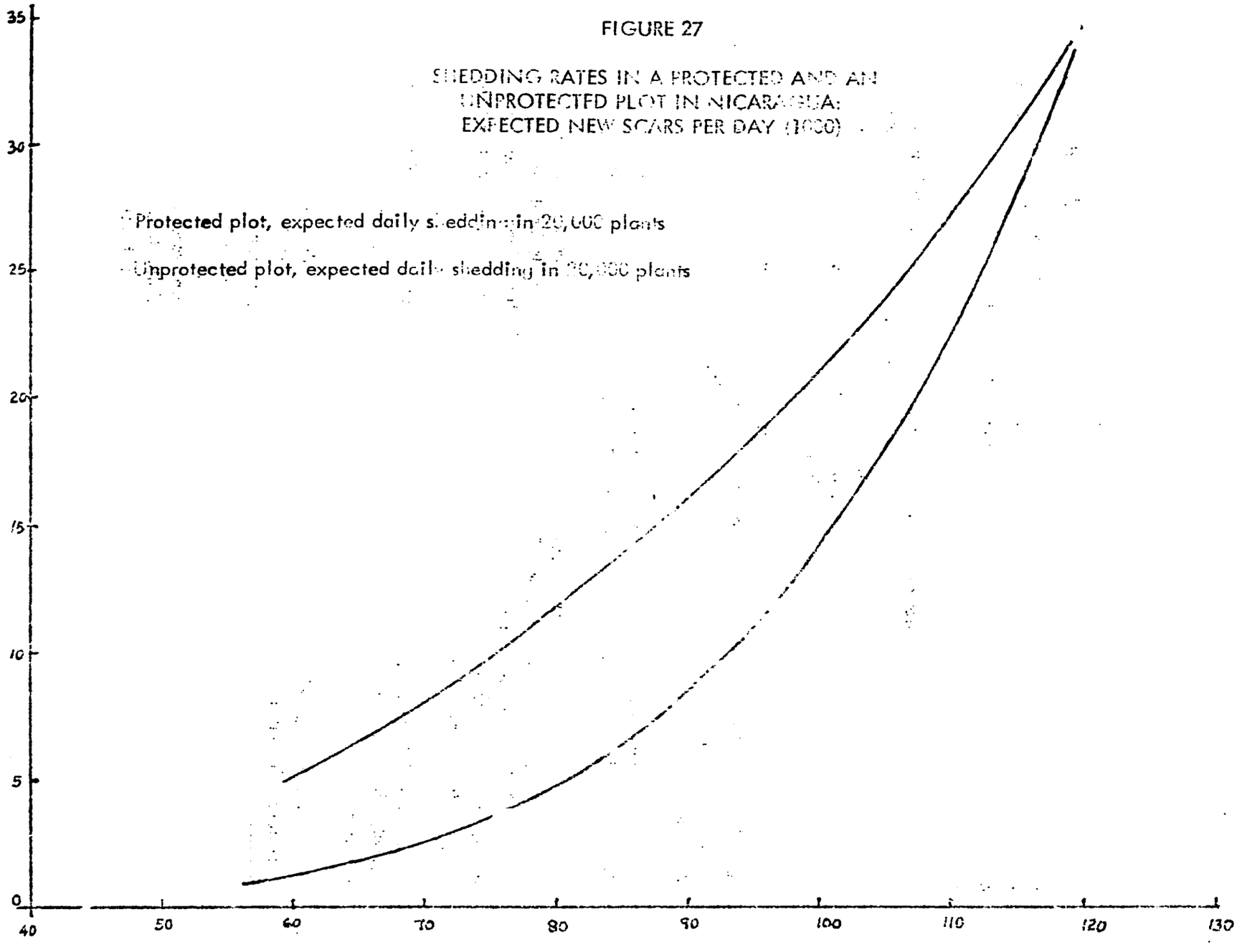
Comparing the integrals of both curves between 60 and 140 days gives total accumulated shedding for that period. This integral was 94.7 fruit parts for the undefended plot and 84.7 for the protected plot. Total shedding was only 10% higher in the unprotected plot, presumably because of pest attacks. Pest-induced shedding indeed seems to compensate for natural shedding to a large extent.

The data seem to support the hypothesis that pest-induced shedding makes natural shedding less necessary. This is consistent with the notion of an energy balance within the plant.

The analysis above has several limitations. One of them is that only two plots in particular circumstances were compared. Furthermore one of the plots is located near Managua and the other in Posoltega, two localities under different conditions of soil and climate. There are no records available of pest-incidence in either plot. It is reportedly difficult to count scars very accurately (although this problem is smaller when only ten plants are being monitored). Nevertheless it is clear that shedding rates increase with time and that possibly pest induced shedding offsets natural shedding to a large extent. This hypothesis must be tested further in order to be accepted without reservations.

FIGURE 27

SHEDDING RATES IN A PROTECTED AND AN UNPROTECTED PLOT IN NICARAGUA: EXPECTED NEW SCARS PER DAY (1000)



5.3.3. Shedding and economic thresholds.

The shedding behavior of the cotton plant contributes substantially to the design of economic thresholds for fruit pests. If pest induced shedding offsets natural shedding to a large extent then the economic thresholds for fruit pests should increase as the plant grows older paralell to increased shedding. This is apparent from the nature of equations (2) and (4) and from figure 27.

Present knowledge indicates that a bollworm larva consumes about one fruit part per day during its 14-day existence as a larva [1,2]. From a pest management standpoint tolerating 8,000 larvae per hectare during one day implies a willingness to lose 8,000 fruit parts that day. If natural shedding rates are above the rate of boll destruction by pests it is likely that total yields will not be smaller because of that particular bollworm population.

If pest-induced shedding can largely substitute for natural shedding (up to 90%, say) and if the shedding rate observed in the protected plot adequately reflects natural shedding one could make some inferences about tolerable populations from equation (4). Those inferences would only be valid for the plot where the observations were made and for the year in which they were made.

In order to maximize the tolerable population (and thereby minimize pesticide use) subject to a condition of no-decrease in "normal" yields one would only have to apply equation (4). From the number of days after planting and a plant population density of 20,000 plants/hectare one could estimate an expected shedding rate. Because of the observed one-to-one correspondence between bollworm population and fruit damage the shedding rate becomes the maximum tolerable population of bollworm larvae during one day which will not result in smaller cotton yields/hectare.

For example, at day 70 the maximum tolerable population would be about 2,500 larvae (large and small). At day 80 it would be 4,800; at day 90 the number would rise to 8,500, at day 100 it would reach 14 071, and so on.

This is not an economic threshold for bollworm because one still needs to take into account the price of cotton and the cost of control. Current seedcotton prices (1976) stand at about $0.20 per pound. It takes an average of 100 bolls to produce one pound of cotton. The potential value of one boll is therefore $.002. Unless localized applications are employed it costs about $10.00 to treat one hectare with a common dosis of usual pesticides. In order to justify spending $10 in an application of pesticides one would have to save (10 ÷ .002) bolls, or 5,000 bolls. One must tolerate, therefore, 5,000 larvae/ha. above the threshold of physical damage to reach the threshold of economic damage. In abstract terms the economic "band" above physical thresholds is given by:

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1. Romero, A., Personal communication, 1976
2. Falcon, L., Personal communication, 1976

$$E = \frac{\frac{Pp}{Pc} * N}{C} \qquad \text{----------(5)}$$

Where Pp = cost of the control measure per unit area
Pc = price of one pound of cotton with seed
N = number of bolls to make one pound of cotton
C = estimated boll consumption by one individual pest in one day

The economic thresholds suggested by equations (4) and (5) with present cotton and pesticide prices and for that particular year (1974 - 75) in that particular plot (Posoltega, Nicaragua) would be as follows.

TABLE 56

Economic Threshold for Bollworm in Posoltega, Nicaragua for 1974-75, in Thousands of Total Larvae/Hectare

Plants/hectare	Day	# of total bollworm larvae*
20,000	60	6,080
20,000	70	7,250
20,000	80	9,320
20,000	90	12,650
20,000	100	17,600
20,000	110	24,800

* This column was calculated as follows:

$$(1.92 * 10^{-10}) D^{4.782} * 0.9 + \frac{\frac{Pp}{Pc} * N}{C}$$, which for the present case

becomes $(1.92 * 10^{-10}) D^{4.782} * 0.9 + 5000.$

Using table 56 for practical purposes would entail several risks. Average shedding rates may be different from one year to the next even in the same plot. Pest-induced shedding need not overlap natural shedding 90%. Prices and costs are alas subject to changes at any time.

Nevertheless present bollworm threshold knowledge makes it possible to give some experimental recommendations. The Nicaraguan integrates pest control assistance program recommends a threshold of 5,700 to 7,000 small larvae per hectare after the first small boll appears (day 60) and 8,600 or more after the first boll opens (day 120 approximately).

The above analysis is consistent with the recommendation of the Nicaraguans at the beginning but suggests that the threshold level might be allowed to rise more rapidly. Table 56 shows a value of 17,600 larvae for day 100, for instance. It would be very easy and perhaps profitable to compare the two thresholds in the field.

The actual threshold that a farmer employs is affected by his risk aversion preferences. A conservative farmer may prefer to invest in pesticides rather than to risk losing a part of his expected crop. A less conservative farmer may be willing to accept more risk. A careful technician is basically in the same position. Furthermore, in deciding to treat a pest-infested plot the technician or the farmer takes into account a number of factors such as climate, beneficial population activity, pest population growth rates and even the phase of the moon.

The simplest way to give and example of risk aversion would be to imagine someone who believes half of what is said above. He would be naturally inclined to halve the numbers given in table 56. It is obvious however, that the threshold need not go below 5,000 larvae/hectare with current prices and costs. So this prudent technician would start with a threshold of 5,000 larvae/hectare at day 60, and would add to that number half of the increment given in table 56 for the rest of the intensive fruit-setting period. Thus, at day 70 he would be using as a point of reference a threshold of 6,125 larva/ha; at day 80 he would raise it to 7,160, at day 90 to 8,825; at day 100 to 11,300; at day 110 to 14,900 and at day 120 to 20,300 total (small and large) larvae per hectare.

These numbers are given mainly to stimulate interest in the potential benefits of more refined thresholds and to give ideas for field experiments. In reality the farmer or technician bases his decision on a number of considerations as stated above. Obviously daily pest counts are almost essential for the application of the principles outlined. Even a threshold based on expected shedding given ecological and climatic conditions would not be more than one reference point in the complex system of a pest management methodology.

The technician and the farmer are especially interested in small bollworm larva (less than 1.27 cm.) because beyond that size chemical control is very difficult. Within the framework of the above analysis one has to add up all the larva together. When control becomes necessary it is hoped that destroying the small larva may be sufficient to drive the population below the threshold. Even so the prudent farmer might decide to control a population because existing environmental and ecological conditions suggest high future populations of large larvae.

Studying fairly intimate details of the behavior of the cotton plant and of its related fruit pests may lead to more efficient pest management criteria. So far a limited understanding of these interactions has probably propitiated a higher insecticide use than would appear to be economically desirable. Many of the points discussed above are common knowledge among cotton technicians. Perhaps a more generalized distribution of research results might encourage a more rational use of pesticides to the benefit of the farmer, the environment and the economy.

6. SYSTEMS ECOLOGY AND ENVIRONMENTAL MANAGEMENT TO REDUCE PESTICIDE POLLUTION IN CENTRAL AMERICA

6.1 Introduction:

A serious environmental problem exists in Central America as a consequence of pesticide use in cotton production. The aim of the research project is to develop a systems management program to reduce the hazards to the environment and public health and also to reduce the economic costs of pesticide use in Central America. Pesticide use is a highly complex environmental problem in Central America and is interrelated with the economy, human welfare, public health, and environmental quality.

An investigation of such complexity necessitates a multi-disciplinary effort. Hence, the research project includes a team of specialists; environmental chemists, public health epidemiologists, economists, pest control specialists, and systems ecologists. The environmental chemists are measuring how widespread and seriously pesticides are distributed in food and water as well as various wild species of plants and animals in Central America. The public health epidemiologists are collecting data on the extent and seriousness of human insecticide poisonings in the population and documenting the relationship of increased human malaria to pesticide use in cotton production. The economists are studying to which extent are present levels of pesticide use necessary for profitable cotton production and what are the social and private costs and benefits of producing cotton to the Central American economy.

The pest control specialists are investigating strategies of reducing insecticide use for insect control in cotton employing an integrated pest control program. The effectiveness of the integrated pest control program is being evaluated based on economic, environmental and health risks and benefits.

The systems ecologists of the project are describing the ecological system related to the environmental pesticide problem by focusing on the interrelationships that exist among the major factors that make up the system. The aim of systems ecology for this multi-disciplinary research effort is three-fold: (1) to identify and describe the major factors and the ecology of the interactions among them; (2) to explain in detail the ramifications of pesticide use in cotton in the Central American ecological system; and (3) to examine all proposed solutions for their possible benefits and risks as they relate to the whole ecological system.

The need for systems ecology is to help guarantee that any new proposed systems management program will not lead to further environmental problems. An equally important need is to provide an understanding of the problem to legislators, public health officials, agriculturalists, economists, environmentalists, and the public in general. Information on the ecological system should provide a clear explanation of how government, laws, the economy, the environment, public health, and the public are all interrelated in this pesticide pollution problem associated with cotton.

The systems ecology information plus the proposed environmental management program will aid each group (government, economy, public health, agriculture, and public) to identify their responsibilities and the necessary policy decisions that have to be implemented to solve this complex environmental problem. Hopefully, this aproach will make the decision making processes more effective by reducing self-interest conflicts.

The systems ecology investigation will be developed in two stages. First, we will provide an overview of the total ecological system as one might view a "forest" from on high. Second, we will focus on each of the major factors that make up the structure of the system and examine the interrelationships of these major factors in detail. Although some of the sub-models such as the economic model of cotton production can be developed by utilizing mathematics, the ecological system involved in this investigation is much too complex at this time for mathematics and exact quantitative relationships. Therefore, our presentation will employ diagrams, matrices, and written explanations to describe and analize the dynamics of the ecological system in Central America.

6.2 Overview:

An overview of the prime factors in the ecological system and the interrelationships that exist among these factors are diagrammed in figure 28. The lines in the diagram indicate the complexity of this ecological system and suggest that any systems environmental management program should involve decision makers from various segments of society such as government, agriculture, industry, environmental concerns, public health, and public interest groups.

The lines in figure 28 indicate some of the interrelationships; details of the interrelations are presented in figures 29-36. An overview of the major factors interrelated with the pesticide pollution problem in Central America are discussed in the following categories:

Cotton and the economy

Agriculture dominates the economy of Central America (figures 28, 29). About 60% of the economically active population is involved in agriculture and an estimated 70% of the nation's exports are food and fiber products. As for the value of export crops, coffee is first followed closely by bananas and cotton. Thus, cotton is a dominant part of the economy of Central America.

An estimated 393,000 ha are in cotton in the Central American nations of El Salvador, Guatemala, Honduras, and Nicaragua. Cotton is a dominant influence in the economy and a large part of the environment in Central America.

Insecticides used in cotton:

The pesticide problem is primarily an insecticide problem (figures 28, 29). Relatively small quantities of fungicides and herbicides are applied to cotton in Central America. Nearly 28,139,000 kg of pesticides are used annually in cotton production; an average of 71.6 kg per hectare is applied to cotton. In El Salvador where insecticide use is the heaviest, an estimated 515 kg is applied per km2. An estimated 1/5 of the world's parathion is applied in this small nation.

Cotton would be difficult to produce in Central America without insecticides because of severe insect problems. Starting about 1950, when insecticides were first used extensively on cotton, about 8 sprays were applied during the cotton season. The number of applications has risen to about 30 and as high as 40 per season in some cases. The reason for the widespread increase in insecticide use is that this action represents the only currently available response of the cotton farmer to deal with increasing insecticide resistance in pest insects and loss of natural controls (beneficial predators and parasites). Because of the large number of treatments and heavy dosages, the cost of cotton production has risen significantly. However, insect pest control is still not satisfactory. Because of this situation, an economic crisis underlies Central American cotton production.

Insects in the cotton ecosystem:

Cotton originated in Central America as well as in the West Indian Islands(figures 28, 34). In addition to being the native home of the cotton plant, Central America is also the native home of some of the most serious cotton pests including the bollweevil and several bollworm species. Because some of the natural resistance to insect pests is absent in commercial cotton and temperature and moisture are optimum, conditions are ideal for these and other cotton pests. Hence, there is a need for some insecticide to prevent pest outbreaks.

Several species of natural enemies(predators and parasites) function effectively to limit cotton-pest insect populations. However, if insecticides are applied without knowledge of both the ecology of the pest and beneficial insect populations, natural control effectively disappears. This has happened in Central America and is on of the reasons that more and more insecticide treatments are necessary to deal with worsening insect pest problems.

Human poisonings:

Non-fatal and fatal human poisonings total about 3,000 annually in Central America (figures 28, 30). Only a small percentage (about 0.5%) of these poisonings are fatal. The insecticide that is primarly responsible for most of the poisonings is methyl and ethyl parathion. Most human contact with the insecticides occurs when farm workers and scouts come in contact with the insecticide-contaminated cotton fields and plants. The insecticide residue is picked up while farm workers are weeding and/or harvesting cotton. The scouts who monitor insect populations are also exposed to toxic dosages of the insecticides while measuring pest and beneficial insect populations.

Malaria and mosquitoes:

The anopheline mosquito (Anopheles albimanus) is the prime vector of malaria in Central America (figures 28,31). The heavy use of insecticides on cotton in the coastal plain regions (and contamination of the aquatic habitat of the mosquito) has resulted in the evolution of mosquito populations that are highly resistant to a wide range of insecticides. Currently, all insecticides, with one possible exception, are relatively ineffective against this mosquito.

One important reason why the mosquito populations in the coastal plains have become resistant to the cotton insecticides is the use of aircraft applications. About 50% of the insecticide applied by aircraft drifts to habitats outside of the cotton fields. Thus, most of costal plain habitat including the mosquito's aquatic habitat has been contaminated with cotton insecticides. With such intense exposure to a wide variety of insecticides, the mosquito population is highly tolerant to a wide variety of insecticides.

Bacause of this high level of resistance to insecticides, mosquito control expenses have increases significantly. For example, house spraying with DDT cost only $7 per house. With resistance to DDT, propoxur (carbamate insecticide) was substituted for DDT. The cost of house spraying increased to about $15 per house. Now with many mosquito populations resistant to propoxur, the only insecticide available is landrin. This material costs about $22 per house treatment. It should be pointed out that houses have to be treated about 4 times a year except when DDT is used.

With increased mosquito populations because of ineffective control, malaria (Plasmodium falciparum) is increasing. In El Salvador, one of the worst problem areas, the incidence of malaria increased from 33,000 cases in 1973 to about 66,000 cases in 1974.

Effect of insecticides on livestock, other crops, and the fishery industry:

Beef cattle that are produced on the coastal plains where cotton is produced may become contaminated with insecticides (figures 28, 29, 31, 33). Beef containinggreater than 5 ppm of DDT, for instance, cannot be exported to the United States. Several shipments of beef have been rejected and/or could not be shipped. Some of this contaminated beef is also sold in the Central American market at lower prices. A few cattle have been killed when they were accidentally exposed to high insecticide dosages.

Milk and other dairy products may contain high pesticide residues. Reported milk contamination averages about 20 ppm and ranges as high as 100 ppm. Beef and dairy cattle obtain insecticide residues from both contaminated forage and contaminated concentrate feed, such as cotton seed meal. The forage becomes contaminated from atmospheric drift via aircraft applications.

Corn is one of the main staples in the diet of the people of Central America. Corn grown adjacent to cotton areas has been found to be contaminated with insecticide resi dues. In addition, circumstantial evidence suggests that corn disease is more prevalent on corn grown in the cotton regions.

The production of other crops such as beans, squash and other food crops may be affected by the insecticide pollution because the necessary pollinating insect populations have been reduced. Crops grown in the coastal plain with cotton also become contaminated with insecticide residues. For example, from 0.1 to 1[illegible] ppm of DDT has been found in beans. How serious the insect problems are because of the residue present in the enviroment has not been determined. Some reports suggest that insect pest problems are more severe on crops in the cotton region. The corn pest problem mentioned earlier is only one example.

Reports have also been received that commercial fish and shrimp populations have been reduced due to severe insecticide contamination. Since accurate population data on fish and shrimp are not available, it is not possible to confirm or deny these claims. However, there is no question of insecticide residues in both the shrimp and fish.

Fresh water and salt water(estuaries) are readily contaminated since pesticides drift in the atmosphere and alight on water, and insecticides are washed from the land into strams and ponds.

Effects of insecticides on the environment:

The water, land and air are all contaminated with insecticides because of the large quantities of insecticides applied and because most of the insecticide is applied by aircraft (figues 28, 33). Less is known about the impact of the pesticides on the biotic environment.

The biotic environment in Central American probably consists of an estimated 100,000 species of plants and animals. Because of the intense biological activity of insecticides, it is expected that the large quantity of toxic insecticides applied to the Central American environment is having a significant impact on many animal and plant populations. Without good population data before insecticides contaminated the environment to compare with after contamination data, it is impossible to give an estimate of the impact. On the basis of experience in the U.S., the impact should be significant.

Government:

The government is included as a major component of the ecological system for several reasons: (1) the government establishes laws such as pesticide regulations that influence use and methods of applying pesticides; (2) the government controls public health programs, establishes industrial hygiene standards, and institutes effective worker compensation programs; and (3) the government responds to public pressure and is constrained by the strength of the nation's economy. Hence, the government, including the legislators, interacts with all the major components discussed (figures 28, 30, 31, 35, 36).

6.3 Ecological System in Central America:

An overall perspective of the ecological system was provided in the overview. This perspective is valuable in gaining a general understanding of the interrelationships of the major components, however, it does not provide the detailed understanding of ecological system that is needed for effective environmental systems management programs.

It should be emphasized that not all factors in the system can be included in this analysis because the ecological system is much too complex and in some cases is beyond current available knowledge. In addition, to include all the factors in this systems analysis would hinder our understanding because many of the important factors would be hidden in the complex maze of many minor factors. For example, there are an estimated 100,000 species of plants and animals in Central America. It the taxonomy and ecology of all of these species were known, the task of analyzing and documenting all of their interactions plus the interactions with the physical environment and man and all of his manipulations would be much too complex for comprehension. Hence, a significant degree of aggregation is necessary and 130 major factors have been identified as significant in this systems analysis. The interrelationship among the 130 factors provides the potential for 16,900 interactions. Some of the interactions have little or minor effects. Consideration in this analysis will be given primarily to those factors that have strong interactions. The focus of this analysis will be to provide an understanding of the ecology of each of the 130 major factors and their interdependencies.

Several flow diagrams (figures 29,36) indicating the major interactions of several factors related to a particular aspect of the ecological system have been prepared. The interdependencies among diagrams are easily detected by identifying one or more factors that occur on another diagram.

The 130 major factors are listed below and an explanation of the major interactions are described:

Parathion:

Parathion (methyl + ethyl) is one of the commonly used insecticides in Central America for cotton production (figure 29). The reason for parathion's widespread use is its relative effectiveness against the bollweevil, bollworms, beet armyworms, leafworms, sucking insects, and other pests of cotton. Parathion also is relatively low in cost and this makes it attractive for use by cotton growers.

Parathion, as well as destroying insect pests, also destroys beneficial lady beetle predators, lacewing predators, other predaceous insects and mites, Trichogramma spp. parasites, and other beneficial insects. When beneficial natural enemy populations are reduced to low levels, pest populations, once free of the effect of parathion, increase rapidly to outbreak levels. These outbreaks require further insecticidal treatments.

The prime cause of the non-fatal and fatal human poisonings is parathion use (figure 30). The LD_{50} to man for parathion is about 10 mg/kg compared with DDT that has an LD_{50} of about 600 mg/kg. Obviously parathion is highly toxic to man. However, an advantage of this toxicant is its low persistance in the environment. On the surface of plants it seldom lasts longer than a week, whereas in soil or water it may persist for a maximum of 3 to 6 months.

The human population most often exposed to parathion are the cotton farm workers and scouts. The farm workers (mostly adult male) come into contact with the parathion while weeding and harvesting cotton in the fields. The scouts who monitor insect populations come in contact with parathion residues on the cotton plant while measuring pest and beneficial insect populations in the field.

Support of the fact that most of the non-fatal and fatal insecticide poisonings are due to parathion is the evidence that the symptoms and signs of the poisonings are cholinergic.

Parathion is applied to cotton as a dosage of about 1 kg/ha using aircraft. Large quantities (about 25 kg/ha) of parathion are used; it is widely dispersed since most applications are made by aircraft (see aircraft application). Parathion is extremely toxic to most animal life. Parathion residues in the environment are one of the prime selective forces causing resistance to evolve in the anopheline mosquito population.

Since all parathion is imported, this is costly to Central America. The pesticide industry in Central America that formulates parathion benefits from the large parathion volume applied to cotton.

DDT:

DDT alone or in mixture with Toxaphene is also a commonly used insecticide in cotton production in Central America (figure 29). The chemical is cheap and relatively effective against bollworms and some sucking insect pests much as plant bugs. An important value of DDT use on cotton is that DDT allows more predators and parasites to survive and remain effective in controlling cotton pests than is the case with parathion.

Because DDT is a persistent pesticide and has a half life of 10 to 30 years, serious residue problems exist in the environment. DDT residues and other chlorinated residues have caused rejection of beef cattle shipments. Residues in milk are also quite high, averaging about 20 ppm and ranging as high as 100 ppm. In this situation, DDT acts as a good marker indicating the movement and accumulation of persistent pesticides in the environment.

As indicated in the parathion section, DDT is relatively non-toxic to man. Hence, although residues of DDT are realtively high in man, all evidence suggests there is no serious health problem from DDT. With predaceous birds, the situation is just the opposite based on US. experience. Hawks, falcons, and other predaceous birds are particularly sentitive to DDT and the effect is eggshell thinning and embryo mortality. Although it has not been investigated in Central America, the situation is probably similar to that in the U.S.

With DDT residues widespread throughout the environment, the anopheline mosquito populations are highly resistant to DDT (figure 31). The resistant mosquitoes are difficult to control and malaria in man has increased. All of the DDT is imported and the pesticide industry does all the formulating in Central America.

Toxaphene:

Toxaphene mixed with DDT, is also commonly used in cotton production in Central America(figure 29). The ecological aspects of toxaphene in the cotton ecosistem and other parts of the environment are similar to that of DDT.

Toxaphene is more toxic than DDT to man and is estimated to have an LD_{50} of about 100 mg/kg.

Propoxur:

Propoxur is a carbamate insecticide used for anopheline mosquito control (figure 31). The chemical was initially effective but now the mosquito populations on the coastal plain where cotton insecticides have contaminated the environment are resistant to propoxur. The result has been an increase in mosquito populations which in turn has resulted in an increase in malaria in some of the cotton regions.

When first used, propoxur contributed to a reduction in mosquitoes and malaria and was a significant factor in improving public health. In many areas, as mentioned, propoxur is no longer effective because of mosquito resistance.

As with the other insecticides, propoxur is imported and then formulated in Central America.

Landrin:

Landrin is a new carbamate insecticide that is effective against anopheline mosquitoes that are resistant to propoxur (figure 31). The chemical, however, is not presently registered for use against mosquitoes. Also the chemical is twice as expensive as propoxur for house spraying (see house spraying).

Since Landrin is also a carbamate, it is doubtful that Landrin will remain effective against the mosquito population for long. The multiple-insecticide resistant-mosquito populations should overcome this chemical in a year or two.

Galecron (Fundal):

Galecron (or Fundal) is a new cotton insecticide that is as effective as parathion for control of some cotton pests but has the advantage of being less toxic to man and to natural enemies in the cotton field (figure 29). These advantages make this insecticide highly desirable for the integrated pest control program (figure 34). However, the principal producer of Galecron has temporarily retired its product from the market because of health hazards.

As with the other insecticides, these chemicals are imported and formulated in Central America.

Cotton production:

As mentioned in the overview cotton production is a vital element in the economy of Central America (figures 29, 32). It is the third most important export crop in Central America. Most of the economically active population (60%) are employed in agriculture, and cotton is a dominant factor in farm worker(including scouts) employment. Most of the work is weeding and harvesting cotton.

Some of the farm workers live in the hill regions and migrate to the coastal plains during the cotton growing season.

Because cotton is native to Central America and many of the pests are also native to the region, serious insect pest problems are common on cotton. Insecticides are presently essential to cotton production.

With large quantities of insecticides (an estimated 60 kg/ha) being used in cotton production and most of these materials applied by aircraft (ultra-low-volume), serious environment contamination has resulted. The residues of chlorinated, phosphate, and carbamate insecticides in the environment has resulted in many, diverse ecological effects(figure 33). Beef, milk, and other foods have been contaminated. In the case of beef some exports have been rejected at the port of entry and in other cases the beef could only be sold in Central America at lower prices.

The soil in cotton fields is contaminated with many kinds of insecticides. These chemicals probably have some effect on the growth of the cotton plant.

Cotton insecticides as mentioned are directly responsible for the resistant mosquitoes and increase in malaria in some cases.

Shrimp and fish populations are resportedly lower than expected because of the toxic effects of the insecticides on these valuable food species. Confirming this effect is not possible because population data have never been collected. However, there is no question about the high insecticide residues present in shrimp, crayfish, and fish populations.

Clearing and managing land for cotton production has had a significant impact on the fauna and flora independent of the use of insecticides. Adding insecticides to cotton culture singificantly increased the impact of cotton on the environment.

Since cotton is one of the most important agricultural enterprises in Central America, the machinery, fertilizer, petro-chemical, and pesticide industries all benefit from this agricultural enterprise.

Corn:

Corn along with beans forms the staple food of the people of Central America(figure 32). Most of the corn needed for the population is raised in small plots throughout both the coastal and hill regions of Central America. Corn is also a dominant factor in the economy, society, public health, nutrition, and other aspects of the ecological system of Central America.

Corn production appears to be affected by the use of insecticides on cotton. Reports exist that corn stunt disease (virus) is more prevalent in corn grown near cotton. Corn stunt disease is transmitted primarily by leaf hoppers. It is possible that natural enemies of the leaf hoppers have been reduced allowing the leaf hopper populations to increase. Another possibility is that the sub-lethal dosages of the insecticides drifting onto the corn has stimulated the rate of increase in the leaf hopper population. Support of this proposition comes from the experiments with sub-lethal dosages of parathion and dieldrin on Colorado potato beetle populations. Beetles exposed to low dosages of these chemicals produced up to 65% more offspring. This suspected increased disease problem in corn is important and deserves investigation.

Corn is also contaminated with pesticides, primarily with chlorinated insecticide residues.

Other crops:

The other crops grown on the coastal plains are exposed to insecticide residues (figure 32). Residues of chlorinated insecticides have been detected on squash and other vegetables used as food by the people.

More severe pest problems have also been reported as occurring on these crops. As with corn, the problem may be associated with a destruction of beneficial natural enemies and/or a stimulation in the reproduction of the insect pests. Production of these crops has been hindered in some cases in the cotton region by a lack of insect pollinators. These pollinators were probably eliminated by insecticide used on cotton.

Beef cattle:

Beef production is an important agricultural industry in Central America(figure 32). Several million dollars worth of beef are exported annually to the U.S.

