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GUATEMALA MEDFLY ENVIRONMENTAL IMPACT ANALYSIS

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EXECUTIVE SUMMARY

A. PURPOSE

Native to Africa, over the past 75 years the Mediterranean fruit fly ("medfly") has entered many new areas via infested produce. An insect pest of fruit, the medfly presently occurs in areas of Africa, the Mediterranean, Europe, Oceania, South America, Central America, and Hawaii. It has entered the U.S. mainland many times since 1929, but eradication programs have prevented the species from establishing in mainland states. Between 1929 and 1986, federal and state expenditures for eradication programs on the mainland totalled nearly U.S. $253 million (see pages 1-4).

The medfly entered Central America in 1955. By 1977, the insect had expanded its range from the original entry site in Costa Rica to southern Mexico. In 1977, the governments of U.S., Mexico, and Guatemala initiated a cooperative program known as MOSCAMED to eradicate the insect from Mexico and Guatemala and halt its northern spread. Beginning in Mexico in 1979, the eradication program used a combination of malathion bait spray, sterile medflies released into the wild populations, and regulatory procedures. In 1982, MOSCAMED declared that the medfly had been eradicated from Mexico and extended their effort into Guatemala.

The Animal and Plant Health Inspection Service (APHIS) of the U.S. Department of Agriculture and U.S. Agency for International Development (A.I.D.) have provided U.S. contributions to the Guatemala eradication effort. APHIS' yearly contribution in 1984-1987 was about U.S. $3 million; A.I.D.'s was about U.S. $1 million in P.L. 480 Title I (local currency) funds.

On September 30, 1987, A.I.D. contracted the Consortium for International Crop Protection (CICP) to conduct a comprehensive environmental impact analysis (EIA) of the Guatemala medfly eradication program. A.I.D. used Title 22 of the code of Federal Regulations, Part 216, and Executive Order 12114 of January 4, 1979 (Environmental Effects Abroad of Major Actions) in developing guidelines for the EIA.

B. HOW THE EIA WAS CONDUCTED

An interdisciplinary team of Americans and Guatemalans collected and analyzed the data and developed the EIA document. The CICP EIA technical team included an ecologist, environmentalist, and economist and a sociologist to coordinate

the technical work. A range of specialists (medical doctor, chemist, pesticide toxicologist, apiculturalist, economist, anthropologist, public health specialist, statisticians, ecologist, agronomists, and entomologists) assisted the CICP EIA team in conducting research and surveys and analyzing data.

To obtain information needed for the EIA, the CICP team did the following:

* Used AGRICOLA and CAB computer databases to search the world literature (in Spanish and English) on medfly, related species of fruit flies, medfly eradication technology, etc.

* Sponsored a start-up workshop in Guatemala toward the beginning of the EIA to discuss the EIA with representatives of the Guatemala government, MOSCAMED, APHIS, and other organizations and to ask for suggestions

* Sponsored two public briefing meetings in Guatemala City to discuss EIA work and ask for suggestions. Seventy nine persons representing 51 public and private organizations participated in the first meeting; 93 persons representing 42 organizations participated in the second meeting

* Conducted research and socioeconomic surveys in Guatemala on a range of subjects

* Interviewed dozens of specialists and officials with public and private organizations in Guatemala, other Central American countries, Mexico, and U.S.

* Received and reviewed written comments from individuals and public and private organizations.

C. WHAT TO FIND IN THE EIA

PART I introduces the medfly problem in Guatemala and the MOSCAMED eradication program and traces steps leading to A.I.D.'s request for the EIA.

PART II discusses the ecological, human, and socioeconomic environment of Guatemala.

PART III reviews the application, effectiveness, field experience, public education needs, and limitations of present and potential tactics for controlling medfly.

PART IV discusses impacts of the MOSCAMED eradication program on the ecological, human, and socioeconomic environment in Guatemala.

PART V suggests measures to mitigate the adverse impacts discussed in PART IV.

PART VI compares requirements, benefits, and limitations of medfly eradication and three alternative courses of action: nonchemical pest management, creation of a stable barrier in Mesoamerica to prevent northern spread of the medfly, and no action.

D. GUATEMALA MOSCAMED MEDFLY CONTROL TACTICS

1. Sterile Insect Technique

The sterile insect technique (SIT) consists of rearing and releasing sterile medflies into areas where they mate with wild medflies (see page 25). Large numbers are reared and sterilized (through gamma ray exposure in the pupal stage) at facilities in Guatemala and Mexico. When a wild medfly population is flooded with large numbers of sterile medflies, the likelihood of a fertile mating is reduced. If the sterile insects are released often enough, and in sufficient numbers, the wild medfly population will decline and eventually be annihilated.

SIT is most effective against low level medfly populations where high overflooding ratios (proportion of sterile to wild medflies) are easier to sustain. Malathion bait spray is normally used to achieve this low density requirement.

2. Malathion Bait Spray

Malathion bait spray is a mixture of the insecticide malathion and a protein hydrolysate bait, Nu-lure, that acts as a medfly attractant and feeding stimulant (see page 27). Bait spray is used to reduce wild medfly populations to a level where sterile medflies can be effective. The bait spray attracts and destroys both male and female adult medflies.

Malathion bait spray is dispensed by aircraft, ground applicators using backpack sprayers, or in a corncob treatment ("olotes") technique.

3. Regulating Procedure

Regulatory programs (see page 32) are used to prevent movement of medflies into regulated areas. Guatemala MOSCAMED has legal authority to restrict both internal and external movement of agricultural commodities that may be infested with medflies.

Quarantine stations are maintained at 21 locations in Guatemala: along motor vehicle routes, Guatemala City international airport, Petén and Poptún airports, and at the water port at El Estor, Lake Izabal. MOSCAMED executes the following actions at the internal quarantine stations: (1) vehicles are inspected for the presence of potential medfly host material, (2) vehicles are treated with insecticide to kill adults, (3) host fruits are confiscated and buried or burned, and (4) commercial fruits and vegetables are fumigated with methyl bromide before continuing in medfly free areas (eight of the quarantine stations are equipped to do fumigation).

Another MOSCAMED regulatory action involves stripping and destroying medfly infested or medfly susceptible fruit in quarantine areas. The practice is to strip and bury all medfly host fruit within 1 km^2 of a medfly infestation confirmed by trapping or fruit sampling.

4. Medfly Monitoring

Monitoring of medflies is not a control tactic, but it is an essential aspect of any eradication or control effort. Guatemala MOSCAMED uses traps, baited with an attractant, and samples known fruit hosts of the medfly to monitor populations (see page 40).

E. IMPACTS OF THE MOSCAMED PROGRAM

PART IV assesses about 65 potentially adverse impacts (ecological, human health, and socioeconomic) of the Guatemala MOSCAMED program (page 45 explains procedures used in identifying potential impacts).

In assessing potential impacts, CICP's EIA team first sought out and used existing Guatemala specific information when available. Experiments, surveys, and observations were conducted to obtain additional Guatemala specific information. However, it was not always possible to find existing site specific information or to conduct the experiments, etc. needed to generate information. Therefore, related information from other countries was sometimes used in assessing potential impacts.

Of the some 65 potentially adverse impacts assessed by the CICP EIA team, about half were placed in Category A and half in Category B, as follows:

* Category A: No adverse impact or negligibly adverse impact identified

* Category B: Adverse impact identified or insufficient information available to dismiss potential importance.

Of those impacts in Category B, more than half are related to use of malathion bait spray.

PART V (see page 107) identifies measures, if known, for mitigating (reducing) the risks of impacts in Category B. Some of the impacts cannot be avoided, even when mitigative measures are used, and are identified when possible. Needs in research leading to a better understanding of impacts of the eradication tactics are also identified.

Cost estimates of the suggested mitigative measures are not provided. Implementation of many of those suggested would not require major new investments or changes in Guatemala MOSCAMED operations.

1. Ecological Impacts

Of tactics used in the Guatemala MOSCAMED program, malathion bait spray has the greatest potential for affecting the environment. During the period 1984-1987, Guatemala MOSCAMED annually sprayed an average of 171,051 hectares of cropland by aircraft (fixed wing planes or helicopters) and an average of 170,944 hectares of cropland by ground application (see pages 28 and 30).

Guatemala MOSCAMED has instituted a range of procedures to reduce harmful effects of spraying. Aerial bait spray is applied in alternate parallel strips, leaving 50% of the treatment area unsprayed, thus reducing harm to honey bees, wild pollinators, and other nontarget species. Other measures to reduce impact on nontarget species include: restricting the malathion bait spray treatments to coffee and fruit plantations, handling isolated medfly infestations by ground spraying host plants, and spraying in calm conditions with large spray droplets to reduce drift. Since the beginning of the Guatemala MOSCAMED program, the amount of malathion applied by ground has been reduced 50%; the amount of malathion applied by aircraft has been reduced 80%.

Malathion bait spraying may still be fairly intensive in some locations during medfly outbreaks. A given field or part of a field might receive eight ground applications made at approximately weekly intervals. The same area would not be treated again for 2-3 months, but if outbreaks recurred the same area may receive eight more applications for a total of 16 in one year (see page 29). Further, in three CICP EIA team observations of MOSCAMED spraying by fixed wing aircraft, the aircraft discharged an average of 1.5 liters/ha of the bait spray which is about 50% more than targeted by MOSCAMED. In four observations of helicopter sprayings, the aircraft discharged an average of 1.12 liters/ha of bait spray, which is about 10% more than targeted by MOSCAMED (see page 27).

a. Impact on Honey Bees

Various studies outside of Guatemala have shown that malathion may cause severe honey bee losses if bees are present during treatment or active within a day after treatment. However, the effect of the bait spray formulation used by Guatemala MOSCAMED is unclear. Data from California (U.S.) suggest that the high salt content in Nu-lure may attract bees during certain times of the year. Observations by Mexican and Guatemalan researchers suggest that bees are not attracted (Mexico) and may even be repelled (Guatemala) by the bait. To obtain more Guatemala specific data, the CICP EIA team placed various kinds of bait spray formulation in containers near bee hives and recorded visiting insects (see page 47). The standard malathion bait spray did not attract the bees. Neither did molasses (sometimes added as a supplement to Nu-lure) alone, Nu-lure alone, or a formulation of molasses, Nu-lure, and malathion.

In addition, the CICP EIA team conducted experiments in which the effects of malathion bait spray on flight activity and mortality were assessed in protected and unprotected, strong and weak colonies (both prior to and after spraying). Results of these experiments were highly variable and concise conclusions were not possible. The CICP EIA team suggests that the variation may have been caused by a number of factors affecting bees in Guatemala that could not be controlled in the experiment. For example, the team found tracheal mites in every colony inspected. The mites, which have been spread by the Africanized honey bees in Guatemala, can adversely affect bees. Nosema disease was also found, and two of six apiaries that the team inspected were infected with American foulbrood--a highly contagious bee disease that is fatal if left untreated. Excessive colony density, poor colony placement, and poor air circulation contributed further to the overall inferior conditions observed in the apiaries. In addition, Africanized honey bees now occupy an estimated 50% of apiaries in Guatemala. Honey yields of Africanized bees are low even under the best of current circumstances.

Nevertheless, of 10 beekeepers (each managing 40 to 400 colonies in the MOSCAMED program area) interviewed by the CICP EIA team, all reported that MOSCAMED spraying was responsible for bee mortality and reduced honey production.

Guatemala MOSCAMED has developed procedures to reduce the harmful effects of malathion bait spraying on bees (see page 113).

b. Effects on Nontarget Invertebrates

Malathion affects a wide range of invertebrate natural enemies. However, information on the effects of malathion when formulated as a bait spray is limited.

Coffee is a major host of medflies in Guatemala and is the only medfly host that MOSCAMED treats aerially with malathion bait spray. The CICP EIA team conducted studies to determine the kinds and numbers of beneficial arthropod species (predators, parasites) that inhabit coffee trees and which may be vulnerable to the bait spray. In one study, malathion plus Nu-lure was applied to coffee trees by ground at a very high rate of 3.3 kg a.i. malathion/ha which is 18.2 times more than Guatemala MOSCAMED targets in ground applications. The variety of beneficial arthropods killed by the high rate application was quite extensive and included as many as 59 species representing 27 families of insects and spiders (see page 52).

The studies indicated that high rates of malathion bait spray are destructive to a wide range of beneficial arthropods. However, other CICP EIA team studies showed (see Tables IV-3-5, pages 53-55) that normal helicopter spraying by Guatemala MOSCAMED had no significant effects on nontarget arthropods (except for parameters evaluated during period 3 in Table IV-4) in a natural montane habitat and coffee plantation. The spray consisted of malathion, Nu-lure, and molasses. With the exception noted for Table IV-4, no statistically significant differences were found in the number of individuals, species, families, or individuals per species or in the species diversity between sprayed and unsprayed areas in either the montane habitat or coffee plantation.

Similar results were obtained in CICP EIA team studies of MOSCAMED spraying (Nu-lure plus malathion at the standard rate) by fixed winged aircraft to a coffee plantation (see page 57). No significant differences were found in the number of individuals, species, orders, or families or species diversity with increasing dose of malathion bait spray regardless of sampling method.

Guatemala MOSCAMED aerial spraying by both fixed wing and helicopter aircraft did kill a range of nontarget arthropod species. However, the mortality represented a very small proportion of the total nontarget arthropod population present (see page 57).

The CICP EIA team conducted two trials in coffee to determine the impact of MOSCAMED helicopter spraying (normal rate of malathion, Nu-lure, and molasses) on arthropods inhabiting topsoil. No statistically significant differences between sprayed and unsprayed coffee were found in number of species, families, or individuals or species diversity of soil arthropods in either trial (see page 60).

The CICP EIA team also conducted experiments in Guatemala to determine the impact of malathion bait spray on ground foraging invertebrates, particularly ant species. No ants or other

invertebrate species were observed feeding on the malathion bait. However, the studies were not designed to determine long term effects of the bait spray on ants or other ground foragers.

Malathion is definitely toxic to a wide range of biological control agents. Potential therefore exists for Guatemala MOSCAMED malathion spraying to disrupt naturally occurring biological control in crops and trigger insect pest outbreaks. Guatemala coffee farmers have blamed medfly spraying for increases of insect pests in coffee including the leafminer. However, the literature reveals that sporadic outbreaks of insect pests such as the coffee leafminer occurred long before the Guatemala MOSCAMED program began. Many factors, including malathion and other pesticides used in coffee (see page 18), may disrupt biological control and lead to pest outbreaks. Long term studies, which have not been conducted in Guatemala, are necessary before malathion's impact relative to impact of the other factors is understood.

c. Impact on Wild Vertebrates

No information could be found on the impact of malathion bait spray on wild birds, mammals, and other vertebrates in Guatemala. Toxicological studies from other countries indicate that malathion's potential hazard to wild vertebrates is low. Risk from the MOSCAMED program, if significant, would be more likely to arise through malathion's destruction of the food supply of insectivorous (insect feeding) species of birds and other wild vertebrates.

d. Impact on Native Plants

Malathion bait spray in the Guatemala MOSCAMED program is directed only at crop plants. However, a variety of native plants coexist with or near sprayed crops. Among these may be orchids. Orchid sexual propagation is entirely dependent on insects and other pollinators. CICP interviews indicated that some people believe MOSCAMED's malathion spraying is harmful to orchid pollinators or causes phytoxicity to orchid plants. The team did not examine existing data or generate new data on the direct or indirect effects of malathion bait spraying on orchids. The team did evaluate phytotoxic effects of malathion bait spray on five native plant species, but the results were inconclusive.

e. Effects on Crop Plants

CICP EIA team interviews indicated that farmers who intercrop coffee with cacao or cardamon generally believe that MOSCAMED spraying kills bees and reduces pollination in both cacao and cardamon, with a subsequent loss in yield. From observations, the team determined that honey bees are important in cardamon pollination in Guatemala. However, the team did not

locate scientific data to make conclusions concerning malathion bait spray's impact on cardamon or cacao yields.

Guatemala MOSCAMED denies there is any phytotoxicity problem in coffee associated with malathion bait spraying. Nevertheless, CICP EIA surveys indicated that many coffee farmers associate phytotoxicity in coffee with MOSCAMED spraying. However, data are unavailable to substantiate such opinions.

The CICP EIA team studied the effect of malathion bait spray on three cultivated species: a Musa sp. (banana or plantain), cardamon, and coffee. Cardamon showed no apparent leaf damage. Young, developing leaves of Musa were burned severely, but the long term effects (i.e., on growth or yield) of damage to the young leaves or effects of bait spray on mature leaves were not determined. The effects on coffee were less clear; after application, many sprayed leaves dropped. Some young coffee leaves displayed obvious burn spots; others were not affected.

f. Impact on Biodiversity

Any chemical pesticide has the potential to reduce biodiversity, an ecological term to reflect richness in species or biotic life forms. It is inevitable that if the number of an abundant species declines there will be some repercussion on other species.