Problems, as mentioned in the overview, have developed in the export market because beef has been contaminated with DDT, toxaphene, and other chlorinated insecticides. Some beef shipments have been rejected because of insecticide contamination. Others were not exported and had to be sold in the Central American market at lower prices. Overall costs incurred reach about $1.5 million.

Beef cattle are being contaminated with insecticides by eating forage that has been contaminated by insecticide drift from the aircraft applications to cotton. Another way that the cattle obtain insecticides is through concentrate feeds that contain cotton seed meal also contaminated with insecticide residues.

Other livestock:

Milk production is important to the livestock industry (figure 32). Most of the milk and milk products are consumed in Central America.

Milk produced in the cotton region has been found to be heavily contaminated with DDT and the other chlorinated insecticides. Residues have averaged about 20 ppm and range as high as 100 ppm. The tolerance level for U.S. milk is only 0.05 ppm of DDT and other chlorinated insecticides. Exactly what impact the consumption of contaminated milk is having on young children is unknown.

Land:

The topography of the land influences soil quality and soil erosion problems(figure 32). More will be said about land quality in the sections on coastal and hill regions.

It is well known that land type influences crop and livestock production industries. Land also provides the habitat for terrestrial plants and animals. Land and the organisms living in the soil are important in the recycling of the vital chemical elements required by all life.

Soil quality:

Soil quality (structure and nutrients) determines the success of crop and livestock production (figure 32). The coastal plain region has good quality and this contributes to the success of agriculture, especially cotton in this region.

Increasing insecticide residues in the soil is degrading soil quality; soil microorganisms, beneficial insect and earthworm(annelids) populations are being reduced based on information, from other studies. These organisms are important in degrading waste, preying on pest insects and microorganisms, and in turning over the soil. In addition, increasing the quantities of insecticide residues in the soil may suppress the growth of cotton and other crop plants.

Soil erosion:

Soil erosion is a serious problem in Central American agriculture. Cotton is normally planted in 40 inch rows (figure 32). This leaves the soil unprotected and severe erosion occurs. On the coastal plains an estimated 16 to 20 tons of top soil are being washed and blown from the cotton fields annually. This erosion degrades the soil for crop production.

At the same time the insecticides deposited on the upper layer of soil are washed or blown with the soil into other parts of the environment. The aquatic habitat particularly receives large quantities of the insecticides transported with the soil.

The soil sediments carried into the aquatic habitats also have a detrimental ecological effect by killing fish, crayfish, insects, and plants.

Steams:

The slow flowing streams on the coastal plains are major factors within the ecological system (figure 33). These streams provide water for many farm workers and families. The streams receive large quantities of insecticides via drift and runoff (soil erosion) from the cotton lands and fish, crayfish, and other organisms in the streams are exposed in some cases to lethal dosages of insecticides.

The insecticide residues do not remain at high levels in streams for long because the contaminated water is flushed into the estuary. These streams are the prime means of transport of pesticides to estuaries. Fish, shrimp, and other organisms are affected in this valuable habitat.

The slow flowing streams on the relatively flat coastal plains are sometimes weed-clogged along their banks. This habitat is ideal for anopheline mosquito breeding. The insecticide contaminated water contributes to the selective pressure on the mosquito population and increasing the level of resistance in the mosquito population.

Drainage ditches:

Most cotton farms have large drainage ditches running through them to carry away the water from the heavy rainfall during the rainy season (figure 30). The water in these ditches is highly contaminated with insecticides. Although this wates is contaminated, it is used for washing by farm workers because adequate washing facilities are seldom available or conveniently located. The situation contributes to the burden of insecticides that the laborers are exposed to.

These ditches also may harbor fish, crayfish, and other organisms, but survival of these organisms in the toxic water is probably poor.

Ponds:

Ponds and pools occur on the coastal plain more frequently than in the hill region (figure 33). These ponds and pools are frequently associated with the streams flowing on the plains. Some of the pools are spring fed and eventually empty into the adjoining streams.

The ponds and pools are a favorite breeding site for Anopheles albimanus. As with the streams these ponds and pools are contaminated with insecticide drift from the aircraft applications to cotton. This insecticide exposure to mosquito larvae and pupae contributes to resistance in the mosquito population.

Rainfall:

Rainfall is necessary for cotton, other crops, livestock, and all other life in Central America(figure 32). It keeps the streams flowing and the ponds and pools full.

Rainfall also has several other effects on the ecological system. Rainfall on agri - cultural soil results in soil erosion. This water and contaminated soil is carried into streams and ponds.

The rainfall reduces insecticide residues on the cotton plant thus helping to reduce the exposure of the farm workers and scouts to toxic levels of insecticides. Of course, washing the insecticide off the plants makes the cotton plant more susceptible to insect attack. Further insecticide applications must be made within a short period.

Other moisture:

The high humidity of the atmosphere contributes to some of the clouds and of course, is essential for rainfall (figure 32).

The high humidity during the rainy season stimulates outbreaks of entomophagous microorganisms in the pest and beneficial insect populations. The cotton plant and other plants and animals are also more subject to attack from pathogenic microorganisms.

Sunlight:

Sunlight is a vital component of the ecosystem and is the prime driving force of the total life system that includes man (figures 32, 33).

Sunlight also plays an important role in breaking down insecticides and reducing exposed residues in the environment.

Moonlight:

Moonlight may affect the activity pattern of some animals and in particular, certain moths(figure 34). Knowing the phase of the moon and when pest moths are active, pest control specialists can predict how severe the insect pest problem will be. Utilizing this information aids the specialist to make the appropriate decision of when to treat or not treat.

Atmosphere:

The atmosphere is a vital factor in the ecological system (figure 33). Its relationship to climate needs no explanation. The atmosphere, of course, provides the medium for insects (including mosquitoes), birds, and other animals to travel.

Aircraft use the atmosphere and the atmosphere is the medium that transports from 50 to 75% of the insecticide applied over cotton to other locations in the coastal plain environment (figures 29, 32, 34).

Wind:

Wind is a component of the atmosphere (figure 29). Wind speed influences the animals that fly as well as the degree of insecticide drift. The 50% to 75% loss of insecticide in the atmosphere is for normal aircraft spray operations of winds less than 10 mph. At higher wind speeds, insecticide drift is a more severe problem.

Aircraft applications:

Most insecticide treatments made in Central America on cotton are applied by aircraft (figure 29). Timing of the treatment is critical. Insecticide applications have to be made within a half day to a day while the insect pest larvae are small and larvae have a high degree of susceptibility and can be effectively controlled.

In addition to ground equipment being too slow, cotton in later stages cannot be driven through with spray equipment without damaging the cotton. The land is wet and muddy during the rainy season and this also hinders the use of ground application equipment.

Aircraft applications contribute importantly to the contamination of the Central American environment with insecticides. Studies have demonstrated that from 50 to 75% of the insecticides applied under normal use conditions by aircraft never reaches the crop but drifts off in the atmosphere. Large quantities of the insecticides settle out in the environment 50 miles or more from the target area. Other crops, livestock, streams, ponds, and other natural areas are contaminated with the drifting insecticides.

Ultra-low volume sprays:

Aircraft applications are made using concentrated sprays utilizing ultra-low volume spray equipment on the aircraft (figure 29). The advantage of this equipment for insecticide applications is that the aircraft can carry a larger payload of active insecticide ingredients. Therefore, the aircraft has to make fewer trips for a re-loading of insecticides for treating.

For larger insects such as caterpillars, ultra-low volume may be effective; however, for small pests such as aphids, mites, and white flies, ultra-low volume sprays are less effective than high volume sprays because the coverage of the plant surface is relatively poor with ultra-low volume equipment. The spray pattern with ultra-low volume includes few concentrated droplets.

The concentrated spray droplets are a great hazard to workers in the cotton fields. The concentrated insecticide droplets easily contaminate farm workers who rub against the treated cotton plants.

The drift problem may also be more severe when using ultra-low volume equipment because of the desire to make the droplet size small for better coverage. Small droplets have a greater tendency to remain in the atmosphere and drift than do the large droplets.

Farm workers:

An estimated 60% of the work force in Central America is involved in agriculture (Figures 29,30, 35, 36). Cotton production employs 17.4% of these workers for weeding and harvesting cotton (half a million peasants, for a total of 36 million man/days). Obviously cotton production is important to the economy of Central America in providing employment.

Employing labor for weeding and harvesting is more economical than using chemical herbicides and mechanical harvesters. Using farm labor, of course, benefits the economy and labor force.

The disadvantages of employing farm workers for weeding and harvesting is exposing the farm workers to toxic levels of insecticides in the freshly treated fields. The workers enter the treated cotton fields the day following treatment. Under these conditions the laborers commonly pick up toxic levels of the insecticide as documented by the large number of human poisonings. There is an obvious need for a longer reentry time and an adequate enforcement of the standars.

The longer reentry time, however, conflicts with the use of farm labor since the workers cannot work if they cannot enter the fields.

Scouts:

The scouts measure pest populations and natural enemy numbers to determine when insecticide treatments should be made (figures 29,30). The scouts are an essential part of the integrated pest control program.

Similar to farm workers, scouts are susceptible to insecticide poisoning. The scouts enter the treated cotton fields soon after treatments. By rubbing against the contaminated cotton plants while counting insects they may become contaminated with toxic levels of insecticides.

Rural population:

The rural population is divided into two groups: those living in the cotton regions and those in the hill regions (figures 29, 32, 34, 36). The population living permanently in the cotton region are exposed to more insecticides than those that live in part or all the time in hills. Although the farm workers (including scouts) are the prime group exposed to insecticides through the work in the cotton fields, the remainder of the rural population are exposed by insecticide drift from the aircraft applications. They also obtain insecticides by consuming contaminated foods and water.

The rural population living on the coastal plain also have a greater chance of contracting malaria than either the urban or rural population living in the hill region. Anopheline mosquitoes are more abundant on the coastal plain because of more suitable breeding habitat and because the mosquitoes are resistant to most insecticides. Since malaria is more abundant, it is also more easily transmitted from person to person.

Cotton and other agricultural activities cause the migration of large numbers of peoseants from the hill regions to the coastal plain. A predominantly indian temporary work force is exposed to entirely different conditions, for one or two months. The changed environment includes of course malaria, pesticides, heat and humidity and strenuous work.

Urban population:

Although the urban population is not affected directly by the events occurring in the rural areas of the coastal plain (cotton producing region), they are indirectly influenced (figures 29, 32, 34, 36). The food crops, meat, and milk they consume may be produced in the cotton growing region and may be contaminated with insecticides. Urban population visitors to the coastal plain may be exposed to malaria in this region.

Cotton contributes significantly to the economy of Central America and therefore this population benefits from cotton production. Numerous industries, especially the pesticide industry, the petro-chemical industry, and the vegetable oils industry, which employs cottonseed benefit from the demands of the cotton industry. Most of the industries employ urban workers.

Non-fatal insecticide poisonings:

The number of reported non-fatal insecticide poisonings is estimated at about 3,000 annually in Central America (figure 30). How many poisonings are unreported is unknown. Most of these poisonings as we had indicated occur to farm workers (including scouts).

The reason the poisonings are primarily non-fatal in the method of exposure to the toxicants. As mentioned, the farm workers are exposed to the insecticides while rubbing against contaminated cotton plants during weeding and harvesting operations. The workers under these conditions obtain only small quantities of the toxicant at a time. Because the sub-lethal dosage is obtained gradually, the workers often begin to feel ill before they secure a lethal dosage. When ill, the workers are no longer able to work in the cotton field and often terminate their exposure temporarily.

Of course, there are spray operators who actually handle the toxic chemicals (parathion in particular) during the spray operation. In this case, exposure from accidental spills may be sufficient to be fatal.

Fatal insecticide poisonings:

Of the 3,000 annual insecticide poisonings, only about 0.5% are fatal (see non-fatal poisonings for an explanation) (figure 30).

Cholinergic symptoms and signs:

The symptoms and signs of most human poisonings suggest reuced cholinesterase activity and poisoning (figure 30). The cholinergic symptoms of most poisonings suggest parathion exposure. Both methyl and ethyl parathion are known to be highly toxic to man.

Seasons:

Since most of the human cases of poisonings occur from cotton spraying, it is not surprising to find a seasonal trend in the occurrence of the incidence of human poisonings (figure 30). The peak period of poisoning cases occurs in September, October, and November when most of the cotton spraying is carried out.

Children:

A considerable number of young children (less than 15 years of age) work in the cotton field during harvest. However, few children are recorded in the human poisoning statistics probably because they are not covered by social security medical programs.

Adult females:

Few female adults work in the cotton fields. The statistics record few poisoning cases in the female group (figure 30).

Adult males:

Most of the human poisonings are males in the age group 15 to 45 years of age. About 99% of the poisonings occur in adult male farm workers (figure 30).

Washing facilities:

Most farm workers are not provided with washing facilities. This and the suffocating heat forces them to use water in the drainage ditches in the cotton fields for what limitated washing they do (figure 30). The drainage water is highly contaminated with insecticides. Washing in insecticide-ladden water contributes further to the insecticide burden the workers have in their bodies.

Washing with only water removes little of the oil on the skin in which the insecticides are present. Good washing facilities, including soap, would help reduce the insecticide exposure in the farm workers.

Workmen's compensation:

The workmen's compensation program that is available influences the number of reported poisonings (figures 30, 32). Without workmen's compensation farm workers struggle to work while ill with insecticide poisoning. If the nation has a good workmen's compensation program, a farm worker who is ill with insecticide poisoning will report to a clinic or hospital for treatment. He is treated and is paid for the time that is required for his recovery. In nations that do not have workmen's compensation, workers seldom report their poisoning because they are not paid while away from their job. These workers continue to work and continue their exposure. The statistics on poisonings are not adequate to determine whether the continued exposure of farm workers already ill from pesticide poisoning leads to a higher fatality rate. This would be the expected result.

Government:

The policies and philosophy of the government influence the use and misuse of pesticides (figues 29,30,35,36). Governments interested in protecting farm workers and the public generally from the hazards of insecticides can do so with appropriate legislation and enforcement. The same applies to protecting the environment. As an example, the legislation of the U. S. controlling the use of pesticides has been quite effective in minimizing public health and environmental hazards.

The workmen's compensation program mentioned earlier is also legislation that has a direct relationship to human exposure to pesticides. Having washing facilities and other appropriate industrial hygiene programs also relates directly to the government and effective legislation.

Laws:

Laws and their enforcement, especially as they relate to pesticide use and the treatment of exposed human beings, play important roles in reducing human pesticide poisonings (figure 30). Or course, the laws that are adopted and enforced depend upon the philosophy and policies of the government in power.

Pesticide regulations:

Few regulations on the use of pesticides exist in Central America (figure 30). Effective pesticide regulations in other nations frequently include:

(1) Restrictions on the dosages and kinds of toxicants that can be applied in agriculture.

(2) Limitations on the atmospheric conditions under which aircraft applications are made.

(3) Restrictions on the time when farm workers can reenter a field after it has been treated with certain pesticides.

(4) Training programs on the safe use and handling of pesticides. With effective pesticide regulations, the exposure of farm workers and the public to pesticides would be significantly reduced in Central America.

Human density:

As the density of the rural population continues to grow in Central America, more and more of the rural population is forced to live close to the cotton field (figure 30). This places these families adjacent to areas where insecticide applications are made. The drift patterns of aircraft applications are extensive as mentioned. Thus the population living close to the cotton field is exposed to large quantities of insecticides.

Climatic conditions, especially rainfall, wind, and temperatures, influence the exposure of the farm workers, the public and environment to insecticides (figures 31,32). Rainfall , for example, 6 to 8 hours after treatment of a cotton field, will reduce the parathion residue present on the cotton plants. Reducing the parathion residue present on the cotton plants would reduce the exposure of the human population to parathion in the cotton field. High air temperatures would also increase the rate of volatilization of parathion in the field and reduce the total quantity present on the cotton plant. On the other hand, high air temperatures encourage farm workers to remove some clothing, this increasing their direct exposure to insecticides. The interactions of the various factors related to pesticide exposure are most complex.

For example, wind speed influences the amount of insecticide that falls into the target cotton field and the amount that drifts off into the environment. A slight breeze of more than 10 mph on a bright sunny day may result in pesticide drift of 50 miles or more down wind. The result is greater pollution of the environment.

Private clinics:

Some of the large cotton producers maintain their own private clinics(figure 30). The reasons for maintaining these are: (1) for greater efficiency in treating illness and poisonings by having clinics close to the farm; (2) costs to the grower are frequently less than sending his workers to government clinics and hospitals; (3) to hinder public health officials from detecting the seriousness of human insecticide poisonings.

These clinics clearly influence the accuracy of the epidemiological statistics.

Malnutrition:

Malnutrition is another factor that influences the incidence of human poisonings (figures 30,35). Workers that are malnourished have a lower tolerance for the toxicity of insecticides. This has been demonstrated with laboratory animals. The diets of farm workers consists mainly of corn (about 500 grams/day) and black beans (about 100 grams/day).

Industrial Hygiene:

Little if any instruction and/or facilities (washing and appropriate protective clothing) are available to protect the farm workers and scouts from insecticide exposure and poisoning (figures 30, 35). With appropriate industrial hygiene programs on cotton farms, a significant reduction in the number of human poisonings would be possible.

Education and literacy:

Education and literacy of the human population relate to the ecological system in several ways (figures 30, 35). Without an education and the ability to read, farm workers are unaware of the dangers of the insecticides they are handling and are unaware of the precautions that should be practiced to protect themselves. Many workers have no knowledge of Spanish, the official language, and can only understand one of the many indian dialects that descend from the ancient language of the Mayas.

An educated worker is also better able to understand and appreciate the toxic nature of pesticides, their routes of entry, and modes of action.

Harvesting cotton:

Farm workers are employed to pick cotton and this exposes the workers to insecticide residues on the cotton plants (figure 30). The workers obtain the poisons while handling and rubbing against the contaminated cotton. Workers reenter the cotton fields for picking a few hours after the fields are treated with insecticides.

Weeding cotton:

Most of the weeding of cotton fields is carried out using farm labor (figure 30). This has the advantage of providing work for this labor force but at the same time weeding operations expose the workers to toxic levels of insecticides for similar reasons given in harvesting cotton.

Cotton bud consumption:

The staple diet of the farm workers as mentioned, is primarily corn (500 g/day) and beans (100 g/day) (figure 30). To add some variety to this monotous diet the workers sometimes eat young cotton buds. When young the buds are reported to have a sweet flavor.

The workers, when harvesting cotton, also will sometimes hold a contaminated stem of cotton in their mouth. These behavior patterns add to the insecticide load and increase the chances of human poisonings.

Locations of homes:

Farm workers, when bluiding homes close to cotton fields, expose themselves and their family to insecticide drift coming from the treated cotton (figure 30). As mentioned, with a high rural population density the location of homes is more likely to be close to cotton fields. At present, it is found that between 80 and 100% of cotton workers live within 100 meters of the cotton fields. Another reason for living close to the cotton fields is the lack of transportation since these workers cannot afford even a bicycle for transport.

Chlorinated insecticide residues:

DDT, Toxaphene, and other chlorinated insecticides used on cotton are generally persistent (10-30 years) (figures 30, 35). This persistence results in residues accumulating in the environment. The materials also become widely distributed in the environment because the long-lived materials have opportunity to more by physical factors in the environment (e.g. water and wind) and by the movements of organisms themselves.

Because much of the environment in the cotton growing regions is contaminated, chlorinated insecticide residues are common in man and most other animals. Man, as mentioned, has a high toleration level for DDT and most of the other chlorinated insecticides, therefore, the impact on man directly is probably minimal. However, other animals are quite sensitive to DDT, Toxaphene, and other chlorinated insecticides. This will be discussed further later on.

Phosphate and carbomate residues:

Parathion, other phosphate, and carbamate insecticides are relatively non-persistent (3 to 6 months) (figures 30,33). Therefore, these residues are not accumulating and are less widespread compared with the chlorinated residues.

The danger from parathion and other phosphate and carbomate insecticide residues is primarily within the target area (cotton field). Farm workers are the group in which significant human poisonings are reported. The drift problem from aircraft applications is important but probably is not as serious in causing human poisonings as exposure in the cotton fields.

Exactly how serious the parathion and other insecticides are in affecting the fauna and flora is inknown. Certainly, some sensitive species are being affected but the extent is unknown.

Reentry time:

Farm workers and scouts, as mentioned, enter treated cotton fields in 12 to 40 hours after treatment (figure 30). With this short reentry time, farm workers and scouts come in contact with highly active, lethal residues of parathion and other insecticides present on the cotton plants. The short reentry time contributes importantly to the incidence of human poisonings. Obviously, if the reentry time were longer, fewer human poisonings would result. Of course, the problem of farm workers having sufficient employment and carrying out the weeding and cotton harvesting tasks would exist with a long reentry time such as a week.

Malaria:

The incidence of malaria in the human population depends directly upon the contagiousness of malaria cases in the population and the abundance and distribution of the vector mosquito (Anopheles albimanus) (figure 31). The contagiousness of malaria is related to human density, distribution of the humans and their homes, incidence of malaria in the population, and the availability of the infected individuals. The factors in the epidemiology of malaria are discussed later.

As with contagiousness of malaria, the abundance and distribution of the vector anopheline mosquito is affected by a great many factors such as aquatic habitats, mosquito fish, other mosquito predators, mosquito parasites, house spraying, and cotton insecticides. The relationships of some of these factors have already been discussed and other will be discussed.

Anopheline mosquito

The adult anopheline mosquito (Anopheles albimanus) is a delicate animal. After

mating and having a blood meal, the female will lay several hundred eggs on the water surface (figure 31). These hatch and the young larvae feed on detritus and other matter in the water. When full grown in a week or less, the larvae pupate. They remain as pupae for 4 to 5 days. The adult mosquitoes emerge from the pupae with mating occurring soon after emergence. The total life cycle may be completed under optimal conditions in about 15-20 days.

The female only feeds on man or other mammals or birds. She must have a blood meal for her eggs to be viable.

The early mosquito stages survive only in the aquatic habitats that have relatively quiet water. Stream water is satisfactory in the water flows slowly as would be typical of the margins of weed chocked streams with a low gradient.

Ponds are also a favorite breeding site for Anopheles albimanus. Small ponds and pools closely associated with streams are often used by the mosquito. These pools are sometimes formed from underground springs. The water from the pools into the associated streams

The mosquito is most abundant on the coastal plains because this is where suitable aquatic habitats (ponds, marshes, and slow moving streams) abound.

The mosquito is less abundant in the hill regions because the water in these regions is usually fast flowing, there are fewer ponds, lower temperature and generally fewer suitable aquatic habitats exist for anopheline mosquitoes.

Mosquito fish:

Several species of fish in Central America prey on mosquito eggs, larvae, and pupae in the aquatic habitat (figure 31). The mosquito fish (Gambusia spp.), introduced into Central America, has proven effective in controlling mosquitoes in a few of the aquatic habitats.

One limitation to use of the mosquito fish is that rural people catch and eat these fish. This occurs inspite of the fact that these fish are relatively small (2-3 inches). Under certain conditions these fish can effectively compete with native fish and can cause the extintion of native fish in a few habitats.

Other mosquito predators:

Several other species of animals prey on anopheline mosquitoes or egg, larva, pupa and adult (figure 31). Notennectics and several other species of aquatic insects prey on the eggs, larvae, and pupae of the mosquito. Certain terrestrial insects such as adult dragonflies prey on adult mosquitoes. Hydra prey on mosquito larvae and pupae. Also nematodes prey on the larvae in the aquatic habitat. Amphibians and reptiles prey actively on adult mosquitoes. Many small birds and bats feed on adult mosquitoes.

Several species of aquatic plants capture mosquito larvae and use the larvae as a source of nutrients. Some aquatic plants also release chemicals into the water that are toxic to mosquito larvae.

Mosquito parasites:

Several species of microrganisms attack mosquito larvae and pupae (figure 31). At least four genera of protozoa have been reported to parasitize mosquito larvae and pupae. Parasitic fungi and bacteria also attack mosquitoes. There are also reports of virus diseases in mosquitoes. All of these parasites have some impact upon anopheline mosquito populations, and under certain conditions significantly limit mosquito numbers.

Coastal plain:

The coastal plains consist mostly of alluvial deposits (figure 32). The land topography is relatively flat including some rolling hills. Soil is deep and rich and hence, is of excellent quality for crop production including cotton.

The flat topography is ideal for slow moving streams and many small ponds and pools. These aquatic habitats are most desirable for anopheline mosquito breeding.

Hill regions:

The hill regions have little suitable land for agriculture especially cotton production (figure 32). The land topography is generally steep and the soil of poor quality.

This habitat is also poor for the anopheline mosquito because the streams are generally fast flowing with the normal steep gradients. Ponds and pools are less common in this habitat.

Contagiousness of malaria:

A sufficient number of humans have to be infected with malaria in a sufficiently dense human population for the infection to be effectively spread (figure 31). At the same time, of course, the anopheline mosquito population must be sufficiently abundant to transmit malaria. Hence, with a suitable mosquito population and suitable population of susceptible humans, a sufficient number of humans must be infected for malaria to persist.

Human parasite load:

The parasite load in man interacts with malnutrition, malaria, and human poisonings (figure 31). Individuals that are carrying a heavy parasite load are more likely to be malnourished. Often these individuals are less likely to survive malaria infections. A similar situation would be true for individuals carrying a heavy parasite load who are exposed to parathion and similar toxic insecticides.

House structure:

Because few of the worker homes have window screening, mosquitoes have easy access to homes and to feed on the people within (figure 31). Certainly this type of house structure contributes to the ability of the mosquito to attack infected and susceptible humans and transmit malaria.

Human mobility:

In open trucks and similar means of transportation, people travel from the hill regions where malaria is scarce to the coastal plains where malaria is prevalent (figure 31). On the coastal plain the "hill people" may become infected with malaria.

Human migration:

Farm workers in several parts of Central America migrate from the hill regions to the coastal plains during the cotton production season (figure 31). While present on the coastal plains the workers and their families are exposed to insecticide residues and are exposed to malaria. Malaria is carried back to the hills but the spread in the hill region is minimal for two reasons: (1) the mosquitoes are less abundant in the hill region; (2) the anopheline mosquitoes in the hills are not resistant to insecticides and thus mosquito control is effective.

Human medication:

With the anopheline mosquito population on the coastal plains where cotton is grown highly resistant to most insecticides, control of mosquitoes in this region is relatively ineffective (figure 31). To offset poor mosquito control and aid in malaria control preventive medication is being provided to the exposed human population. The aim is to reduce malaria by attacking the mosquito and treating the human population to reduce the contagiousness of malaria. Hopefully this will slow the spread of malaria.

Public health:

Public health policies determine how effectively the programs aid insecticide poisoning victims and what is done for malaria control (figure 31). All public health programs have budget limitations and the budget priorities determine what each of the health programs will be.

For instance, in one Central American nation additional health clinics were needed. Thus, the priority of the public health program was to construct clinics. Some of the monies for the construction had to come from the malaria control program. The reduction in malaria control resulted in some increase in malaria. Trading increased malaria for more clinics is a difficult decision.

House spraying:

Malaria control costs have increased significantly because of increased resistance in the mosquito population and the increased costs of the newer insecticides (figure 31). When DDT was the prime insecticide for house spraying the cost per treatment was around $7 per treated house. The houses had to be treated about 2 times per year with DDT.

When the mosquitoes became resistant to DDT, propoxur (carbamate) was employed for mosquito control. The cost per house treatment increased to $15 and the houses had to be treated 4 times per year. Most of the mosquito populations on the coastal plain region are now resistant to propoxur and the need is for another effective insecticide. Preliminary tests with landrin (carbamate) indicate that it would be effective, if registered, for this use. However, the cost per house treatment would rise to $22 and treatments would still have to be made 4 times per year.

Exactly how long landrin would remain effective is a question since it is also a carbamate insecticide. However, there is no question that the increased cost of malaria control is having a significant impact upon the public health program of Central America, and diverting medical resources from other important public health problems.

Insecticide costs:

The costs of house spraying for effective mosquito control have increased, as mentioned, from about $14 per house per year to $60 per house per year (figure 31). The newest material (landrin) which is effective (if registered) will cost $88 per house per year.

In cotton production, insecticide costs have increased but not as drastically as in public health. In most cases, insecticide costs have increased 2 fold. This still means a great deal of money because of the large quantity of insecticide that is employed in cotton production.

The advantage of the high insecticide costs (if one could term high costs an advantage) is that it will encourage the adoption of integrated control procedures for pest control. In other words, reducing the number of sprays and amount of insecticide used will have a stronger economic incentive. This will in turn benefit the environment.

Multiple insecticide resistance in mosquito:

The anopheline mosquito populations on the coastal plain have a high level of resistance to a wide variety of insecticides (figure 31). The cause of this has been the exposure of the mosquito population to the wide variety of insecticides employed in cotton. The cotton insecticides have drifted and/or been washed into the aquatic habitat of the mosquito from cotton field applications.

Genetics of mosquito resistance:

The type of resistance that has evolved in the anopheline mosquito population is controlled by dominant genes (figure 31). The result is a high level of resistance that is relatively persistent in the mosquito population.

Zoophilic:

The anopheline mosquito can feed on various birds and mammals including livestock to obtain its necessary blood meal for egg production (figure 31). The behavior contributes to the abundance of the mosquitoes.

Aquatic plants:

The abundance of aquatic plants is streams and ponds help protect the egg, larvae, and pupae from predator attack (figure 31). These same plants slow the flow in some parts of the streams to almost a standstill making the stream water highly attractive for mosquito breeding. The decaying aquatic plants also provide necessary food for the larvae of the mosquito in streams and ponds.

Cotton yields:

The yield of cotton per hectare determines in part the profits to be realized from production (figure 35). Insect pests tend to reduce yields whereas both natural enemies and insecticide usage generally tend to increase yields. The effectiveness of the insecticide depends on what chemical is used, the dosage used and when it is applied. The cost of the insecticide depends on both the material used and the dosage applied. The evidence thus for collected suggests that more insecticide is being used than is profitable based on marginal yield responses to insecticide use.

Cotton prices:

Cotton prices directly influence the results of the cost/benefit equation of cotton production (figure 35). With high prices and relatively low insecticide costs, growers would be more apt to use larger quantities of insecticides. Hence, cotton prices may affect any environmental management program.

Exports:

Cotton, as mentioned, is the third most important export crop in Central America, after coffee and bananas (figure 35). Hence, it is a significant factor in the economy of Central America. Because of cotton's dominant role in the economy of the nations, it significantly influences the social structure of Central America.

Imports:

Related to the equation of economics and the social system is the cost and quantity of imports (figure 35). One important import item is the insecticide used in cotton. The value of insecticide imports in Central America amounts to about $100 million annually.

Petroleum costs:

The rapidly increasing petroleum prices in the world are having significant impact on the economics of cotton production because so many items used in cotton production utilize petroleum in manufacture (figure 35). Central America has to import most of its petroleum since it lacks oil as an abundant natural resource.

Petroleum for farm machinery is more than 2-3 times more expensive than it was 3 years ago. Insecticides and fertilizers both require large inputs of petroleum for production, and the prices of these items have increased 3 to 4-fold during the past couple of years. The high price of petroleum has increased cotton production costs about 2-fold during the past 3 years.

Machinery:

Most of the machinery is imported and the cost of operating this equipment is expensive (figure 35). Farm machinery costs are a significant item in cotton production. The cost of this equipment has also increased greatly because of the high cost of the energy used in its production.

Nitrogen:

Nitrogen as a fertilizer is separated out because the price of nitrogen has increased 3 to 4-fold during the past 3 years (figure 35). The reason for the high cost is that large quantities of energy (about 15,000 kcal/kg) are required for nitrogen production. Most of the nitrogen fertilizer is imported.

Phosphorus and potassium:

Most of the phosphorus and potassium fertilizers used in cotton production are imported (figure 35). Not only are these imports an expense in cotton production but these fertilizer costs have also increased.

Saprophytic insects & mites:

Some species of insects and mites are saprophytic (figure 34). These organisms along with some microorganisms, earthworms, and other animals play a vital role in degrading plant and animal wastes. Without these organisms wastes would accumulate on land and in the water and the life system would eventually run out of the vital elements such as C, H, N, O, P, and K. Many of the saprophytic insects also serve as food for many other animals such

as mammals, birds, amphibians, and reptiles.

On the basis of previous studies, we expect that the large quantities of insecticides used in cotton production has drastically reduced the numbers of saprophytic insects and mites in the cotton fields and nearby these fields. The costs to the Central American ecosystem for this reduction are unknown.

Herbivorous insects and mites:

Many species of insects and mites are herbivores and graze on living plants (figure 34). In nature, due to the natural resistance in plants, parasites, and predators, seldom do these herbivorous insects and mites consume more than 5 to 10% of plant protoplasm.

However, when man modified the environment and the genetic make-up of plants for use as crops, some species of herbivorous insects and mites became pests. This is true with cotton in Central America. The prime herbivore pests of cotton include the bollweevil, bollworms, armyworms, leafworms, and sucking insects. These pest species plus the other pests of cotton and other crops make up less than 1% of all the estimated 100,000 plant and animal species in Central America.

Entomophagous microorganisms:

Entomophagous microorganisms (viruses, bacteria, fungi, protozoa, and nematodes) parasitize both beneficial and pest insect species (figure 34). With the pest species, these entomophagous microorganisms may provide effective control of the populations at certain times. However, when these microorganisms reduce the numbers of beneficial insect populations, the result is often pest insect population outbreaks. This occurs mostly during the rainy season when entomophagous pathogens increase rapidly and beneficial insect populations are substantially reduced. The resulting increase in pest populations then requires insectivide treatments.

Pollinating insects:

Several species of insects pollinate most of the blossoms on crops and natural plants in Central America (figures 33,34). Without these pollinating insects many species of plant would no longer survive and several crops would totally disappear. The use of insecticides in cotton is destroying some pollinators that are sensitive to insecticides. What impact this is having on the effectiveness of these insects in pollinating food crops and natural plants is unknown.

Shrimp and crayfish:

Shrimp and crayfish species are used as human food (figures 33,34). Shrimp are also captured and packaged for export, to the United States. These animals provide a valuable income for the fishing industry on the west coast of Central America.

Shrimp and crayfish are highly sensitive to insecticides and the circumstantial evidence suggests that in the cotton region, these populations have been reduced. The insecticides causing this reduction are probably DDT, Toxaphene, and the other chlorinated insecticides. These insecticides persist in the environment and are easily concentrated in shrimp and crayfish populations.

The residues in shrimp have been reported in some cases to be too high for export to the United States.

Fishes:

Because large quantities of insecticides are washed into and drift into fresh waters and estuaries, these aquatic habitats accumulate large quantities of insecticides (figure 33). This is particularly true of the persistent chlorinated insecticides, like DDT and Toxaphene. Fish populations are especially sensitive to insecticides for two reasons. First, the fishes have tremendous capacity for the biological accumulation of insecticides. For example, one species of fish in water containing 0.5 ppb of parathion bioaccumulated this insecticide to a level of 100,000 times that in the water. Second, most fishes are predators feeding on other animals. The prey animals in the aquatic habitat bioaccumulate insecticides; then when fishes feed on their prey they further concentrate the insecticides in their bodies. The accumulated insecticides are sometimes lethal to the fish populations.

Fish are an important protein-food source in Central America. Again circumstantial evidence suggests that some fish populations have been reduced because of the large quantities of pesticides applied to cotton.

Annelids:

Earthworms and other annelids are important in the ecosystem in degrading plant and animal wastes (figure 33). They also play an important role in circulating and aerating the soil. Earthworms may number 2000 to 3000 kg per hectare. Thus, they have a significant impact on agricultural soils.

Earthworms also are important food for birds, mammals, and many other organisms in the ecosystem (figure 33). Because earthworms are in the soil, they pick up large quantities of insecticides. The other animals that feed on them may obtain high dosages of insecticides. This was documented in a study that reported about 10 ppm of DDT in the soil, about 140 ppm of DDT in the earthworm, and 444 ppm of DDT in the robins that fed on the earthworms.

Mollusks:

Both fresh and salt water mollusks are used as food by man as well as by other animals (figure 33). Because some of the aquatic mollusks feed by filtering organic materials our of water, they are particularly effective in accumulating large dosages of insecticides.

For example, oysters in sea water containing 0.5 ppb DDT accumulated this insecticide in their bodies to levels of 10,000 times the level in salt water. Other animals such as predaceous birds feeding on the mollusks may themselves accumulate toxic dosages.

Predaceous birds:

Predaceous birds are quite sensitive to insecticides especially DDT, Toxaphene, and other chlorinated insecticides (figure 33). First of all these birds have a low level of tolerance that makes them susceptible to low dosages of the toxicant in the environment. Another reason that these birds are affected in the natural environment is that they feed on animals that already have accumulated relatively large dosages of the insecticide from the environment. This is especially so for aquatic predaceous birds that feed on insecticide contaminated fish.

Other birds:

The seed, insect, and fruit-eating birds are probably being contaminated with insecticides in the cotton region (figure 33). What impact the pesticides are having on these birds is unknown.

Birds are an important component of the environment especially form an aesthetic standpoint. Ecologically they do not appear vital to the survival of the Central American ecosystem as is the case for insects, earthworms, and microorganisms.

Mammals:

Several species of wild mammals are active in the ecosystem and some are a source of food for man (figure 33). With the occassional exception of rats, few of the animal species are serious pests of cotton.

Some of the mammals are contaminated with insecticides in the cotton growing region. However, the impact of the insecticides on the populations is unknown.

As with the birds, we doubt that the mammals are vital to the survival of the ecosystem in Central America. Nevertheless their protection may be desirable from aesthetic or other standpoints.

Reptiles and amphibians:

Many species of reptiles and amphibians occur in the Central American environment (figure 33). Most of the species are beneficial to man by preying on rodents and pest insects. Because these animals are in contact with the residues in the soil and are feeding on animal life that is contaminated with insecticide residues from the environment, one would expect that the reptile and amphibian populations are being reduced by the large quantities of insecticides being applied to cotton.

Pathogens of animals:

Numerous species of pathogens (viruses, bacteria, fungi, and protozoa) parasitize animal life in Central America including man (figure 33). These organisms play a role in limiting the numbers of the animal populations.

Evidence concerning birds and fishes suggests that sublethal dosages of insecticides make animals more susceptible to disease organisms. However, the actual impact of insecticides on the incidence of disease in the animal populations of Central America is unknown.

Pathogens of plants:

As with animals, the pathogens (viruses, bacteria, and fungi) of plants limit the abundance and distribution of some plants (figure 33). Although it has not been demonstrated, information on other systems suggest that the physiological stress caused by insecticides on plants may make some species of plants more susceptible to diseases.

This has been well demonstrated in the case of herbicides with plants. The herbicide, 2, 4-D for instance, increases the susceptibility of corn to corn smuth disease and corn leaf blight. Similar effects have been reported for other plants.

Terrestrial plants:

Terrestrial plants are vital to the survival of the ecosystem (figure 33). They collect light energy, produce protoplasm, and serve as the prime suppliers of food for the terrestrial ecosystem. These plants may be influenced in several ways with the addition of the insecticides in the coastal plain. Natualenemies that may control some herbivorous animals that feed on the terrestrial plants may be reduced thus freeing an intense attack of the herbivores on the terrestrial plants.

DDT, Toxaphene, and other insecticides have been found to alter the micro-and macro-element content of plants at low dosages. This alteration may influence the nutritional quality of the plants either resulting in outbreaks of herbivorous animals on the plant or resulting in declines in the animal feeding species.

Soil midroorganisms:

Few appreciate the large numbers of microorganisms that exist in rich soil (figure 33). The bacteria, fungi, and protozoa alone may weigh about 5,000 kg/ha. They out-weigh the livestock per hectare 10 to 20-fold.

These microorganisms play a vital role in degrading plant and animal wastes making the critical elements (C, H, N, O, P, K, etc.) available to plants for reuse. The ecosystem would not survive without this recycling process.

The biological fixation of nitrogen is an important process to the ecosystem. In Central America an estimated 85% of the nitrogen used by crop plants is added by nature and only 15% by commercial processes. There is documented evidence that some of the herbicides influence nitrifying bacteria but no evidence exists relative to insecticides. However, one should immediately point out that this question has received little attention in past investigations.

Cotton growth:

The growth rate of the cotton plant is influenced by pest insect feeding pressure, weed competition, plant pathogens, insecticide toxicity, rainfall, solar radiation, temperature and fertilizers used, particularly nitrogen (figure 33).

The cotton plant is a perennial. By adding nitrogen at appropriate times the plant will continue its indeterminate growth. This forces the plant to continue to grow and produce cotton and also makes the plant an attractive food host for pest insecticts. This has advantages and disadvantages to pest control. The advantage is that with pest hosts present, natural enemies have food and also remain at high densities. The disadvantage is that the pest populations also remain at high densities. In general, the advantages of maintaining large numbers of natural enemies outweigh the disadvantages.

Bollweevil:

The bollweevil is the most serious pest of cotton in Central America (figure 33). The use of wide-spectrum, highly toxic insecticides on this pest usually results in increased chances for human intoxication and in reductions in the number of natural enemies of the other pests like the bollworms. Hence, bollweevil control is critical to the integrated pest control program, because what is done about the bollweevil often affects the success of the control for bollworms and the other cotton pests.

One of the two important means of limiting bollweevil populations is leaving suitable live cotton growing to keep both the bollweevil and its natural enemies interacting through the off season. With large numbers of natural enemies available, these control agents can move into the newly planted cotton fields to control bollweevils that invade these fields. Another advantage of not destroying crop residues in the cotton fields is to reduce soil erosion especially by wind during the off-season.

For control of the bollweevil as well as the bollworms, growing cotton with a short season program limits pest attack because the number of generations of pests is reduced. Reducing the number of generations prevents pest populations from increasing to outbreak levels.

Bollworms:

The cotton bollworms are normally controlled by an array of predator and parasite enemies, however, during the rainy season the entomophagous microorganisms may reduce natural enemies of the bollworm to dangerously low levels allowing the bollworms to ex - plode (figure 33).

Early in the cotton season, if insecticides have to be used against the bollweevil, these insecticides may also reduce the numbers of the natural enemies of the bollworm. The result is a rapid increase in number of bollworms.

The integrated control program aims at keeping insecticide use against the boll - weevil to a minimum to encourage the natural enemies of the bollworm. Also in this program, insecticides are employed that have minimal impact on natural enemies but maximal impact on cotton pests.

Beet armyworms:

Beet armyworms are important pests of cotton and have to be controlled to prevent serious losses in cotton production (figure 33). Again natural enemies are important in controlling these pests.

As with other pest populations, if the natural enemies are reduced because of in - secticides and/or entomophagous microorganisms, then the armyworms increase rapidly and reach outbreak levels.

Integrated control aims to reduce armyworms using minimum insecticide quantities that have minimal impact on natural enemy populations.

Cotton leafworms:

The ecological situation with leafworms is similar to the beet armyworms (figure 33).

Sucking insects:

The "sucking insect" group includes aphids, plant bugs, white flies, and several other insect and mite species that feed on the plant using their sucking-type mouth parts (figure 33).

These sucking insects are usually effectively controlled by both predators and parasites. However, using an improper insecticide that destroys or reduces the number of natural enemies can result in serious outbreaks of these pests. Certain climatic conditions may also reduce the natural enemy population while allowing this population to increase rapidly.

Outbreaks of these sucking insect have occurred often during the rainy season when entomophagous microorganisms increase and reduce the natural enemies. With few natural enemies, the sucking insect population may explode in number and have to be controlled utilizing insecticides.

Other insect pests:

In addition to bollweevils, bollworms, beet armyworms, leafworms, and sucking insects, there are several other species of insects and mites that are pests of cotton (figure 33). These other insect pests are less serious but as a group do contribute to the losses in cotton.

From year to year occasional outbreaks of an individual species may occur. One cause of the outbreaks of one or more of these pest groups is the use of an insecticide that kills the predators and/or parasites of the pest population. Without further control a particular pest population may explode in numbers and seriously damage the cotton.

Lady beetle predators:

Lady beetle predators are also known as "coccinellids" (figure 33). Both the larvae and adults of this beetle family are predaceous on aphids, small bollworm larvae, and other small soft-bodied insects. These lady beetles can be highly effective in controlling the numbers of pest insects in cotton.

The aim of the integrated control program is to keep the use of insecticides to a minimum and at the same time employ an insecticide that is more toxic to the pest populations than the lady beetle populations.

Lacewing predators:

The larval stages of the lacewing are sometimes called "aphid lions" (figure 33). These small predators can be highly effective in controlling aphids, small bollworm larvae, and other small soft bodied insect pests.

As a part of the integrated control, the aim is to encourage these predators through the judicious use of insecticides, i.e. those insecticides that are less toxic to lacewings than to the pests. Also the use of insecticides is held to a minimum so as not to reduce or interfere with the normal activities of this predator.

Other predators:

Many types of predaceous animals other than lady beetle predators and lacewing predators are present in the cotton fields (figure 33). These predators that include other insects as well as predaceous mites and predaceous vertebrates (amphibians and reptiles) have some impact on the pest populations.

All of these predators have some degree of susceptibility to the different insecticides.

The aim is to use insecticides that have minimal impact on these predaceous species.

Trichogramma spp. parasite:

The minute Trichogramma spp. wasps parasitize the eggs of bollworms and are highly effective in limiting the numbers of bollworms (figure 33).

Because these parasites are susceptible to insecticides, the integrated pest control program selects insecticides that have minimal effect on this parasite and maximal effect on pest populations. The result is effective pest control that fully utilizes the natural enemies.

The egg parasite, Trichogramma spp., can be reared and released in cotton fields. These releases help increase parasite numbers so they are more effective in the field.

Releasing parasites may often reduce the number of insecticide treatments that have to be made.

Other insect parasites:

Several species of insects are parasitic especially on larvae and pupae of bollworms, leaf worms, armyworms, and other caterpillars (figure 33). Hence, every effort is made in the integrated control program to cause minimal effect on these parasitic insect populations.

Birthrate:

The birthrate in Central America runs about 42.2 per thousand per year. The relatively high birthrate and low death rate results in a population growth rate of 3.2 % per year (figure 36). The cause for the high rate of growth in the population is due primarily to reduced death rates and the birthrate remaining relatively high.

A rapidly growing population, as is typical in Central America, places a significant strain on the economy. Rapid population growth slows the growth of incomes and perpetuates the inequalities that exist in the economy. Food supplies and food production must be greatly increased to meet the needs of the rapidly growing population. Also because the number of people that are entering the labor force is large, unemployment and underemployment is a problem. This relates to the large numbers of farm workers who are employed in cotton production for weeding and harvesting.

Age structure:

The age structure of the population is skewed toward large numbers of young(figure 36). This has the effect of creating stress in society as a whole. At the same time it puts a strain on public health programs and education programs, primarily because there is lack of funds to support these programs. In addition, with large numbers of young, insufficient trained adults are available for teaching as well as staffing the public health programs.

With the population made up of large numbers of young, the birthrate is higher than normal.

Military:

The military is a costly item in the economy of the nations of Central America (figure 35). The need for a military program has always been debated by the people of all nations in the world. Still, little appears to be done about the over large military expenses to both rich and poor nations.

On the positive side, the military have been used in some cases to straighten stream channels on the coastal plain to eliminate mosquito breeding pools. Altering the stream channels also increased the flow of water helping make these streams poor mosquito habitats.

Sanitation:

Pollution is becoming a greater problem in Central America as it is in other nations of the world (figure 35). Poor sanitation is related to the increasing population numbers in Central America and the increased use of goods and resources.

With a weak economy, sanitation and public health programs are likely to also be weak. Increased disease rates such as malaria are a further drain on society and the economy as a whole. Malnutrition is also a type of desease and has a depressing effect upon the economy.

Petro-chemical industries:

Petro-chemical industries in Central America are present (figure 35). They do contribute to the economy of Central America and are vital to providing many of the inputs such as fuel needed in cotton production.

These industries, as well as most other industries are located close to the large urban centers.

Pesticide industry:

Only Toxaphene is produced in Central America (figure 35). Otherwise the pesticide industry imports the technical pesticide material from other nations and formulates the pesticide for field use. Cotton production is the largest user of pesticides in Central America and accounts for 85% of all pesticides used.

Food industry:

The food industry processes and packages various foods for use in Central America as well as export. The food industry is concerned about pesticide contamination of the foods they process. Having pesticide residues in export foods could result in these foods being destroyed. At the same time this would reflect on quality control carried out at the plants in Central America. In turn, this could hurt export sales.

Service industries:

The service industries are an important part of the economy of Central America (figure 35). The cotton producers provide a large amount of income to the service industries since they make good use of these services and are an important part of the economy of Central America.

Other industries:

Many other industries have a relationship to cotton production and the economy of Central America as a whole (figure 35). Little more needs to be said about their valuable role in the ecosystem of Central America. It is important, however, to mention the vegetable oil industry because it uses cottonseed as a basic raw material. Fluctuations in cotton production attributable to price or other changes may affect this vital industrial activity.

Police and firemen:

These are public services provided by the governments in Central America (figure 36). They are expensive services but are vital to the maintenance of stability in the human society of Central America.

Economy:

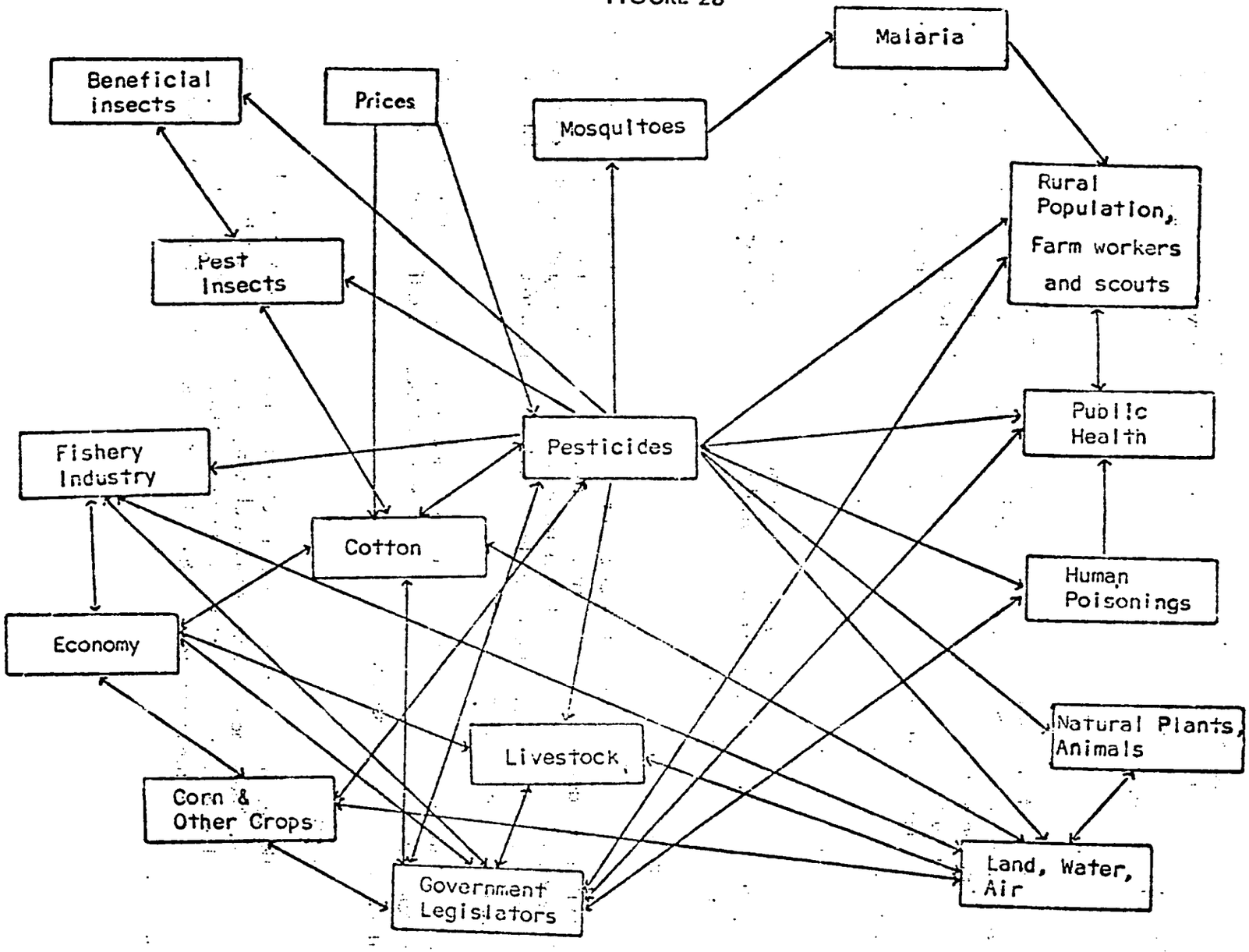
The economy of Central America determines many of the policies of the government, activities of industry, and the dynamics of society (figure 35). As mentioned, a large labor force is utilized for weeding and harvesting cotton instead of using chemical herbicides and mechanical harvesters. Employing large numbers of farm workers is a beneficial procedure in the Central American economy.

The economy of Central America influences many other factors in the ecological system such as public health and malaria control, but these are self evident and were mentioned in earlier discussions.

Society:

The society in Central America is related to many factors in the ecological system (figure 36). These include such factors as climate, land, water, vegetation, animals, diseases, population density, birthrates, age structure, agriculture, industries, and many other factors. Again, interrelationships of these factors in the ecological system have been discussed.

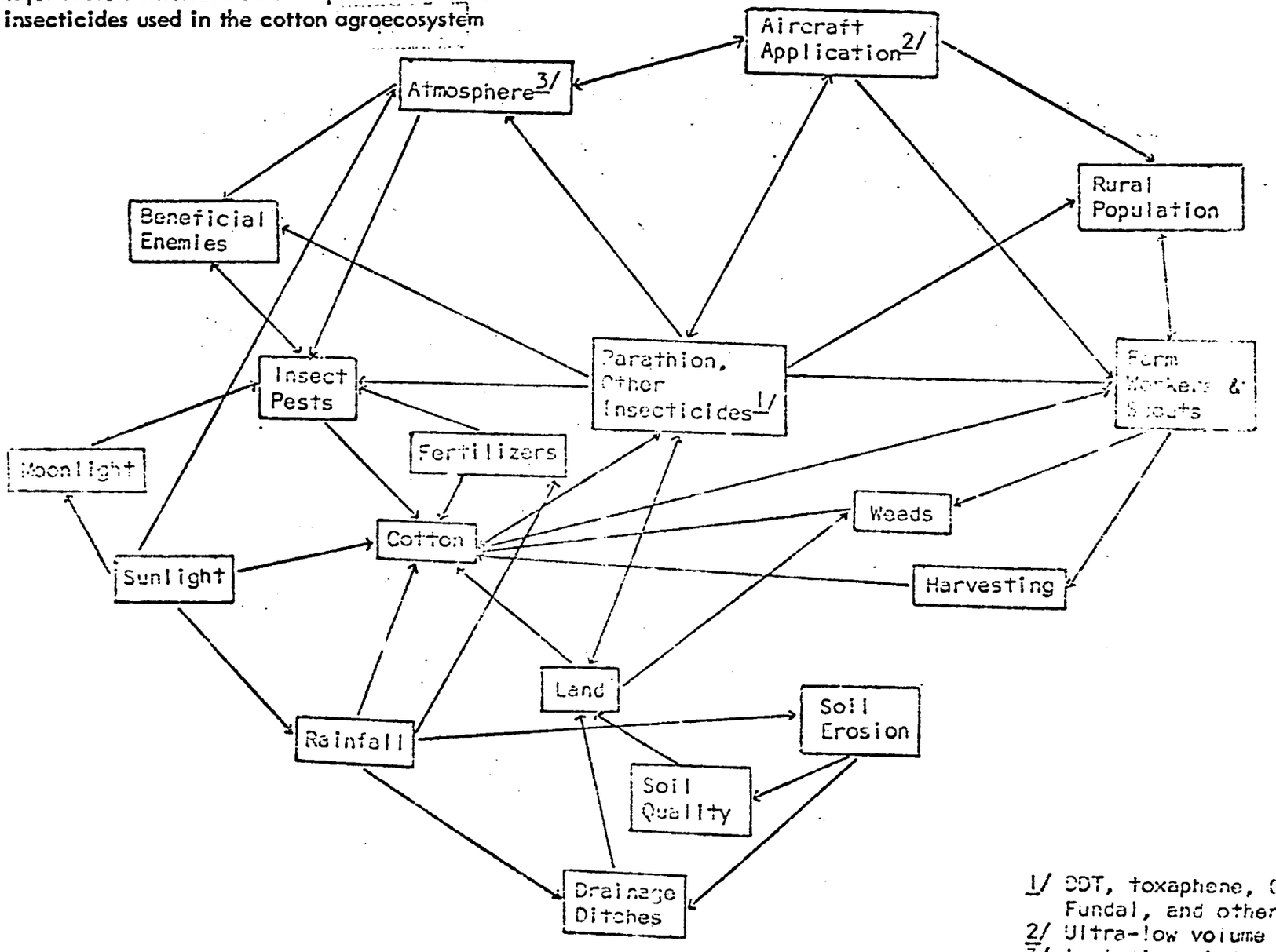
FIGURE 28



An "overview" of the major factors interrelated with the [illegible] of pesticide use in Central America

FIGURE 29

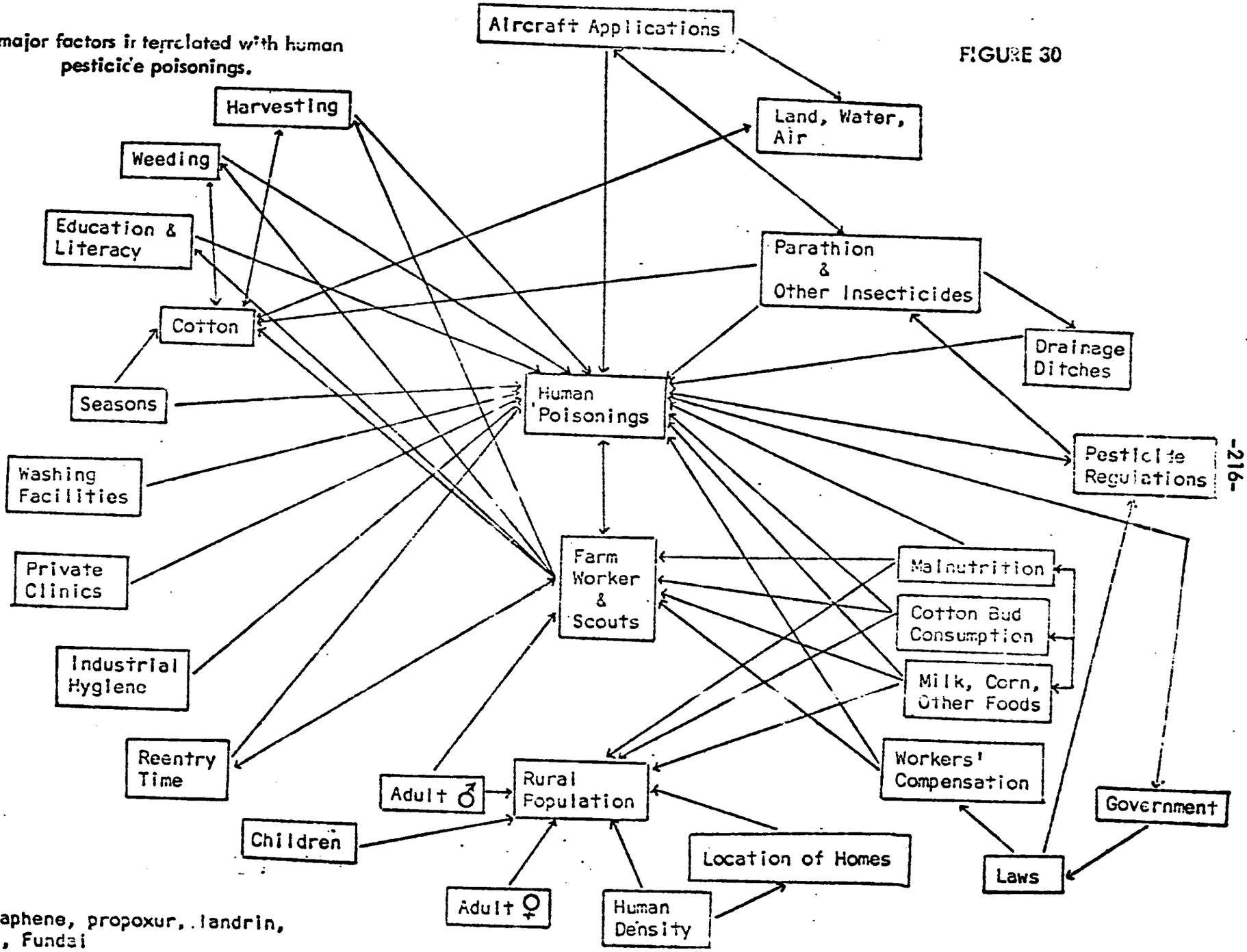
The major factors interrelated with parathion and other insecticides used in the cotton agroecosystem



1/ DDT, toxaphene, Galecron, Fundal, and other insecticides
2/ Ultra-low volume spray
3/ Including wind

The major factors interrelated with human pesticide poisonings.