Published data from countries other than Guatemala, and data collected by the CICP EIA team in Guatemala, reveal that malathion bait spray may affect a wide range of species. What is not clear are the long term implications of medfly spraying on species abundance and biodiversity.

Although attractive and intuitively appealing, the direct approach of investigating the influence of malathion bait spray on biodiversity is experimentally difficult, and data must be collected systematically over a long period. Without such data, which do not exist for Guatemala, definitive conclusions cannot be drawn.

g. Impact on Sensitive Ecological Areas

Some ecologically sensitive and protected areas (existing or proposed), see page 18, lie within or next to Guatemala MOSCAMED work zones.

Guatemala MOSCAMED maintains medfly traps in protected and ecologically sensitive areas such as Lake Atitlán National Park, Rio Samala watershed (protected by the Instituto Nacional Forestal), and bordering volcanic forests proposed for protection near San Marcos. MOSCAMED's policy is not to use malathion bait

spray in such areas. Human error, drift, and complex habitat patterns are likely to account for whatever chemical treatment of protected and ecologically sensitive areas that does take place.

Helicopters are used to apply malathion bait spray selectively in broken terrain and where coffee and forest form a patchwork pattern. Where more exact targeting is required, ground spraying is used.

h. Impact on Natural Aquatic Ecosystems and Aquaculture

Guatemala's primary coffee and fruit growing areas, infested with the medfly, overlap the country's major river basins and watersheds and are interlaced with small rivers and streams.

There have been no substantiated fish kills or other problems in aquatic habitat due to Guatemala MOSCAMED's malathion bait spraying, although MOSCAMED has not routinely monitored aquatic habitats in sprayed areas. Small streams in coffee plantations would appear to be the aquatic habitats most at risk. In CICP EIA studies, two water samples taken from a stream in a coffee plantation after aerial spraying with malathion bait showed malathion residues of 0.46 and 4.6 ppb. Water samples from open containers (about 30-38 liters) placed in the coffee plantation being sprayed showed malathion residues of 4.02 to 174.21 ppb (see pages 65 and 70). Spraying did not cause death or signs of malathion intoxication in tadpoles (*Bufo* sp.) or minnows (*Profundulus* sp.) held in open containers of water in the coffee while being sprayed. Malathion effects on other organisms inhabiting Guatemala's aquatic ecosystem were not studied.

2. Human Health Impacts

CICP EIA team studies and observations of potential health effects of pesticide use in Guatemala MOSCAMED's program indicated: (1) MOSCAMED's malathion bait spray applied aerially or by ground presents low risks to the general population, (2) MOSCAMED employees regularly working with pesticides (pesticide applicators, mixers, loaders, and quarantine station workers) may be exposed to significant pesticide risks, and (3) the general population may be exposed to significant pesticide risks at MOSCAMED quarantine stations. The risks could be greatly reduced through proper training, use of safety equipment and apparel, and use of appropriate chemicals at quarantine stations.

a. Pesticide Risks to General Population

At Guatemala MOSCAMED's targeted aerial application rate of malathion bait spray, about 11 mg/m^2 a.i. g malathion is applied. This quantity is equivalent to about 1/6,000 of malathion's acute oral LD_{50} (see Appendix 1, page 190, for definition) or 1/17,000

of the acute dermal LD_{50} for a person weighing 50 kg. Ground applications average about 18 mg/m^2 which is about 1/3,666 of the oral LD_{50} for a person weighing 50 kg. Even when the application rate is 50% more than the MOSCAMED targeted rate, the malathion bait spraying operation would present very low risks. Nevertheless, CICP EIA team interviews with 476 community leaders indicated that: 24% think MOSCAMED activities are harmful to health, 25% do not, and the remainder are unsure (see page 76).

For comparison, malathion is used against leafminers in coffee at a rate of 369 mg/m^2, which is 21 times higher than Guatemala MOSCAMED's highest application rate. Two other pesticides used in coffee in Guatemala, aldicarb (acute oral LD_{50} = 1 mg/kg) and paraquat (acute oral LD_{50} = 150 mg ion/kg), pose a much greater risk than malathion (acute oral LD_{50} = 1,375 mg/kg) does.

b. Pesticide Risks to MOSCAMED Workers

CICP EIA inspections of Guatemala MOSCAMED facilities, field operations, and interviews with workers revealed that pesticide safety equipment and apparel (e.g., face masks, fumigation respirators, overalls, boots, and gloves) are in short supply. Workers in several parts of Guatemala reported that use of pesticides without safety equipment or apparel frequently resulted in headaches and sometimes nausea, vomiting, and dizziness. CICP EIA team surveys of 118 Guatemala MOSCAMED workers who apply or mix malathion indicated that a substantial number fear health risks from the chemical. When asked if there was anything dangerous about their job, 59% stated that malathion was dangerous.

During inspections of MOSCAMED aerial operations, the CICP EIA team observed workers with hands, forearms, and feet wet from malathion bait, and on a number of occasions technical malathion. Spills and dermal contamination resulted from mixing operations. Workers without gloves were observed removing and cleaning spray nozzles that had become clogged with bait spray.

A physician working for the CICP EIA team examined 140 Guatemala MOSCAMED workers for symptoms of health effects related to pesticides (see page 72). Seven of the workers reported symptoms commonly observed in patients with confirmed clinical pesticide poisoning; of these, five were malathion bait spray ground applicators. Medical histories indicated that roughly half of the 140 workers had at one time experienced clinical symptoms consistent with, but not necessarily related to, pesticide overexposure. Some of these symptoms, however, may also be related to stress, fatigue, rapid temperature changes, or malnutrition.

In addition, the 140 workers were tested for blood plasma cholinesterase levels. When absorbed through the skin, ingested, or inhaled in sufficient quantity, malathion inhibits cholinestrase in humans. Cholinesterase is an enzyme necessary for normal nerve transmission; when sufficiently inhibited by organophosphate or carbamate insecticides, signs and symptoms of cholinergic poisoning will appear.

Ninety-eight percent of the 140 MOSCAMED workers had blood plasma cholinesterase levels in normal limits. Of the three workers (2%) who exhibited undesirable cholinesterase inhibition, one was a ground applicator of malathion bait spray, one was a fruit stripper, and one had a MOSCAMED job that did not expose him to pesticides. It is possible that any of the workers either sustained exposures to other organophosphate insecticides in the area or suffered from malnutrition.

A second cholinesterase survey was conducted in 15 MOSCAMED workers who were mixing malathion bait spray and loading it into aircraft. After 3 weeks of this work, six of the 15 workers exhibited a 10 to 22% decline in their cholinesterase level compared to individual pre-exposure baselines. None of the workers exhibited clinical signs of poisoning. However, post-exposure cholinesterase levels confirmed that workers had been exposed to undesirable levels of malathion and emphasized the need for protective clothing.

c. Pesticide Risks at Quarantine Stations

Guatemala MOSCAMED's policy is to treat vehicles passing through quarantine stations into medfly free areas with d-phenothrin. This pyrethroid insecticide has relatively low toxicity and is the only insecticide approved by Guatemala MOSCAMED for this use. However, CICP EIA team inspections at quarantine stations and interviews with MOSCAMED workers revealed that d-phenothrin was rarely used. Instead, the stations used various formulations of the much more toxic chemicals dichlorvos and propoxur. Guatemala MOSCAMED's Director pointed out that all uses of propoxur and dichlorvos were discontinued shortly after the CICP EIA inspections in April 1988 and use of d-phenothrin was reinstated. On June 6, 1988, CICP EIA team members inspected three MOSCAMED quarantine stations and determined that only 2% d-phenothrin was being used to treat vehicles.

Guatemala MOSCAMED uses the fumigant methyl bromide to treat fruit at quarantine stations. Fruit is placed in a chamber and fumigated with methyl bromide gas to destroy any medfly infestations. Methyl bromide is highly toxic to humans.

The CICP EIA team observed workers at one Guatemala MOSCAMED station playing cards in the methyl bromide fumigation chamber. At another station, CICP EIA team members discovered that workers

sleep in the chambers at night. At another station, the CICP EIA team learned that handling the fruit to be fumigated (putting the fruit into the chamber and removing it) requires the help of two MOSCAMED workers, yet the station had only one respirator. The worker without the respirator wrapped a handkerchief around his nose and mouth before entering the fumigation chamber. At another station, the CICP EIA team observed that instructions for replacement cartridges for the respirators were only in English. Although anecdotal, these reports indicate that methyl bromide fumigation at quarantine stations presents potentially serious health problems for workers.

d. Impact on Drinking Water

Of concern in any large scale program using pesticides is the risk of contaminating surface and ground water used for drinking. In the Guatemala MOSCAMED program areas, some drinking water may come from small ponds or roof top catchment basins. Therefore, the EIA includes a worst case scenario for malathion contamination in a small pond used for drinking (see page 76). Assuming the entire pond was sprayed with the standard dosage (118 g a.i. malathion/ha), malathion contamination in the water would be 1.118×10^6 ppb. If a child weighing 10 kg drank 1 liter of contaminated water, the calculated intake of malathion would be less than 1/5,000 of the lowest published lethal dose to humans. The 1.118×10^6 ppb of malathion is 6,417.5 times greater than the 174.2 ppb CICP's EIA team detected in the most heavily contaminated container of water held in coffee while being sprayed with malathion bait (see page 70). Public health is unlikely to be affected through drinking water from treated areas.

3. Social Impacts

a. Public Perceptions

Results of CICP EIA team surveys conducted throughout Guatemala show that the public has little information or understanding about the techniques and objectives of the MOSCAMED program (see pages 81, 84, 89, and 95). Misconceptions about the program are common. MOSCAMED's emphasis on and support of public education and public relations has been inadequate. An effective public education and public relations program is necessary to deal with complaints and potential organized opposition of beekeepers (see page 48), cardamon growers (see page 62), and coffee growers (see page 62) have about the MOSCAMED program.

Aerial application of malathion bait spray is the most controversial aspect of MOSCAMED's program. Based on CICP EIA surveys, a significant portion of the public appears to believe that MOSCAMED spraying has been responsible for: (1) human health and animal illnesses, (2) yield reductions of agricultural

crops, and (3) environmental damage. There appears to be less negative feeling about released sterile medflies or MOSCAMED's medfly monitoring program. Resentment over regulatory controls, especially quarantine stations, is high.

b. Institutional Constraints

In 1988, the medfly free and post eradication zones were reinfested and reached levels similar to those of 3 years earlier. Guatemala MOSCAMED blamed the increase on its inability to carry out the full scale eradication program needed due to: (1) AID's freeze on use of PL 480 funds until this EIA is completed, (2) decline in value of Mexican peso and delays in receiving Mexican funds, (3) directive by U.S. Congress to limit the medfly control activities, and (4) limited disbursement of funds from APHIS. (APHIS disbursement of funds was consistent with continuing resolution allocation of U.S. $1.9 million. Once the budget allocation was approved, in late January 1988, disbursements were made at revised levels). Strikes by labor unions, drastic personnel reductions, and low morale among employees have accompanied the reduced eradication effort. Bureaucratic and institutional problems such as these can seriously limit the effectiveness of the MOSCAMED program.

3. Economic Impacts

a. Program Benefits

Benefits of the MOSCAMED eradication program fall in four categories, which are discussed on page 140: (1) elimination of crop losses inflicted by medfly, (2) relaxing export constraints to countries that restrict products from medfly infested areas, (3) aggregate benefits (political and human capital benefits) such as improving international cooperation linkages and providing training for program workers, and (4) direct program benefits, such as providing jobs. The first three are permanent benefits. The fourth benefit would continue only while the eradication program is in progress.

Eradication of the medfly in Guatemala would potentially reduce threat of the medfly's northern spread and entry into the U.S. However, the EIA document does not estimate potential cost benefits for the U.S.

(1) Elimination of Crop Losses

The medfly's major commercial crop hosts in Guatemala are coffee throughout its entire growing range; mangoes and oranges, especially in areas south of the coffee area; and apples, peaches, and pears principally to the north of the coffee area (see page 141). In addition, the medfly attacks many crops of lesser commercial importance (see page 142).

Medfly losses to the major commercial crops are estimated at U.S. $0.44 million per year (1987 loss estimates); see page 145. Therefore, it is expected that medfly eradication would reduce annual losses by this amount in these crops. Reduction in losses in crops of lesser commercial importance would probably be less.

Coffee is the most important medfly host in Guatemala, but there are no scientific data from Guatemala on effect of the pest on coffee yield or quality. If the annual loss is only 2%, and if all coffee saved by eradicating the medfly were sold at current market prices, estimated benefits over 20 years (discounted at 14%) would be U.S. $50.7 million. Under these circumstances, medfly eradication would be very economically attractive for Guatemala. However, coffee growers in Guatemala and other Central American countries state that the medfly causes no noticeable reduction in coffee yield. Costa Rica also has the medfly and there are no organized efforts to control the pest in coffee; yet per hectare coffee yields in Costa Rica are more than double those in Guatemala.

(2) Relaxing Export Constraints

Eradication of the medfly would probably be an incentive for Guatemala to seek new export markets for crops that presently cannot be exported to the U.S. because of medfly quarantine restrictions. Green peppers and papaya appear to have greatest potential and benefits are estimated at U.S. $1.5 million annually (see page 146).

(3) Aggregate Benefits

MOSCAMED has strengthened Guatemala-Mexico relationships in agriculture. It has stimulated regular exchange of information and visits between officials and technicians of the two countries. Mexico contributes a large number of sterile medflies to the Guatemala MOSCAMED program. The cooperative medfly eradication effort therefore has political value in strengthening relations between the two countries.

Human capital benefits must also be considered. Guatemala MOSCAMED has provided training in medfly control for numerous Guatemalans. These individuals represent a valuable resource. Their training and experience have contributed to increasing Guatemala's overall capacity in pest management.

(4) Direct Program Benefits

MOSCAMED has benefited Guatemala directly by creating employment. In May 1988, the MOSCAMED program employed 1,000 Guatemalans, about half the number it employed in early 1987 (see page 139). Benefits from employment, which include a multiplier effect, will continue to accrue as long as the eradication

program exists. Estimated yearly employment benefits from the Guatemala MOSCAMED program have been about U.S. $3 million (based on average wages during January 1987-February 1988, see page 148). Similar benefits would be expected every year of the eradication effort, assuming wage levels, unemployment rates, and multiplier effects stayed constant.

b. Program Costs

Costs of medfly eradication include direct costs needed to run the eradication program and indirect ("external") costs such as fruit stripping in the regulatory program and costs to environment (see page 148).

The EIA document estimates costs to eradicate the medfly from all of Guatemala for each of three time-based options (see page 148). Options one, two, and three differ in the amount of time (4, 5, and 6 years, respectively) that is required for the eradication effort to progress across all of Guatemala (see page 130). The strategy for all options assumes that the eradication effort would begin at a time when medfly populations were at 1987 levels.

Table ES-1 provides estimates of direct costs for the three eradication options. These costs are based on the assumptions presented below in section F.

Total costs of option one are estimated at U.S. $32.3 million, option two U.S. $36.9 million, and option three U.S. $41.9 million (the estimates include costs of sterile medflies which would be contributed by Mexico). In addition, unless the medfly is also eradicated from El Salvador and Honduras, an estimated U.S. $6.87 million would be needed annually to maintain a medfly barrier at the Guatemala-El Salvador-Honduras border.

Table ES-1. Estimates of direct costs (U.S. $ million) to eradicate the medfly from Guatemala and maintain a medfly barrier at the Guatemala-El Salvador-Honduras border

Option	Total eradication costs	Annual barrier costs
One (4 years)	32.3	6.87
Two (5 years)	36.9	6.87
Three (6 years)	41.9	6.87

Of external costs, only regulatory control costs (fruit confiscation and destruction) could be quantified and were estimated at U.S. $0.54 million for 1987. These costs would increase as the MOSCAMED program spread into larger areas, but to what extent cannot be predicted.

As an eradication program proceeded east through Guatemala, movement of fruit from medfly infested to medfly free areas would increase and so would the need for quarantines and their associated external costs. Presently, most fruit produced in the medfly infested area is consumed in this area. Therefore, disruptions in trade patterns are small. Disruptions would be expected to increase when Guatemala City, the country's major consumer of fruit, was liberated from medflies. Costs due to trucking delays would increase, as traffic lines formed at quarantine stations. As delays became more serious, parallel service facilities might be needed. These costs would have to be borne throughout the entire eradication program.

Under option two, indirect costs would be borne for one more year (5 versus 4 years) than they would be in option one. Some reductions would take place as a consequence of reduced pesticide use each year, but on the whole indirect costs could be 20% greater under option two.

Option three (6 year eradication) would take 50% more time than option one would, which means that indirect costs would be increased almost proportionately. Pesticide use per year would be less, but overall use would increase under option three. Indirect costs under option three might be 40% higher than indirect costs under option one.

Both direct and indirect costs would be reduced significantly under option one.