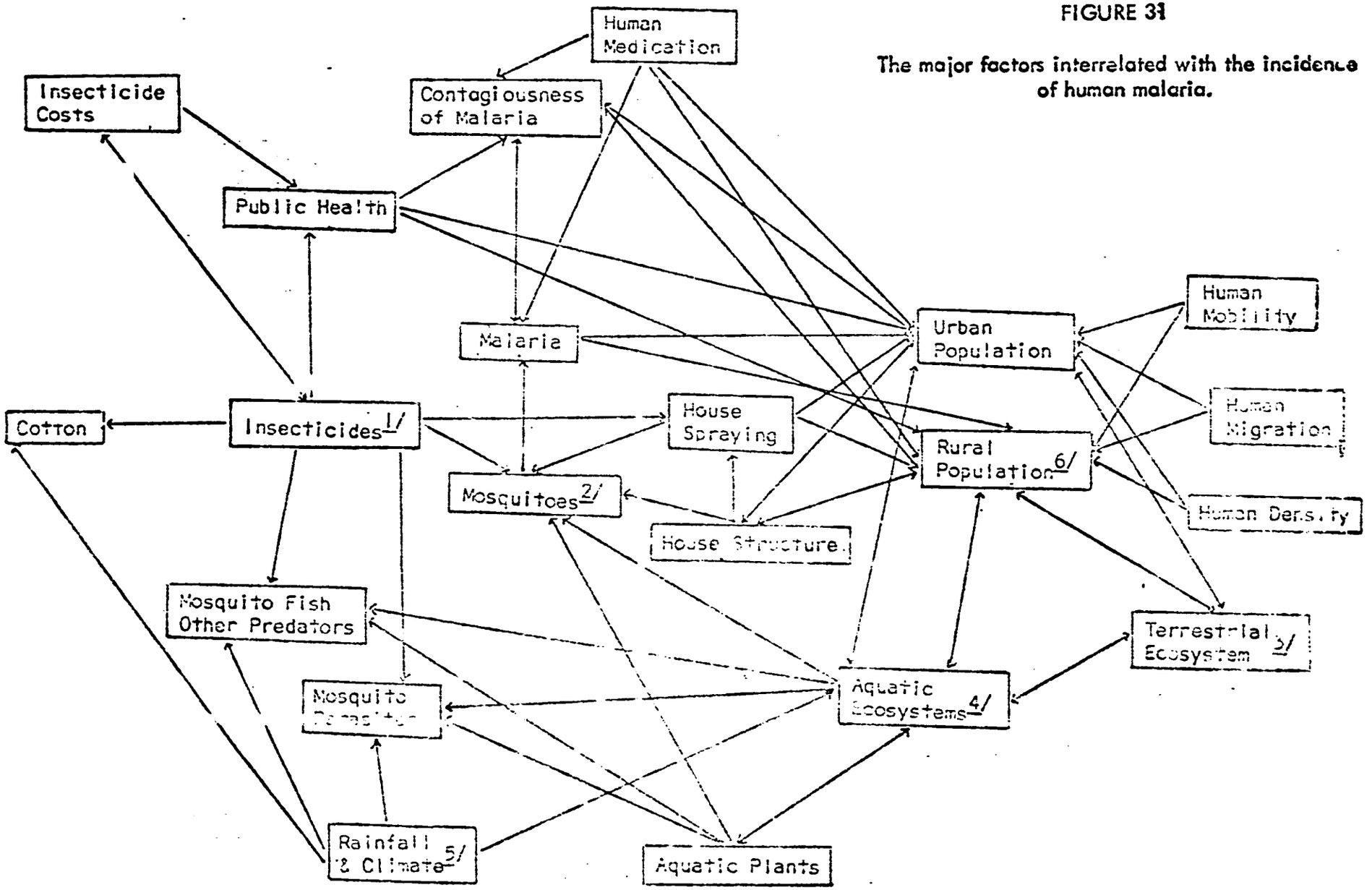
FIGURE 30



/ DDT, toxaphene, propoxur, landrin, Galecron, Fundal

FIGURE 31

The major factors interrelated with the incidence of human malaria.



Parathion, DDT, toxaphene, Galecron, Fundal, propoxur, landrin

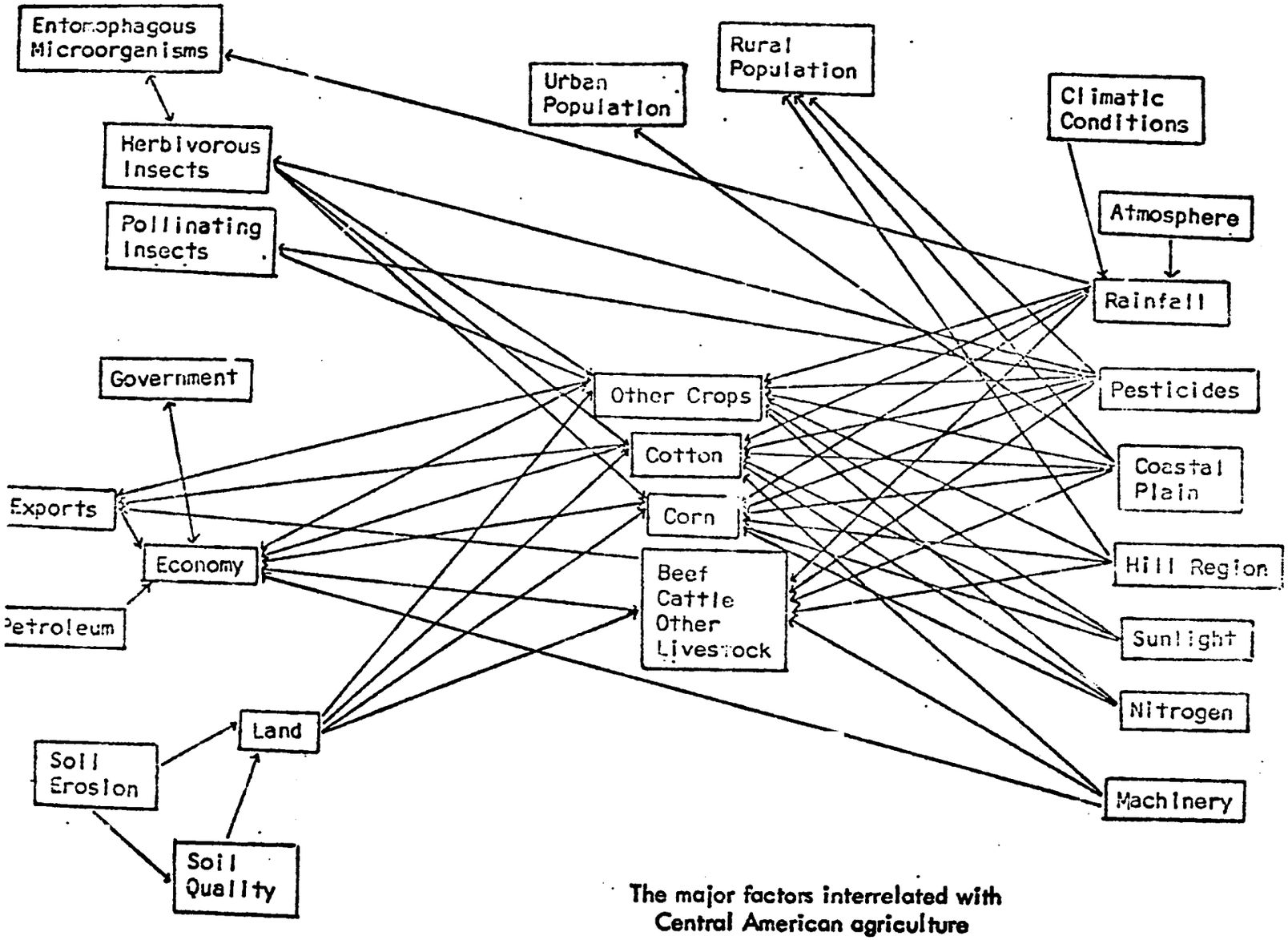
Including genetics of mosquitoes, zoophilic habits

Including coastal plain, hill region

4/ Including streams, ponds, and drainage ditches

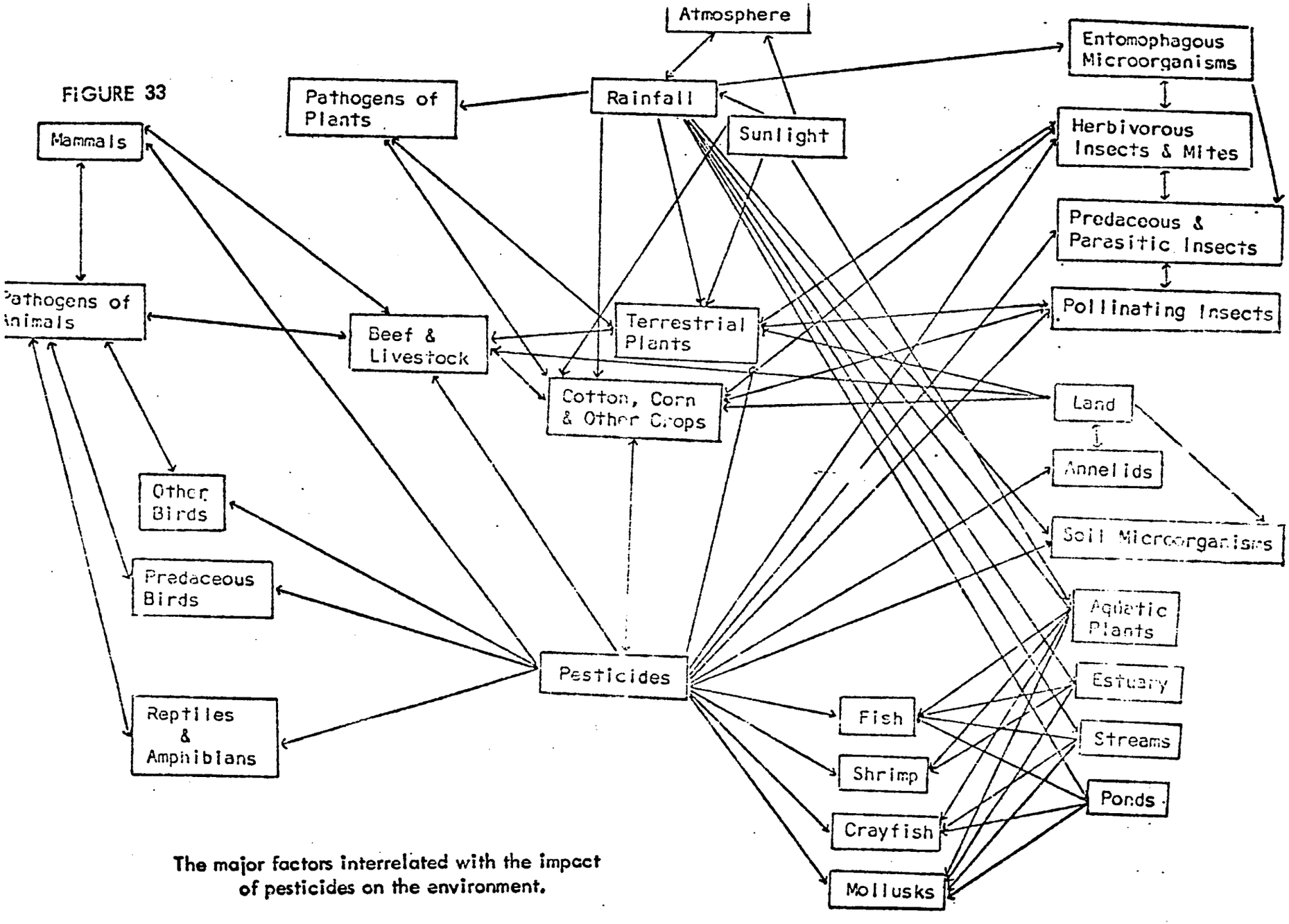
5/ Including atmosphere and other other moisture

FIGURE 32



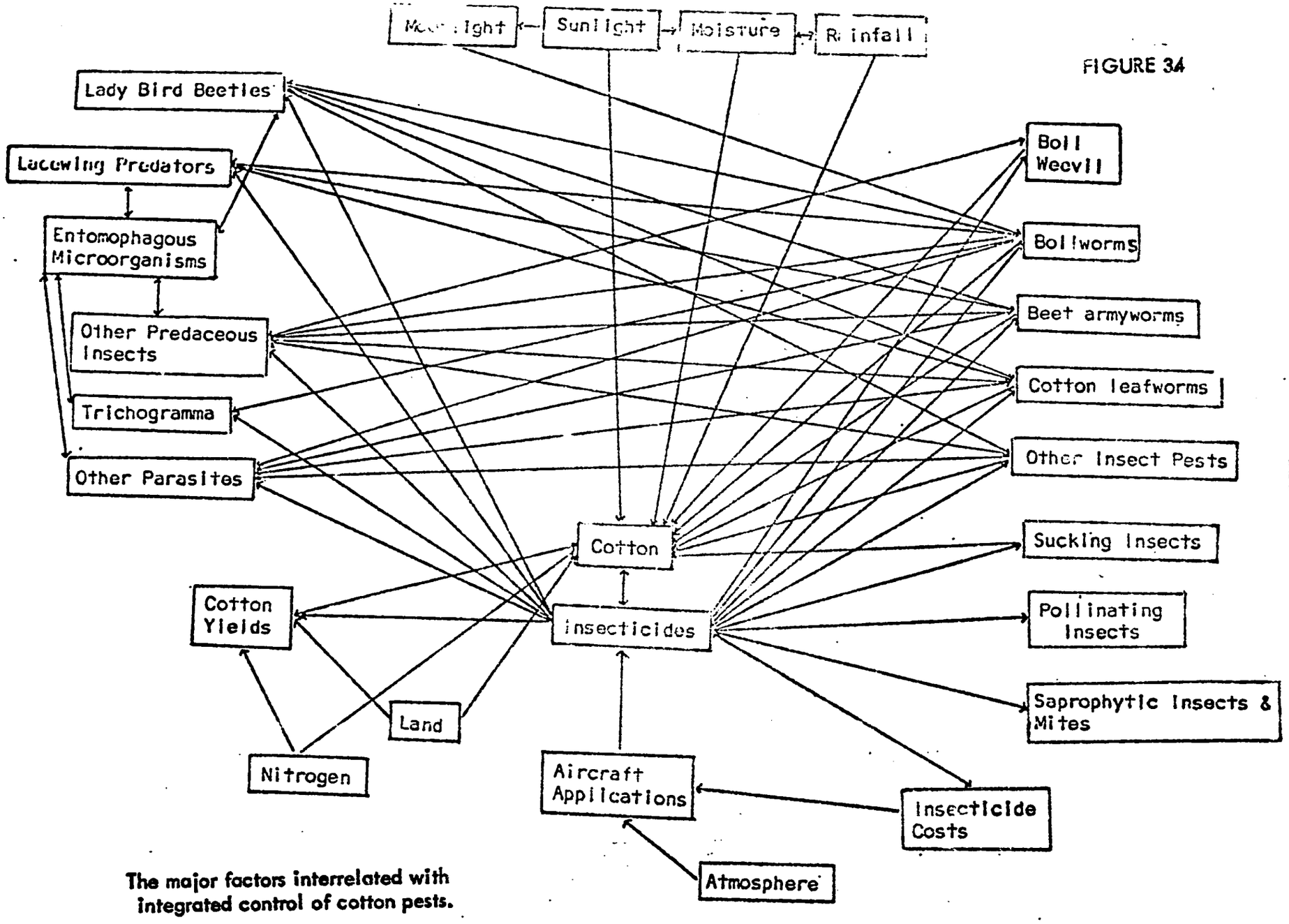
The major factors interrelated with Central American agriculture

FIGURE 33



The major factors interrelated with the impact of pesticides on the environment.

FIGURE 34



The major factors interrelated with integrated control of cotton pests.

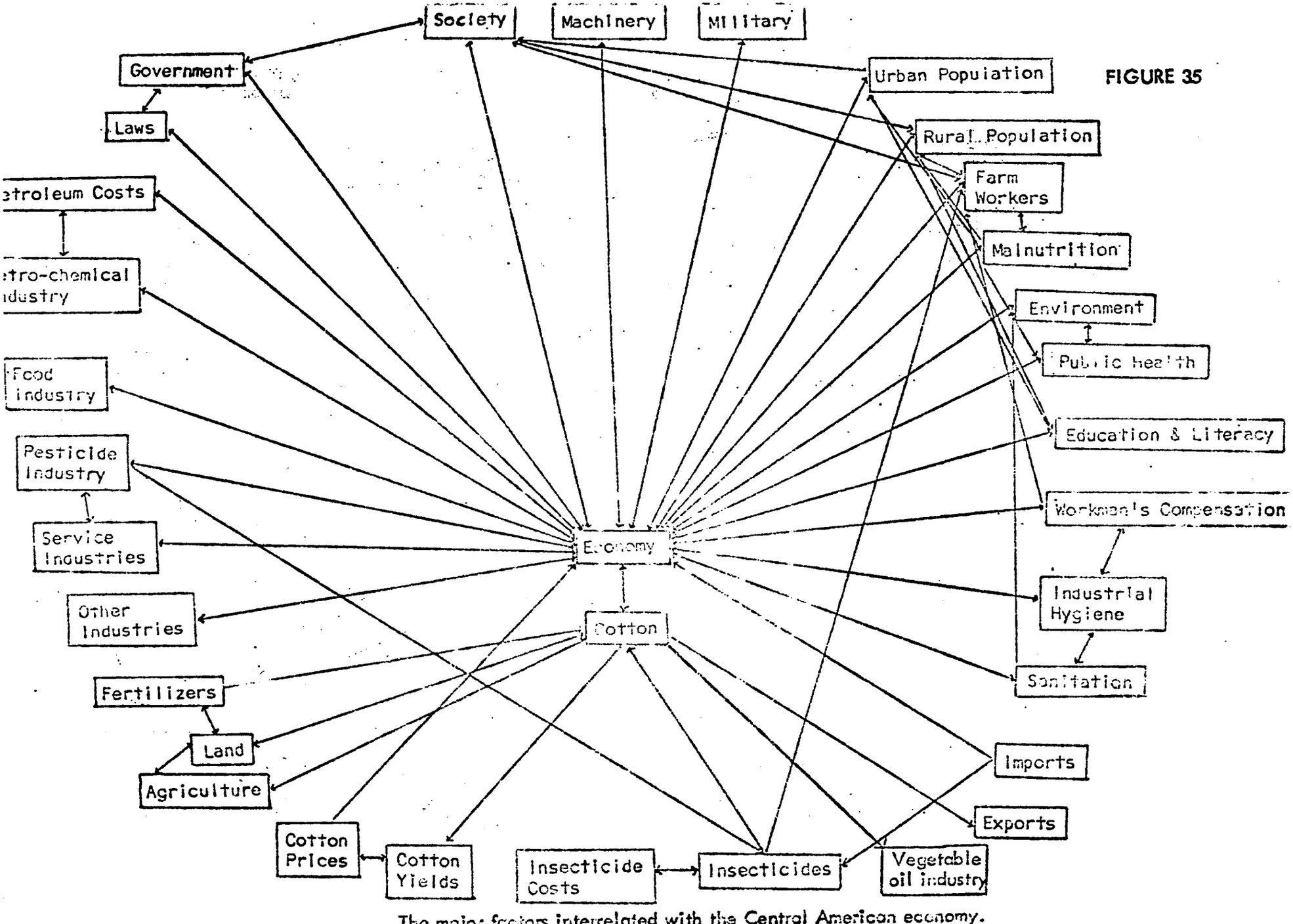
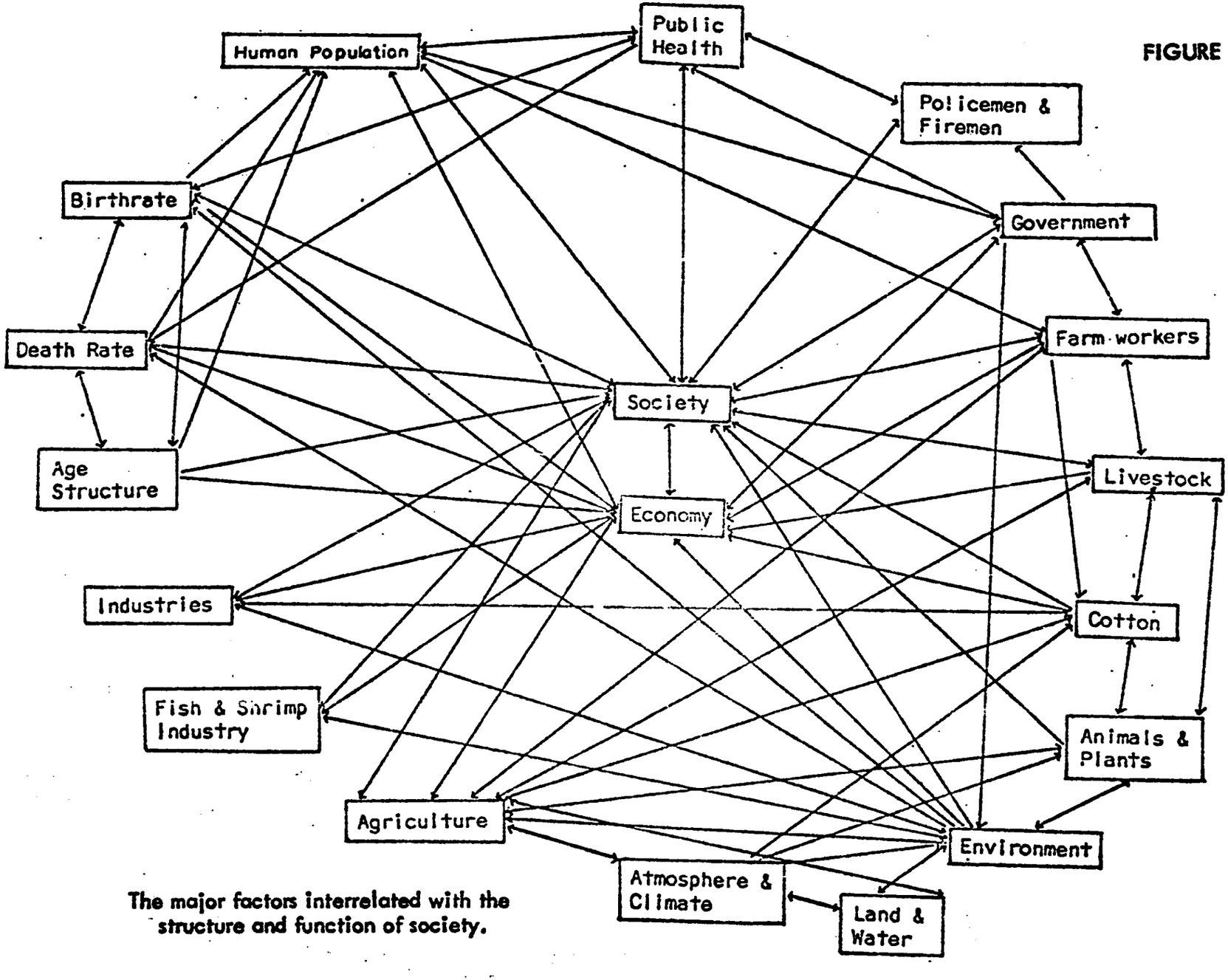


FIGURE 35

The major factors interrelated with the Central American economy.

FIGURE 36



The major factors interrelated with the structure and function of society.

APPENDIX 1

ENVIRONMENTAL STUDIES

This appendix presents samples of analysis performed for several types of pesticides in all countries of Central America as well as other relevant environmental data which was not included in the text of the report.

TABLE 57

GUATEMALA: RESIDUAL PESTICIDES IN FOODS, FORAGE, WATERS, FLORA, AND FAUNA DURING THE COTTON GROWING SEASON 1974-75

COUNTY	Area km^2	% of cotton growing area	SAMPLE	# of samples	Average of Residues in PPM		
					DDT + metabolites	Toxaphene	Dieldrin
Santo Domingo	242	49	meat	18	4.03	-	-
La Gomera	640	48	meat	26	10.70	0.14	-
			water(well)	1	0.0001	-	-
			fruits	1	1.18	-	-
			cotton seed	4	56.23	63.49	0.04
			cowmilk	25	5.10	-	-
			forage	3	0.046	-	-
Champerico	416	43	fish	3	1.02	-	-
			shrimp	2	5.89	9.35	-
			edible greens	3	0.016	-	-
			water(well)	3	0.00017	-	-
			cowmilk	3	3.88	-	-
			clams	1	7.51	22.03	-
			seafood	1	7.04	3.97	-
			meat	3	14.07	-	-
Tiquisate	892	26	meat	20	6.84	0.080	-
			cowmilk	6	11.76	-	-
			water (river)	10	0.0367	-	-
			water (well)	13	0.00051	-	-
			fish	4	7.52	10.36	

TABLE 57
(Cont.)

COUNTY	Area km^2	% of cotton growing area	SAMPLE	# of samples	Average of Residues in PPM DDT + metabolites	Toxaphene	Dieldrin
Tiquisate	892	26	amphibians and annelids	3	3.16	-	-
			fruits	5	0.048	-	-
			edible greens	3	0.25	-	-
			corn	2	0.0083	-	-
Retalhuleu	796	15	meat	49	7.36	-	-
			edible greens	3	0.29	0.30	-
			cowmilk	3	5.93	-	-
			fish(river)	1	41.0	65.09	-
			lobster	1	0.43	-	-
			birds	2	8.57	-	-
			reptiles	3	0.17	-	0.02
			forage	8	1.61	3.86	0.02
			water (river)	3	0.0004	-	-
			cotton seed	2	0.067	-	-
			sarghum	2	0.64	1.83	-
			water(well)	2	0.0002	-	0.0006
Coatepeque	372	10	meat	3	3.66	-	-
Chiquimulilla	499	6	meat	15	2.87	0.30	-
San Andrés V.S.	256	5	meat	23	6.90	0.18	-

TABLE 57
(cont.)

COUNTY	Area km^2	% of cotton growing area	SAMPLE	# of samples	Average of Residues in PPM DDT + metabolites	Toxaphene	Dieldrin
Masagua	448	2	meat	26	2.07	0.04	0.002
La Democracic	320	1	meat	21	4.35	-	-
			cowmilk	38	0.97	-	-
			forage	5	0.132	-	-
Chisec	1488	0	meat	8	0.58	-	-
Antigua	78	0	cowmilk	13	0.35	-	-
Guatemala		0	concentrate for cattle	2	0.056	-	-
			milk	4	0.57	-	-
Panajachel		0	milk	2	0.30	-	-

TABLE 58

EL SALVADOR: RESIDUAL PESTICIDES IN FOODS, FORAGE, WATERS, FLORA, AND FAUNA DURING THE COTTON GROWING SEASON 1974-75

COUNTY	Area Km^2	% of cotton growing area	SAMPLE	# of samples	Average of Residues in Parts per Million (PPM) DDT+ metabolites	Tox.	Diel.	Methyl parath.	Ethyl parath.
San Luis Talpa	42	88	meat	1	3.09	-	-	-	-
San Pedro Masahuat	146	62	corn	1	0.0041	-	-	-	-
San Pedro Masahuat	146	62	beans	2	0.011	-	0.0003	-	-
El Tránsito	48	56	meat	1	24.48	-	-	-	-
El Tránsito	48	56	corn	2	0.0050	-	-	-	-
El Tránsito	48	56	milk	1	1.94	-	-	-	-
Jiquilisco	400	41	corn	3	0.0041	-	-	-	-
Jiquilisco	400	41	sorghum	2	0.051	-	0.0005	-	-
Jiquilisco	400	41	milk	7	24.34	-	0.20	-	-
La Unión	24	36	sorghum	1	0.0093	-	0.001	-	-
La Unión	24	36	clams	2	0.20	-	-	-	-
La Unión	24	36	fish	14	1.06	0.09	-	0.05	0.34
La Unión	24	36	oysters	1	0.28	-	-	-	-
Tecoluca	268	29	sorghum	1	1.19	1.77	-	-	-
Tecoluca	268	29	cheese	7	6.08	0.03	-	-	-
Tecoluca	268	29	meat	2	20.47	4.46	-	-	-
Tecoluca	268	29	milk	4	2.81	-	0.25	-	-
Chirilagua	54	25	milk	4	5.39	-	0.13	-	-
Chirilagua	54	25	sorghum	1	0.05	-	---	-	-
Chirilagua	54	25	cheese	3	1.90	-	0.09	-	-
San Miguel	640	24	sorghum	2	0.11	-	0.0013	-	-
San Miguel	640	24	melon	2	0.005	0.195	0.0005	-	-
San Miguel	640	24	water(river)	1	0.00034	-	0.0006	-	-

TABLE 58
(Cont.)

COUNTY	Area Km^2	% of cotton growing area	SAMPLE	# of samples	Average of Residues in Parts per Million (FPM) DDT+ metabolites	Tox.	Diel.	Methyl Parath.	Ethyl Parath.
San Miguel	640	24	corn	6	0.0004	-	-	-	-
San Miguel	640	24	meat	1	3.54	-	-	-	-
San Miguel	640	24	beans	3	0.023	-	0.001	-	-
San Miguel	640	24	fish(fresh water)	6	10.95	5.24	-	-	-
Usulután	156	20	corn	5	0.0014	-	-	-	-
Usulután	156	20	sorghum	2	0.63	1.34	0.005	-	-
Usulután	156	20	pepper	1	0.0105	-	-	-	-
Usulután	156	20	melon	2	0.02	-	0.0002	-	-
Usulután	156	20	beans	4	0.0026	-	0.0001	-	-
Usulután	156	20	clams	25	0.21	-	0.001	-	0.07
Usulután	156	20	crab	1	0.11	-	-	-	-
Usulután	156	20	conch	8	0.12	-	-	-	-
Usulután	156	20	shrimp	12	0.24	-	0.003	-	-
Usulután	156	20	fish	20	2.38	6.22	-	0.39	0.16
Usulután	156	20	water(river)	1	-	-	-	-	-
La Libertad	158	19	meat	1	0.42	-	-	-	-
La Libertad	158	19	fish	15	1.68	4.58	-	0.007	-
La Libertad	158	19	oysters	3	0.14	-	0.006	0.04	-
Zacatecoluca	327	18	milk	3	1.72	-	0.015	-	-
Acajutla	111	12	corn	1	0.016	-	-	-	-
Acajutla	111	12	fish	8	0.79	0.09	-	1.32	-
Acajutla	111	12	shrimp	1	2.30	-	-	-	-
Acajutla	111	12	meat	1	0.81	-	-	-	-
Acajutla	111	12	plantain	1	-	-	-	-	-

TABLE 58
(Cont.)

COUNTY	Area Km^2	% of cotton growing area	SAMPLE	# of samples	Average of Residues in parts per Million(PPM) DDT+ metabolites	Tox.	Diel.	Methyl Parath.	Ethyl Parath.
Sonsonate	250	11	milk	2	2.06	-	-	-	-
Sonsonate	250	11	plaintain	1	-	-	-	-	-
San Vicente	252	11	beans	1	0.035	-	-	-	-
Olocuiltla	1200	9	milk	2	4.47	-	-	-	-
Pto. El Triunfo	40	8	conch	9	2.01	4.12	0.001	-	-
Pto. El Triunfo	40	8	shrimp	35	0.49	-	0.001	-	-
Pto. El Triunfo	40	8	crab	2	0.57	-	-	-	-
Pto. El Triunfo	40	8	fish	26	6.20	3.54	0.02	-	-
Pto. El Triunfo	40	8	milk	3	1.89	-	-	-	-
Intipuca	88	6	milk	1	1.12	-	0.20	-	-
Intipuca	88	6	cheese	4	1.55	-	0.01	-	-
Jucuarán	224	5	milk	2	32.31	-	0.02	-	-
Conchagua	264	4	sorghum	1	0.015	-	0.001	-	-
Conchagua	264	4	fish	12	1.72	-	-	0.01	0.04
Conchagua	264	4	oysters	2	0.18	-	-	-	-
Jujutla	312	2	fish	6	0.93	-	-	0.94	-
Jujutla	312	2	corn	1	0.029	-	-	-	-
El Carmen	120	2	corn	1	0.006	-	-	-	-
El Carmen	120	2	sorghum	2	0.020	-	0.0005	-	-
El Carmen	120	2	fish(fresh water)	2	0.86	-	-	-	-
San Jorge	56	2	tomato	1	0.043	-	0.003	-	-
Chalatenango	135	1	meat	1	0.87	-	0.25	-	-

TABLE 58
(Cont.)

COUNTY	Area Km^2	% of cotton growing area	SAMPLE	# of samples	Average of Residues in Parts per Million(PPM) DDT + metabolites	Tox.	Diel.	Methyl Parath.	Ethyl Parath.
Ilobasco	200	0.1	beans	2	0.007	-	-	-	-
San Carlos	20	0.01	meat	2	0.52	-	-	-	-
Nueva Concepción	258	0	meat	2	2.58	-	0.025	-	-
Nueva Concepción	258	0	milk	8	0.94	-	-	-	-
Nueva Concepción	258	0	cheese	3	1.33	-	-	-	-
Zaragoza	27	0	meat	1	0.95	-	0.05	-	-
San Isidro	84	0	milk	3	0.50	-	-	-	-
San Isidro	84	0	cheese	1	1.09	-	-	-	-
Atiquisaya	54	0	corn	1	0.0058	-	-	-	-
Ciudad Arce	92	0	corn	2	0.0018	-	-	-	-
Ciudad Arce	92	0	beans	7	0.012	-	-	-	-
Ciudad Arce	92	0	pepper	3	0.014	-	0.0002	-	-
Ciudad Arce	92	0	tomato	6	0.088	-	0.001	-	-

TABLE 59

HONDURAS: RESIDUAL PESTICIDES IN FOODS, FORAGE, WATERS, FLORA, AND FAUNA DURING THE COTTON GROWING SEASON 1974-75

DEPT.	COUNTY	Area Km2	% of cotton growing area	SAMPLE	# of samples	Average of Residues in Parts per Million (PPM) DDT+ metabolites	Tox.	Diel.	Methyl Parath.	Ethyl Parath.
Choluteca		4211	1							
Choluteca	Namasigue			corn	2	0.010	-	-	-	-
Choluteca	Namasigue			water(well)	3	0.00019	-	-	-	-
Choluteca	Namasigue			water(river)	1	-	-	-	-	-
Choluteca	Namasigue			fish	3	0.27	-	-	-	-
Choluteca	Apacilagua			corn	1	0.076	-	0.0004	-	-
Choluteca	Apacilagua			sorghum	1	0.03	-	0.0004	-	-
Choluteca	Yusguare			corn	1	0.08	-	0.006	-	-
Choluteca	Yusguare			sesame	1	0.015	-	-	-	-
Choluteca	Yusguare			sorghum	1	0.03	-	0.002	-	-
Choluteca	Yusguare			beans	1	0.011	-	-	-	-
Choluteca	Triunfo			corn	1	0.0031	-	0.0003	-	-
Choluteca	Triunfo			water(river)	1	0.00013	-	-	-	-
Choluteca	Triunfo			water(well)	1	0.00005	-	-	-	-
Choluteca	Marcovia			corn	1	0.006	-	0.0003	-	-
Choluteca	Marcovia			fish	8	0.80	-	-	-	-
Choluteca	Choluteca			water(river)	2	0.0013	-	-	-	-
Choluteca	Choluteca			water(well)	4	0.0011	-	-	-	-
Choluteca	Choluteca			gull	1	4.63	-	-	-	-
Choluteca	Choluteca			lizard	1	-	-	-	-	-
Choluteca	Roca			water(river)	1	0.0023	-	-	-	-
Olancho		24350	0.2							
Olancho	Catacamas			milk	1	0.30	-	-	-	-

TABLE 59
(Cont.)

DEPT.	COUNTY	Area Km^2	% of cotton growing area	SAMPLE	# of samples	Average of Residues in Parts per Million(PPM) DDT + metabolites	Tox.	Diel.	Methyl Parath.	Ethyl Parath.
Olancho	Catacamas			corn	1	0.014	-	-	-	-
Olancho	Catacamas			concentrate	1	0.063	-	-	-	-
Olancho	Catacamas			beans	1	0.006	-	-	-	-
Olancho	Catacamas			water(well)	1	-	-	-	-	-
Olancho	Sn.Fco. Becerra			corn	1	0.010	-	-	-	-
Olancho	Sn.Fco.Becerra			rice	1	0.72	-	-	-	-
Olancho	Sn. Fco. Becerra			Sorghum	1	0.08	-	0.006	-	-
Olancho	Sn.Fco.Becerra			greens	2	0.031	-	-	-	-
Olancho	Sn. Fco. Becerra			beans	1	0.012	-	-	-	-
Olancho	Sn.Fco.Becerra			cotton seed	1	0.14	-	-	-	-
Olancho	Sn. Fco. Becerra			water(well)	1	-	-	-	-	-
Olancho	Sn.Fco.Becerra			fish	1	0.02	-	-	-	-
Olancho	Sta. Ma. del Real			corn	1	0.012	-	-	-	-
Olancho	Sta. Ma. del Real			beans	1	0.012	-	-	-	-
Olancho	Sta. Ma. del Real			water(well)	1	-	-	-	-	-
Olancho	Juticalpa			corn	2	0.006	-	-	-	-
Olancho	Juticalpa			rice	2	0.125	-	-	-	-
Olancho	Juticalpa			beans	2	0.027	-	-	-	-
Olancho	Juticalpa			water(river)	1	-	-	-	-	-
Olancho	Juticalpa			water(well)	1	-	-	-	-	-
Olancho	Olancho			cotton seed	3	0.054	-	-	-	-
Valle		1565	1							
Valle	Nacaome			milk	2	4.76	-	-	-	-

TABLE 59
(Cont.)

DEPT.	COUNTY	Area Km^2	% of cotton growing area	SAMPLE	# of samples	Average of Residues in Parts per Million (PPM DDT+ metabolites	Tox.	Diel.	Methyl Parath.	Ethyl Parath.
Valle	Nicaome			corn	1	0.018	-	-	-	-
Valle	Naccome			sorghum	2	0.05	-	0.002	-	-
Valle	Alianza	1565	1	milk	1	0.45	-	-	-	-
Valle	Alianza			corn	1	0.014	-	-	-	-
Valle	Alianza			sorghum	1	0.016	-	-	-	-
Valle	Alianza			lizard	2	0.027	-	-	-	-
Valle	Coray			corn	1	0.063	-	-	-	-
Valle	Coray			sorghum	1	0.013	-	-	-	-
Valle	Coray			milk	1	0.70	-	-	-	-
Valle	Valle			fish	3	1.31	-	-	-	-
Valle	San Lorenzo			water(estuary)	1	0.0003	-	-	-	-
Valle	San Lorenzo			fish	6	0.14	-	-	-	-
Valle	San Lorenzo			shrimp	2	0.09	-	-	-	-
Valle	San Lorenzo			oysters	1	0.071	-	-	-	-

NOTE: The percentage of cotton growing area refers to the whole Department.

TABLE 59-A

AVERAGE CUMULATIVE DDT USE PER HECTARE IN 9 COTTON FARMS OF LA GOMERA, 1975

WEEK	DDT USE (CUM.) KG/HA a.i.
12 - 18 Sep.	0.014
19-25	0.544
26-2 Oct.	1.229
3 - 9	1.669
10-16	2.367
17-23	3.237
24-30	4.321
31- 6 Nov.	5.217
7-13	5.972
14-20	6.792
21-27	7.892
28-4 Dic.	8.739
5-11	9.505
12-18	9.955
19-25	10.225

SOURCE: ICAITI

APPENDIX 2

PUBLIC HEALTH

This appendix consists of information on malaria and factors associated to human poisonings in Central America.

TABLE 60

RESULTS OF THE STUDY OF 131 PESTICIDE POISONING CASES IN GUATEMALA, 1974

1. Distribution by age groups

less than 1 year	1	
1-5 years	2	7.6%
6-10 years	7	
11-15 years	17	
16-20 years	29	68.7%
26-30 years	15	
31-35 years	29	
36-40 years	9	
41-45 years	12	
46-50 years	3	21.4%
51-55 years	1	
56-60 years	3	
61-65 years	1	2.3%
66-70 years	2	
TOTAL	131	100%

6. Distribution by Month

January	17	13.08%
February	2	1.5%
March	0	
April	0	
May	0	
June	0	
July	0	
August	0	
September	0	
October	42	32.1%
November	37	28.2%
December	33	25.2%
TOTAL	131	100%

8. Days of Stay

Minimum	Maximum
1	4

2. Distribution by sex

Men	128	97.7%
Women	3	
TOTAL	131	

4. Distribution of residence

Temporary	100	76.3%
Permanent	31	23.7%
TOTAL	131	100%

7. Symptoms and Signs

Giddiness
Nausea
Vomits
Stomachache
Headache
Asthenia
Myalgia
Ataxia
Hyperdrosis
Sialorhea
Diarrhea
Myosis
Mydriasis
Conjuntivitis
High blood pressure
Unconsciousness
Phlegms

3. Distribution by activity

day laborer	106	80.9%
loader	9	6.9%
flag man	4	3.0%
tractor operator	2	1.5%

5. Distribution by graveness

T	S	M	S	D
131	73	45	13	0
100%	55.7%	34.3%	10%	

9. Insecticides Reported

Tamaron-Ethyl-Methyl
Phosphorated-Chlorinated
Ethyl -Methyl
Toxide-Fundal
Bladan-Galecron
Galecron-Niran
Tamaron-Toxaphene
Tamaron-Bladan
Tamaron-Ethyl-Methyl
Bladan-Toxide
Niran-Carbicron
Tamaron
Toxaphene
Melathion
Baygon
Valexon
Lannate
Phosphorated
Chlorinated
Bladan

TABLE 61

An Analysis of 131 Cases of Human Poisonings in a Municipality in Guatemala during 1974

Analysis of Human Poisonings

AGE (YEARS)	No.	SEX	No.	WORK	No.	INHABITANTS	No.
1	1	Male	128	Day worker	106	Permanent	31
1-5	2	Female	3	Tower	9	Temporary	100
6-10	7			Banderillero	4		
11-15	17			Tractor driver	2		
16-20	29			Field Scout	2		
26-30	15			Other	8		
31-35	29						
36-40	9						
41-45	12						
46-50	3						
51-55	1						
56-60	3						
61-65	1						
66-70	2						
TOTALS	131		131		131		131

TABLE 62

EL SALVADOR: POISONING CASES BY PESTICIDES AS NOTIFIED BY HEALTH SERVICES BY MONTH AND BY YEAR, 1964-1974

MONTHS	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	TOTAL	%
JANUARY	133	26	25	26	6	12	24	2	22	49	41	366	3.3
FEBRUARY	50	28	4	22	7	18	7	14	28	13	30	221	2.0
MARCH	27	9	7	2	-	6	22	11	32	116	28	260	2.4
APRIL	12	7	4	3	1	10	30	20	22	14	32	155	1.4
MAY	6	3	38	11	21	20	9	18	72	18	32	248	2.3
JUNE	5	13	39	22	74	45	61	43	68	70	63	503	4.6
JULY	26	44	32	37	13	27	60	39	56	28	78	440	4.0
AUGUST	93	57	87	51	7	33	16	27	123	72	41	607	5.5
SEPTEMBER	277	236	183	110	228	53	102	100	385	119	158	1951	17.8
OCTOBER	180	330	227	194	195	194	33	175	726	376	378	3008	27.4
NOVEMBER	110	145	65	82	31	111	38	53	826	279	163	1903	17.4
DECEMBER	68	45	91	32	19	55	72	84	500	108	230	1304	11.9
	987	943	802	592	602	584	474	586	2860	1262	1274	10966	100.0
	9.0%	8.6%	7.0%	5.4%	5.5%	5.3%	4.3%	5.3%	26.1%	11.5%	11.6%	100.0%	

SOURCE: División de Epidemiología, Dirección General de Salud.

TABLE 63

HONDURAS: PESTICIDE POISONING CASES BY AGE AND SEVERITY
1972 AND 1973

By years

1972	19 cases	67.8%
1973	9 cases	32.2%
TOTAL	28 cases	100.0%

By age group

from 14-20 years	7 cases	25 %
from 20-25 years	12 cases	42.8%
from 25-30 years	4 cases	14.3%
	5 cases	17.9%
TOTAL	28 cases	100.0%

By severity

Mild	15 cases	53.6% Mortality: 0%
Moderate	8 cases	28.5%
Severe	5 cases	17.9%
TOTAL	28 cases	100.0%

By Department

Choluteca	19 cases	67.8%
Valle	9 cases	32.2%
TOTAL	28 cases	100.0%

TABLE 64

HONDURAS: EPIDEMIOLOGIC STUDY OF 44 PESTICIDE POISONING CASES TREATED AT SAN FELIPE HOSPITAL. YEARS 1972, 1973, AND 1974

DISTRIBUTION BY YEARS

TOTAL	1972	%	1973	%	1974	%	TOTAL
44	4	9.0	21	47.7	19	43.2	100%

DISTRIBUTION BY DEGREE OF SEVERITY

TOTAL	MILD	%	MODERATE	%	SEVERE	%	UNKNOWN	%
44	31	70.5	5	11.3	7	15.9	1	2.3

3. Distribution by age group

14-15 years	6	13.7%
16-20 years	19	43.2%
21-25 years	9	20.4%
26-30 years	4	9.1%
31-35 years	2	4.5%
36-40 years	0	0.0%
40 and more	4	9.1%
TOTAL	44	100.0%

4. Distribution by sex

Men	24	54.5%
Women	20	45.5%
TOTAL	44	100.0%

5. Distribution by marital status

Single	41	93.2%
Married	3	6.8%
TOTAL	44	100.0%

6. Type of Pesticide

phosphate	32	72.8%
chlorinate	2	4.5%
carbomate	2	4.5%
rodenticide	2	4.5%
without spectrum	6	13.7%
TOTAL	44	100.0%

7. Distribution by Occupation

student	9	20.4%
housewife	14	31.8%
farmer	14	31.8%
military men	1	2.3%
motorist	1	2.3%
carpenter	2	2.3%
teacher (grammar)	1	2.3%
artist	1	2.3%
masons	1	2.3%
TOTAL	44	100.0%

8. Penetration Tract

Ingestion	37	84.1%
Spraying	4	9.1%
not specified	3	6.8%
TOTAL	44	100.0%

9.

Accidental ing.	16	43.3%
Intentional ing.	21	56.7%
TOTAL	44	100.0%

10. Distribution by Discharge

Recovered	43	97.7%
Deaths	1	2.3%
TOTAL	44	100.0%

11. Days of Stay

Minimum	1 day
Maximum	10 days
TOTAL	67 days

TABLE 64
(cont.)

12.
Distribution by Location

Tegucigalpa, Morazán	14	31.8%
Comayaguela, Morazán	19	43.1%
Sn.Vicente,Sta.Bárbara	2	4.5%
Ojos de Agua,El Paraíso	2	4.5%
Ald.Mateo, Morazán	1	2.3%
El Chimbo, Morazán	1	2.3%
Suyapa, Morazán	1	2.3%
Sn. Matías, Morazán	1	2.3%
Ald.Casitas, Morazán	1	2.3%
Ald. Conacaste,Morazán	1	2.3%
Tamara,Morazán	1	2.3%

13.
Symptoms and Signs Observed

Vomits	13	Loss of	9
Giddiness	10	conciousness	6
Nausea	7	Tachycardia	5
General Tremor	6	Headache	5
Blurred vision	5	Cold	2
Weakness	4	Stomach burn	2
Diarrhea	2	Distress	15
Cramps	1	Myosis	9
Lack of pupillary		Sialorrhea	6
reflexes	9	Hyperreflexia	4
Insecticide smell	9	Phlegm	4
Tochypnea	5	Tremor	4
Lung rattles	4	Excitation	3
Breathing failures	4	Cyanosis	3
Teary eyes	3	Vomits	3
Obnubilation	3	Distress	2
Convultions	3	Diarrhea	2
Unconciousness	2	Stomachache-	
Bradycardia	2	touch	2
Fasciculation	2	Stress	1
Nose fluttering	1	Lack of coor-	
Disorientation	1	dination	1
Disarthria	1	Fibrillation	1
Hematemesis	1	Sweat	4
Stomachache	1		

TABLE 65

NICARAGUA

RESULTS OF A STUDY OF 243 POISONING CASES, 1973

1.

Distribution by Age Group

0-1 year	3	1.2	7.0%
1-5 years	14	5.8	
6-10 years	7	2.9	12.0%
11-15 years	22	9.1	
16-20 years	78	32.1	63.4%
21-25 years	49	20.2	
26-30 years	27	11.1	
31-35 years	16	6.6	12.8%
36-40 years	9	3.7	
41-45 years	6	2.5	
46-50 years	4	1.6	3.2%
51-55 years	1	0.4	
56-60 years	3	1.2	
61-65 years	0	0.0	
66-70 years	2	0.8	1.6%
71-75 years	2	0.8	
TOTAL	243	100.0	

Distribution by sex

Men	219	90.1%
Women	24	9.9%
TOTAL	243	100.0%

3.

Distribution by Month

		%	
January	9	3.7	
February	4	1.6	
March	0	0.0	
April	4	1.6	
May	8	3.3	
June	14	5.8	
July	5	2.1	
August	2	0.8	
September	21	8.6	
October	79	32.6	77.4%
November	88	36.2	
December	9	3.7	
TOTAL	243	100.0	

Distribution by Activity

		%
Day laborers	170	69.9
Unknown activities	30	12.3
Housewife	17	7.0
Others	12	5.0
Students	8	3.3
Aircraft mechanic	6	2.5
TOTAL	243	100.0

TABLE 66

MALARIA, MORBIDITY BY MONTH AND PERCENTAGES FOR THE FOUR COUNTRIES, YEARS 1972, 1973, 1974

MONTH	1972 CASES	1972 %	1973 CASES	1973 %	1974 CASES	1974 %
JANUARY	7 296	13.54	3 981	6.90	7 644	8.60
FEBRUARY	4 446	8.25	4 775	8.28	7 129	8.02
MARCH	3 534	6.56	3 435	5.95	6 165	6.94
APRIL	3 534	6.56	2 416	4.19	4 526	5.10
MAY	4 671	8.67	3 114	5.40	8 580	9.66
JUNE	4 135	7.67	4 230	7.33	6 936	7.81
JULY	7 377	13.69	4 317	7.48	6 821	7.68
AUGUST	7 896	14.65	6 857	11.88	6 485	7.30
SEPTEMBER	2 926	5.43	7 115	12.33	6 714	7.56
OCTOBER	3 831	7.11	6 251	10.83	10 788	12.14
NOVEMBER	2 968	5.51	6 400	11.09	10 544	11.87
DECEMBER	1 274	2.36	4 811	8.34	8 496	9.56
TOTAL	53 888	100.00	57 702	100.00	88 828	100.00

TABLE67

GUATEMALA: COUNTIES WHERE NOPHELES ALBIMANUS IS RESISTANT TO OMS -33

COUNTY	DEPARTMENT	POPULATION	No. OF TESTS	% RESISTANCE
*Ocós	San Marcos	10413	2	60
Ocós	San Marcos	10413	14	88
*Coatepeque	Quezaltenango	17795	1	6
*Sn Andrés V.S.	Retalhuléu	23189	2	95
*Sn Andrés V.S.	Retalhuléu	23189	19	98
*Champerico	Retalhuléu	18008	1	47
*Champerico	Retalhuléu	18008	40	98
*Retalhuléu	Retalhuléu	35316	1	11
*Mazatenango	Suchitepéquez	26518	4	96
*Mazatenango	Suchitepéquez	26518	16	94
*Mazatenango	Suchitepéquez	26518	1	4
*Tiquisate	Escuintla	32099	2	89
*Tiquisate	Escuintla	32099	16	100
*La Gomera	Escuintla	27878	7	100
*Masagua	Escuintla	17367	1	41
Pto.Sn José	Escuintla	19538	1	28
Pto.Sn José	Escuintla	19538	19	88
Iztapa	Escuintla	4345	2	3
Guanagazapa	Escuintla	5798	1	80
Guanagazapa	Escuintla	5798	1	6
Taxisco	Santa Rosa	12678	3	66
Taxisco	Santa Rosa	12678	14	8
*Guazacapán	Santa Rosa	8204	1	33
*Guazacapán	Santa Rosa	8204	4	12
*Chiquimulilla	Santa Rosa	28080	1	35
*Chiquimulilla	Santa Rosa	28080	7	50
Pasaco	Jutiapa	4932	1	42
Pasaco	Jutiapa	4932	1	3
Moyuta	Jutiapa	19920	3	12

SOURCE: National Service for Malaria Erradication (SNEM) 1974.

* All these counties have cotton growing areas.

TABLE 68

EL SALVADOR: SENSITIVITY TESTS TO OMS-33 MADE DURING THE YEAR 1972

Location	County	Department	Conc.	time of exposure	Date	Mortality % Exposed	Mortality % Control	No. of mosquitoes used Exposed	No. of mosquitoes used Control
Miraflores	San Miguel	San Miguel	.1	240'	15/12/72	84	4	54	25
Tecomatal	"	"	.1	240'	15/12/72	86	0	100	25
Sn.Ant. Silva	"	"	.1	240'	13/12/72	97.6	16	100	25
Sn Ant Silva	San Ant Silva	"	0.01	240'	13/12/72	36	28	98	25(+)
El Brazo	"	"	.1	240'	30/11/72	33.7	8	100	25
El Brazo	"	"	0.01	240'	30/11/72	10	4	98	25
El Zamorán	"	"	.1	240'	25/11/72	43	0	97	24
Santa Inés	"	"	.1	240'	23/11/72	54	4	48	23
La Trinidad	"	"	.1	240'	22/11/72	87	0	98	25
Tecomatal	"	"	.1	480'	18/11/72	84	0	98	25
El Brazo	"	"	.1	480'	2/11/72	65.2	8	99	25
El Brazo	"	"	0.01	480'	5/10/72	12.1	9	96	23
Anehico	"	"	.1	480'	22/9/72	95.2	16	50	25
Sn Ant Silva	"	"	.1	480'	19/9/72	95.4	12	50	25
El Brazo	"	"	0.01	480'	7/9/72	48	4	100	25
El Brazo	"	"	.1	480'	7/9/72	96	4	50	25
San Pedro	Chirilagua	"	.1	75'	22/1/72	2	0	60	25
San Pedro	Chirilagua	"	.1	120'	22/1/72	98	0	100	25
San Pedro	"	"	.1	30'	21/1/72	86	0	58	23
El Brazo	San Miguel	"	.1	30'	20/1/72	44	0	50	25
El Brazo	"	"	.1	480'	20/1/72	86	0	99	25
El Brazo	"	"	.1	60'	15/1/72	60.2	12	100	50
Puerto Avalos	Jiquilisco	Usulutlán	.1	480'	21/7/72	80	0	100	25
Puerto Avalos	"	"	.1	480'	21/7/72	81.0	16	100	25
La Canoa	"	"	.1	480'	18/8/72	56	0	100	25
La Anchila	Concep.Batres	"	.1	240'	25/8/72	88	0	75	25
S. del Potrero	Jiquilisco	"	.1	480'	18/11/72	65.9	12	50	25(1)
S. del Potrero	"	"	.1	480'	3/11/72	68.2	12	50	25(1)
S. del Potrero	"	"	.031	480'	27/6/72	90.9	12	50	25(1)

TABLE 68 (Cont.)

Location	County	Department	Conc.	time of exposure	Date	Mobility % Exposed	Mobility % Control	No. of Mosquitoes used Exposed	No. of Mosquitoes used Control
S. del Potrero	Jiquilisco	Usulután	.125	480'	27/6/72	97.8	8	50	25(1)
S. del Potrero	"	"	.125	480'	5/7/72	82	0	98	25(L)
S. del Potrero	"	"	.1	480'	11/7/72	97.7	12	98	25(1)
S. del Potrero	"	"	.1	480'	12/7/72	92.8	8	92	25(1)
S. del Potrero	"	"	.1	480'	20/7/72	90	4	98	24(1)
S. del Potrero	"	"	.1	480'	20/7/72	70	0	100	25(1)
San Felipe	Concep. Batres	"	.1	240'	26/7/72	82.6	8	50	25(L)
Miravalles	Sonsonate	Sonsonate	.1	60'	28/7/72	100	5	38	20
Sacramento	S. Fco Menéndez	Ahuachapán	.1	60'	12/7/72	100	0	25	25
La Ceiba	"	"	.1	60'	18/7/72	100	0	50	25
La Ceiba	"	"	0.01	300'	18/7/72	56	4	50	25
Faya	Jucutla	"	0.01	480'	25/7/72	59.1	12	50	25
Faya	"	"	.1	60'	25/7/72	96	0	50	25
Calderas	Apastepeque	San Vicente	.1	60'	10/7/72	98.8	16	100	25 (2)
Calderas	"	"	.1	60'	20/11/72	100	16	100	25(2)
El Sauce	Stgo Nonualco	La Paz	.1	480'	11/7/72	100	0	100	25 (3)
Hato los Reyes	Zacatecoluca	"	.1	480'	22/7/72	18.2	12	73	25
Hato Nuevo	San Alejo	La Unión	.0.31	240'	27/7/72	100	12	50	23(4)
Hato Nuevo	San Alejo	"	.125	15'	27/6/72	100	4	50	25 (4)
Hato Nuevo	"	"	.125	120'	27/6/72	100	12	50	25 (4)
Hato Nuevo	"	"	.1	120'	12/7/72	98.9	12	100	25 (4)
Hato Nuevo	"	"	.1	480'	20/9/72	96	4	50	25 (4)
Hato Nuevo	"	"	.1	480'	20/9/72	90	12	50	25 (4)
Hato Nuevo	"	"	.1	480'	3/11/72	78.6	16	50	25 (L)
Hato Nuevo	"	"	.1	120'	3/11/72	57.1	16	50	25(4)
Hato Nuevo	"	"	.16	240'	27/5/72	99	0	100	25 (4)
Hato Nuevo	"	"	.16	120'	14/4/72	96	4	50	25 (4)
Hato Nuevo	"	"	.16	60'	14/4/72	94	4	49	25 (4)
Hato Nuevo	"	"	.16	30'	14/4/72	94	4	49	25 (L)
Calderas	Apastepeque	San Vicente	.1	60'	20/1/72	58	0	100	25
Miravalles	Sonsonare	Sonsonare	.1	30'	26/1/72	42	0	100	25
Miravalles	"	"	.1	120'	26/1/72	87	4	99	25

TABLE 68 (Cont.)

Location	County	Department	Conc.	time of exposure	Date	Mortality % Exposed	Mortality % Control	No. of mosquitoes used Exposed	No. of mosquitoes used Control
Miravalles	Sonsonate	Sonsonate	0.01	60'	27/1/72	12	0	100	25
Miravalles	"	"	.1	240'	27/1/72	97.8	8	99	25
Miravalles	"	"	0.01	480'	28/1/72	95	4	100	25
Miravalles	"	"	.1	60'	28/1/72	81	0	74	25
Las Piedras	Ishuatán	"	.16	120'	19/4/72	96	0	50	25
Las Piedras	"	"	.16	60'	19/4/72	94	0	50	25
Las Piedras	"	"	.16	30'	19/4/72	86	0	50	25
Las Piedras	"	"	0.01	480'	20/4/72	84	0	50	25
Las Piedras	"	"	0.01	240'	20/4/72	64	0	50	25
Las Piedras	"	"	0.01	120'	20/4/72	18	0	50	25
San Julían	Acajutla	"	.16	30'	18/5/72	88	0	60	20
San Dionisio	San Dionisio	Usulután	.1	60'	14/1/72	38.9	10	94	50
San Dionisio	"	"	.1	480'	14/1/72	80.4	8	50	25
San Dionisio	"	"	.1	480'	19/1/72	89.1	8	99	25
S. del Potrero	Jiquilisco	"	.16	240'	26/5/72	75.	0	100	25

LEGEND:

+ = Unsatisfactory

1 = Colonia Salinas del Potrero Strain (CNAP)

2 = Colonia Calderas strain, Malaria Research Center

3 = Colonia El Sauce Strain

4. = Colonia Hato Nuevo strain (CNAP)

L = Local strain

TABLE 69

NUMBER OF BLOOD SAMPLES ANALYZED FOR MALARIA IN NICARAGUA, POSITIVE SAMPLES, VECTOR SPECIES FOUND 1958-1973

NUMBER OF SAMPLES ANALYZED				SPECIES FOUND		
YEAR	SAMPLES	CASES	Percent	P. Falciparum	P. Vivax	P. Malaria
1958	23982	890	3.7	4619	1256	
1959	38966	1875	4.8	4217	3311	
1960	70074	7528	10.2	3001	5721	
1961	109293	8722	8.0	3428	7772	
1962	162733	11200	6.9	2742	7851	
1963	152239	10593	6.9	2403	8794	
1964	173968	11179	6.5	883	7787	
1965	167589	8670	5.2	2045	11850	
1966	197472	13895	7.0	2353	13968	
1967	269575	16321	6.1	479	7771	
1968	411544	8250	2.0	2673	13370	
1969	498119	16043	3.2	518[illegible]	22080	
1970	281386	27260	9.7	3041	22262	
1971	223098	25303	11.3	6666	8929	
1972	208232	9595	4.6	161	3053	
1973	174320	3214	1.84			

Source: National Malaria Eradication Service.

TABLE 70

NUMBER OF BLOOD SAMPLES ANALYZED FOR MALARIA IN GUATEMALA
POSITIVE SAMPLES, VECTOR SPECIES FOUND, 1955 973

NUMBER OF SAMPLES ANALYZED				SPECIES FOUND			
	POSITIVE SAMPLES						ASSOCIATED
YEAR	SAMPLES	CASES	Percent	P. VIVAX	P. Falciparum	P. Malaria	SPECIES
1955	3716	351	9.44	295	55	1	-
1956	12698	3088	24.32	2192	889	-	7
1957	25232	5653	22.40	3812	1792	4	45
1958	62119	12829	20.65	7786	4960	-	83
1959	108047	7849	7.30	6346	1524	-	24
1960	129742	3387	2.61	2969	409	1	8
1961	219628	4083	1.86	3298	767	5	13
1962	323373	5996	1.85	4375	1575	20	26
1963	348866	15116	4.33	9510	5404	49	153
1964	289058	20401	7.05	15358	4769	40	234
1965	380562	14472	3.80	12157	2095	2	218
1966	376439	22045	5.80	18815	3003	3	224
1967	439192	19684	3.94	18307	1284	-	93
1968	492940	10407	2.11	10043	346	-	18
1969	521336	10494	2.01	10284	198	1	11
1970	447706	11044	2.50	10961	80	-	3
1971	332531	8280	2.50	8246	32	1	1
1972	345156	7750	2.25	7746	4	-	-
1973	38626	6182	1.60	6179	3	-	-

Source: National Malaria Eradication Service

TABLE 71

GUATEMALA: MORBIDITY RATES OF MALARIA FOR COUNTIES WITH COTTON AREAS , YEARS 1972 - 74

COUNTY	Rate per 1000 inhabitants		
	1972	1973	1974
Ayutla	4.0	0.4	0.1
Ocós	22.5	2.9	3.9
Coatepeque	1.6	0.2	0.05
Retalhuleu	2.8	1.9	1.1
Champerico	23.6	7.1	8.8
San Andrés Villa Seca	17.6	4.7	1.9
Mazatenango	7.8	1.2	1.9
Santo Domingo S.	1.2	2.0	1.1
Tiquisate	1.7	0.4	0.3
La Gomera	2.0	0.8	2.0
La Democracia	4.0	0.7	1.0
Masagua	2.1	1.9	1.4
Chiquimulilla	0.2	0.7	0.6
Guazacapán	2.8	0.2	0.4

SOURCE: ICAITI

TABLE 72

GUATEMALA: SPECIFIC RATES OF MALARIA MORBIDITY IN COUNTIES WITHOUT COTTON AREAS. DEPARTMENTS OF BAJA VERAPAZ, IZABAL AND EL PETEN, YEARS 1972, 1973, 1974.