Estimated indirect costs of option one would be 80-88% smaller than in option two and 67-77% smaller than in option three depending on whether costs or time proportions are used. Estimated indirect costs in option two would be between 80-88% smaller than in option three.

F. TECHNOLOGICAL LIMITATIONS

Successful medfly eradication would be influenced by many factors. For Guatemala MOSCAMED to achieve successful country wide eradication, the following assumptions must be met (these assumptions were used when deriving estimates of costs, presented above):

* Medfly control technology is sufficient to achieve eradication

* Eradication technology would provide consistent results with no loss of effectiveness

* Medfly populations at the beginning of the eradication effort (i.e., at the beginning of the 4, 5, or 6 year effort depending on the option chosen) would not exceed the levels of 1987 or occur in areas not infested in 1987 (see page 153 for discussion of the 1988 infestation levels)

* Any unforeseen problems resulting from budget cuts, inconsistent release of funds, inclement weather, earthquakes, political disturbances, workers strikes, etc. would not delay completion of the eradication effort

* Monitoring and education programs would help meet all needs required for success

* The quarantine program would prevent reinfestation of medfly free zones

* Prices for program inputs and resources, and prices for crops saved, would remain the same

* At the end of the program neighboring countries to the south of Guatemala would have to undertake an eradication effort or Guatemala would have to maintain a long term barrier at its border to prevent reinfestation.

A serious limitation to the eradication effort is the quarantine program. The CICP EIA team observed that vehicle inspection at the quarantine stations is not always thorough. Treatment of vehicles is sporadic; and some of the stations lack proper fumigation equipment; confiscated fruit is not always disposed of; and commercial fruits and vegetables are not consistently fumigated. Some quarantine stations can be avoided by using alternate roads.

Curbing all movement of medfly infested fruit and vegetables into medfly free zones in Guatemala is probably not possible as long as other Central and South American countries are infested with medflies. The U.S. quarantine program has not been able to keep the medfly out of the U.S. mainland. The medfly has entered the U.S. mainland many times despite a very intensive and costly APHIS vigilance at all international airports and seaports.

Eradication of the medfly in Guatemala may reduce the threat of direct invasion via Mexico. However, eradicating the pest in Guatemala, and for that matter all of Mexico and Central America,

will not eliminate the threat of the insect entering the U.S. Guatemala is currently responsible for only a small percentage of the total medflies intercepted at the U.S. mainland ports (see page 155).

Finally, if the medfly were eradicated in Guatemala, the farmers would still be confronted with Anastrepha. A fruit fly complex related to medfly, Anastrepha has a number of economically important species. The Anastrepha complex reduces crop yields and prevents the export of fruits it attacks to the U.S. since the complex contains species that the U.S. quarantines.

Observations of the CICP EIA team indicated that Anastrepha is a much more serious pest of major commercial fruit than medfly (see pages 87 and 145). The team analyzed data of 18,734 fruit samples (1987 data provided by Guatemala MOSCAMED) to determine the relation between medfly and Anastrepha infestations. The fruits produced 96,669 (94.6% of the total) Anastrepha larvae and 5,521 (5.4% of the total) medfly larvae or about 17 times more Anastrepha than medflies. Of 31,511 fruit fly larvae from fruit sampled in MOSCAMED Zones A and B where medfly densities are very low (see page 130), 99.8% were Anastrepha. Of 79,696 larvae from fruit sampled in Zone E where medfly densities are high, 93.2% were Anastrepha.

G. ALTERNATIVE COURSES OF ACTION

PART VI (page 129) discusses the program components, requirements, benefits, and limitations of medfly eradication and three alternative courses of actions: creation of a stable barrier in Mesoamerica to prevent spread of the medfly, nonchemical pest management, and no action.

The stable barrier (see page 156) would use the same medfly control techniques presently used in the Guatemala MOSCAMED eradication program. Three different barrier locations are discussed: Isthmus of Tehuantepec in Mexico, mid-Guatemala, and southern Guatemala border. The Isthmus of Tehuantepec barrier would present the least annual costs. How effective a barrier would be in deterring the medfly's advance toward the U.S. cannot be predicted.

The nonchemical pest management alternative (see page 165) would reject all uses of chemical pesticides. It therefore would appeal to environmentalists and others opposed to pesticides. Further, it would eliminate most of the negative ecological and human health impacts identified in this EIA. However, a major nonchemical medfly management program as proposed (using sterile medflies, cultural practices, biological control, and nonchemical

postharvest quarantine techniques) has never been undertaken. Therefore, its potential for effectively managing the medfly in Guatemala and deterring its northern spread cannot be predicted.

The no action alternative (terminating the Guatemala MOSCAMED eradication program and not replacing it with the barrier or nonchemical alternative; see page 171) would increase the chances of the medfly's northern spread. The most damaging impact on Guatemala would appear to be loss of employment. Impact on crop production in Guatemala would be minimal.

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PART I

INTRODUCTION

Native to Africa, over the past 75 years the Mediterranean fruit fly (Ceratitis capitata (Wiedemann), commonly known as the "medfly," has entered many new areas via infested produce. The insect pest presently occurs in areas of Africa, the Mediterranean, Europe, Oceania, South America, Central America, and Hawaii (see Figure I-1).

Worldwide, the medfly attacks at least 250 species of plants (unpublished host data provided by USDA-APHIS). It attacks about 40 species in Guatemala and in nearby areas of Mexico (see Part II, B.2.). Adult females insert their eggs in ripening or ripe fruits and vegetables. Emerging larvae (maggots) shed their skin twice as they feed and grow. At completion of the third larval stage (third instar), the larval skin hardens to form a puparium (pupal case). Pupation usually takes place in the soil. The adults emerge, attain sexual maturity in a few days to a week or more, mate, and begin a new cycle (see Figure I-2).

The larvae feed and develop in fruit pulp. The entire fruit may be lost from feeding damage or the decay that frequently results. Additionally, oviposition "stings" made by a female medfly may spoil appearance of a fruit and reduce its grade, storage life, and shipping quality.

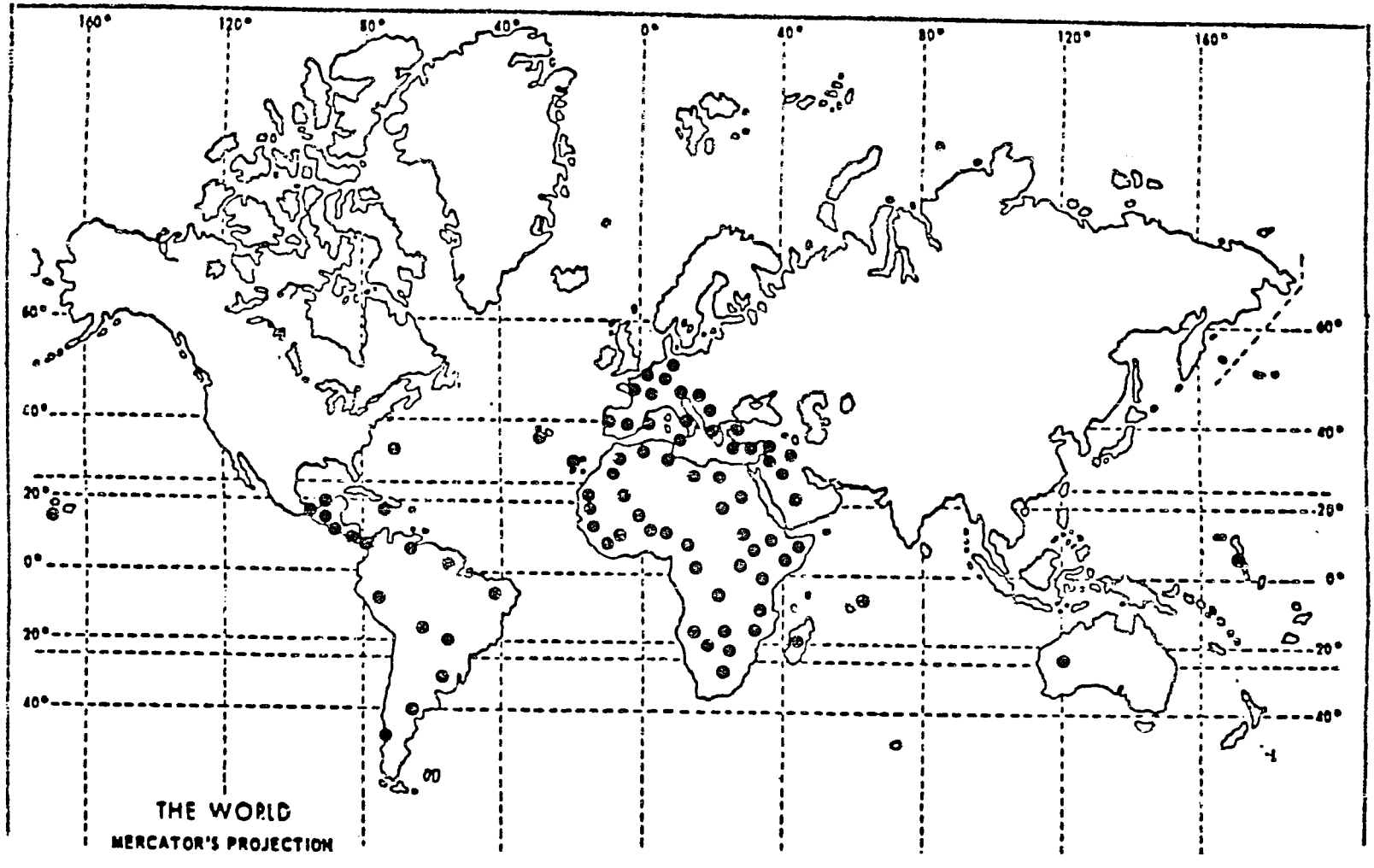
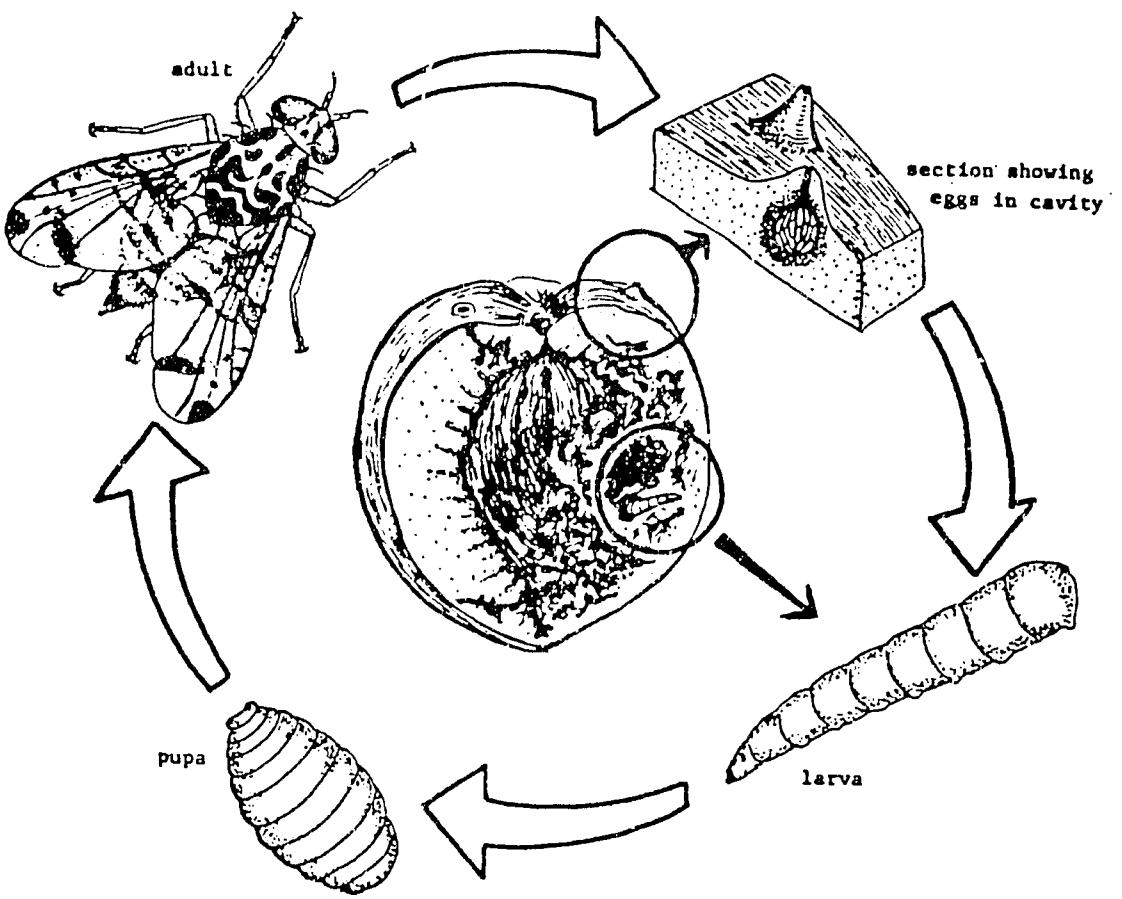


Figure I-1. World distribution of medfly

Figure I-2 Medfly life cycle



The medfly became established in the Hawaiian Islands in 1910. It has entered the U.S. mainland many times since 1929, but eradication programs have kept the species from establishing in mainland states. Between 1929 and 1986, federal and state expenditures for eradication programs on the mainland totalled nearly $253 million (APHIS 1987a).

The medfly entered Central America in 1955. By 1977, the insect had expanded its range from the original entry site in Costa Rica to southern Mexico (APHIS 1987a). In 1977, the governments of U.S., Mexico, and Guatemala initiated a cooperative program, known as MOSCAMED, to eradicate the insect from Mexico and Guatemala and halt its northern spread. Beginning in Mexico in 1979, the eradication program used a combination of malathion bait spray, sterile medflies released into the wild populations, and regulatory procedures. In 1982, MOSCAMED declared that the medfly had been eradicated from Mexico and extended the eradication effort into Guatemala (Ortiz et al. 1987).

A. A.I.D.'S PARTICIPATION IN THE MOSCAMED PROGRAM

The governments of Mexico, Guatemala, and U.S. have funded the medfly eradication program in Guatemala. The Animal and Plant Health Inspection Service (APHIS) of U.S. Department of Agriculture (USDA) and U.S. Agency for International Development (A.I.D.) have provided U.S. funds. A.I.D.'s contribution in 1984-1987 was about U.S. $1 million per year in P.L. 480, Title I (local currency) funds. APHIS' yearly contribution during this period was about U.S. $3 million.

B. A.I.D.'S REQUEST FOR THE EIA

In 1987, A.I.D. requested a comprehensive environmental impact analysis (EIA) of the Guatemala medfly eradication program.

APHIS conducted an environmental assessment of the Guatemala medfly eradication effort in 1987 (APHIS 1987a). However, A.I.D. rejected APHIS' assessment on grounds that it did not meet needs for a site specific analysis (James S. Hester, A.I.D., personal communication 1987).

C. HOW THE EIA WAS CONDUCTED

On September 30, 1987, A.I.D. awarded a contract to the Consortium for International Crop Protection (CICP) to conduct the EIA. Work on the EIA in Guatemala began December 1, 1987. A nonprofit consortium of 13 U.S. universities (including the University of Puerto Rico) and USDA, CICP has conducted dozens of environmental assessments for A.I.D. In addition, during 1983-1985, CICP conducted an environmental impact statement for a

proposed APHIS program to eradicate the "trifly" complex (medfly plus two related species of fruit flies) from the state of Hawaii (USDA-APHIS 1985).

The following team of Americans and Guatemalans conducted the EIA for CICP:

Team Member	Role on Team	Degree
Jim Murphrey	Team leader	M.Ed., Ag. Ed. Adm.
Ronald Estrada	Guat. counterpart	M.S., Agronomy
Pedro Barbosa	Ecologist	Ph.D., Insect Ecology
Katrina Eadie	Sociologist	Ph.D., Develop. Sociol.
Lawrence J. Pinto	Environmentalist	M.S., Insect Ecology
Eduardo Villagrán	Economist	M.S., Ag. Economics
Dale G. Bottrell	Contract manager	Ph.D., Entomology

The consultants and research assistants listed in Appendix 2 assisted the team.

The Instituto Interamericano de Cooperación para la Agricultura (IICA) in Guatemala City provided the Guatemalan counterpart, research assistant, and consultants, office facilities, transportation, and secretarial and administrative services.