COUNTY	Rate per 1000 inhabitants		
	1972	1973	1974
Cubulco	2.35	0.13	0.26
El Chol	3.69	1.44	0.56
Granados	23.57	4.66	0.56
Rabinal	1.70	1.38	1.14
Salamá	1.82	2.19	0.31
San Miguel Chicaj	4.45	0.11	0.22
El Estor	27.74	11.77	2.58
Livingston	3.95	7.74	6.22
Los Amates	0.52	0.91	0.23
Morales	0.78	0.78	0.77
Puerto Barrios	0.18	0.23	0.05
Dolores	20.80	11.04	21.85
Flores	5.79	3.95	2.52
Melchor de Mencos	24.74	15.39	4.02
Santa Ana	34.40	20.47	16.65
Sayaxché	63.96	34.68	32.88
Poptún	8.38	3.78	1.88

SOURCE: ICAITI

APPENDIX 3

AGROECOSYSTEM MANAGEMENT

The Existing Conditions for Developing Integrated Cotton Pest Control in Central America:

Cotton in Central America:

Ecological characteristics and agricultural techniques make an evaluation of cotton production in Central America somewhat confusing. Cotton yields rank among the highest in the world, for instance. Yields in Guatemala are second only to those of Israel; El Salvador and Nicaragua rank among the first five. Yet the studies carried out in the past 2 years clearly show that present cotton technology in Central America could be substantially improved.

Some parts of the Central American Pacific plains are almost ideal for cotton production. The soils, of volcanic or alluvial origin, are deep, loamy and well-drained. Average ambient temperatures are within the optimal range for the growth and development of the cotton plant. The rains normally start in mid-May and end in early November, providing sufficient moisture for an adequate period in which the cotton fruits can grow, followed by a dry period for the open bolls to dry. According to some experts, Cotton (Gossypium hirsutum) is native to Central America. Also native is a landless rural population with a strong agricultural vocation which is willing to work for very low wages ($1.25-$1.50 per day).

Thus stimulated, many farmers and entrepreneurs have entered the cotton activity and made cotton the third most important export crop of the region after coffee and bananas. The same favorable conditions have somewhat prevented the development of production techniques, especially in the area of pest management. Thus, while compounding pest problems force cotton growers to use increasing amounts of pesticides, other favorable conditions and the reasonable hope of good prices keep them confident and often skeptical about improvements in cotton production technology.

Cotton production in Central America fits with reasonable adequacy in the slot labeled by Smith as "stage of crisis": (1) Increasingly frequent applications of pesticides are necessary; these start earlier in the season and their effectiveness is smaller every year as resistance becomes generalized. Secondary species become pests; production costs climb every season: a consequence of greater insecticide use because of resistance and secondary pest outbreaks.

The situation varies from country to country. Some are nearer the exploitation, or "boom" phase, like Honduras; and others, like Nicaragua are proceeding into the integrated control stage. This affects the potential receptiveness to integrated control programs, and will be discussed in that context.

(1) Smith, Ray F. and Louis A. Falcon, Manual de Control Integrado de Plagas del Algodonero. (Rome: FAO, 1974) P. %

Integrated pest control for Central America:

Although an integrated pest control program in cotton is technically feasible and economically desirable, there are institutional and cultural realities which would condition its acceptance and its eventual success. Institutions vary from country to country. Yet the mentality and culture is remarkably similar throughout, especially with regards to receptivility.

Technical assistance (the instrument of change) is a two-way flow of information; it benefits from basic grounds for communication above and beyond self-interest and the need to get a job done. The person in charge of conducting technical assistance must have a thorough, intimate knowledge of the area and the cultureif he is to succeed establishing effective channels of information. He must be able to communicate at the same level and in the same language with the farmers and technicians, even with the same sense of humor. Above all, he must be an expert in integrated control in cotton in Central America.

The role of other international experts in integrated cotton pest control must be sharply defined. Their expertise will provide an invaluable technological input into the communication (extension) process. Yet their knowledge will be needlessly wasted unless they have a Central American counterpart who can be the leader in the field.

Aside from a solid scientific background, the only recommendations for a Central American integrated control program to succeed is to have a strong component of local staff in positions of responsibility, perhaps as counterpart to international experts .

To different degrees, all countries have counterparts, laboratory and office facili - ties, extension services of a general nature, favorable access to universities, and in all countries it is possible to secure the cooperation of cotton growers in order to set up demonstration areas. In matters specifically related to cotton, the infraestructure available in one country varies greatly from the next. This is reflected in table 41.

In spite of these differences, there exist bases for joint research. The cotton growing area is an ecological (and cultural) homologue. In fact, these differences open possi - bilities for technical transfer within the region with a minimum of adjustments.

Honduras: Cotton activity is still embryonic in this country. Planted area went from 8234 ha in 1974/75 to about 4800 ha in 1975/76 (by comparison, planted area in Ni - caragua, Guatemala and El Salvador were 177 800 ha, 111 138 ha and 100 470 ha, respectively). This incipient status as a cotton producing country manifests itself in most aspects of the cotton activity in Honduras.

Yields, for instance, are lowest in Honduras than anywhere else in the region. For 1974/75, these were 1766.7 kg/ha, 14% less than the second lowest, Nicaragua, and 35% smaller than the highest, Guatemala. This is primarily caused by the relatively lower level of technology (highly technified Honduran growers produced 3376 kg/ha this past season. 91% above for national average which goes to show the defficiency of ordinary agroecosystem management techniques in the country). A possible explanation is the increasing participation of peasant associations with low levels of technology, whose yields are correspondingly lower.

Related to the lower yields are the low levels of pesticide use. Farmers used an average of 20 kg/ha of pesticide active ingredient in 1974/75 (averages in Guatemala were 4 times higher). This results in lower levels of environmental degradation (see chapter on the environment p 35), and a lower intoxication rate (p 97).

While there exists notable interest for the production of cotton in Honduras, the activity is hindered at the present time by technological , financial and institutional difficulties. The application of land reform lows has broken up large holdings and has all but stopped the capacity to cultivate cotton on rented lands. Although large credit programs for cotton are being contemplated, the flow of capital has been insufficient in the past. Even though the main cotton institution, Cooperativa Agropecuaria Algodonera del Sur, has mounted a serious, well-organized extension program, most farmers are still to become more open to suggestions, especially the agricultural cooperatives.

In comparison with cotton farmers elsewhere , Honduras growers generally show lower levels of entrepreneurship. This reflects the pervasive conditions of social and economic development in that country. The aggresive, innovative farmers easily succeed, which shows one aspect of the real constrainst to efficient cotton production.

The Hondurcn cotton cooperative is making substantial efforts in technical assistance of the extension type. This past season, a total of 67 agricultural enterprises received continuous technical counseling thoughout the whole season. Six cotton technicians covered 3568 hectares, 75% of the total area planted this year (75/76). Most farmers received between 3 and 6 visits per week, a very significant effort by Central American standards.

In order to fully exploit the benefits of the extension program, it is apparent that many of the technicians could receive further training outside Honduras. There is a substantial body of knowledge available in nearby Nicaragua or elsewhere, and to which they can easily become exposed.

To sum up , there exists in Honduras a definite potential for cotton production if the entreprenurial capacity is further developed and the technical assistance, perfected. The existing institutional framework (with particular reference to land reform) is not favorable to the cotton activity. Honduras stands at a point in its development where it is possible to design a cotton agroecosystem management program which benefits from the mistakes (economic, agricultural and environmental) that have been made elsewhere in the region and which maximizes the benefits of cotton production.

A strategy for Honduras: The most expedient way to develop an integrated cotton pest control program in Honduras would be to work jointly with the extension service which the Cooperativa Agropecuaria Algodonera del Sur sponsors. The group is well-organized motivated and eager to learn. It is well- known and accepted by cotton growers, a significant quality. The program could be easily complemented and expanded.

TABLE 73

CENTRAL AMERICA: EXISTING INFRAESTRUCTURE FOR THE DEVELOPMENT OF AN INTEGRATED COTTON PEST CONTROL PROGRAM.

ITEM	El Salvador	Guatemala	Honduras	Nicaragua
National cotton plant protection program	on the wane	no	yes	yes
Cotton research center	yes	no	no	yes
Integrated cotton pest control experts	2	1	3	7
Adequate cotton extension services	fair	poor	medium	good
Proximity to universities engaged in cotton-related research	fair	poor	fair	good
Availability of demonstration and research areas	good	good	good	good
Cotton-related publications	2	1	1	3

SOURCE: ICAITI

An integrated control expert who knows the people and the zone could easily convince the cooperative of his capacity to motivate cotton growers and obtain the cooperative's backing. More than in any other country, the Honduran cultural make-up makes it highly desirable to detach personnel who can communicate with growers and technicians at their level and in their words. The cooperative would act as the executing agency in charge of channeling the program there.

A research group, closely related to the cotton research center in Nicaragua, could be developed parallel to the extension program. The Nicaraguan center is only 120 kilometers away from the heart of the Honduran cotton zone. Joint experiments and tests could be developed by the two countries, avoiding unnecessary duplications.

Training could take place with the assitance of two agricultural schools: The Escuela Panamericana de Agricultura and the Escuela Nacional de Agricultura. Short courses for growers and auxiliary personnel could be developed with the assistance of these centers. Also the schools could provide student help for specific research or extension projects, with mutual benefits. The training of technical personnel could be more efficiently effected in the University of Nicaragua at León .

The Cooperativa Agropecuaria Algodonera del Sur publishes periodical information bulletins. These should be improved, expanded and coordinated with similar publications in the rest of Central America. The goal is to achieve a national publication in every country, adapted to the needs and circumstances of each, but centrally coordinated for the whole region. Subjects of general and specific interest could flow from research centers to the growers and back. Dissemination would become more effective and responsive in spreading integrated pest control methodologies and philosophy.

It was apparent that some cotton is grown in lands not suited for that crop. A preliminary zoning would help concentrate the extension efforts in the more suitable areas and discourabe cotton production in the rest.

Last, some efforts should be made to change present governmental indifference towards cotton growing. The development of any program could be facilitated within an atmosphere of protection and encouragement from the Honduran national government.

Guatemala: The situation in Guatemala can be summed up as follows: excellent cotton lands, aggresive entrepreneurs, high use of pesticides, fertilizer and machinery and absolete pest management technology. This results in high yields (although no longer increasing), over-confident farmers and worsening pest problems. Cotton production in Guatemala is at the threshold of the crisis stage, and there are no institutions presently engaged in cotton research or extension.

It is apparent that a peak was reached in 1971/72 and that yields have reached a plateau with a tendency to decline. During the past decade, cotton yields in Guatemala have gone from 2272 kg/ha in 1965/66 to a peak of 3359 kg/ha in 1971/72; the following year they declined to 2870 kg/ha, rose again to 3333 kg/ha and again declined to 2715 kg/ha in 1974/75.

Meanwhile, pesticide use has been increasing markedly. From an average of about 50 kilograms of pesticide active ingredient applied per hectare per season in 1971/72, use levels went to 80 kg/ha in 1974/75. These high levels have resulted in sharp increases in production costs, which tend to lower profits.

Guatemalan cotton farmers are not easily open to suggestions on how to manage pest populations and pesticide applications are made according to the calendar in many cases. Their only exposure to technical assistance was unsuccessful mainly because the few experts imported were not sufficiently familiar with local conditions. Typical farmers are wealthy, with relatively large farms, easy access to capital and their own airplanes and machinery.

Partly because of their economic solvency, they attract and support large numbers of pesticide salesmen. The salesmen reinforce the belief that "the only insect is a dead insect" and that the purpose of cotton production is to obtain the highest possible yield (often without regard to costs).

The one fortuitous circumstance which makes cotton production profitable (and perhaps enhances the farmers' over-confidence) is the relatively high yields. Aside from possesing all the characteristics of prime cotton land, about 60% of the Guatemalan cotton zone remains moist throughout the year because of underground seepage from a lake in the highlands. The loamy soil facilitates rood penetration and subsequent tapping of underground highlands. The loamy soil facilitates root penetration and subsequent tapping of underground water deposits. Cotton plants continue to produce new fruit after the first-formed bolls are open. The farmers get a second, smaller crop with a similar investment in pesticides and fertilizer and are thus able to obtain the second highest cotton yields in the world.

The farmers' self-confidence, however, is being continually eroded by yields which show a certain tendency to decline, the inability of pesticides to control resistant pests, wild fluctuation in cotton prices and ever-increasing prices for petro-chemical inputs. There is a dawning understanding that cotton-growing is a business for the purpose of maximizing profits, not yields. Although at present there are no scientific institutions engaged in cotton research and extension, farmers are already becoming increasingly curious about new technologies. Any effort to improve cotton technology in this country will encounter the obstacles outlined above.

A strategy for Guatemala: A program for Guatemala has to begin by persuading growers through successfully demonstrating the advantages of integrated control . There are no technical assistance services at the national level, nor is there much hope for one in the future. The reason is that growers have relatively large farms and tend to be wealthy beyond the need of government help.

The strategy would be to contact the Consejo Nacional del Algodón (National Cotton Council) and the Association of Cotton Growers and obtain their support. They are in a position to provide some degree of economic aid, such as counterpart salaries, and the opportunity should be explored. The council and the association can also arrange for the provision of adequate demonstration areas for the program.

The first year, an expert and his counterpart could stage a demonstration in some 350 hectares. This would help to unify methodologies and serve as a showcase. The following year, the area of demonstration could be expanded and the expert and his counterpart would take care of different units. The Faculty of Agronomy at the National University could work together with the expert and counterpart. Training and demonstration could proceed parallel to one another and at the greatest possible speed.

Once enough growers have been convinced and there is a large number of trained technicians, a technical assitance program can be started. The sponsor could be the Consejo Nacional del Algodón and/or the Cotton Growers Association and the growers could pay for the program on a per unit - area basis. Enough technicians should be trained, taking into account the fact that a number of them will be hired away by the growers while the group develops.

The existing publication of the National Cotton Council, "algodón", should cover aspects of immediate practical importance to the farmer as well as subjects of general interest and statistics. Obtaining enough high quality material would be facilitated by coordinating with other Central American Cotton Publications. The aim is to publish four magazines one in each country, under one editorial coordination to achieve the highest possible level of dissemination of integrated control.

There is a government sponsored research group, but its activities do not include cotton at the present time. A way should be found to integrate the Instituto de Ciencia y Tecnología Agrícola (ICTA) to the program .

Only through continuing demonstration for a number of years can enough bases be built to launch an integrated cotton pest control program. In Guatemala, most of the work is still ahead.

El Salvador: The oldest producer of cotton in Central America has already reached the stage of crisis, made a false start toward integrated control and reverted back to a near-critical situation. Cotton continues to be profitable mainly because of a producer's cooperative which facilitates the acquisition of inputs and takes care of commercialization. Technicians are not overly receptive to innovations.

Insecticide use reached a peak of 85 kg per hectare in 1967/68, when an extension program based on pest management was started with the assistance of a foreign government. The program was very successful in the beginning, and by 1970/71, insecticide use had dropped to 41 kilograms per hectare, over 50% the initial amount. Reportedly, from this year on the technicians who started the program began to be hired elsewhere. The second generation of cotton experts was unable to maintain the program's credibility and, under the now negative influence of the old experts insecticide use began to climb. By 1974/75 average use levels were back to almost where they statted, 70 kilograms per hectare.

Pest control technology is in frank recession. All the problems which characterize the "crisis" stage of cotton production are present: high resitance of pests, declining yields, high levels of insecticide use, diminishing returns. The one redeeming feature of the Salvadorean situation is the existence of the cotton growers cooperative.

The Cooperativa Algodonera Salvadoreña contributes to maintain the cotton activity profitable and may be instrumental in its eventual recovery through integrated pest control. All cotton growers in the country belong and in return they have an option to buy inputs and pesticide application services at reduced prices. The cooperative buys all the cotton, processes it and sells it. Through efficient, bulk marketing (and clean harvest procedures) the Salvadoreans consistently get higher prices for their cotton than the rest of the Central American countries.

Although nominally there exists a technical extension program which covers cotton, its poor credibility with the farmers makes it ineffectual. Worse, farmers seem to be predisposed against help in matters related to pest control.

For this coming season (1976/77) the cooperative had shown interest in obtaining assistance to launch a large fully-supervised 5000-hectare integrated control demonstration program. Because of institutional difficulties this was not possible but the option remains The potential role of the Salvadorean cotton cooperative will be subtantial in improving cotton production technology. It already supports a research station with one fulltime scientist and several technicians who could easily spearhead an integrated control program for the whole country.

A strategy for El Salvador: The Cooperativa Algodonera Salvadoreña could carry out research and extension, and become the executing agency which utilizes existing institutional infraestructure. This includes a technical assistance program which, although with difficulties, embodies the experience of several years; a national center for Agricultural technology, with ample laboratory facilities, a school of agriculture, and a school of biology.

The cooperative itself already has facilities useful to an integrated control program. There is a small but well-mounted cotton research department which deals with pest control, agricultural practices, genetics and fiber technology. A laboratory for the mass-production of Trichogramma wasps is functioning continuously. The cooperative owns a large, 210-hectare farm which operates at a commercial scale and can be used for research and demonstration.

An integrated cotton pest control program could be developed by international or central american experts. Training at the lower levels could be effected with the assistance of the school of agriculture. The school of biology could help prepare technicians whose training would be completed in the University of Nicaragua at León.

The cotton cooperative and the Ministry of Agriculture have both established cotton related publications. These should be integrated, coordinated with the rest of Central America, and expanded.

The National Government is aware of the importance of cotton to the local economy. The key factor in developing a successful program in El Salvador is the capacity to integrate all existing institutions into a coordinated effort under the leadership of the cooperativa Algodonera Salvadoreña.

Cotton production and technology in Nicaragua: Although with important qualifications, Nicaragua has made the greatest progress towards integrated pest control in cotton in Central America. Yields may not be the highest, but insecticide use (49 kg/ha) is the lowest in the area (with the exception of Honduras). There is a coordinated effort to spread integrated control and a cotton research center operating.

Pesticide use in Nicaragua has been stable or decreasing in the last few years. In 1972/73, 51 kg/ha were employed; in 1973/74 the number was pushed down to 44 kg/ha and this past season 49 kg/ha . As for the rest of Central America, Guatemala used 80 kg/ha; El Salvador 70 kg/ha and Honduras 20 kg/ha. A steadying in the use of pesticides reflects favorably the success obtained by the integrated control extension program in Nicaragua.

After a low point in 1969/70, yields have remained fairly constant. They were 2039 kg/ha in 1974/75, a little smaller than the average of the previous 4 years. A slight reduction in pesticide use was achieved with essentially constant yields.

Ironically, the main potential problem underlying the Nicaraguan cotton technology situation has resulted from its success. The first crop of trained technicians is being hired away by international institutions and private growers. Those who remain , although technically experts, have still to develop the skills and the philosophy which will make them successful scientists in applied ecology. The lack of financial support to capable groups has propitiated a "brain-drain" which might send Nicaragua back into the ranks of the technologically defficient.

Another obstacle to the generalization of advanced pest management techniques lies in the average size of cotton farms. About 80% of the farmers have relatively small fields, of less than 35 ha. Their capacity to obtain private technical assistance is low. Any national program designed to spread pest management information should take into consideration the agrarian structures of the country and specifically set out to reach the numerous small farmers.

A strategy for Nicaragua: A sensible course of action in this country would be to reorganize and expand existing integrated pest control efforts. There is an on-going program, coordinated by an integrated cotton pest control committee and which includes the activities of six institutions plus private cotton technicians. Activities include extension (mainly through the Proyecto Algodonero de Asistencia Técnica PAAT) , research conducted by the Cotton Research Center(CEA), training in applied ecology at the University of Nicaragua (UNAN -LEON) and dissemination through several independently-published magazines and bulletins.

Through the integrated cotton pest control committee two significant modifications can be implemented: transfering the extension group, Proyecto Algodonero de Asistencia Técnica (PAAT), to the National Cotton Commission(Comisión Nacional del Algodón - CONAL) to give it national projection, and, through that program, reaching the 80% of the cotton activity which is concentrated in small farms. Since its inception, PAAT has been under the National Bank of Nicaragua and this imposes natural limitations to its eventual growth.

Once the program has been transfered and expanded, the human reservoir available in Nicaragua can be tapped. There is a relatively large number of technicians and auxiliary personnel with a working knowledge of integrated control.

The expanded program would have two objectives: continue to influence and coordinate private technicians who work with large farmers, and organize direct technical assistance for small growers.

In order to achieve the second objective, the program would asign small areas (850 - to 400 ha) to an integrated control technician. He would teach the farmer to identify and count arthropod populations, and complement the grower's knowledge in other agricultural matters such as soil preparation, planting date and density, fertilization, harvest etc. The farmer would periodically report his daily data to the technician and the technician would keep up-dated records. He would analyze the data and give pest control recommendations "as needed". The records would serve at the end of the season as evidence of the program's merits. The technician could be informally in charge of catalysing any associative tendencies or efforts evident in his zone, with a view to obtaining economies of scale for the farmers.

The program would start in a pilot form and expand taking into account resource availability constrainst such as money and qualified technicians. Although a subsidy may be initially needed, the program could become increasingly self-supportive as its benefits become apparent to the farmer.

Cotton research and training should continue , but receive technical and financial aid in order to expand. The infraestructure is basically sound and should be developed.

The three or four existing publications should be integrated and coordinated. As in the rest of Central America, topics of immediate relevance to the farmer should be complemented by more general aspects and by price and production statistics. With a minimum amount of effort, the magazine "Algodonero" could easily become quite effective as source of integrated cotton pest control methodology dissemination.

Summary:

The cotton area fo Central America is located inside a strip 900 km long and 30 km wide which runs parallel to the Pacific coast between 12° and 16° latitude north. It is essentially uniform with regards to temperatures, timing and amount of rainfall, soil characteristics and associated fauna and flora. Its ecological homogeneity makes it possible to design an agroecosystem management program at a regional level with subsequent minor adjustments for each particular country.

As discussed, the program would have four major components: Technical assistance, research, training and dissemination. These would be developed in close coordination. The technical assistance would consist of establishing constant communication between cotton growers and integrated pest control experts. The research group would be in charge of expanding this knowledge in light of priorities established jointly with the technical assistance group. The training would consist of transmitting knowledge to selected personnel so they can effect successful technical assistance. The dissemination would employ all available means to spread the integrated control philosophy and methodology in a language that can be easily understood by farmers, technicians and public officials engaged in cotton-related activities.

As with any science, progress is constantly being made in the field of integrated cotton pest control. A future of certain petrochemical scarcity and growing world needs requires that increasingly refined agroecosystem management methods be discovered and applied. It is also necessary to fully comprehend the factors affecting crop production and their main interrelations in order to take full advantage of ecological principles already known. An integrated pest control research center is a necessary complement for an extension program.

No extension program could succeed without a parallel development of human expertise. Three groups are of prime interest: farmers, auxiliary personnel (field scouts) and technicians. Inevitably most of the training would be "on-the job". The three groups would have to be instructed step-by-step about the tasks they are responsible for. There would be conferences designed primarily for farmers and technicians; short courses for all groups and university training for technicians only. The better integrated control is understood, the easier it will be to apply it.

A last, related component of the integrated control program is the dissemination of research results and extension experiences. This should be accomplished by a specialized group who can communicate at a scientific level and at a popular level. At least one publication should be developed in each country, and all publications would be coordinated through a regional editorial board. In this manner, relevancy and generality can be achieved and experiences shared.

TABLE 74

COMPARISON BETWEEN PEST CONTROL COSTS AND OTHER COSTS AND PROFITS BETWEEN INTEGRATED CONTROL PLOTS AND TRADITIONAL CONTROL PLOTS IN EL SALVADOR IN 1974 - 75

	Integrated Control	Conventional Control
1. Planted area (mz)*	60	68
2. Pesticides and applications (CA$/mz)	161.53	197.68
3. Field scouts and supervisors (CA$/mz)	25.00	15.00
4. Other costs (CA$/mz)**	275.52	270.92
5. Total costs (CA$/mz)**	462.05	483.60
6. Yield (qq/mz)***	54.0	46.6
7. Cotton price (CA$/qq)	15.00	15.00
8. Total income (CA$/mz)	810.00	699.00
9. Profits (CA$/mz)	347.95	215.40
10. Profits/costs (%)	75.3	44.5
11. Control cost/yield (CA$/qq)	3.45	4.56

* 1 manzana (mz) equal 0.7 hectares.

** Land cost not included, hence profits are taken as a return to administration and land.

*** 1 quintal (qq) equal 45.35 kilograms. Figures are given in quintales of seedcotton.

TABLE 75

COMPARISON BETWEEN PEST CONTROL COSTS AND OTHER COSTS AND PROFITS BETWEEN INTEGRATED CONTROL PLOTS AND TRADITIONAL CONTROL PLOTS IN GUATEMALA (TIQUISATE ZONE) IN 1974-75

	Integrated Control	Conventional Control
1. Planted area (mz)	52.4	83.0
2. Pesticides and applications (CA$/mz)	110.92	272.10
3. Field scouts and supervisors (CA$/mz)	25.00	15.00
4. Other costs (CA$/mz)*	360.16	344.67
5. Total costs (CA$/mz)*	481.08	661.77
6. Yield (qq/mz)**	40	55
7. Cotton price (CA$/qq)	15	15
8. Total income (CA$/mz)	600	825
9. Profits (CA$/mz)	118.92	163.23
10. Profits/costs(%)	25	25
11. Control cost/yield(CA$/qq)	3.40	5.22

* Includes land cost, so that profits are a return to management.
** Estimated yields.

TABLE 76

COMPARISON BETWEEN PEST CONTROL COSTS AND OTHER COSTS AND PROFITS BETWEEN INTEGRATED CONTROL PLOTS AND TRADITIONAL CONTROL PLOTS IN GUATEMALA (RETALHULEU ZONE) IN 1974-75

	Integrated Control	Conventional Control
1. Planted area (mz)	36.0	53.8
2. Pesticides and applications (CA$/mz)	103.09	167.36
3. Field scouts and supervisors (CA$/mz)	25.36	15.36
4. Other costs (CA$/mz)*	314.02	336.03
5. Total costs (CA$/mz)	442.47	518.57
6. Yield (qq/mz)	25.10	25.92
7. Cotton price (CA$/qq)	15.00	15.00
8. Total income (CA$/mz)	376.50	388.80
9. Profits (CA$/mz)	- 65.97	129.77
10. Profits/costs (%)	- 14.91	25.02
11. Control cost/yields (CA$/qq)	5.121	7.04

* Includes estimated costs of CA$100 for land rent, so that profits are a return to management.

TABLE 77

COMPARISON BETWEEN PEST CONTROL COSTS AND OTHER COSTS, AND PROFITS BETWEEN INTEGRATED CONTROL PLOTS AND TRADITIONAL CONTROL PLOTS IN HONDURAS IN 1974-75

	Integrated Control	Conventional Control
1. Planted area (mz)	186	470
2. Pesticides and applications (CA$/mz)	188.09	168.00*
3. Field scouts and supervisors (CA$/mz)	25.00	15.00
4. Other costs (CA$/mz)	293.25	345.00*
5. Total costs (CA$/mz)	506.34	528.00 *
6. Yield (qq/mz)	52.22	33.00*
7. Cotton price (CA$/qq)	15.00	15.00
8. Total income (CA$/mz)	783.30	495.00
9. Profits (CA$/mz)	276.96	- 33.00
10. Profits/costs (%)	54.69	- 6.00
11. Cost control/yield (CA$/qq)	4.08	5.55

* Estimated

TABLE 78

COMPARISON BETWEEN PEST CONTROL COSTS AND OTHER COSTS AND PROFITS BETWEEN INTEGRATED CONTROL PLOTS AND TRADITIONAL CONTROL PLOTS IN NICARAGUA (LEON ZONE) IN 1974-75

	Integrated Control	Conventional Control
1. Planted area (mz)	20	20
2. Pesticides and applications	101.15	145.28
3. Field scouts and supervisors (CA$/mz)	25.00	15.00
4. Other costs (CA$/mz)	425.00	454.00
5. Total costs (CA$/mz)	580.15	614.28
6. Yield (qq/mz)	46	46
7. Cotton priece(CA$/qq)	15	15
8. Total income(CA$/mz)	690	690
9. Profits (CA$/mz)	109.85	75.72
10. Profits/costs(%)	18.9	12.3
11. Control cost/yield(CA$/qq)	2.74	3.48

Source: Cotton Technical Assistance Programme, National Bank of Nicaragua.