Title 22 of the Code of Federal Regulations, Part 216, and Executive Order 12114 of January 4, 1979 (Environmental Effects Abroad of Major Actions) was used to develop guidelines for the EIA. The scope of work developed by Higgins et al. (1987) provided additional guidance. To obtain information needed for the EIA, the CICP team did the following:

* Searched the literature: Using AGRICOLA and CAB computer databases, the team searched the world literature (in Spanish and English) for publications on medfly and related fruit flies (Anastrepha). Librarians at IICA assisted in finding Central American literature and unpublished reports

* Sponsored a start-up workshop: IICA and CICP sponsored a workshop in Guatemala toward the beginning of the EIA assignment (January 18-22, 1988). One of the objectives was to discuss the EIA with representatives of the Guatemala government, MOSCAMED, APHIS, and other organizations and to ask for suggestions

* Sponsored two public briefing meetings: IICA and CICP sponsored two briefing meetings (February 18 and May 26, 1988) in Guatemala City. The first meeting informed participants of the EIA's objectives, progress, and plans and asked for suggestions; the second presented preliminary findings of the CICP EIA

team. The meetings were announced in the Federal Register in the U.S. Seventy-nine persons representing 51 public and private organizations participated in the first meeting. Ninety-three persons representing 42 of these organizations participated in the second meeting (see Appendix 3)

* Conducted research and socioeconomic surveys: The team conducted short term research and socioeconomic surveys in Guatemala to collect data in several subject areas (see Appendix 4). Results of the research and surveys are summarized in the respective subject areas in the EIA document

* Interviewed specialists and officials: The CICP team contacted the specialists and officials shown in Appendix 3. These contacts in Guatemala, other Central American Countries, and U.S. provided information on a wide range of subjects

* Reviewed written comments: The team received and reviewed written comments from persons and organizations.

D. LIMITATIONS TO THE EIA

This analysis was done in 7 months, from December 1, 1987 to June 30, 1988. Field observations, research, and surveys were conducted during the relatively short period of late January to mid-May 1988. This period corresponds to Guatemala's dry season, which ecologically contrasts drastically to the wet season. Further, MOSCAMED applications of malathion bait spray by fixed wing aircraft were made during only one month (early April-early May) of this period. These constraints put certain limitations on the information presented and conclusions reached in this EIA document. For example, to determine malathion bait spray's real impact on biodiversity and ecological stability might take years of continuous observation and complex research in representative ecosystems. Determining the technical feasibility of medfly eradication in various Guatemalan agroecosystems and answering many other important questions might also take years.

E. THE EIA DOCUMENT REVIEW PROCESS

CICP distributed drafts of the EIA document to the following contacts with a request to review and submit comments on the drafts. The CICP EIA team considered all reviewers' comments

when revising the preliminary drafts and preparing this final document. Asterisks (*) indicate which individuals submitted written comments:

A.I.D., Washington, D.C.	Preliminary drafts	Final draft
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Dr. Mary Lou Higgins	*	*
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U.S.A.I.D., Guatemala		
Mr. Brian Rudert		
Guatemala MOSCAMED		
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In addition, CICP recruited the following consultants to review the final draft:

Name	Specialty
Dr. Wallace Mitchell	Entomologist
Lic. Rolando Alfaro A.	Lawyer
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Dr. Patricia Matteson	Entomologist

F. What TO FIND IN THE EIA DOCUMENT

PART II discusses the ecological, human, and socioeconomic environment of Guatemala; PART III discusses present and potential tactics for controlling the medfly; PART IV discusses environmental impacts of the Guatemala MOSCAMED eradication program; PART V suggests measures to mitigate the adverse impacts; PART VI compares requirements, benefits, and limitations

of medfly eradication and three alternative courses of action: nonchemical pest management, creation of a stable barrier in Mesoamerica to prevent northern spread of the medfly, and no action.

For unfamiliar acronyms, abbreviations, and technical terms, the reader is referred to Appendix 1.

PART II

THE GUATEMALA ENVIRONMENT

A. GEOGRAPHY

1. Landforms

Guatemala's position atop three tectonic plates provides a geological instability characterized by earthquakes and the presence of over 30 volcanoes in its highland interior. Several of the volcanoes are active.

The Sierra Madre and Cuchumatanes mountain ranges divide the country into three broad geographic zones: Pacific lowlands, highlands, and Atlantic lowlands. The terrain affects MOSCAMED's operations. In the flat lowland areas, the malathion bait spray can be applied by fixed wing aircraft. The terrain is too rugged and broken for fixed wing aircraft in parts of the central highlands and in areas near Coban. Helicopters or ground crews apply the bait spray in these areas.

2. Soils

Pacific lowland soils are primarily volcanic in origin and agriculturally productive. Throughout the Petén and the Atlantic lowlands many soils are only marginally suited for agriculture due to poor drainage. When covered with lowland forests, soils are productive but rapidly deteriorate when farmed intensively. Highland soils range from rich volcanic soils to thin, rocky mountain soils and are not suited for intensive cultivation. Hillside and highland zones comprise 82% of the total land area of Guatemala; of these, 35% are good deep soils, 14% poor deep soils, and 51% thin soils (Leonard 1987). The FAO-UNESCO classification system lists four major soil groups: Cambisoles (20%), Luvisoles (22%), Rendiznas (14%), Acrisoles (10.5%), and Nitosoles (9.3%), Landivar (1984).

3. Water

Of about 220,000 million m^3 of annual rainfall, 45% becomes superficial runoff. The Pacific Watershed (24,000 km^2) discharges an estimated 23,000 million m^3 of runoff. The Atlantic Watershed (78,000 km^2) is divided into two parts: one discharging into the Atlantic (34,100 km^2) and another draining into the gulf of Mexico (Landivar 1984).

Guatemala has over 300 lakes covering 1,000 km^2. Lake Izabal in the Atlantic watershed (590 km^2) and Lake Atitlan (130 km^2) in the Pacific watershed are the largest. The Usumacinta River, with a basin of 51,538 km^2, is the largest river,

dominating water flow into the Gulf of Mexico. The Motagua, which flows to the Atlantic, has the largest basin (14,453 km^2) in that watershed. All of the river systems in the Pacific slope are relatively small, although many are fast running, especially in the rainy season.

4. Climate

The Atlantic lowlands receive rainfall throughout the year and support moist tropical forests. Average annual days of rainfall there vary from 150 to 210 (rainfall is heaviest from June to November), and annual rainfall is 2,000-4,000 mm. The upper Motagua valley, located on the Atlantic side of Guatemala, is the driest part of the country with an annual rainfall of 500 mm falling over a period of about 60 days. The Pacific lowlands have a short, intense rainy season and annually receive about 2,000 mm over a period of 120-150 days. The highland mountains and plateaus are temperate and relatively dry, although they may be cold and wet at higher elevations. Intense storm activity in the lowlands during the rainy season limits medfly control activities.

The annual mean temperature in the tropical lowlands of both coasts is about 25 C; this contrasts to 10-20 C in the highlands. In lowland areas during summer months, a maximum daily temperature of 32 C is common. A maximum daily temperature of 26 C is common during winter in the lowlands (Land 1970).

Winds rarely exceed 80 km/hr. in any part of the country (Landivar 1984). MOSCAMED avoids aerial spraying and aerial releases of sterile medflies in the afternoon when winds tend to be highest. Aerial spraying and relcases are executed in the morning when winds are generally calmer.

5. Life Zones

Guatemala has a diversity of ecosystems ranging from (about 30%) temperate (dominated by conifers and broadleaved trees) to tropical and sub-tropical habitats (70%). The country has several types of tropical, subtropical, lower montane, and montane forests. The northern Petén and Pacific coastal areas are characterized by tropical dry forests while the southern Petén and the Atlantic lowlands are dominated by tropical broadleaved moist forests. Highland coniferous forests are found in the west and mangroves in the tidal flow areas of the Pacific coast (Landivar 1984).

The greatest variety of plant and animal life is found in the Atlantic lowlands, north to the Petén. Species are less abundant in the drier Pacific lowlands than in the Atlantic lowlands. Temperate highland areas and transitional zones have fewer plant and animal species than tropical areas.

B. FAUNA AND FLORA

1. Fauna

Guatemala is a transition zone between the northern Nearctic fauna and the southern Neotropical fauna. It therefore has a diverse group of animal species characteristic of both faunal zones. The Latin American Program of the Nature Conservancy lists 1,156 terrestrial vertebrate species in Guatemala: birds, 679; mammals, 174; reptiles, 204; and amphibians, 99 (David Mehlman, personal communication 1988).

In 1988, 4% (46) of the total number of vertebrate species in Guatemala were considered to be endemic. These include 0.1, 2.3, 8.3, and 24.3%, respectively, of the bird, mammal, reptilian, and amphibian species in Guatemala (Based on Central Scientific Data Bases of the Nature Conservancy).

The Atlantic lowlands and the Petén have 303 resident species, and 89 of these are endemic to these areas. Resident bird species in the Pacific lowlands are usually found in the Atlantic lowlands also; 202 species occur in the Pacific zone. There are 125 resident bird species in the highlands, and many of these are migratory (Land 1970).

In winter, 134 temperate North American and Mexican migratory bird species are found in Guatemala, which is the southernmost limit for 20 species. An additional 38 species pass through Guatemala in autumn or spring. Most migrants are in the families Parulidae (wood-warblers, 37 species), Vireonidae (Vireos, 6 species), and Tyrannidae (Tyrant Flycatchers, 15 species). These three families are completely insectivorous and many of their members reside in plantation habitats such as second growth vegetation and forest edges (Land 1970, Peterson and Chalif 1973).

Populations of western North American birds that winter in the highlands and the Pacific slope of Central America (including Guatemala) have declined recently. The decline may be due to dwindling resource availability, particularly deforestation and a narrow and precarious food supply margin in their winter range (Leonard 1987).

2. Flora

There are an estimated 8,000 species of vascular plants in Guatemala. Of these, 1,171 are endemic. Approximately 70% of the high mountain vascular flora is endemic (Davis et al. 1986). Over 550 species of Guatemalan plants are orchids. Primary-growth trees in montane forests that may border coffee plantations and large trees left in the plantations are prime habitats for orchids. The MOSCAMED operations include areas

where orchid diversity is greatest: Coban area, volcanic slopes between Guatemala city and Mexico (800-1,550/2,000 m), Sierra de las Minas, and mountains bordering the Polochic River. Among Annex I species (i.e., those designated as in imminent danger of extinction by IUCN) are the national flower, Lycaste virginalis alba (an estimated 200 plants remain in the Coban area, although other color forms of the species are much less rare), and Cattleya skinneri found in coffee plantations and forests on volcano slopes. A number of extremely rare orchid species previously known only from Costa Rica were recently discovered in virgin forests bordering coffee plantations in the Polochic River area: Eriopsis biloba, Lycaste dowiana, and miniature species with very specific habitat requirements (Otto Tinscher, commercial orchid producer, personal communication 1988). Most orchids are pollinated by insects, although orchid pollination biology is poorly known.

3. Endangered and Threatened Species

The CICP EIA team contacted a range of private and governmental organizations and requested a list of species in Guatemala that have been designated as endangered or threatened. None of the contacts could identify an "official" list sanctioned by the Guatemala government. Table II-1 is a tally of all lists found by the CICP EIA team.

Table II-1. Endangered or threatened species of animals and plants in Guatemala

Latin name	English name	Spanish name
Meleagris ocellata (or Agriocharis ocellata)	Ocellated Turkey	Pavo de El Petén
Podilymbus gigas	Giant Grebe	Poc, or Pato Zambullidor
Oreophasis derbianus	Horned Cuan	Pavo de Cacho
Pharomacrus mocinno	Resplendent Quetzal	Quetzal
Pelecanus occidentalls	Brown Pelican	Pelicano Pardo
Burhinus bistriatus	Thick Knees	Peretete
Amazona albifrons	White-fronted parrot	Loro
Harpya harpya	Harpy Eagle	Aguila Harp a
Falco peregrinus anatum	American Peregrine Falcon	Halcón Peregrinó
Falco peregrinus tundriusa	Arctic Peregrine Falcon	Halcón Peregrinó
Phynhptta sp		Cotorra
Ara macao		Guacamaya
Colinus virgianus		Codorniz
Gyrtomix sp		Cordorniz
Mycteria americana	Wood Stork	Garzón Pulido
Sterna antillarum	Least Tern	--
Grus americana		Grulla
Compehilus imperiales		Carpintero
Penelopina nigra		Chachalaca negra
Myrmecophaza tridactyla	Giant Anteater	Oso hormiguero
Enhydra nutris		Nutria marina
Myrmecophaga tridactyla	Giant Anteater	Oso Hormiquero
Tapirus bairdii	Tapir	Danta
Felis onca	Jaguar	Tigre o Jaguar
Felis pardalis	Ocelot	Tigrina
Felis weidii	Margay	Tigrillo
Felis concolor	Puma	León, Puma
Felis vagouaroundi	Jaguarundi	Once, Leon Miquero
Trichechus manatus	Manatee	Manatí
Odocoileus virginianus	White-tailed Deer	Venado
Manzana americana	Brocket Deer	Cabrito
Tamandua tetradactyla	Tamandua	Oso Colmenero
Ateles Geoffroyi	Spider Monkey	Mico
Alouatta villosa	Howler Monkey	Mono Zaraguate
Alouatta pigraa	Black Howler Monkey	--
Lutra annectens	Otter	Perro de agua
Crocodylus moreletti	Morelet's Crocodile	Lagarto del Petén
Crocodylus actus	American Crocodile	Lagarto
Alligatoridae sp.		Caimán de anteojos
Chelonia mydas agazzisi	Pacific Green Turtle	Tortuga verde
Dermatamys mawiib	Central American River	--
Bufo sp.	Toad	Sapo
Iguana rincophala	Iguana	Iguana
Helodema horridum	Gila Monster	Monstruo de Guila

(continued)

Latin name	English name	Spanish name
Boa constrictor		Mazacuata
Lycaste virginalis	White Monk Orchid	Monja Blanca
Cattleya skinneri	Orchid	Candelaria
Abies guatemalensis	Guatemalan Fir	Pinabete
Magnolia guatemalensis	Guate. Magnolia	Magnolia
Engelharotia pterocarpa	--	Palo Colorado
Numenius borealis[a]	Eskimo Curlew	
Caimán crocodilus[a]	Spectacled caimán	
Eretmochelys imbricata	Hawksbill Turtle	
Lepidochelys olivacea[c]	Olive Ridley	
Lepidochelys kempii[b]	Kemp's Ridley Sea Turtle	
Caretta caretta[a]	Loggerhead Sea Turtle	
Dormochelys coriacea[c]	Leatherback	

Sources: Nations and Komer (1984) and Landivar (1987)

[a] Considered threatened rather than endangered by ICUN Conservation Monitoring Centre but not necessarily by other sources cited here

[b] Based on "Agreement on the International Commerce of Endangered Wild Fauna and Flora," International Union for Conservation of Nature and Natural Resources, IUCN Conservation Monitoring Centre; information provided by Defensores de la Naturaleza, Guatemala; and information provided by Elma Diaz, Director Guatemala National Park System

[c] Central Scientific Databases, The Nature Conservancy

A.I.D.'s policy is to conduct its assistance programs in a manner that is sensitive to the protection of endangered or threatened species and their critical habitats (22 CFR 216.5; U.S. Foreign Assistance Act, Section 119, 22 USCS 2151). These concerns are addressed in Parts IV and V.

4. Medfly Host Plants

Guatemala's terrain and climate affect the composition of wild and cultivated host plants of the medfly. Cultivated and wild hosts of the species in Guatemala and in nearby areas of Mexico are listed in Table II-2. Distribution of primary commercial crop hosts in Guatemala appears in Figure VI-4 (Part VI, A.8.a.).

Table II-2. Plant hosts of the medfly in Guatemala and nearby areas of Mexico

Common Name	Scientific Name
Coffee	*Coffea arabiga*
Star apple	*Chrysophyllum caimito*
Sour orange	*Citrus aurantium*
Sweet orange	*Citrus sinensis*
Grapefruit	*Citrus paradisi*
Lemon	*Citrus sp.*
Lime	*Citrus limetta*
Tangerine	*Citrus reticulata*
Royal lemon	*Citrus sp.*
Lemon lime	*Citrus aurantifolia*
Pomelo	*Citrus grandis*
Mediterranean tangerine	*Citrus deliciosa*
Cleopatra tangerine	*Citrus reshni*
Pear	*Pyrus communis*
Apple	*Pyrus malus*
Capulin cherry	*Prunus capuli*
Plum	*Prunus domestica*
Peach	*Prunus persica*
Guava	*Psidium guajava*
Strawberry guava	*Psidium littorale*
Mango	*Manguifera indica*
Tropical almond	*Terminalia catappa*
Chico	*Achras zapota*
Medlar	*Eriobotrya japonica*
Roseapple	*Eugenia jambos*
Matasano	*Casimiroa sapote*
White sapote	*Casimiroa edulis*
Purple mombin	*Spondias purpurea*
Papaya	*Carica sp.*
Persimmon	*Dyospiros decandra*
Carambola	*Averrhoa carambola*
Calamondin	*Sargentia gregii*
Guanaba	*Annona muricata*
Nance	*Byrsonima crassifolia*
Icaco	*Chrysobalanus icaco*
Baricaco	*Micropholis sp.*
Craboo	*Byronima crassifolia*
Strawberry tree	*Muntingia calabura*
Cuachilote	*Paramentiera edulis*
Avocado	*Persea americana*
Sapote	*Pouteria mamose*
--	*Pouteria viridis*

Source: MOSCAMED (1987) and Eskafi and Cunningham (1987)

C. LAND USE

Estimates of Guatemala's forest cover in 1980 ranged from 27% to 41% (Leonard 1987). Approximately 40% of this cover lies in the country's temperate zone and is primarily covered with conifers (16 species) and broadleaf trees (450 species). The remainder of the country is, or was, covered with tropical or subtropical forests. Much of the remaining forest land is secondary growth common in the transition zones between the lowlands and highlands. Between 1970 and 1980, Guatemala's woodland and forest land declined an estimated 11% (Leonard 1987). Forests have been cleared, in part, to expand agriculture and pasture land. While the conversion continues, much of the new cultivated land is not suited for intensive agriculture. Other lands, such as steep hillsides, quickly erode when the forests are cleared. Table II-3 shows land use patterns in Guatemala.

Table II-3. Land use in Guatemala

	%
Agriculture	
Intensive annual crops	4
Limited annual and perennial crops and pasture	22
Mixed perennial crops and forest plantation	21
Forestry	
Production forest	37
Protected forest	14

Source: Leonard (1987)

1. Agriculture

Agricultural production contributes over 25% of the gross domestic product and provides jobs for 53% of the Guatemala labor force. In Guatemala, as in other Central American countries, agricultural production and tenure are skewed: a large number of small farms produce commodities for domestic consumption while relatively few large farms produce commodities for export. Large export enterprises occupy 72% of the available land. Of the total agricultural landholdings in the country, 0.2% make up 36% of the land area (Leonard 1987). Subsistence farms, which support most of Guatemala's rural population, occupy 28% of the landholdings of less than 1 ha (Landivar 1984). The rapid population increase in rural areas has forced farming on marginal lands and has added to the problem of deforestation.

Guatemala's major food crops are corn, beans, wheat, rice, and potatoes (Landivar 1984). Production of the basic foods has not kept pace with demand. Per capita production declined 10% between 1975 and 1981. Between 1981 and 1983, Guatemala had a trade deficit of U.S. $31.6 million in cereals and processed cereals (Leonard 1987).

Primary export crops are coffee, sugar cane, cotton, and banana. Coffee is the most important export, and it generated 40% of all export earnings in 1986 (Inter-American Development Bank 1987). Nearly 70% of the coffee farms are less than 3.5 ha; however, these small farms occupy only about 10% of the total coffee area and produce less than 6% of the country's annual coffee harvest. By comparison, 450 farms (0.5% of the total coffee farms) occupy one-third of the total coffee area and produce 37% of the annual coffee harvest (Landivar 1984).

Coffee yields in Guatemala (600 kg/ha) are less than half the coffee yields in Costa Rica (1,300 kg/ha), Leonard (1987). Medfly attacks coffee in both countries. Where coffee is the major crop included in the Guatemala MOSCAMED medfly eradication effort, the crop is not included in any organized pest control effort in Costa Rica. As discussed in Part VI, A.8.a., the coffee grower is faced with more important problems (e.g., prices, labor, taxes, political instability, the possibility of agrarian reform and other pests) than the medfly.

Pesticide use in Guatemala coffee is high because of a number of pest problems. Table II-4 estimates the use of major pesticide products in coffee in 1987. The MOSCAMED medfly eradication program contributes very little to the total pesticide load in coffee (see Part III, B.1. for rates of malathion bait spray applied in the program).

Table II-4. Estimates of use of major pesticides in Guatemala coffee, based on some 255,500 hectares (Guatemala 1987)

Pesticide	Total use (kg)
Copper chloride	821,941
Ferban	277,815
Thiodan	455,620
Lebaycid	197,520
Banrot	3,440

Source: Jesus Alvarado, ANACAFE, personal communication 1988

2. Parks, Reserves, and Sensitive Areas

Guatemala has a variety of natural areas designated by the government as protected areas (although they are not necessarily managed) and National Parks. Tables II-5, -6, and -7 show, respectively, protected areas that are managed, protected areas that are not managed, and proposed protection areas. The National Parks may be biological reserves or public recreational sites with no wildlife or wilderness. INAFOR, the national forest institute, manages most of the government owned parks through its Department of National Parks and Wildlife. A variety of other organizations, mostly public sector and nonprofit, administer other natural areas. In addition, there are a number of privately-owned reserves in Guatemala.

In 1984, IUCN listed only two protected areas in Guatemala as adequate: Tikal World Heritage Site (57,000 ha) and Pacaya Volcano National Monument (2,000 ha). Tikal is a unique archeological site surrounded by jungle with over 280 species of birds and a range of rare and endangered mammals, reptiles, and amphibians. Other protected areas, not listed by IUCN but which Guatemala considers to be of major importance, are Lake Atitlán National Park (13,000 ha), Rio Dulce National Park (24,200 ha), and El Rosario National Park (1,030 ha). IUCN omitted these areas because of their size or inadequate funding for management of wildlife.

Table II-5. Protected areas in Guatemala that are managed

Name	Area (ha)	Location Lat. x Long.
El Hawaii	42	13°56' x 90°03'
Laguna del Pino	73	14°23' x 90°23'
Las Victorias	82	15°29' x 90°25'
Las Naciones Unidas	158	14°29' x 90°36'
San Jose la Colonia	914	15°29' x 90°23'
El Rosario	1,105	16°31' x 90°09'
Rio Dulce	9,610	15°18' x 89°01'
Laguna de Lachua	10,000	15°55' x 90°41'
Parque Nacional Atitlan	54,000	14°43' x 91°10'

Source: Information provided by Elma Diaz, National Park System, INAFOR, Guatemala

Table II-6. Protected areas in Guatemala that are not managed

Name	Area (ha)	Location Lat. x Long.
Grutas de Lankin	Sin dato	15°34' x 89°59'
Riscos de Momostenango	Sin dato	15°02' x 91°23'
Cerro del Baul	240	14°18' x 91°28'
El Reformador	60	14°51' x 91°05'
Los Aposentos	10	14°38' x 90°48'
Cerro Mira-Mundo	902	14°56' x 89°23'
Santa Rosalia	1,000	15°41' x 89°42'
Bahia de Santo Tomas	1,000	15°41' x 88°35'
Cuevas del Silvino	8	15°32' x 88°45'
Volcan de Pacaya	4,800	14°25' x 90°35'
Ruinas de Iximche	50	14°43' x 90°59'
Sipacate Naranjo	2,000	13°56' x 91°05'

Source: Information provided by Elma Diaz, National Park System, INAFOR, Guatemala

Table 11-7. Proposed protected areas in Guatemala

Name	Name
Laguna el Tigre-Rio Escondido-El Repasto	Cerro San Gil
Piedras Negras	Ixcan
El Peru	Blaia
San Miguel La Poloteada	Chixoy
Holmul	Chama
Naranjo	Semuc-Champey
Laguna Perdida	Chalem-Ha
Yaxja	Cuchumatenas
Ixlu	Sierra de las Minas
Chiquibul	Tajumulco
Polol	Maria Tecun
Altar de Sacrificios	Rio Tambor
Montanas Mayas-Mopan	San Rafael Pixcaya
Poptun	El Fero
Machaquila	Santa Maria
Yolnabaj	Volcan Toliman
FTN	Volcan de Fuego y Ac
Chinaja	Trifinio
Nenton	Manchon Rio Ocosito
Manabique	Medio Monte
Santa Cruz	Pacaya
	Rio Samala

Source: Information provided by Elma Diaz, National Park System, INAFOR, Guatemala

There are several other conservation units, managed by the Center for Conservation Studies, known as "biotopos." The biotopos are designed to protect specific species of animals, such as quetzals, although other wildlife in the units is also protected. Habitats are not manipulated to support the populations.

Interest in conservation in Guatemala has increased in recent years. However, management of currently established parks and sensitive areas is constrained because there are no maps which clearly define their boundaries, professional staffing is limited, and financing is inadequate.

3. Urban Areas

Only 33% of Guatemala's population lives in urban areas and is concentrated around the capital city. The urban population was estimated at 2.9 million in 1988 (information provided by Guatemala's Population Reference Bureau 1988). Of the 21 departments in the country, only the Departments of Guatemala (where the capital is located) and Sacatepequez (the department adjacent to the capital) are considered urban. The rate of growth in urban population appears to be decreasing. Between 1960 and 1970, 1970 and 1980, and 1980 and 1985, growth rates in urban areas were 45.8%, 48.1%, and 23.0%, respectively. The largest cities in each region are the Department capitals, especially: Quetzaltenango, Coban, Huehuetenango, Escuintla, and Puerto Barrios.

D. POPULATION

1. Distribution

Guatemala's population growth has reached levels as high as 3.5% in some years in the past 3 decades. In 1988, the estimated population is 8.7 million and the annual rate of increase 3.2%. Continuing at this rate, the population would double in 22 years, reaching 12.2 million by 2,000 (information supplied by Guatemala's Population Reference Bureau 1988).

The population of Guatemala is unevenly distributed. Nearly two-thirds of the people live in the central highlands. While it appears that the overall population density is low (79 persons/ km^2), if density is calculated on the basis of cultivated land, the figure soars to 469 km^2. The government has developed policies to induce settlement in frontier areas, such as the Petén and the area around Huehuetenango, Coban, and Mexico (Leonard 1987).

2. Social Structure

Guatemala has the most diverse indigenous population of any Central American country with three predominant ethnic groups: Spanish, Indians, and Ladinos (Indians intermixed with Spanish who have adopted non-Indian culture). Pure Indians comprise nearly 55% of the population. The majority of the Indian population lives in the western highlands and in the Departments of Alta and Baja Verapaz.

Over 30 dialects are spoken in Guatemala. Most dialects are different enough to be mutually unintelligible. In some parts of the country, such as Alta and Baja Verapaz, where Keckchi is the dominant language, estimates of monolingualism (e.g., no Spanish fluency) are as high as 90%. Nationwide, monolingual non-Spanish speakers account for an estimated 50% of the population (Landivar 1984). The distribution of monolingualism is skewed among specific groups, especially women. Of the population age 15 and older, only 40% are literate in Spanish (Landivar 1984).

The quality of life in Guatemala, although improving, is still below acceptable levels for many segments of the population. Life expectancy is 61 years, and infant mortality is estimated to be 65 deaths per 1,000 (information provided by Population Reference Bureau, Inc. 1988). Malnutrition, especially among children, is widespread. Eighty percent of children have a weight to age relationship that indicates inadequate growth (Delgado 1987). Seventy-nine percent of the rural population is undernourished (Delgado 1987). Lack of potable water contributes to a variety of gastrointestinal problems and is linked to the high infant mortality. Potable water is available to only 45% of the total population and 18% of the rural population (Leonard 1987).

Income inequality is prevalent; the poorest 20% of the population hold only 5% of national income, while the richest 20% hold 54%, according to a 1980 study (Leonard 1987). The Indian population generally is worse off than the Spanish or Ladino population, which is reflected in lower income and quality of life indicators.

3. Political Factors

Civil strife has been a common part of life in many areas of Guatemala for several decades, especially since the military coup in 1954. Although the country is now under civilian rule with a democratically elected president, memories of the civil strife have not receded, and in some parts of the country, insurgency and counter-insurgency activities continue. Estimates of the incidence of violence indicate that as many as 150,000 people may have died since 1970, and since 1980, 150,000 have migrated to Mexico for political reasons (Bazzy 1986). The turmoil has made

many Guatemalans, especially the rural and Indian populations, fearful of "outsiders," including the government. The effect of this attitude needs to be considered in understanding the potential psychological impacts of the MOSCAMED program on the Guatemalan population as well as some of the program's limitations.

PART III

MEDFLY CONTROL TACTICS

PART III reviews presently available and potential tactics for controlling the medfly in Guatemala. The application, effectiveness, field experience, and some of the limitations are discussed for each tactic. Needs in public education to make the tactics work are also discussed.

A. STERILE INSECT TECHNIQUE

1. Description and Application

The sterile insect technique (SIT) consists of rearing and releasing sterile medflies into areas where they mate with wild medflies. The matings produce only infertile eggs.

Large numbers of medflies are reared and sterilized (in the late pupal stage) with gamma rays (10-18 Krad) from a cesium, cobalt-60, or other irradiation source in a nitrogen atmosphere (Ohinata et al. 1978). Chemosterilants (Keiser et al. 1965) and heat (El-Gazzar 1979) have been used in place of irradiation to achieve sterilization.

When a medfly area is flooded with large numbers of sterile medflies, the likelihood of a fertile mating is reduced. If the sterile insects are released often enough, and in sufficient numbers, the wild population will decline and eventually be annihilated.

SIT is most effective against low level medfly populations where high overflooding ratios (proportion of sterile to wild medflies) are easier to sustain. Malathion bait spray is normally used to achieve this low-density requirement. According to APHIS (1987a), SIT is effective when the ratio is 100 sterile medflies per wild medfly. However, MOSCAMED experience in Guatemala has shown that a ratio of 200 to 1 is a more appropriate rate (Franz Hentze, Guatemala MOSCAMED, personal communication 1988).

2. Effectiveness and Field Experience

A number of medfly suppression programs have used SIT, including efforts in Hawaii (Steiner et al. 1962), California (Cunningham et al. 1980), and Florida (USDA-APHIS 1985) in the U.S., Nicaragua (Rhode et al. 1971), Tunisia (Cheikh et al. 1975), and Italy (de Murtas et al. 1970). The use of SIT has provided significant (90%) reductions of medfly populations (Steiner et al. 1962, Rhode et al. 1971) or eradication (de Murtas et al. 1970, Cunningham et al. 1980).

The sterile insect technique has been used for the past three decades. In combination with malathion bait spray, it has been the principal tactic used in successful medfly eradication efforts. MOSCAMED used SIT in combination with malathion bait spray to eradicate the medfly from southern Mexico (Ortiz et al. 1987). The full scale eradication program began in 1979 when the rearing facility in Metapa de Dominguez, Mexico reached a production capacity of 500 million sterile medflies per week. MOSCAMED declared the fly eradicated from Mexico in 1982.

3. Rearing Facilities

Sterile medflies used in the Guatemala MOSCAMED program are produced at MOSCAMED's rearing facilities in San Miguel Petapa, Guatemala and Metapa de Dominguez, Mexico. The medfly eggs are collected from the facilities' brood colonies and placed in a diet medium containing bagasse (crushed processed sugar cane). Medfly larvae develop in the diet and are separated from it when mature. The pupae are irradiated 2 days prior to adult emergence and placed in paper bags (14,000-16,000 pupae/bag) where the adults emerge. The irradiation dosage is approximately 14.5 Krad (dosage may range from 10 to 18 Krads, distributed in a normal curve). The adults are held in the bags for 2 days at 14 C before ground or aircraft release.

The Guatemala MOSCAMED rearing facility has produced an average of about 159 million sterile medflies per week; however, maximum rearing capacity is about 250 million sterile medflies per week (Flavio Linares, Guatemala MOSCAMED, Personal communication 1988). Disease outbreaks have created problems in both Guatemala and Mexico rearing facilities in the past 4 years. During the first outbreak, Guatemala's facility production dropped 20%. Better quality control and use of steam to sterilize the rearing media significantly reduced the problem of disease. However, disease still has a potential of reducing sterile medfly production by 10%. The Guatemala facility is presently working to improve procedures for identifying the causative organisms and eliminating disease outbreaks (MOSCAMED 1987).

4. Field Monitoring

Medfly traps baited with an attractant are the main way to track sterile fly releases and to determine sterile-to-wild fly ratios (see section G. for a description of the traps).

5. Limitations

SIT is species specific, i.e., it acts only against the medfly. It therefore offers a means for achieving ecological selectivity in a control tactic. Yet, there are potentially adverse impacts connected with the technique, evaluated in PART IV, B.

B. MALATHION BAIT SPRAY

1. Description and Application

Malathion bait spray is a mixture of a toxicant (malathion) and a bait (protein hydrolysate, e.g., Nu-lure). The bait acts as a medfly attractant and feeding stimulant (Hagen 1953). Bait spray containing the toxicant is used to reduce wild medfly populations to a level where sterile medflies can be effective. The bait spray attracts and destroys both male and female adult medflies.

Malathion bait spray is dispensed by aircraft, by ground applicators using backpack sprayers, or in a corncob treatment ("olotes") technique. The following procedures have been used in the Guatemala MOSCAMED eradication program:

a. Aerial Strip Spray

The aerial spray technique is limited to use in coffee. The aerial spray consists of a mixture of one part ultra low volume (ULV) malathion (91 or 95%) and nine parts protein bait (Nu-lure). (In early 1987, MOSCAMED did not have sufficient protein bait for aerial applications of malathion bait and therefore substituted a mixture of molasses and starch, (MOSCAMED 1987, 1988.) When fixed wing aircraft are used, the aerial spray is applied to coffee in 100 m wide strips; it is applied in 50 m wide strips when helicopters are used. The treated strips alternate with untreated strips of equal width. The spray mixture is discharged in large droplets (the droplet size targeted by Guatemala MOSCAMED is 2-3 mm in diameter). Guatemala MOSCAMED's targeted application rate is 1 liter/ha (111.8 g a.i. malathion/ha). The material is dispensed from a height of 30-90 m depending on the terrain and aircraft.