TABLE 79

COMPARISON BETWEEN PEST CONTROL COSTS AND OTHER COSTS AND PROFITS BETWEEN INTEGRATED CONTROL PLOTS AND TRADITIONAL CONTROL PLOTS IN NICARAGUA (CHINANDEGA ZONE) IN 1974-75

	Integrated Control	Conventional Control
1. Planted area(mz)	372	350
2. Pesticides and applications (CA$/mz)	157.14	228.06
3. Field scouts and supervisors (CA$/mz)	25.00	15.00
4. Other costs (CA$/mz)	416.00	428.88
5. Total costs (CA$/mz)	607.14	671.94
6. Yield (qq/mz)	58.00	50.00
7. Cotton price (CA$/qq)	15	15
8. Total income (CA$/mz)	870.00	750
9. Profits (CA$/mz)	262.86	78.06
10. Profits/costs (%)	43.00	16.6
11. Control cost/yield (CA$/qq)	3.14	4.84

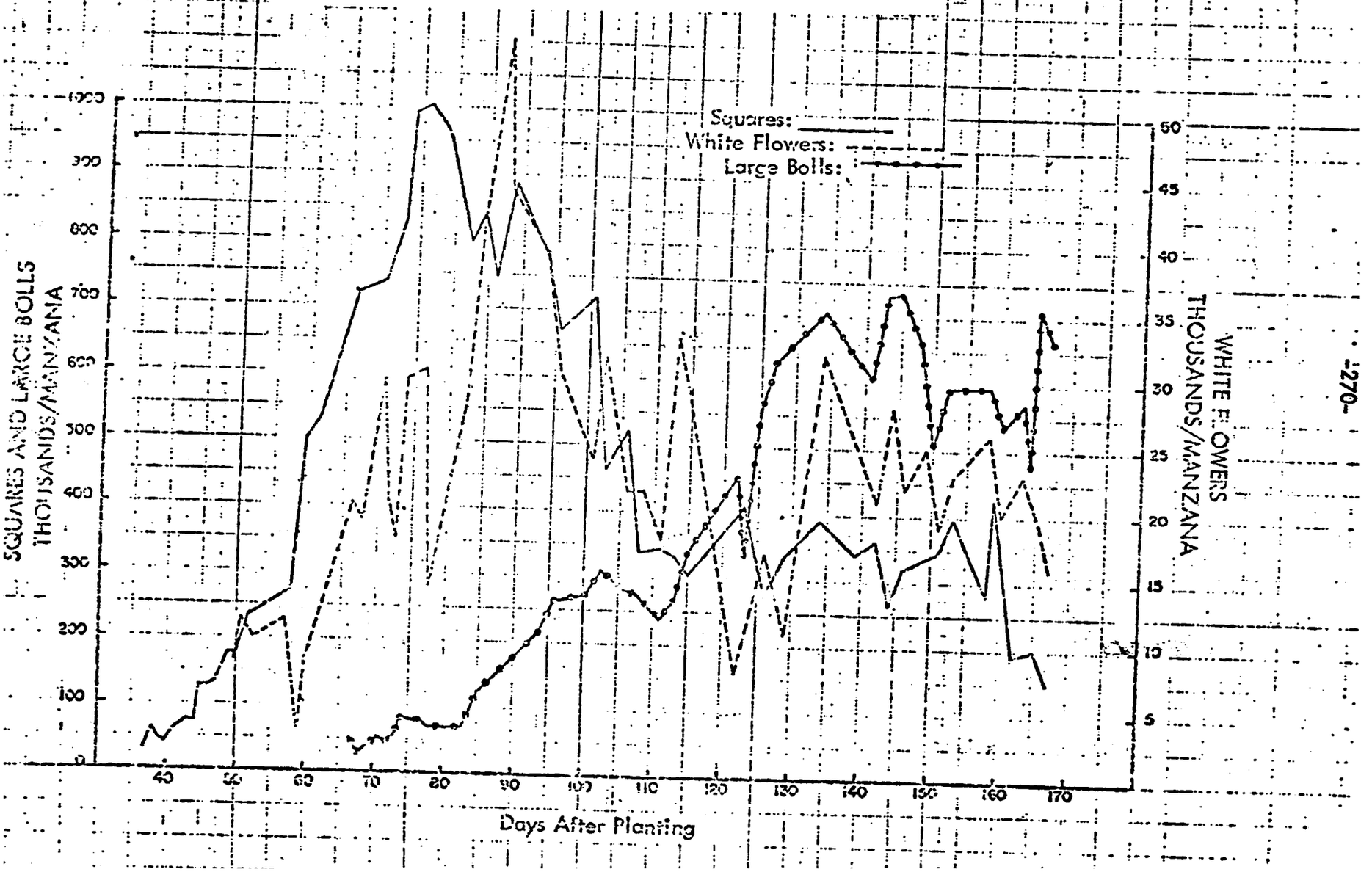
Source: Cotton Technical Assistance Programme, National Bank of Nicaragua.

TABLE 80

INSECTICIDE USE IN SOME OF THE INTEGRATED PEST CONTROL DEMONSTRATION PLOTS
1974-75 (in kg (a.i.)/ha)

PESTICIDE	GUATEMALA (I) Integrated control	GUATEMALA (I) Conventional check plot	GUATEMALA (II) Integrated control	GUATEMALA (II) Traditional check plot	EL SALVADOR Integrated control	EL SALVADOR Traditional check plot
Toxaphene (kg/ha)	28.53	-	24.50	22.57	20.75	22.37
DDT	14.01	-	12.26	11.93	10.37	11.19
Methyl Parathion	-	20.94	7.33	16.99	13.10	16.54
Ethyl Parathion	-	21.7	4.02	15.30	15.82	21.92
Monocrotophos	-	-	.45	.87	1.78	1.78
Methomyl	-	-	-	-	.23	.23
Chlorphenamidine	1.28	3.50	.52	.32	.43	.21
Endosulfan	1.62	-	2.04	-	-	-
Dicrotophos	-	.39	-	-	-	-
Metamidophos	1.23	2.40	.81	.81	-	-
Endrine	-	-	-	2.59	-	-
Mevinphos	-	-	.26	1.75	-	-
Trichorfon	-	.29	-	-	-	-
TOTAL	46.67	49.22	52.19	73.13	62.48	74.24

FIGURE 37
DEVELOPMENT OF COTTON PLANTS
FRUIT PRODUCTION THROUGH TIME, PLOT "B"
Finca Tolimán, Guatemala, 1974-75



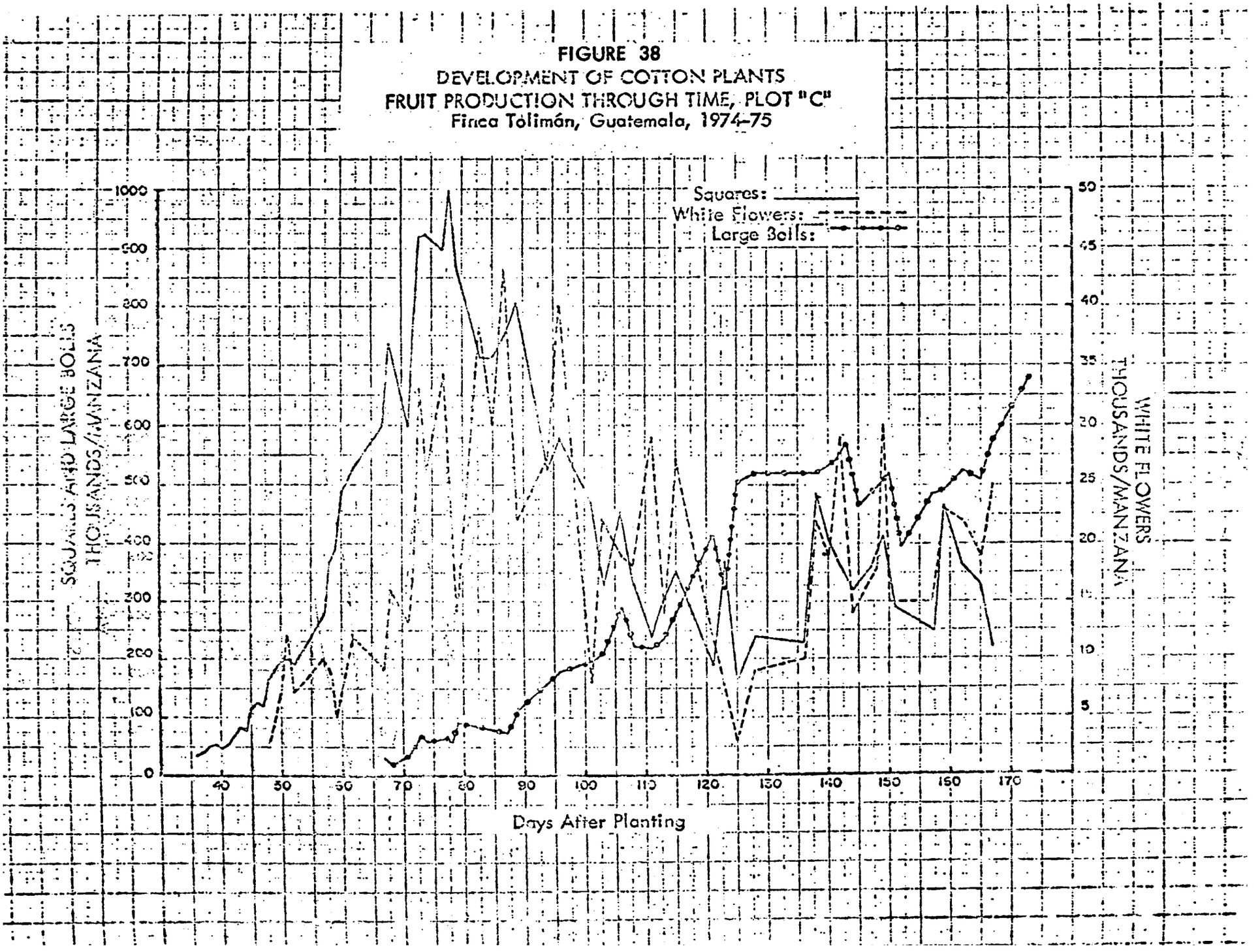


FIGURE 38
DEVELOPMENT OF COTTON PLANTS
FRUIT PRODUCTION THROUGH TIME, PLOT "C"
Finca Tolimán, Guatemala, 1974-75

FIGURE 39
DEVELOPMENT OF COTTON PLANTS
FINCA ENTRE RIOS, GUATEMALA
1974-75

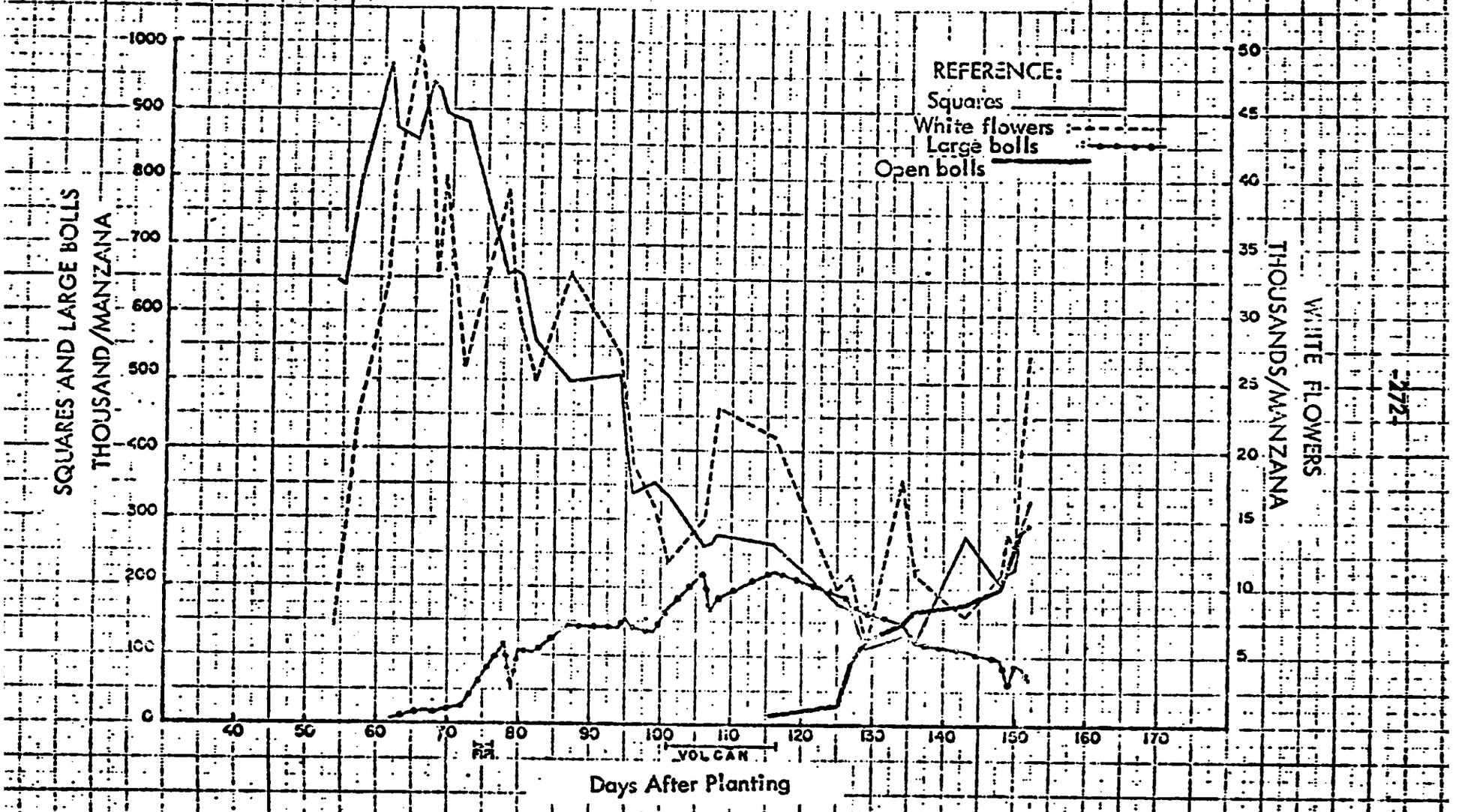
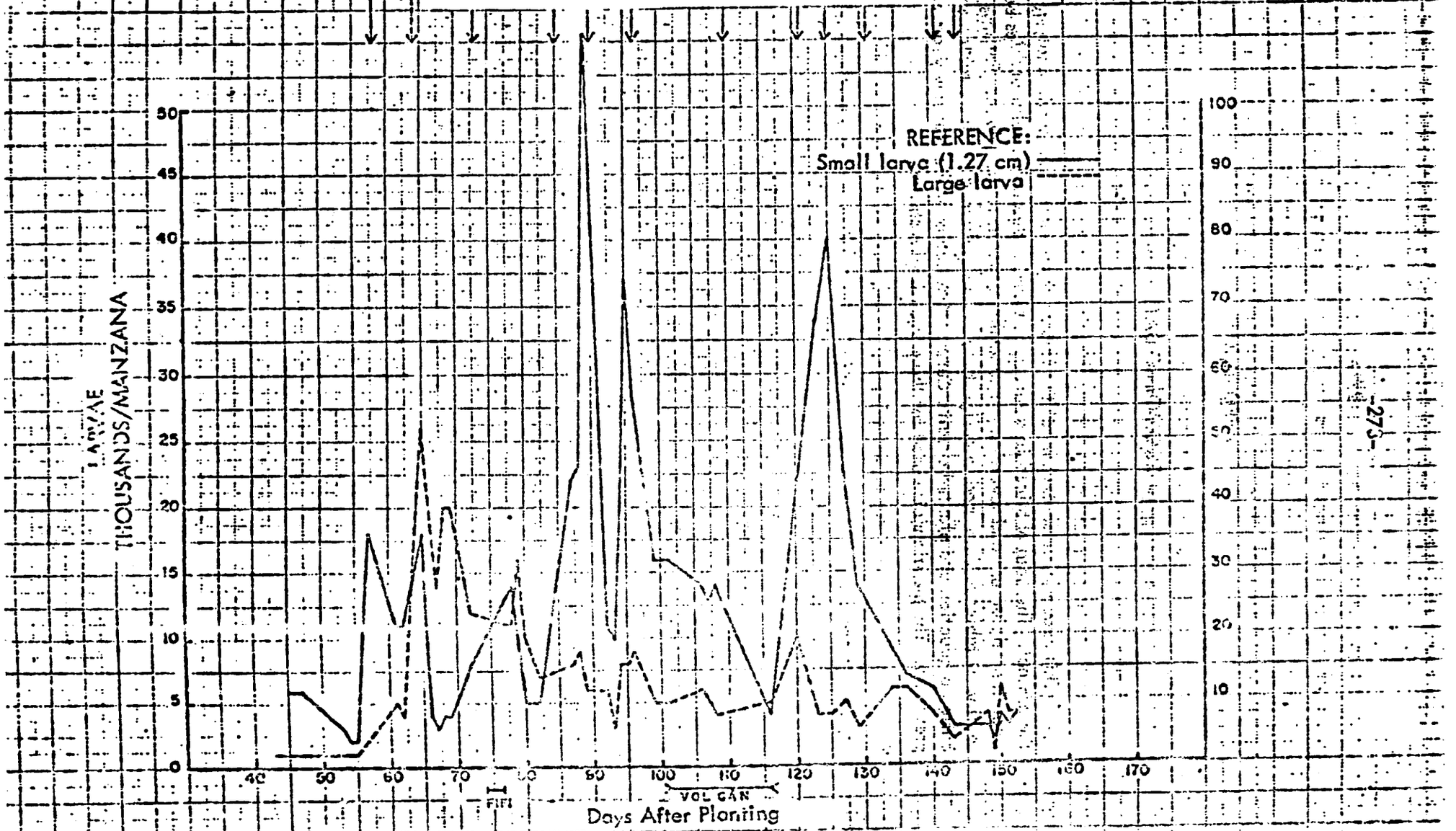


FIGURE 40
BOLLWORM POPULATION
FINCA ENTRE RIOS, GUATEMALA
1974-75



APPENDIX 4

ECONOMIC DATA

This appendix presents some of the information used for economic analysis in the project. The data obtained in a survey of farms to determine relationships between insecticide use and several agroeconomic variables is first given. Follows a section of tables of data used to design the cotton supply model. Some tables on cotton production and planted area in Central America over the last few years are presented. The questionnaire used for the survey is also shown.

TABLE 81

AGROECONOMIC FACTORS ASSOCIATED TO PESTICIDE USE IN CENTRAL AMERICA, 1974-75 EL SALVADOR

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	84.2	44.1	2.00	1.69	7.5	1	1	28	60	0	1	12.8	700	55.9	1	134	80	43	243	298	143
2	32.2	90.7	2.35	1.59	7.0	1	1	21	130	0	1	5.6	250	56.3	1	278.0	80	38	195	593	123
3	63.1	0.0	2.81	-	7.0	0	0	0	0	0	1	1.0	[illegible]	60.0	1	214.0	79	16	170	639	127
4	70.4	41.4	2.31	1.45	3.0	1	1	9	150	0	1	2.9	100	45.0	1	719.0	80	35	243	639	139
5	34.8	48.0	2.32	1.28	5.0	1	1	19	140	0	1	6.9	375	63.0	1	2.8.5	93	40.3	244	439	[illegible]
6	42.3	82.1	2.31	1.35	5.5	1	1	50	60	243	0	11.4	620	56.0	1	243.0	95	43.5	243	713	137
7	47.1	72.6	2.28	1.93	4.5	1	1	23	0	240	0	9.0	475	49.0	1	335.5	79	49.5	243	776	131
8	45.0	0	2.33	-	4.0	0	0	0	15	0	1	1.0	11	51.0	1	2.8.0	70	33.0	193	739	105
9	43.9	0	2.20	-	3.0	1	0	0	8	0	1	1.0	10	73.0	1	1[illegible]1.0	73	35.0	215	833	102
10	84.7	32.2	2.74	1.74	4.5	1	1	1[illegible]	130	0	1	2.42	115.0	61.0	1	297.0	73	76.5	215		[illegible]
11	36.6	65.0	2.40	1.45	4.5	1	1	6	140	0	1	3.54	1[illegible]1.0	56.0	1	265.5	90	45.0	7.5		[illegible]
12	70.3	28.2	2.23	1.76	4.0	0	0	0	20	0	1	5.27	425	54.0	1	300.0	90	[illegible]	243		137
13	44.4	18.6	2.50	1.48	4.5	1	-	13	0	0	1	7.0	140	55.5	1	332.6	80	[illegible]	148		[illegible]
14	49.6	7.2	2.27	1.55	5.0	.25	0	10	0	0	1	3.6	270	57.0	1	265.5	[illegible]	[illegible]	215	113	[illegible]
15	39.4	7.2	2.18	2.30	7.0	.64	1	40	50	201	1	12.7	914	54.5	1	275.1	80	74.0	[illegible]	[illegible]	134
16	45.3	40.4	2.27	1.49	.5	1	1	19	20	233	1	4.1	257	45.0	1	325.0	95	55.0	[illegible]	777	122
17	50.8	50.8	2.35	1.45	9.0	1	0	16	140	0	1	7.5	450	66.0	1	297.0	80	[illegible]	[illegible]	[illegible]	40
18	55.4	17.3	2.74	2.10	5.5	1	1	30	100	235	1	8.6	600	57.0	1	266.5	90	45.0	[illegible]		[illegible]
19	54.7	13.3	2.38	1.45	4.0	.5	0	17	20	[illegible]	1	9.6	[illegible]	4[illegible].5	1	335.4	70	34.0	216	[illegible]	[illegible]
20	57.4	32.7	2.23	1.73	5.0	.66	0	18	110	0	1	8.6	475	56.0	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	58.4	19.4	2.35	1.39	7.0	.56	0	12	35	0	1	[illegible]	415	53.0	1	324.0	90	39.5	[illegible]	[illegible]	[illegible]
22	42.2	74.5	2.25	1.54	8.5	.59	1	70	150	0	1	14.9	[illegible]	55.5	1	265.5	90	[illegible]	[illegible]	745	[illegible]
23	40.4	55.2	2.23	1.57	6.5	.62	1	4[illegible]	170	230	0	22.7	1000	58.5	1	222.4	90	56.0	[illegible]	812	132
24	41.8	63.9	2.21	1.56	4.0	.75	0	1	140	0	0	3.1	170	55.0	1	[illegible]	90	[illegible]	[illegible]	[illegible]	[illegible]
25	101.5	53.6	2.21	1.50	[illegible]	.59	1	2	15	275	0	15.6	[illegible]	52.5	1	[illegible]	80	[illegible]	[illegible]	[illegible]	[illegible]
26	80.1	54.2	2.37	1.47	4.5	1	1	4	140	0	1	5.2	[illegible]	54.0	1	[illegible]	20	[illegible]	[illegible]	[illegible]	[illegible]
27	50.31	51.6	2.19	1.67	6.0	1	1	0	20	234	1	4.7	160	65.5	1	255.0	80	47.0	[illegible]	[illegible]	[illegible]
28	42.2	9.0	2.70	1.87	6.5	1	0	1[illegible]	80	0	1	5.2	120	60.0	1	273.[illegible]	90	33.5	191		[illegible]
29	55.7	62.7	2.21	1.55	6.5	1	0	7	40	0	0	5.0	130	46.5	1	254.5	80	41.0	123	[illegible]	125
30	52.5	49.0	2.50	1.41	7.5	.60	[illegible]	6	[illegible]	0	0	10.1	[illegible]	54.5	1	351.0	90	46.0	[illegible]	[illegible]	[illegible]
31	43.4	23.0	2.43	2.75	4	.5	0	0	150	0	1	2.[illegible]	15	75	1	321	80	25	[illegible]		[illegible]
32	33.9	10.2	2.24	3.56	4	1	0	10	168	0	1	2.0	[illegible]	56	1	335	80	39	[illegible]		21
33	54.6	77.2	2.23	1.47	6	1	0	0	145	0	1	4.93	130	63	1	297	80	45	218		[illegible]
34	32.17	81.55	2.19	1.36	5.5	.5	0	13	15	0	1	4.05	103	57	1	320.5	80	42	216		[illegible]
35	76.54	77.00	2.32	1.27	3	0	1	0	0	225	0	7.79	300	55	1	2.0.7	80	47.5	225	[illegible]	105
36	[illegible]		[illegible]		2	[illegible]	0	0	10	0	1	1	20	75	1	2.4.5	80	37	210		119
37	53.14	24.83	2.31	2.13	4	1	0	1[illegible]	100	0	1	4.67	[illegible]	65	1	[illegible]	90	45	195		[illegible]
38	43.91	22	2.28	1.76	8.5	1	0	1[illegible]	130	0	1	4.12	350	50.5	1	254.5	80	45	255		119
39	43.73	42.56	2.25	1.47	5.5	1	0	0	0	0	1	4.69	225	57	1	257.0	80	44	221		[illegible]
40	49.67	41.74	2.27	1.45	8.5	1	0	0	145	0	1	3.11	202	55.5	1	249.0	80	49	217		122
41	60.94	52.84	2.75	1.28	4	1	0	0	0	0	1	2.53	226	61.5	1	292.0	80	43	210		111
42	29.49	92.97	2.16	1.42	8	1	1	60	30	230	1	19.83	2475	65	1	223.07	80	47½	210	225	123
43	33.53	14.04	2.34	1.53	4	0	1	0	10	0	1	1	25	55	1	297	80	43	140		97
44	82.60	1.94	2.21	9.34	7.5	1	0	0	155	0	1	2.78	131	58.5	1	276	80	46	228		149
45	45.38	100.96	2.27	1.49	0	1	0	0	160	0	1	1	80	51	1	276	90	50	235		144

TABLE 81 (cont.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
46	49.54	79.76	2.12	1.36	7	1	1	2	150	0	1	1.39	80	57.9	1	348	90	49	239		139
47	39.35	88.79	2.31	1.61	6.5	1	0	16	150	0	1	2.40	184	54	1	172.75	90	46	224	843	125
48	39.50	69.85	2.27	1.48	8	1	0	4	140	0	1	2.29	80	51.5	1	299.5	90	42	204		143
49	15.08	73.54		1.59	13	0	0	0	9	0	0	1	7	51	1	320	80	30	173		102
50	22.75	11.54		1.31	6	0	0	0	6	0	0	1	10	56	1	276	80	30½	195		109
51	22.72	91.00	5.74	1.23	4	0	0	0	11	0	0	1	6	53	1	255	80	37	193		109
52	34.44	11.15	2.95	1.57	4	1	0	0	20	0	1	2	40	50	1	276	80	34	189		111
53	17.4		2.10		8	0	0	0	12	0	1	1	10	50	1	276	90	37½	210		121
54	44.48		2.42		7	0	0	0	4	0	1	1	5	20	1	245	80	28	176		84
55	43.92		2.30		2	0	0	0	10	0	1	1	20	40	1	324.5	70	32	190		103
56	38.75	91.70	2.17	1.34	5	1	0	4	150	0	0	5.0	292	63.5	1	297	80	46	230		107
57	24.51	84.75	2.52	1.78	3	1	0	0	14	0	0	1	32	67	1	301.5	80	23	184		125
58	30.20	81	5.03	1.23	3	1	0	0	9	0	0	1	12	61	1	105.40	70	35	203		137
59	65		2.77		2	1	0	0	10	0	1	1	8	54	1	147.4	80	34	201		112
60	51.52	73.99	2.46	1.57	4	1	0	0	17	0	1	1	50	63	1	210.5	70	40	213		152
61	41.59	81.24	2.34	1.53	3	1	0	0	11	0	1	1	40	65	1	230.5	80	38	232		125
62	37.60	70.0	5.03	1.28	4	1	0	0	7	0	0	1	10	72	1	259.5	80	33.0	216		156
63	26.22	54.25	2.27	1.78	2	1	0	0	5	0	0	1	16	56	1	207	80	30	200		96
64	20.23	89.30	5.03	4.57	1	1	0	0	11	0	0	1	14½	64	1	278	90	34	34		[illegible]
65	42.37	194.4	5.03	1.78	3	0	0	0	9	0	0	1	10	44	1	165	80	30	190		95
66	44	77.00	2.34	1.51	4	1	0	0	125	0	1	1	40	40	1	297	90	41	201		118
67	92.12	1.22	2.25	4.72	4	1	0	0	120	0	1	1	80	50	1	270	90	45	217		114
68	78.93	37.56	2.34	1.33	5	1	0	0	10	0	0	1	50	60	1	249	80	43	192		165
69	41.91	1.24	2.19	2.36	6	1	0	14	10	0	1	2	140	56	1	297	90	48	215		122
70	47.74	54.74	2.33	0.31	6	1	0	0	10	0	1	1	100	67	1	297	80	40	202		101
71	36.09	84.52	2.31	1.41	6.5	1	0	0	150	0	0	4	250	64	1	247	90	49	224		112
72	58.79	61.73	2.24	1.44	10.5	1	0	20	160	0	1	8.57	450	56	1	345	90	50	225		190
73	69.76	39.75	2.22	1.56	3	1	0	0	145	0	1	3.77	180	59.5	1	261	80	47.5	228	796	114
74	35.4	77.69	2.19	1.49	6.5	1	0	30	150	0	0	7.64	420	64	1	276	80	48	235		112
75	51.97	61.48	2.31	1.43	4.5	1	0	0	145	0	1	2.93	205	64.5	1	297	90	48	224		117
76	44.99	66.43	2.12	1.33	7.5	0.83	0	30	160	0	0	11.36	625	58	1	271	80	47	229	710	122
77	60		2.27		4	0	0	0	5	0	1	1	8	67	1	180	70	30	175		83
78	10.63	30.37	2.95	1.33	5	3.33	0	0	100	0	1	3.20	128	55.5	1	318	80	39	219		125
79	50.61	91.26	2.30	1.35	6.5	1	0	74	140	0	0	4.14	300	62	1	300	80	41	220		115
80	36		2.27		3	1	0	0	6	0	1	1	1	66	1	228	70	24	120		78

REFERENCES:

1. Farm cultivar
2. Phosphate use lb./ha
3. Chlorine use lb./ha
4. Phosphate price $/lb
5. Chlorine price $/lb
6. Scout experience (years)
7. Scout training (%)
8. Entomological information (1,0)
9. Salesman visits (No.)
10. Technical assistance (1,0)
11. Private agronomist (1,0)
12. Early parathion use (1,0)
13. Total area a plot size
14. Farm size (ha)
15. Days first treatment
16. Treatment criterion
17. Fertilizer use lb./ha
18. Land value $/ha
19. Yield, kg/ha
20. Length of season
21. Rainfall, Sep., Oct., Nov. (mm)
22. Scouting visits (No.)