The CICP EIA team observed Guatemala MOSCAMED's aerial spraying operations to determine, among other things, the actual rate of bait spray discharge and droplet size (see Appendix 4, 03). In three observations of fixed wing aircraft sprayings, the rates of bait spray discharge were 1.6, 1.4, and 1.6 liters/ha for an average of 1.5 liter/ha or about 50% more than the rate targeted by MOSCAMED. In four observations of helicopter sprayings, the rates of bait spray discharge were 1.30, 0.80, 0.94, and 1.45 liters/ha for an average of 1.12 liters/ha. The bait spray droplets averaged 3.0 mm in diameter (range 1.0-5.0 mm).

Table III-1 shows number of hectares receiving aerial applications of malathion bait spray by month from January 1984 through March 1988. MOSCAMED's stated policy on aerial spraying is as follows: One aerial application every 12 months is made to coffee plantations at lower elevations (800 m or less above sea

level). At higher elevations, one application every 8 months is made. At the higher elevations, temperatures are lower, and the life cycle of the medfly is longer, thus more frequent applications are necessary. Occasionally, one application every 6 months or less may be necessary during medfly outbreaks. Extra aerial treatments are made if it rains within a few hours after treatment (Franz Hentze, Guatemala MOSCAMED, personal communication 1988).

Table III-1. Number of hectares receiving aerial applications of malathion bait spray in Guatemala MOSCAMED program, 1984-1988

Month	1984	1985	1986	1987	1988	Average	% by month
January	9,644	0	14,277	0	2,687	5,322	3.87
February	53,880	34,216	15,194	0	0	20,658	15.04
March	43,839	0	9,499	0	0	10,668	7.77
April	56,486	0	0	88,722		36,302	21.14
May	37,050	7,968	0	100,629		36,412	21.20
June	0	0	50,542	67,396		29,485	17.17
July	0	0	0	0		0	0.00
August	0	0	0	0		0	0.00
September	0	0	0	0		0	0.00
October	0	0	0	0		0	0.00
November	0	49,465	0	0		12,366	7.20
December	0	41,118	0	4,277		11,349	6.61
Total	**200,899**	132,767	**89,512**	**261,024**	**2,687**		

Source: Fredy Morales, Guatemala MOSCAMED, personal communication, April 22, 1988

b. Ground Spray

In this treatment method, malathion bait spray is dispensed from a backpack sprayer. MOSCAMED's stated procedures for ground spraying are as follows: Spray is applied only to about 25% of a plant's foliage area. The spray consists of one part of malathion (57% emulsifiable concentrate), three parts of Nu-lure, and 96 parts of water and is applied at the rate of 30 liters/ha (181.2 g a.i. malathion/ha).

Guatemala MOSCAMED's policy is to treat all medfly host plants found within 1 km^2 of a medfly infestation area. The ground applications are made in cycles: one cycle is eight applications made at approximately weekly intervals. According to Roger Valenzuela (Guatemala MOSCAMED, personal communication, June 24, 1988), there are never more than eight continuous applications to control medfly outbreaks. If outbreaks recur, the 1 km^2 area may receive another eight-application cycle, but 2-3 months would lapse between cycles. As many as 3 or 4 eight-application cycles (i.e., 32 applications) may take place in one year in the same MOSCAMED quadrant (field unit of 100 km^2). However, 2-3 months would always lapse between consecutive cycles, and a maximum of 16 applications would be made in a given 1 km^2 area (Roger Valenzuela, Guatemala MOSCAMED, personal communication 1988).

Ground applications are made on larger coffee plantations during the wet season when aircraft cannot be used, and to reduce medfly outbreaks (all seasons) in the medfly free and post eradication zones (see PART VI, A. for description of zones). Ground spraying is the primary method for controlling medflies on small farms and around villages and towns. Table III-2 shows the number of hectares receiving ground applications by month from January 1984 through March 1988.

Table III-2. Number of hectares receiving ground applications of malathion bait spray in Guatemala MOSCAMED program, 1984-1988

Month	1984	1985	1986	1987	1988	Average	% by month
January	1,897	6,082	8,030	40,000	6,866	12,575	7.60
February	3,945	3,014	32,084	17,246	2,676	11,793	7.13
March	7,504	10,021	21,942	6,862	2,789	9,824	5.94
April	7,758	9,920	20,984	8,755		11,854	7.16
May	11,664	9,486	13,778	10,451		11,345	6.86
June	11,516	13,734	16,684	9,318		12,813	7.74
July	3,752	15,628	27,224	9,597		14,050	8.49
August	4,201	21,855	27,136	8,656		15,462	9.34
September	1,902	19,363	35,207	14,576		17,762	10.73
October	6,915	16,398	39,389	13,274		18,994	11.48
November	5,168	5,726	35,524	12,020		14,610	8.83
December	4,449	4,279	37,892	10,968		14,397	8.70
Total	**70,671**	**135,506**	**315,874**	**161,723**	**12,331**		

Source: Fredy Morales, Guatemala MOSCAMED, personal communication, April 22, 1988

c. "Olotes"

The olote treatment uses corncobs saturated with one part of 95% malathion and seven parts bait (Nu-lure), above which is added a cotton wick containing a chemical attractant (trimedlure) to lure medflies to the olotes. Olotes are suspended in trees by a wire and covered with a cardboard canopy.

Guatemala MOSCAMED uses olotes in urban areas, ecologically sensitive areas, and in coffee plantations when the owners refuse the standard plantation bait spray. MOSCAMED uses about 3,000 olotes at any one time: 1/ha in coffee plantations and up to 5/ha in urban areas.

2. Effectiveness and Field Experience

Malathion bait spray has been used successfully in numerous eradication efforts against the medfly (USDA-APHIS 1985, APHIS 1987a, Ortiz et al. 1987): Florida, 1956-1957, 1962-1963, 1983, 1985, 1986; Texas, 1966; California, 1975-1976, 1980-1982, 1987; and Mexico, 1979-1982. In 1987, a medfly infestation in Los Angeles, California was eradicated after one aerial application of malathion bait spray followed by SIT (Robert Spaide, APHIS, personal communication 1988).

In the successful 1980-1982 California medfly eradication program, aerial spraying was carried out during 13 of the 27 months of the program. (Aerial spraying was not done early in the program because of public and political opposition to it.) The aerially treated area encompassed eight counties, 44 cities, and approximately 2 million homes. During peak spray periods, over 2,092 km^2 were sprayed weekly by a fleet of 12 helicopters and eight fixed wing aircraft (four DC-4's, and four PV-2's). The overall aerial operation (counting multiple applications) resulted in treatment of more than 4.05 million ha of land. In addition, counting multiple applications, there were more than 0.5 million ground applications of malathion bait spray (CDFA-CDF 1982). Much of the application of bait spray in California was made over large urban areas.

3. Monitoring

Aerial and ground applications of malathion bait spray and their impacts on the environment should be monitored to ensure that the spray is being applied effectively and that no harm is done to the environment or human health (see Part VI, A.5.).

4. Limitations

There are potentially adverse impacts associated with the malathion bait spray technique, and these are discussed in Part IV, B.

C. CULTURAL CONTROLS

Various cultural controls are recommended for use in reducing infestations of medflies.

1. The Techniques

Careful harvesting, combined with destruction of infested and unmarketable medfly host crops, may be important in reducing medfly populations. In Hawaii, removal of Kona coffee beans that remain on the plants in January and February, after harvest, helps prevent medfly population increases (USDA-APHIS 1985).

Sanitation measures, including farmers' practices of collecting and burying host fruit left over after harvest, destroying damaged fruit, and removing unwanted or wild alternate hosts in and around fields, are often recommended for suppressing medfly infestations. However, field sanitation may be of limited effectiveness in Guatemala coffee because of the long and variable harvest period and large numbers of plants and berries in a given plantation.

Other cultural practices that have been recommended for reducing medfly populations include: (1) scheduling plantings of short season fruit and vegetable crops, when possible, so fruit ripening does not coincide with peak medfly activity, (2) harvesting the fruit before it reaches a stage of ripeness highly susceptible to medfly attack, (3) using insecticide treated trap crops, and (4) selecting, when available, crop varieties that are non-hosts or partially resistant to the medfly. Mechanisms that may serve as a basis for host plant resistance to the medfly have been demonstrated in some crops that it attacks (Greany et al. 1983, Eskafi 1988).

2. Limitations

Some cultural controls are labor intensive. Farmers may therefore refuse to cooperate in implementing them in organized medfly suppression efforts.

D. REGULATORY CONTROLS

1. Quarantines

Quarantine programs are used to prevent movement of medflies into regulated areas and are an important element of eradication or pest management. Guatemala MOSCAMED has legal authority to restrict both internal and external movement of agricultural commodities. The regulatory actions (inspection, treatment, and confiscation) are enforced by the Ministry of Agriculture and Food.

Quarantine stations are maintained at 21 locations in Guatemala: along motor vehicle routes, Guatemala City international airport, Petén and Poptún airports, and at the water port at El Estor, Lake Izabal. MOSCAMED takes four principal control actions at internal quarantines: (1) vehicles are inspected for the presence of potential host material, (2) vehicles are treated with d-phenothrin to kill adults, (3) host fruits are confiscated and buried or burned, and (4) commercial fruits and vegetables are fumigated with methyl bromide before continuing into medfly free areas at eight of the quarantine stations (MOSCAMED 1988).

In addition, there are quarantine facilities at 12 points along Guatemala's international boundaries. However, none of the international quarantine stations carry out inspections for medflies (Manuel Cano, OIRSA-Guatemala, personal communication 1988).

The CICP EIA team observed (see Appendix 4, 02) that vehicle inspection at the quarantine stations is not always thorough. Treatment of vehicles is sporadic; and some of the stations lack proper fumigation equipment; confiscated fruit is not always disposed of; and commercial fruits and vegetables are not consistently fumigated. Some quarantine stations can be avoided by using alternate roads.

Guatemala City is now in a medfly infested area. Therefore, airplanes arriving in Guatemala from other medfly infested areas are not presently inspected for medflies or subject to quarantine treatment. However, airplanes departing Guatemala City for Petén or Poptún (both in medfly free areas) are inspected for medflies and subject to quarantine treatment. As a further precaution, the Petén and Poptún airports have quarantine inspection and treatment programs to eliminate medflies on the arriving aircraft.

Boats embarking and disembarking at El Estor are also subject to quarantine inspection and treatment.

2. Pesticide Use in Quarantines

a. Treatment of Conveyances

Guatemala MOSCAMED treats vehicles passing through the quarantine stations to kill adult medflies that may be inside. Although only a 2% solution of d-phenothrin has been approved by Guatemala MOSCAMED for this use, the CICP EIA team found that the much more toxic insecticides dichlorvos and propoxur (see PART IV, G.2.a. and Appendix 5) were being used instead. (According to Franz Hentze, Director of Guatemala MOSCAMED, personal communication 1988, all uses of propoxur and dichlorvos were discontinued shortly after the CICP EIA inspections in April 1988

and use of d-phenothrin was reinstated. On June 6, 1988, CICP EIA team members inspected three MOSCAMED quarantine stations and determined that only 2% d-phenothrin was being used to treat vehicles.)

b. Fumigation of Agricultural Commodities

The MOSCAMED program in Guatemala stopped using the fumigant EDB in 1987 and replaced it with methyl bromide (MB). APHIS (1987b) has developed procedures for using methyl bromide to treat known medfly hosts in Guatemala (Table III-1). The methyl bromide treatments in Table III-3 cannot be applied to fruits, vegetables, or other food commodities for export to the U.S. The treatments do not meet quarantine security requirements established to meet probit 9 (see Table III-3), or at that level the treatment damages fruit (Robert Spaide, APHIS, personal communication 1988).

Table III-3. Methyl bromide treatments for medfly hosts in Guatemala

For coffee, berries, grapes, and cactus fruit (tuna):

MB at normal atmospheric pressure (NAP)--chamber only--32 g/m^3 for 3-1/2 hr. at 21 C or above or 32 g/m^3 for 4 hr. at 18 to 20.5 C.

For all other fruit fly hosts:

MB at NAP--chamber only
24 g/m^3 for 2.5 hr. at 30 C or above.

The same schedule could be used at temperatures betwe- 21 C and 29 C but a lesser degree of quarantine security near probit 8.54 would be expected from the treatment alone.

Probit 8.54 provides 99.9760% mortality which equates to less than 3 surviving insects in a load of 1 million fruit infested at the 0.5% level.

A greater degree of quarantine security approaching probit 9 or greater can be assured at temperatures between 21 C and 29 C by combining the treatment with a specified sampling plan.

Source: APHIS (1987b)

c. Treatment of Exports

As noted, the U.S. will not accept fruit from Guatemala that has been fumigated with methyl bromide because of quarantine security requirements. Principal alternative treatments to methyl bromide include gamma irradiation and heat treatment.

Gamma irradiation will prevent emergence of adult medflies from some medfly infested fruits and vegetables (Moy et al. 1983). Pupae are harder to kill than eggs and larvae and require higher dosages (Burditt and Seo 1971, Seo et al. 1973). One limitation to the gamma irradiation technique is that it may cause cosmetic damage, modify texture, or distort the color or flavor of some fruits.

Elevating the temperature to 43 C and increasing the humidity to saturated conditions for a period of 8 3/4 hr. will kill immature medflies in some fruits. Similarly, lowering the temperature and humidity (for 16 hr. or more) will kill the immature forms in some fruits (Paper 0009/591.5 EC 17 IICA, no author).

Neither gamma irradiation nor the temperature treatment is practical when large quantities (or certain kinds) of fruit must be treated since special chambers and equipment are needed.

3. Fruit Destruction

Stripping and destroying medfly infested or medfly susceptible fruits are especially important during quarantine periods when spot infestations are detected. Fruit stripping has been an integral part of the medfly eradication effort in Guatemala. The practice has been to strip and bury all medfly susceptible fruit found within 1 km^2 of a medfly infestation (confirmed by trapping or fruit sampling) in the medfly free or post eradication zones (Comisión MOSCAMED Document MM. No. 47; undated, no author).

4. Limitations

Pesticides used at quarantine stations may affect health of the workers or people in treated vehicles, and fumigation practices may damage certain fruits and vegetables. For commercial growers, shipping costs may increase and markets may be lost because of delays. Inconveniences and risks of having fruits and vegetables confiscated may cause people to seek alternative routes and may cause resentment against the program and government. Part IV, G. reviews the potentially adverse impacts of the Guatemala MOSCAMED regulatory control program.

E. POTENTIAL TACTICS

1. Boric Acid

Boric acid, also known as boracic acid and orthoboric acid, is an inorganic boron compound. It is used as a fungicide, a herbicide, and an insecticide. In the U.S., the Environmental Protection Agency (EPA) has registered the compound for control of indoor insect pests: mainly cockroaches, silverfish, and ants. It is not registered for use against any outdoor pests.

Boric acid has been evaluated in Guatemala as a possible substitute for malathion in the medfly bait spray treatment. In laboratory studies, at concentrations of 10-30%, both boron in the form of boric acid and borax, when mixed with hydrolized protein bait, produced 99% mortality in medfly adults (Chambers et al. n.d.). No useful interpretation can be drawn from results achieved in field studies where 10% boric acid bait spray was compared with malathion bait spray (MOSCAMED 1988).

Boric acid has certain features that should be considered before it is used against the medfly. It can cause serious human health effects. Hallenbeck and Cunningham-Burns (1985) listed 36 acute exposure effects (ranging from headache to death due to CNS

depression, circulatory collapse, or renal failure), 22 chronic exposure effects (ranging from digestive disturbances to hypoplastic anemia), and four suspected effects of boric acid.

Boric acid is toxic to plants. Its label states that the compound should not be applied to plants or soil containing plants. The closely related compound borax is one of the oldest known nonselective herbicides. Boric acid is also toxic to some species of fish. Its label states that the compound should be kept out of aquatic systems.

Since boric acid has not been registered for use outdoors, there is little information on its impact on nontarget organisms. It is very stable, and if undisturbed in dry environments it can persist for long periods.

2. Biological Control

Various predators, parasitoids, and pathogens operate against the medfly. These "biological control" agents may be important in the natural regulation of the medfly. Ideally, they could be used to replace, or at least reduce dependency of, malathion in medfly control efforts. However, much more research and development are needed before biological control of medfly can be exploited.

a. Parasitoids

Insect parasitoids are probably the most important form of naturally occurring biological control agents for the medfly. A complex of these organisms attacks eggs, larvae, and pupae and naturally occurring parasitism is often fairly high. Overall parasitism of immature forms of medfly collected from all hosts at Maui, Hawaii was 40%; the rate was highest in medflies attacking peaches (60%). Of parasitoids recovered, 80% were *Biosteres oophilus* (Wong et al. 1984a). Percent parasitism was relatively constant despite large fluctuations in the populations of fruits, medflies, and parasitoids.

The medfly is heavily parasitized in Africa, wherever it is found, according to Le Pelley (1968). When the medfly was first discovered in Costa Rica, a number of parasitoids were introduced against it: *Trybliographa daci*, *Aceratoneuromyia indica*, *Dirhinus giffardi*, *Pachycrepoideus vindemiae*, *Biosteres oophilus*, *B. tryoni*, *B. vandenboschi*, *B. formosanus*, *B. compensans*, *B. longicaudatus*, *B. l. novocaledonicus*, *B. l. thaiensis*, *B. l. malaiensis*, *Opius concolor*, and *O. incisi*. In addition, native species like *Corytobracon crawfordi*, *D. cereus*, and *Ganaspis carvalhoi* parasitized the pest (Morales 1984).

Releases of parasitoids also have been made to control the medfly in El Salvador, Panama, and Nicaragua. Of the species

introduced into Central America, apparently only B. longicaudatus (in Costa Rica and El Salvador) and A. indica and P. vindemiae (in Costa Rica) have become established. Pachycrepoideus vindemiae is apparently widely distributed throughout Central America (Mitchell et al. 1977).

The impact of introduced natural enemies has been studied more in Costa Rica than in other Central American countries. In Costa Rica, in 1971-1972, parasitism by B. longicaudatus ranged from 8% to 30% and by P. vindemiae from 2% to 14%. The highest total parasitism was 35% in 1971-1972 and 60.2% in 197[illegible] (Mitchell et al. 1977).

The models of Knipling (1979) suggest that inundative releases of parasitoids (colonization and liberation of large numbers) to reduce medfly abundance prior to release of sterile flies may have promise. The production of parasitoids for release in the field has been accomplished according to Chong (1962), Gonzalez (1981), Finney (1953), and Harris and Okamoto (1983). The state of Hawaii produced about 50,000 parasitoid specimens (various species) using medfly hosts reared in 25.5-35.1 kg of fruit mixed with honey, sugar, and soybean hydrolysate. Only one full-time trained employee and part-time help on the weekends were needed to perform the essential tasks (Chong 1962).

b. Predators

The role of predators in regulation of medfly populations is unclear. Steyn (1955) recorded Pheidole megacephala preying on medfly larvae. Morales (1984) found a fire ant (Solenopsis geminata) important as a predator of medfly in Costa Rica. Wong et al. (1984b) estimated that ant predation caused about 3% mortality in medfly larvae and 39% mortality in medfly pupae and new (teneral) adults.

c. Nematodes

Insect specific parasitic nematodes (roundworms) applied to the soil in medfly habitats infect and kill the larvae, and to a lesser degree, pupae. Studies of the parasitic nematode Steinernema feltiae showed that the different life stages of the medfly reacted differently to the nematode treatment (Lindegren and Vail 1986). There is no evidence that the parasitic nematodes harm native species of arthropods inhabiting the treated soil.

d. Symbionts

Bacteria and other microorganisms play essential roles in medfly nutrition and physiology. Copper carbonate interferes with the medfly's intestinal flora and thus is toxic to the pest.

A copper and sugar mixture (copper sucrete) showed promise against the medfly (Christenson and Foote 1960).

e. Pathogens

Plus and Cavalloro (1983) reported two viruses in *C. capitata*: a Picornavirus (called V) and a Reovirus (called I). Medfly was found to be a permissive host for two *Drosophila* viruses: Rhabdovirus Sigma and Picornavirus C (DCV). Although very little is known about these viruses, Reoviruses are usually only mildly pathogenic in insects.

3. Genetic Manipulation

Genetic manipulation involves the use of genetically altered insects whose sperm carries genes that make the wild populations less vigorous, less prolific, or genetically sterile. Genetic research on fruit flies has centered on sex ratio distortions, translocation homozygotes, conditional lethal genes, and isochromosomes. None of these tactics has yet reached the stage of practical implementation, and most are in an early stage of research.

The so-called "combi-fly" concept proposes the use of a stock carrying a male (Y-chromosome)-linked three chromosome, double translocation with a degree of inherited sterility of up to 75%. In medflies such translocations have been isolated, produced, do not cause logistic problems in mass rearing, and are inherited by all male progeny. A combination of induced and inherited sterility could be produced by irradiating these flies with a sub-sterilizing dose (e.g., 4 Krad). The presumed advantages would be: (1) a residual effect would result because the sterility is heritable, (2) combi-flies exhibit better field performance and competitiveness than sterile medflies do, and (3) the degree of induced sterility can be varied to meet the needs of the program (Steffens 1982, 1983). The approach has not been field tested on the medfly.

4. Other Tactics

Tactics used in past eradication efforts but not presently used in Guatemala are: (1) chemical soil treatment and (2) host elimination.

a. Chemical Soil Treatment

This technique consists of the application of insecticide to the soil surface around medfly host plants. The insecticide kills medfly larvae crawling on the soil surface or burrowing in the soil to pupate and medfly adults emerging from the soil after pupation. Saul et al. (1983) evaluated a number of soil chemical treatments against the medfly in Kula, Hawaii. When tested in a

peach orchard, diazinon reduced the populations 90-99%, depending on the dose and timing.

Soil treatments of fenthion and diazinon were used during the 1980-1982 medfly eradication program in California.

b. Host Elimination

Host elimination involves destruction of wild hosts (not cultivated plants) of the medflies. The technique is not often used because of the difficulty in accessing and removing all wild hosts which are often in rugged terrain (Takara et al. 1983), and because of potential ecological harm.

F. INTEGRATED PEST MANAGEMENT

1. Description and Application

Integrated pest management (IPM) combines a variety of control techniques to reduce and keep pest populations to acceptable levels. Eradication is never a goal of IPM. Pesticides are used only when the pests reach an infestation level at which costs of control just equal crop returns. Crops included in the IPM programs must be regularly monitored for pests and pest damage; the economic threshold serves as a guide, indicating when use of a pesticide becomes profitable. IPM has provided cost effective, environmentally sound solutions for a wide variety of pests and crops.

Some IPM components (e.g., cultural controls and selective use of insecticides) have been used against the medfly. However, there are no organized comprehensive IPM programs now in effect against medfly in Guatemala. The focus in Guatemala and in most other countries where medfly is a pest has been eradication, not management. Therefore, economic threshold criteria have not been developed. Further, control tactics such as biological control and various cultural measures, potentially useful in IPM schemes but not very useful in eradication schemes, have not been emphasized sufficiently.

G. MEDFLY MONITORING

Monitoring of medflies is not a control tactic, but it is an essential aspect of any eradication or control effort. Guatemala MOSCAMED uses traps, baited with an attractant, and samples known fruit hosts of the medfly to monitor the populations.

Guatemala MOSCAMED uses a laminated cardboard trap called the Jackson trap. Presently the trap must be baited every 2 weeks with dental wicks (1.9 x 3.8 cm) containing 2 ml of the attractant trimedlure. However, a new plastic trimedlure dispenser will soon be available that has to be replaced only

every 6-8 weeks (Franz Hentze, Guatemala MOSCAMED, personal communication 1988). Medflies responding to the trimedlure become entangled in the trap's sticky surface. The traps are placed in the middle third of the tree canopy and checked about every 7 days.

Fruit sampling involves periodically collecting fruit (i.e., tree fruit, vegetables, coffee fruit) from known hosts of the medfly. Part of the collected material is dissected in the laboratory to determine the presence of immature medflies. Part of it is held in cages in the laboratory and observed for emerging medflies and parasitoids.

Data from the traps and fruit samples are used to determine: (1) the ratio of wild to sterile medflies in the SIT release areas, (2) mating status, (3) presence of wild medflies in uninfested areas and the need to take action against them, (4) if medfly eradication has been achieved, (5) seasonal distribution and abundance of wild medfly populations in different ecological areas in Guatemala, and (6) if any parasitoids are attacking the immature medflies.

Monitoring to determine progress in controlling or eradicating the medfly should continue for a specified time after the last control tactics have been applied. The minimum monitoring time should be based on length of time required for the medfly to complete its life cycle which is temperature dependent. Egg, larval, and adult development are influenced by air temperature and pupal development by soil temperature. Cool temperature, characteristic of high elevations, will prolong the life cycle period. Host fruits may also influence length of life cycle. Therefore, the high variability in development time complicates the monitoring program.

A more valid procedure for establishing guidelines on monitoring time involves use of temperature threshold data. First, for both above ground and below ground environments, a minimum temperature threshold is established below which no measurable development takes place. Then, a model that uses temperature data for each of the medfly's life stages, is developed to predict the development time based on "day-degrees" (USDA-APHIS 1982). To determine if the medfly existed after an eradication effort ceased would probably require continuous monitoring for at least 1 year following application of the last control tactic (USDA-APHIS 1985).

H. PUBLIC EDUCATION AND RELATIONS

Public education is a critical component of any control program. No matter which combination of control tactics is selected, success may depend on the public's perceptions and understanding of the program. Both real and perceived risks

should be considered in program planning. The difference between public education and public relations should be considered also. The former stresses education; the latter tries to convince people of something. Both are necessary in explaining and promoting a control program. Critical elements of any public education campaign are the following: affected population, participation, timing, scope, dissemination, monitoring, and evaluation.

1. Affected Population

The public education campaign should be designed for a variety of target populations and specific interest groups whose attributes (e.g., gender, ethnicity, occupation), understanding, and concerns may differ from those of the general population. All people who will be affected by program activities should receive both education and information. For example, certain groups may have specific objections to a specific control method due to moral, religious, or economic reasons. A preliminary assessment should be carried out for each control method to define the affected populations, how their perceptions or fears are related to the control method, the special interest groups that exist, and the best way to disseminate information.

2. Participation

Educating the public is not sufficient. There must be a process to identify, understand, and incorporate public concerns into the planning process for the control program. It is much easier to propose alternatives and modify a proposed program during the design phase than after the program is operational. Developing systems for public participation in the control program's planning process is essential.

3. Timing

The timing of any public relations campaign should precede the initiation of the control program far enough in advance so as to allow for modifications in the proposed control program where necessary. Early initiation of public education activities helps to assure that the control program will not be impeded because of public opposition resulting from lack of understanding of information or rumors. Further, the public should be given progress reports on the success of the control tactics or proposed changes throughout the life of the control program.

4. Scope

The scope of the program gives an indication of the breadth and depth of the coverage of the public education component. A determination of the scope should consider several criteria, such as educational level of the target population, control methods

proposed (program complexity), duration of control efforts, and involvement of affected populations. For some control techniques such as ground release of sterile medflies to control isolated outbreaks, relatively few people (e.g., rural residents) may be aware of or feel affected by the action. In this situation, a locally based small scale information campaign may be sufficient. However, if the same technique were to be used in a barrier situation (long term duration constantly affecting the same individuals, see Part VI, B.) a broad based campaign would be necessary to ensure public understanding of the benefits and negative consequences and to enlist cooperation.

5. Dissemination

There are many ways to disseminate information to the public: television, radio, billboards, leaflets, door to door, rallies, etc. Key community leaders such as mayors, clergy, educators, agricultural extension agents, etc., should be well informed. The selection and balance of methods depend significantly on the preceding four factors. For example, in-depth presentation of technical information to a specific group of affected individuals may be best achieved through the distribution of literature. However, the in-depth presentation assumes a level of literacy and initial interest in the control program which may not exist. The specific dissemination plan needs to be tested on a subset of the target population before it is promoted. It should be recognized that some dissemination methods are best for education and others are best for publicity and vice versa.

6. Monitoring and Evaluation

To be successful, a public relations campaign must include an active monitoring program. Monitoring is necessary to judge the effectiveness of the campaign and provide a basis for altering the public education program where necessary. A particular public concern may shift rapidly due to new factors or the effectiveness of the education program may vary due to a number of factors. What "works" in terms of public education will change over time and across affected populations. An effective monitoring program is one of the few ways to ensure that the information the public needs and receives is coordinated with the control program.

PART IV

ENVIRONMENTAL IMPACTS OF MOSCAMED ERADICATION PROGRAM

PART IV will discuss the environmental impacts of the Guatemala MOSCAMED eradication program. Impacts potentially affecting the ecological, human, or socioeconomic environment in Guatemala will be reviewed. The following procedures were used to identify impacts considered in the review:

* A.I.D.'s scope of work for the EIA, developed by Higgins et al. (1987), specified that the impacts should be addressed

* The impacts were identified in the literature, start-up workshop, public briefing meetings, surveys, interviews, and written comments that PART I, C. discussed

* Reviewers of initial EIA drafts suggested impacts for the CICP EIA team to consider.

In assessing the potential impacts, the CICP EIA team first sought out and used existing Guatemala specific information when available. Experiments, surveys, and observations were conducted to obtain additional Guatemala specific information. However, it was not always possible to find site-specific existing information or to conduct the experiments, etc., needed to generate the information. Therefore, related information from other countries was sometimes used in assessing the potential impacts.

A. INFORMATION ON PESTICIDES AND OTHER CHEMICALS

Information on the chemistry and toxicology of pesticides and other chemicals used in the Guatemala MOSCAMED program is presented in Appendix 5.

B. MALATHION BAIT SPRAY

Malathion is an organophosphate, introduced in 1950, that has both insecticidal and acaricidal (mite control) properties. It is marketed under a variety of names and formulations for a wide range of uses. The compound has been approved by the World Health Organization of the United Nations (WHO) for use against malaria mosquitoes and other arthropod disease vectors. In the U.S., malathion is registered for use on fruits, nuts, vegetables, field crops, herbs and spices, grasses, legume forages, hay, stored products, rangeland pasture, forests, ornamentals, residences, food handling establishments, dairy barns, greenhouses, parks and municipalities, lawns, poultry,

livestock, and pets. Malathion has been approved for use in Guatemala by the Ministry of Agriculture and Food in accordance with Guatemala's pesticide law; see PART IV, H.4. (Mario Gaytán, Ministry of Agriculture and Food, personal communication 1988).

Tolerances (safe residue lev ls permitted on harvested products) for malathion have been established in the U.S. on 147 raw agricultural commodities. The tolerances range from 0.1 to 8 ppm on food crops, and up to 135 ppm on forage crops. Malathion tolerances established by WHO range from 0.5 to 8 ppm (EPA 1975). Trade names of the malathion products used in the MOSCAMED program in Guatemala are CYTHION, MALATHION ULV CONCENTRATE, LUCATHION, and MALATHION EC (57%).

For medfly control, malathion is combined with a protein bait (Nu-lure), and sprayed on the medfly's host crops at relatively low dosages (see PART III, B.). The malathion bait spray is designed to attract male and female adult medflies, induce the insects to feed, and kill them.

1. Ecological Impacts

a. Impact on Naturally Occurring Nontarget Organisms

(1) Impact on Honey bees

(a) Factors Affecting Impacts on Honey Bees

Use of malathion may cause severe losses if the bees are present during treatment or active within a day after treatment (Atkins et al. 1977). However, the effect of the malathion bait spray formulation is subject to debate.

Ultra low volume (ULV) applications of malathion at 0.68 kg/ha (about six times MOSCAMED's targeted aerial application rate) in Wyoming, U.S. killed most foraging honey bees even though they were confined during the actual spraying. Colonies did not recover to produce surplus honey (Hitchcock et al. 1966). However, Herbert and Shimanuki (1983) found that weekly ground applications of 91% ULV malathion (sprayed by ground equipment traveling 14 km/hr., discharging 12 cl/min.) to an apiary in Maryland, U.S. did not affect honey production or cause bee mortality.

Gary and Mussen (1984) reported significant mortality in adult bees in an eradication area in California, U.S. that received weekly applications of malathion bait spray (1:4 ratio of malathion to bait at a dosage of 160 ml of malathion a.i./ha) over a 6 week period; foraging activity diminished to the point that pollination and honey production were impaired.

Morán Rosales (1983) reported that eight aerial applications of malathion bait spray (applied 1 liter/ha per application) over a 2 month period in Montemorelos, Mexico killed 9.52% of honey bees in the field. Colonies recovered and produced honey normally after spraying ceased. Martinez Díaz (1984) reported a significant increase in adult bee mortality following eight applications of malathion bait spray made wee ly. The applications did not affect the bee brood, however.