TABLE 82

AGROECONOMIC FACTORS ASSOCIATED TO PESTICIDE USE IN CENTRAL AMERICA, 1974-75 NICARAGUA

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
81	39.39	110.91	2.64	1.23	19	0	0	-	-	0	1	1	7	42	1	188	142.86	37	214	-	163
82	15.8	1.25	4.22	6.06	3	1	1	3	10	38	1	1	15	26	0	234	142.86	40	200		33.33
83	27.29	59.53	4.51	1.41	-	0	1	3	15	37	1	1	25	22	0	300	114.29	39	200		50.67
84	10.8	10.8	2.78	9.40	4	0.67	0	-	10	0	0	3.01	440	60	0	168	85.71	59.60	200	92.3	25.00
85	15.33	16.88	2.80	3.69	5	1	1	3	48	0	1	3.82	392	75	1	213	142.86	55.12	100		[illegible]
86	21.52	4.61	n.a.	n.a.	4	0.67	-	50	40	0	1	12.8	440	55	1	213	142.86	50	240		20.750
87	28.16	51.53	3.52	1.55	4	0	-	-	-	22	1	5.20	550	76.8	1	280	85.71	25	[illegible]		[illegible]
88	64.5	2.38	3.55	5.08	15	0	-	-	4	0	1	1	14	45	1	257.5	85.71	45	[illegible]		79
89	7.82	4.65	5.50	5.47	4	0	0	-	-	0	0	1	6	104	1	284	71.43	45	160		[illegible]
90	18.75	97.58	-	0.65	12	0	0	-	-	0	1	1	25	20	1	215	85.71	35	210		150
91	124.47	97.74	2.60	1.40	-	0	0	-	-	0	0	1	3	60	1	576	85.71	50			67
92	27.52	100.75	4.26	0.97	15	0	1	-	12	0	1	1	8	75	1	234	142.86	35			[illegible]
93	38.42	52.5	3.52	1.27	12	0	0	-	-	0	0	1	4	45	1	234	100	30	232		145
94	22.95	45.06	3.27	1.23	3.5	0.5	1	24	22	0	1	2.06	275	43.5	1	374.8	142.86	50	715		119
95	24.40	91.78	3.84	1.25	-	0	1	-	2	21	0	2	290	53.5	1	284	200	40	235		24
96	27.47	86.76	3.22	1.32	2.5	1	1	44	30	8	0	2.02	272	43	1	225	114.29	57.12	240		44
97	28.73	20.16	3.41	1.55	6	1	1	-	-	0	1	1	04	53.5	1	213	171.43	57	210		62.5
98	21.08	33.19	4.88	1.22	4.5	1	1	8	10	162	1	7.45	275	48	0	161	171.71	55	160		[illegible]
99	25.41	77.16	1.78	1.22	1.5	1	1	7	3	1	0	7	140	60	1	251.5	171.43	42.7	[illegible]		35.33
100	55.21	1.77	2.63	7.48	7	0	0	25	-	0	1	2.96	292	43.5	0	[illegible]	171.43	50			56
101	29.68	49.25			-	0	1	2	10	40	0	1	47	50	1	263	64.29	25			[illegible]
102	26.2	1.87	3.63	6.21	2.75	0.4	1	4	-	20	1	5	160	56	1	[illegible]	64.29	[illegible]	242		19.29
103	24.67	64.3	3.89	3.25	2	0.5	1	8		155	1	2	[illegible]	64	1	242	64.29	32	255		150
104	25.37	79.5	3.16	1.23	10	0.5	1	4	5	40	0	2	300	22.5	1	192	42.86	34	299		47
105	22.25	53.66	4.28	1.37	2.75	0.4	1	10	34	22	0	7.29	260	45	1	236	64.29	45			47.86
106	24.3	35.14	3.44	2.03	8	1	1	6	10	12	0	1.91	400	42	1	259	64.29	32.05	[illegible]		16
107	29.93	43.38	3.63	1.62	15	0	0	-	7	0	1	1	21	70	1	134	71.43	43	213		118
108	81.92	39.12	3.46	1.44	10	0	0	-	-	20	1	1	6[illegible]	70	1	224	71.43	23	[illegible]		[illegible]
109	47.09	8.93	3.28	2.47	4.5	0	0	-	-	0	1	2	240	57.5	1	234	71.43	[illegible]	254		[illegible]
110	31.52	109.7	3.14	1.20	5	0	0	-	5	0	1	1	[illegible]	55	1	213	64.[illegible]	30			135
111	27.79	9.50	4.32	2.04	5	1	1	3	8	32	1	4.05	405	42	1	65	71.43	43	253		22.5
112	22.95	38.04	2.50	1.43	-	0	0	-	-	0	0	6.5	45	46	1	91	42.86	32	249		74.5
113	23.78	54.18	2.45	1.53	3	0	-	A1 -	-	0	0	5.[illegible]	5	50	1	112	42.86	28	205		72.5
114	24.63	109.5	5.60	1.67	15	0	1	-	3	0	0	40	40	65	1	125.5	100	56			[illegible]
115	[illegible]	[illegible]	4.92	[illegible]	3	0	0	-	8	0	1	16	[illegible]	33	1	[illegible]	42.66	25	210		50
116	26.71	16	2.74	1.19	3	0	0	-	-	0	0	5	5	45	1	67	42.86	35	210		40
117	26.54	87.35	6.03	1.37	15	0	1	-	4	0	0	34	34	60	1	125.5	71.43	35	198		65
118	20.48	44.44	2.67	0.56	3	1	1	7	7	96	1	4.01	950	84	1	161	71.43	48	270		242
119	31.05	64.3	4.50	1.22	7	0.67	1	2	22	0	1	3	300	50	1	110	64.29	40	253		150
120	37.25	47.5	3.70	1.38	3.5	0	1	12	-	35	1	5.58	420	49	1	136	64.29	44	268	10008	57.5
121	23.14	13.20	2.97	2.96	6	1	1	-	28	40	1	10	1100	59.5	0	123.5	71.43	41	[illegible]		145
122	19.25	45.16	3.55	1.52	4	0.80	1	4	5	280	1	5.[illegible]	1030	52.5	1	136	71.43	49	290	31	95
123	41.31	88.23	3.53	1.71	9.5	1	1	6	22	40	1	3.44	550	43.5	1	243	71.43	45	265	862.5	90
124	33.98	27.76	3.45	1.98	2.5	1	1	-	-	28	1	3.2	320	51.5	1	98	71.43	38	280		68.5
125	36.26	11.30	3.99	3.77	3	1	1	4	16	51	1	18.5	370	52.5	1	139.5	71.43	38	270		45

TABLE 82 (cont.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
126	26.07	8.67	2.87	7.95	-	1	1	-	3	54	1	2.20	320	45	1	111	35.71	35	270		50
127	5.58	6.25	3.17	2.50	4.5	0.55	1	3	5	72	0	12	1200	78	1	90	42.86	45	246		200
128	27.24	37.06	3.74	4.67	4	0.75	1	-	12	20	1	3.95	450	42.5	1	115	71.43	36	245		40
129	33.36	51.34	2.97	1.46	7.5	0.50	1	16	15	41	0	8	400	51	0	136.5	85.71	49	205	510	70
130	42.56	24.26	2.76	1.59	5.5	1	1	10	25	49	1	4.04	302	67.5	0	90	64.29	36	200	599	60
131	46.69	4.74	2.67	4.24	5	1	1	22	20	39	1	4	400	54.5	0	92.5	71.43	41	174	481	52.5
132	41.72	75.51	2.83	1.39	3	1.5	1	10	20	25	1	7.12	356	34	0	90	85.71	38	209	409	51
133	34	18.16	2.87	2.73	4	1	1	15	15	48	1	19	950	51.5	0	90	85.71	49.07	240	697	60
134	47.55	31.49	3.02	1.79	3	1	1	4	2	32	1	1	120	67	1	136	71.43	37.6	206		169
135	28.06	56.61	3.49	4.80	2	0.5	1	-	23	0	1	2.04	265	67.5	1	77	71.43	40	256		72.5
136	16.94	13.45	3.97	4.51	1.5	1	1	-	26	8	0	2	160	45	1	90	71.43	23	265		43.75
137	38.74	85.93	3.27	1.33	19	1	0	-	-	0	1	3	270	53	1	94	74.43	42	270		36.25
138	29.56	72.48	3.75	1.58	6	1	1	1	24	0	1	1	170	46.5	1	85	71.43	47	270		47
139	46.02	58.13	3.43	1.65	8	1	0	10	2	52	1	5	100	71	1	145.5	47.85	42	270		53
140	31.75	17.25	2.59	2.09	3	1	1	2	-	35	1	1	100	90	1	182	85.71	54	190		150
141	36.42	53.76	4.14	2.08	5	0.67	1	1	3	24	1	3	290	70.5	1	135	71.43	48	198		61
142	20.47	70.73	3.17	1.22	4	0.67	1	-	[illegible]	0	0	3	290	66	1	95	71.43	48	243	50.65	[illegible]
143	46.27	48.84			6.5	0	0	-	23	0	0	2	150	60	1	142	121.57	46	260		13.57
144	37.16	74.50	3.25	1.25	8	1	0	-	10	0	0	1	230	59	1	94	142.16	45	230		92
145	45.05	54.04	2.85	1.46	5	0	0	-	8	0	1	1	90	60	1	136	100	52	[illegible]		57.5
146	26.49	36.57	3.57	1.38	4	1	1	-	5	36	1	2	150	57	1	136		50.5	[illegible]		81
147	31.41	41.76	2.10	1.57	2.5	1	1	2	8	35	1	2	250	51	1	136	71.43	36	215		51.5
148	32.81	56.55	4.34	1.50	5.5	1	1	2	6	18	0	2.07	277	26	1	136		60	[illegible]		[illegible]
149	42.51	21.09	3.04	1.09	5	1	1	-	24	14	1	2	260	77.5	1	95	[illegible]	52	240		1.14
150	22.51	73.48	3.60	1.22	4	1	1	-	24	0	1	1	240	47	0	115	176.57	51	270		90
151	33.53	57.46	3.78	1.48	8	1	1	-	7	0	0	1.86	150	65.5	1	136		46	24[illegible]		71
152	41.56	53.93	2.93	1.44	6	0.67	1	18	[illegible]	21	0	3	290	46.5	0	135.5	64.29	35	210		57
153	22.74	47.71	2.90	1.79	10	0	0	-	-	0	1	1	50	60	1	94	64.29	26	223		57.5
154	49.63	51.45	2.79	1.44	4	0.50	1	5	[illegible]	7	1	2.89	130	47	0	137	71.43	45	[illegible]	425	75
155	35.23	52.02	2.79	1.73	5	0	1	5	10	5	1	5.55	250	58	0	135.5	85.71	27	190	529	67.5
156	24.00	42.36	2.90	1.56	4	1	1	20	[illegible]	46	1	4.25	170	46.5	0	90.5	64.29	41	227	379	57.5
157	25.73	90.86	2.76	1.44	2.5	0	1	10	10	49	0	5.4	270	40	0	113.5	85.71	24	235	251	79
158	27.51	51.83	2.80	1.43	2.5	0.5	1	17	15	46	0	6.25	250	44.5	0	90	71.43	42	240		75
159	57.6	41.5	3.63	1.86	3	1	1	-	15	18	1	[illegible]	100	52.5	1	136	71.43	365	192		155
160	34.33	57.38	3.14	1.45	8	1	1	5	23	24	0	[illegible]	175	55	1	136	71.43	37	215		88.5

REFERENCES:

1. Farm number
2. Phosphate use lbs/ac
3. Potassium use lbs/ac
4. Phosphate price $/lb
5. Chemical price $/lb
6. Scout experience (years)
7. Scout rating (%)
8. Extensionist Information (1,0)
9. Salesman visits (times)
10. Technical assistance (visits)
11. Private agronomist (1,0)
12. Early parathion use (1,0)
13. Total area of plot size
14. Farm size (ac)
15. Days first treatment
16. Treatment criterion
17. Fertilizer use lbs/ac
18. Land value $/ac
19. Yield, qq/ac
20. Length of season
21. Rainfall, Sept., Oct., Nov. (mm)
22. Scouting visits (times)

TABLE 83

GUATEMALA: INCOME PER HECTARE AND AREA PLANTED THE FOLLOWING YEAR

YEAR	$/Bale	Yield Bales/ha	Theoretical Gross income $/Ha.	Area planted following year
1965/66	124.28	3.64	452.38	84111
1966/67	126.67	3.54	448.41	89544
1967/68	139.43	4.00	557.72	96269
1968/69	113.52	3.52	399.59	34633
1969/70	117.59	2.93	344.54	72488
1970/71	121.89	3.48	424.18	69700
1971/72	143.40	5.38	771.49	89381
1972/73	167.30	4.60	769.58	103656
1973/74	304.01	5.34	1623.41	109901 *

* Preliminar

SOURCE: ICAITI, based on SIECA's data and tables 88 and 84.

TABLE 84

COTTON PRICES "STRICT MIDDLING 1-1/6", IN CA$ CIF LIVERPOOL

MONTH	CA$/AVERAGE POUND
January	.8841
February	.8216
March	.7400
April	.7016
May	.6501
June	.6231
July	.6202
August	.6142
September	.5899
October	.5376
March (75)	.4300

TABLE 85

EL SALVADOR: INCOME PER HECTARE AND AREA PLANTED THE FOLLOWING YEAR

YEAR	$/Bale	Yield Bales/Ha.	Theoretical Gross income $/Ha.	Area planted following year
1965/66	124.28	2.44	303.24	68300
1966/67	126.67	2.62	331.88	43305
1967/68	139.43	3.55	494.98	55944
1968/69	107.55	3.72	400.09	58358
1969/70	117.59	3.65	429.20	63471
1970/71	121.89	4.02	490.00	74171
1971/72	143.40	4.27	612.32	94222
1972/73	172.65	3.31	571.47	99428
1973/74	313.71	3.44	1079.16	98000

* Preliminar

SOURCE: Same as Table 83 , ICAITI, based on SIECA's information and tables 84, 88.

TABLE 86

HONDURAS: INCOME PER HECTARE AND AREA PLANTED THE FOLLOWING YEAR

YEAR	Price per bale $/bale	Yield Bales/Ha.	Theoretical Gross income $/Ha.	Area planted the following year
1965/66	119.40	2.67	318.80	14956
1966/67	122.13	3.12	381.05	11152
1967/68	131.45	3.50	460.08	10139
1968/69	95.60	3.55	339.38	3974
1969/70	114.72	3.77	432.49	3251
1970/71	120.31	3.08	370.55	3624
1971/72	130.02	3.04	395.26	7268
1972/73	154.44	2.61	403.09	8400
1973/74	280.63	2.86	802.60	9100 *

* Preliminar

SOURCE: ICAITI, based on SIECA's information and tables 88 and 84.

TABLE 87

NICARAGUA: INCOME PER HECTARE AND AREA PLANTED THE FOLLOWING YEAR

YEAR	Price per bale $/bale	Yield Bales/ Ha.	Theoretical Gross income $/Ha.	Area planted the following year
1965/66	119.83	3.55	425.40	150140
1966/67	121.27	3.52	426.87	145742
1967/68	131.21	3,23	423.81	131293
1968/69	109.94	3.27	359.50	108536
1969/70	111.61	2.91	324.79	94992
1970/71	117.06	3.82	447.17	108787
1971/72	126.67	4.38	554.81	147639
1972/73	156.83	3.16	495.58	181547
1973/74	284.98	3.63	1034.48	168000 *

* Preliminar

SOURCE: Same as previous table

TABLE 88

CENTRAL AMERICA: COTTON PLANTED AREA 1967/68 - 1973/74
IN HECTARES

COUNTRY	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74
El Salvador	45 305	55 944	58 358	63 476	74 171	94 222	99 428
Guatemala	89 544	96 269	84 633	72 488	69 700	89 381	103 656
Honduras	11 152	10 139	3 974	3 251	3 624	7 268	8 400
Nicaragua	145 742	131 293	108 536	94 992	108 787	147 639	181 547
TOTAL	291 743	293 645	255 501	234 207	256 282	338 510	393 031

SOURCE: SIECA, Cotton in Central America (several years). National Cotton Council, Guatemala; Cotton Growers Cooperative of El Salvador; Southern Cotton Growers Cooperative of Honduras; and National Cotton Commission, Nicaragua.

TABLE 89

CENTRAL AMERICA: COTTON PRODUCTION, 1967/68, - 1973/74
IN THOUSAND BALES *

COUNTRY	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74
El Salvador	161	208	213	255	317	312	342
Guatemala	358	339	248	252	375	411	553
Honduras	39	36	15	10	11	19	24
Nicaragua	471	429	316	363	477	467	659
TOTAL	1029	1012	792	880	1180	1209	1578

SOURCES: SIECA, Cotton in Central America (several years). National Cotton Council, Guatemala; Cotton Growers Cooperative of El Salvador. El Salvador; Southern Cotton Growers Cooperative of Honduras; and National Cotton Commission, Nicaragua

* 1 Bale = 479 lbs.

TABLE 90

NICARAGUA: PRODUCTION COST PER HECTARE AND PER BALE
1971/72 - 1973/74 (in $)

	$/HECTARE			$/ BALE		
	1971/72	1972/73	1973/74	1971/72	1972/73	1973/74
Labour + services	192.33	184.22	285.83	43.91	58.29	78.74
Pesticides and application	118.24	121.06	159.18	27.00	38.31	43.85
Fertilizers	32.00	38.98	54.37	7.30	12.33	14.98
Land rental	66.68	72.68	79.57	15.22	23.00	21.92
Others	24.34	26.06	30.33	5.53	8.25	8.36
TOTAL	434.34	443.03	609.28	99.16	140.20	167.84

SOURCE: National Cotton Commision and Central Bank of Nicaragua.

TABLE 91

NICARAGUA : AVERAGE PRODUCTION COSTS PER HECTARE
1971/72 - 1973/74, in PERCENTAGE

	1971/72(%)	1972/73(%)	1973/74(%)
Labour + services	44.29	41.58	46.91
Pesticide and application	27.23	27.33	26.13
Fertilizers	7.37	8.80	8.92
Land rental	15.36	16.41	13.06
Others	5.58	5.88	4.98
TOTAL	100.00	100.00	100.00

NOTE: Total may not add up due to rounding of partial figures.

SOURCE: Tables 88 and 89 and National Cotton Commission.

TABLE 92

EL SALVADOR: AVERAGE PRODUCTION COSTS PER HECTARE PER BALE PRODUCED 1971/72-1974/75

	1971/72	1972/73	1973/74	1974/75*	1971/72	1972/73	1973/74	1974/75
Labour + services	203.43	253.14	302.91	388.86	47.64	76.48	89.51	110.47
Pesticides and application	120.00	188.57	224.28	394.28	28.10	56.97	65.20	112.01
Fertilizers	36.28	50.28	75.42	85.71	8.50	15.19	21.92	24.35
Land rental	71.43	71.43	71.43	71.43	16.73	21.58	20.76	20.29
Others	17.71	22.86	23.14	35.43	4.15	6.91	6.73	10.06
TOTAL	448.86	586.28	702.10	990.00	105.12	177.12	204.12	281.25

* Preliminar

SOURCE: Tables 88, 89, and Cotton Growers Cooperative of El Salvador.

TABLE 93

EL SALVADOR: AVERAGE COSTS PER HA. (%)
1971/72 - 1974 / 75

	1971/72	1972/73	1973/74	1974/75 *
Labour + services	45.32%	43.18%	43.85%	39.28%
Pesticides and application	26.73	32.16	31.94	39.83
Fertilizers	8.08	8.58	10.74	8.66
Land rental	15.91	12.18	10.17	7.22
Others	3.94	3.90	3.30	3.58
TOTAL	100.00%	100.00%	100.00%	100.00 %

* Preliminar

SOURCE: Same as table 92

TABLE 94

HONDURAS: PRODUCTION COSTS PER HECTARE AND PER BALE 1971/72 (in CAS and %)

	Costs per Hectare ($/Ha)	Costs per Bale ($/BALE)	Costs per Hectare as percentage of the total
Labour	162.12	53.33	44.04
Pesticides	100.43	33.03	27.45
Fertilizers	43.04	14.16	11.76
Others	60.25	19.82	16.47
TOTAL	365.85	120.34	100.00

NOTE: Total do not add up due to rounding of figures.

SOURCE: Tables 88,89, and Southern Cotton Growers Cooperative.

TABLE 95

SCAR COUNTS FOR AN UNPROTECTED PLOT IN EL OJOCHE, NICARAGUA, 1974 - 1975

DAY	TOTAL SCARS
48	3.0
54	2.5
58	2.0
62	4.5
64	4.0
68	9.0
71	8.0
75	7.5
78	8.0
88	23.5
92	23.5
95	28.5
99	37.5
103	60.0
106	64.0
110	59.5
113	50.0
117	55.0
120	54.0
124	63.0
127	58.5
131	62.5
134	61.0
138	76.0
141	66.5

SOURCE: Rainer Daxl, FAO -- Nicaragua.

TABLE 96

PLANT GROWTH DATA FOR A PROTECTED PLOT IN POSOLTEGA, NICARAGUA, 1974-75

Cotton Model Nicaragua — Posoltega 1974-75 — Plant Growth and Fruiting ($\bar{x}$ + s for 10 plants)

Crop age (days)	Leaves		MSN		SQUARES 1/4		SQUARES 1/2		Flowers		BOLLS + 1/2		BOLLS + 1/2		SCARS Squares		SCARS Bolls		Open Bolls		Plant height cm	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
37	11.2	4.05	8.8	1.81																		
41	18.0	7.54	10.5	1.84	0.90	1.66																
43	18.2	9.51	10.0	2.11	1.70	2.16																
48	29.5	10.17	13.5	1.84	8.6	5.15	0.20	0.63														
51	42.4	8.42	13.9	1.20	7.9	3.75	2.2	1.32	0.4	0.7												
54	34.20	23.40	12.8	1.81	4.0	4.24	0.6	1.07	0	-												
58	42.2	11.37	14.6	1.26	5.4	3.84	3.9	2.96	0.5	0.71	0.2	0.42			0.2	0.42						
61	40.0	10.38	14.8	1.14	5.50	3.37	2.10	1.6	0.1	-	0.3	-			1.20	1.99						
65	56.1	20.66	16.2	1.48	8.2	2.97	7.11	5.04	0.4	0.7	0.2	-	0.1	-	2.0	1.76					58.5	6.98
68	64.8	21.26	17.8	1.03	12.2	5.27	7.1	5.7	0.2	-	1.4	1.26	1.60	1.17	0.7	0.95	0.1	-			74.8	8.4
71	44.3	13.86	15.2	2.15	7.8	2.82	5.7	2.63	0.2	-	0.3	-	0.2	-	0.6	-					53.1	17.87
76	83.9	30.48	19.4	2.32	14.7	6.83	10.2	2.7	1.0	0.82	1.20	1.03	1.3	1.83	3.3	3.68		-			86.8	13.53
79	68.4	16.08	19.6	1.84	13.6	7.92	10.4	2.95	0.6	0.84	2.2	1.23	0.4	-	1.8	1.55		-			84.3	5.74
82	99.2	30.99	19.6	1.65	27.3	12.13	7.2	4.83	0.4	-	5.7	5.38	1.5	0.71	6.0	7.3	0.4	-			98.8	5.31
86	111.4	47.78	22.3	1.64	22.2	9.98	19.20	10.56	2.4	2.5	4.7	1.95	5.2	5.03	6.9	5.57	0.1	-			107.1	9.88
90	176.4	53.72	23.8	1.23	33.0	14.46	22.4	13.02	3.22	1.92	8.0	4.74	7.5	7.14	3.7	2.83	3.0	3.5			119.5	10.37
94	133.2	46.43	21.80	2.3	36.3	13.02	8.3	5.44	0.6	-	9.5	6.2	6.4	4.22	7.5	7.06	16.0	10.4			108.2	14.89
98	135.0	34.74	23.8	2.15	23.5	9.95	14.7	8.23	2.7	1.64	10.0	3.02	8.9	4.51	8.8	8.08	3.6	4.09			122.6	10.77
101	146.3	36.47	24.5	1.08	30.9	7.42	11.3	4.35	2.5	1.96	12.4	9.58	6.1	3.25	7.5	5.04	6.7	7.15			140.1	12.53
104	141.2	40.95	24.7	2.00	22.4	13.82	15.2	8.18	5.10	3.31	10.2	7.32	13.3	7.62	18.6	29.52	5.4	4.25			135.1	16.87
107	163.2	54.29	27.4	2.27	32.6	14.45	17.6	11.81	4.2	2.53	14.4	7.14	16.5	10.96	11.7	7.17	12.7	10.3			146.9	16.39
111	143.3	65.95	26.8	2.78	28.2	11.91	11.7	11.19	2.7	1.57	8.2	5.57	13.8	10.21	8.2	5.98	24.5	15.92			157.4	15.69
115	128.22	54.13	26.67	2.06	21.44	10.63	9.22	7.22	1.89	0.78	9.22	5.36	16.56	11.63	14.88	8.04	16.63	13.16			153.2	25.52
119	133.9	59.29	25.6	2.37	25.6	15.96	8.10	4.33	4.0	3.43	11.5	5.52	18.40	21.09	13.9	9.27	13.75	14.28			156.9	16.43
122	116.0	49.5	27.2	2.15	23.7	12.60	11.4	9.67	1.80	1.32	11.2	7.27	13.50	9.91	12.7	12.24	12.8	12.78			152.9	19.32
126	140.6	36.31	29.3	1.49	15.6	11.9	20.4	20.32	4.3	2.36	12.1	6.3	27.8	10.75	10.0	5.58	31.2	7.5			151.3	13.03
129	136.8	44.48	30.2	1.99	13.7	6.45	13.4	5.87	1.9	1.2	11.6	5.27	21.5	5.36	14.8	10.12	28.9	9.86			172.3	12.34
133	143.3	32.88	30.1	1.97	7.5	5.04	7.4	4.33	1.6	2.12	16.1	7.02	35.4	9.92	23.5	24.72	59.3	115.92			159.2	15.4
137	125.6	34.53	30.7	2.11	9.0	6.8	7.8	4.89	3.2	1.93	17.0	8.71	29.9	10.83	28.60	20.98	24.70	22.66	1.6	2.07	169.40	7.75
139	98.4	59.02	28.6	4.35	3.7	5.10	3.0	4.22	2.1	2.77	7.8	7.63	19.6	13.22	22.0	18.78	25.6	18.08	1.7	2.0	145.1	3[illegible].33
142	145.0	33.9	31.3	1.64	0.7	1.25	3.8	6.21	1.0	1.33	15.7	11.26	36.5	11.28	35.5	21.25	48.10	23.4	6.1	4.56	175.3	17.0
146	123.9	31.5	28.9	2.64	0.4	-	1.1	1.73	0.8	-	10.1	5.82	33.6	10.69	25.1	26.14	36.9	18.92	4.2	3.74	169.6	8.33
149	121.3	45.98	30.2	1.75	0.9	1.85	0.5	-	0.2	-	7.9	7.02	29.91	13.36	30.8	20.94	44.8	31.15	4.9	2.42	176.9	11.45
153	109.3	38.38	28.5	4.03	0.5	-	0.4	-	0.2	-	6.3	6.96	28.9	10.93	28.1	20.32	45.7	11.14	4.5	6.42	155.7	29.5
156	149.0	54.97	31.1	3.14	0.4	-	1.4	-	0	-	4.8	3.55	44.3	17.03	23.4	21.65	62.4	19.3	16.0	8.46	171.6	14.81
160	140.7	36.02	30.4	2.8	1.4	-	1.7	-	0	-	2.5	3.34	41.8	17.34	21.7	30.59	53.7	23.25	17.4	11.09	168.2	10.22
163	48.8	41.93	32.0	1.83	0.2	-	0.2	-	0	-	0.9	-	38.9	12.25	21.8	15.55	75.9	25.56	18.4	15.0	174.9	18.38
167	96.8	26.64	29.9	2.81	0.1	-	0	-	0	-	1.0	0.67	37.6	12.57	3.8	4.02	81.9	75.9	21.9	11.27	172.1	8.94
170	81.2	27.21	32.1	2.69	0.1	-	0.3	-	0	-	0.6	-	33.7	9.31	10.4	8.67	71.5	29.34	22.1	11.26	178.1	14.62
174	111.3	68.17	32.1	3.07	0.3	-	0.3	-	0.1	-	0.4	-	39.1	13.18	15.1	20.97	82.9	49.06	23.2	12.37	178.9	19.91
177	67.8	18.14	29.6	2.17	1.4	1.35	4.5	4.51	0	-	0	-	36.2	7.52	7.2	7.32	76.0	75.56	31.3	9.06	174.8	10.64
181	83.5	32.25	31.7	2.54	1.5	2.51	1.2	2.49	0	-	0.5	-	43.8	18.67	2.6	3.89	68.4	27.20	37.2	18.43	181.0	21.15
184	60.0	14.88	32.2	2.49	1.7	2.45	0.3	-	0.1	-	4.2	8.75	41.6	14.1	6.4	8.00	73.5	36.5	40.9	13.62	175.4	18.01
187	45.4	25.33	30.7	4.06	2.8	5.59	0.6	-	0	-	0.9	1.20	36.4	6.65	1.1	-	68.6	25.01	36.8	7.15	158.4	22.99
190	46.1	18.12	30.9	3.31	1.7	1.34	0.8	1.03	0	-	0.9	-	32.8	7.67	4.1	5.57	49.7	36.62	32.6	8.00	160.8	12.32
194	61.5	33.77	32.44	2.65	1.3	-	0.4	-	0	-	0.3	-	35.4	11.06	4.5	5.87	86.0	40.02	35.3	11.04	172.4	18.06
197	58.0	23.2	31.0	3.0	0.7	1.34																
201	48.1	23.76	28.9	2.33	1.1	-	0.3	-														
204	65.8	53.14	32.6	4.03	5.0	4.47	1.5	1.84			0.2											
206	115.0	68.88	34.1	3.54	12.3	15.21	4.4	4.45	0.1	-	0.1	-										
211	150.7	123.34	36.3	3.09	20.8	21.67	11.0	12.27	0	-	0.5	0.53										
215	83.2	43.95	33.9	4.91	5.1	3.35	2.3	3.02	0	-	0.5	-	0.2	-								
218	89.9	33.79	29.3	5.81	7.9	6.14	4.7	6.33	0	-	0.2	-										
221	133.9	81.55	33.5	5.93	14.3	13.98	9.2	7.10	0	-	1.6	2.5	0.1	-								
224	116.2	39.06	31.2	5.83	12.5	9.13	4.1	5.97	0.3	-	0.3	-	0.2	-								
228	98.6	49.96	36.5	4.48	5.6	4.06	6.5	4.01	0.1	-	1.0	1.25	0.3	-								
230	160.6	97.1	29.6	5.46	21.2	21.88	11.9	12.97	0.7	-	1.8	3.33	1.2	1.55								
235	134.1	76.0	33.7	4.37	6.5	3.54	9.7	5.96	0.4	-	2.5	2.92	0.3	-								

SOURCE: Rainier Daxl and Denis Corrales.
FAO-Nicaragua and Banco Nacional de Nicaragua.

TABLE 97

SAMPLE OF QUESTIONNAIRE USED FOR FARM SURVEY
ICAITI - NAS - UNEP

Cuestionario para entender los factores que afectan el alto y bajo uso de plaguicidas a nivel de finca;

Localizacion _____

Area sembrada de algodón _____ mz.

Años de cultivar algódón: Propietario _____

Mandador _____

Uso de insecticidas, temporada 1975/1976

Número de Aplicaciones generales _____

Materiales usados

Nombre	Galones	Precio/galón

Costo de aplicación aérea _____ por mz. (conv) _____ (UBV)

tractor _____ por mz.

a mano _____ por mz.

TABLE 97 (cont.)

Plagueo:

Número de plagueros: _____

Fecha inicio de plagueo(en relación a la fecha de siembra) _____

Intervalo de plagueo/lote _____

Tamaño de lote _____

Método de recuento _____

Número de plagueros con cursillo de plagueros _____

Control de Plagas:

Quien toma las decisiones _____

Qué criterio usa _____

_____

_____

_____

_____

A los cuantos días después de la siembra se hizo la primera aplicación _____

Contra qué plaga _____ que producto usó _____ dósis _____

área tratada _____ a los cuantos días se hizo la pri -

mera aplicación general _____

Asistencia técnica:

Tiene técnico privado _____

Asiste el técnico a reuniones técnicas _____ cuáles _____

TABLE 97 (cont.)

Recibe boletines informativos _____ De casas comerciales _____

de instituciones _____

Cuántas visitas de técnicos recibió durante la temporada pasada? de técnico privado

_____ de técnico de casas comerciales _____ de técnicos de instituciones

_____.

Tiene su técnico entrenamiento en ecología aplicada a nivel técnico _____

a nivel post-grado _____

Esfuerzo de ventas de agroquímicas:

Cuántas visitas de vendedores de insecticidas recibió la temporada pasada _____

Tiene piloto propio _____ le paga sueldo fijo _____

Aspectos generales:

Cosecha por manzana 1975/76 _____

Edad del plantió al finalizar la cosecha _____ _____

Uso de fertilizante:		area
Urea	_____ qq/mz	_____ mz
Sulfato de amonio	_____ qq/mz.	_____ mz
Abono completo	_____ qq/mz	_____ mz
Foliar	_____ qq/mz	_____ mz

Valor del alquiler de la tierra en su finca o los alrededores: _____

Precipitación Pluvial: por mes en temporada 1975/76:

_____ mm	_____ mm	_____ mm	_____ mm
_____ mm	_____ mm	_____ mm	_____ mm
_____ mm	_____ mm	_____ mm	_____ mm
_____ mm	_____ mm	_____ mm	_____ mm