Various studies have pointed to the presence of malathion residues in bee pollen, honeycomb, and honey. Hitchcock et al. (1966) found 0.7 ppm malathion in pollen stored in comb in a hive colony that had apparently died of pesticide exposure; honey in the hive was not contaminated. Gary and Mussen (1984) found residue levels from 0.01 ppm (the minimum level detectable) to 7.64 ppm in pollen collected from colonies in Hayward, California, U.S. APHIS, working at the University of San Carlos in Guatemala in 1985, found malathion residues up to 0.04 ppm in samples of pollen and honeycomb collected near Retalhuleu, Guatemala (1985 unpublished data provided by APHIS, Guatemala). Contamination of honey in the hive has not been found (Martinez Díaz 1984, Morán Rosales 1983, Gary and Mussen 1984).

Researchers in past medfly control programs disagree whether bees are attracted or repelled by malathion bait spray. Data of Gary and Mussen (1984) suggest that the high salt content in the bait spray would attract bees during certain times of the year. However, observations in Mexico indicate that bees are not attracted to the bait spray (William Wilson, USDA, ARS, Personal communication 1988; Morán Rosales 1983). In Guatemala, Martinez Díaz (1984) reported that bees are repelled by the bait spray.

The CICP EIA team conducted an experiment in Guatemala (see Appendix 4, E3) to determine malathion bait spray's attractiveness to honey bees. Bait spray formulation, placed in containers 2 m from hives for 3 and 7 days, did not attract the bees. Further, molasses (sometimes used as a supplement to protein hydrolysate) alone, protein hydrolysate alone, and a formulation of molasses, protein bait, and malathion did not attract the bees when placed in containers (2 m from hives) for 2 days.

The CICP EIA team also conducted experiments in which the effects of malathion bait spray on flight activity and mortality were assessed in protected and unprotected, strong and weak colonies (both prior to and after spraying). Results of these experiments were highly variable and thus concise conclusions were not possible. The CICP EIA team suggests that a number of factors, which were not controlled in the experiment, may have been responsible for the variable results; see B.1.a.(1)(c).

(b) Effects of MOSCAMED Operations on Guatemalan Honey Bees

Officers of the Regional Program for Control of the Africanized Honey Bee in Guatemala report that honey bees have suffered from the Guatemala MOSCAMED program (Lidia Garcia and Robin Ibarra, personal communications 1988). Of 10 beekeepers (each managing 40 to 400 colonies in the MOSCAMED program area) that the CICP EIA team interviewed, all reported that MOSCAMED spraying caused bee mortality and reduced honey production.

MOSCAMED experience, according to Franz Hentze (Guatemala MOSCAMED, personal communication 1988), suggests that deterioration in colony numbers and production is actually due to tracheal mites, diseases, and "Africanization" but beekeepers blame MOSCAMED in order to receive indemnification. Hentze points to results of a study in Guatemala which showed that malathion bait spray will cause mortality in foraging bees (Martinez Díaz 1984) but does not affect brood and honey production.

Martinez Díaz's (1984) study, conducted over a period of 8 weeks, had some limitations. For example, the study was conducted after the main honey flow was over. Further, Martinez Díaz (1984) did not estimate mortality in honey bees while they were foraging in the field, nor did he use an alternate method to assess field mortality (e.g., assessing flight activity before and after spraying). Bee mortality at the hives may represent only a small fraction of the total bee mortality caused by malathion bait spray (Gary and Mussen 1984). Honey bees make multiple daily foraging trips for nectar, pollen, water, and propolis within approximately a 5 km radius of their hives. Martinez Díaz (1984) did not account for mortality except near hives.

Results of other studies contradict Martinez Díaz's (1984) results on reproductive behavior and those on the behavior of bees towards other bees carrying contaminated pollen (Dadant and sons 1975, Hitchcock, et al. 1966, Gary and Mussen 1984).

(c) Other Factors Causing Honey Bee Mortality and Loss of Production

William Wilson (USDA, ARS, personal communication 1988) surveyed honey bee colonies in southwestern Guatemala in May, 1985 for diseases, mites, and Africanization. He found a minor incidence of European foulbrood but no other disease problems. The bees were not Africanized and tracheal mites (*Acarapis woodi*) were not present. However, the honey bee situation seems to have changed since his survey in 1985.

In 1988, according to Alberto Moreno (University of San Carlos, personal communication 1988) tracheal mites infest 40-60% of Guatemala's honey bee colonies; 90% of the bees in some colonies may be infested. Tracheal mites, which have been spread by the Africanized honey bees in Guatemala, shorten adult bee longevity and reduce the amount of nectar and pollen they collect. Gruszka (1987) reported that colonies are adversely affected when more than 30% of the adult honey bees are infested.

The CICP EIA team found tracheal mites in every colony inspected. Beekeepers were unaware of the problem of tracheal mites. They attributed the problem to Nosema disease (caused by Nosema apis), which the CICP EIA team did find when inspecting colonies. In addition, two of six apiaries that the team inspected were infected with American foulbrood, a highly contagious bee disease that is fatal if untreated. Excessive colony density, poor colony placement, and poor air circulation contributed further to the overall inferior conditions observed in the apiaries.

The degree of Africanization in Guatemala is now estimated at about 50% (Alberto Moreno, University of San Carlos, personal communication 1988). Honey yields of Africanized bees are low even under the best of current circumstances.

(2) Impact on Invertebrate Natural Enemies

Malathion affects a wide range of invertebrate natural enemies (Abdelrahman 1973, Bartlett 1963, Hoy and Dahlsten 1984, Wilkinson et al. 1975, Cohen et al. 1987). However, information on the effects of malathion when formulated as a bait spray is limited. In an evaluation of the protein component of the malathion bait spray, Troetschler (1983) found no significant differences in the numbers of spiders or insects (e.g., vespids, chalcids, and braconids) entering unbaited traps or traps baited with protein hydrolysate. Hagen et al. (1970) and Ben Saad and Bishop (1976) showed that insect predators (syrphids, chrysopids, and coccinelids) will respond to the protein hydrolysate bait.

Ehler and Endicott (1984) demonstrated in laboratory experiments that exposure to malathion and protein bait resulted in mortality in several species of parasitoids (Table IV-1).

Table IV-1. Effect of malathion bait on selected insects in laboratory bioassays

Insects	No.	Stage	Exposure time (hr.)	Average Percent Mortality[a] Water	Bait	Malathion + bait
PESTS						
Black scale[b]	40	Crawler	4	5 a	5 a	17.5a
Latania scale[b]	120	Crawler	3	8.3a	9.9a	47.4b
Oleander scale[c]	120	Crawler	4	25.8a	34.1a	61.6b
Cottony-cushion scale[b]	40	Crawler	4	12.5a	22.5a	65 b
Walnut aphid[b]	40	Adult	4	0 a	2.5a	12.5a
PARASITOIDS						
Metaphycus helvolus[c]	40	Adult	3	7.5a	17.5a	95 b
Trioxys pallidus[b]	37	Adult	4	18.4a	30.7a	97.2b
Trioxys pallidus[d]	37	Adult	4	16.1a	27.2a	70.4b
Aphytis melinus[c]	40	Adult	3	5 a	7.5a	95 b
Aphytis melinus[d]	40	Adult	2	10 a	25 a	95 b
Platygaster californica[b]	40	Adult	4	0 a	2.5a	100 b
Torymus koebelei[b]	40	Adult	4	3.3a	10 a	67.5b
T. baccharidis[b]	40	Adult	4	5 a	7.5a	92.5b
Zatropis capitis[b]	40	Adult	4	6.6a	6.6a	72.5b

[a] Row means followed by the same letter are not significantly different at the 5% level

[b] Collected in the field near Davis (Yolo County) California, U.S.

[c] From a laboratory culture supplied by Rincon-Vitova Insectaries, Inc. (California, U.S. Company)

[d] Exposed to treatments 3 weeks after application

Source: Ehler and Endicott (1984)

Granett and Horton (1982) concluded, based on data from laboratory studies to evaluate impact of malathion on predators, that lady beetles (Hippodamia convergens) in the field "have the potential of being severely affected by the malathion sprays for medfly." In their studies the malathion bait spray was more toxic to immature lady beetles than it was to adults.

Hoy (1982) reported that malathion was toxic to an organophosphate resistant strain of the predatory mite, Metaseiulus occidentalis, although the bait alone appeared not to be toxic. However, M. occidentalis is an obligatory predator (i.e., depends on living prey) and does not feed on pollen and honeydew (Marjorie Hoy, University of California, Berkeley, personal communication 1988). Hoy (1982) also reported that predator females were not attracted to the bait. Thus, she concluded that it was "likely that the bait sprays, applied by air in highly dispersed droplets, would have relatively low toxicity to this predator, particularly if there is adequate prey present." On the other hand, malathion was much more toxic to Amblyseius californicus, another predatory mite, than it was to M. occidentalis. Amblyseius californicus appeared to be attracted to the bait. These studies point to the variation that can occur in the response to bait and its effect on mortality. Details on the behavior and physiology of specific species of natural enemies must be obtained before generalizations can be made.

Ichinoke et al. (1977) conducted a survey of the arthropods killed by malathion bait spray used in an eradication program directed against the melon fly, a fruit fly similar to the medfly. They concluded that the bait spray had little impact on the beneficial species. They did observe mortality in various species (i.e., lacewings, syrphids, ichneumonid and braconid parasitoids, ants, and 17 species of spiders in 9 families), but the total number killed for any species in a year's time did not exceed 42 individuals.

The CICP EIA team conducted studies in Guatemala to determine the kinds and numbers of beneficial arthropod species inhabiting coffee trees (see Appendix 4, E1). In one study, malathion plus Nu-lure was applied to coffee trees by ground applicator at 3.3 kg a.i. malathion/ha, 18.2 times the per hectare amount Guatemala MOSCAMED targets for ground applications. The variety of beneficial arthropods was quite extensive and included as many as 59 species (trial 1) representing 27 families of insects and spiders (Table IV-2).

Table IV-2. Number of species in families of beneficial arthropods caught in hanging mantas during two days after spraying coffee trees with high rate (3.3 kg a.i.) of malathion bait spray by ground (MBS)a

Family	Trial 1b MBS	Trial 2c MBS	Trial 2c Control
CLASS INSECTA			
ORDER COLEOPTERA			
Coccinellidae	1	-	-
Cucujidae	1	2	-
Staphylinidae	2	6	2
ORDER HYMENOPTERA			
Agaonidae	1	2	-
Braconidae	-	1	-
Chalcidoidead	2	6	-
Eulophidae	3	3	-
Eupelmidae	-	2	-
Formicidae	7	7	2
Mymaridae	-	2	-
Perilampidae	-	1	-
Platygasteridae	1	3	-
Pteromalidae	1	-	-
Scelionidae	6	5	-
ORDER NEUROPTERA			
Hemerobiidae	-	2	1
ORDER DIPTERA			
Dolichopodidae	2	1	-
Empididae	-	1	-
Pipunculidae	1	-	-
Phoridae	4	5	-
Syrphidae	-	1	-
Tachinidae	1	-	-
CLASS ARACHNIDA			
ORDER ARANEAE			
Agelenidae	-	3	-
Araneidae	1	2	-
Oxyopidae	-	1	-
Salticidae	4	-	-
Tetragnathidae	2	2	-
Thomisidae	1	1	-

[a] See Appendix 4, E1 for procedure; one 0.6 m diameter manta/tree, 5-10 trees per treatment

[b] Coffee plantation at about 1,540 m

[c] Coffee plantation at about 1,700-1,845 m

[d] Super family, not family

Very high dosages of malathion bait spray obviously are harmful to a wide range of nontarget arthropods as shown in Table IV-3. However, CICP EIA team studies showed that normal helicopter spraying (at rates used by Guatemala MOSCAMED, see PART III, B.1.a.) had no significant effects on nontarget arthropods (except for parameters evaluated during period 3 in Table IV-4) in a natural montane habitat and coffee plantation (see Tables IV-3-5). The spray consisted of malathion, protein hydrolysate, and molasses. With the exception noted for Table IV-4, no statistically significant differences were found (in number of individuals, species, families, or individuals per species or species diversity) between sprayed and unsprayed areas, in either the montane habitat or coffee plantation (Tables IV-3-5).

Table IV-3. Impact of malathion bait spray (MBS) applied by helicopter on nontarget arthropods inhabiting a natural montane habitat at Finca Las Nubes, Guatemala 1988 (see Appendix 4, E1 for procedures)

Parameter	Mean no. arthropods per pitfall trap[a]			
	Period 1[b]		Period 2[c]	
	Control	MBS	Control	MBS
No. species	4.20	5.70	5.10	5.30
No. families	3.70	4.80	4.40	4.20
No. individuals	18.10	21.20	8.50	9.40
Individual/species	4.12	3.97	1.75	1.72
S-W Function[d]	1.06	1.27	1.46	1.11

[a] Ten pitfall traps for each control and MBS for each period; period 1 = trap catches taken days 1-3 after treatment; period 2 = trap catches taken days 4-6 after treatment

[b] No significant differences between control and MBS, of any pair, at 5% level using Student t test

[c] No significant differences between control and MBS, of any pair, at 5% level using Student t test

[d] Shannon-Weaver Function (see Appendix 1)

Table IV-4. Impact of malathion bait spray (MBS) applied by helicopter on nontarget arthropods inhabiting a coffee plantation at Finca Las Nubes Guatemala 1988 (see Appendix 4, E1 for procedures)

Parameter	Mean no. arthropods per pitfall trap[a]					
	Period 1[b]		Period 2[c]		Period 3[d]	
	Control	MBS	Control	MBS	Control	MBS
No. species	4.67	6.80	5.33	5.30	4.44*	7.30*
No. families	3.44	4.70	4.56	3.60	3.33*	5.50*
No. individuals	21.00	37.70	14.80	15.90	9.90	14.20
Individuals/species	4.31	5.18	2.64	3.91	2.26	1.94
S-W Function[e]	1.18	1.36	1.41	1.14	1.13	1.45

[a] Ten pitfall traps for each control and MBS for each period: period 1 = trap catches taken days 1-2 after treatment; period 2 = trap catches taken days 3-4 after treatment; period 3 = trap catches taken days 5-6 after treatment

[b] No significant differences between control and MBS, of any pair, at 5% level using Student t test

[c] No significant differences between control and MBS, of any pair, at 5% level using Student t test

[d] Control and MBS of a pair are significantly different at 5% level using Student t test if noted by asterisk (*)

[e] Shannon-Weaver Function (see Appendix 1)

Table IV-5. Impact of malathion bait spray (MBS) applied by helicopter on nontarget arthropods inhabiting a natural montane habitat and coffee plantation at Finca Las Nubes, Guatemala 1988 (see Appendix 4, E1 for procedures)

Parameter	Mean no. arthropods per yellow sticky trap[a]			
	Montane[b]		Coffee[c]	
	Control	Treated	Control	Treated
No. species	5.80	7.40	10.20	11.40
No. families	4.60	4.70	7.30	8.30
No. individuals	9.50	12.80	22.20	31.30
Individuals/species	1.41	1.64	2.18	2.74
S-W Function[d]	1.38	1.79	2.02	2.17

[a] Ten yellow sticky traps for each control and MBS

[b] No significant differences between control and MBS, of any pair, at 5% level using Student t test

[c] No significant differences between control and MBS, of any pair, at 5% level using Student t test

[d] Shannon-Weaver Function (see Appendix 1)

(3) Impact on Other Invertebrates

The CICP EIA team conducted experiments in Guatemala (see Appendix 4, E1) to determine the impact of malathion bait spray on ground foraging invertebrates, particularly ant species. No ants or other invertebrate species were observed feeding on the malathion bait. However, the studies were not designed to determine long term effects of malathion bait spray on ants or other ground foragers.

The study of Troetschler (1983), which compared arthropods captured in traps baited with protein hydrolysate and unbaited traps, showed that some insects (e.g., Collembola, aphids, whiteflies, Mordellidae, and calypterate muscoid flies) were not attracted to the bait. However, other insects (e.g., mirids, carabids, ants, nematocera, and acalypterate muscoid flies) and soil mites were attracted to the bait.

Ehler et al. (1984) evaluated the impact of malathion bait spray on an endemic gall midge (Rhopalomyia californica Felt) and its parasitoids. The malathion bait spray was used in a medfly eradication program in the south San Francisco Bay area of California, U.S. in 1982-1983. The gall midge population increased after bait spray was applied and the increase appeared to correlate with the number of malathion bait sprays. Populations in the treated areas reached levels five times higher than populations in adjacent untreated areas after 12 treatments, and 90 times higher after 24 treatments. Ehler et al. (1984) suggested that the outbreaks of the gall midge were due to chemical destruction of its natural enemies by malathion.

Ichinoke et al. (1977), working in Japan, recorded mortality of 99 species of arthropods in 48 families following the use of malathion bait spray; the most abundant group was in the insect order Diptera, followed by the insect orders Blatteria, Hymenoptera, and Orthoptera. Except for two species, the number of dead individuals recorded over a year's period did not exceed 200.

Guatemala MOSCAMED applies aerial spray in alternate parallel strips, leaving 50% of the treatment area unsprayed in order to minimize damage to nontarget species. Other measures to reduce impact on nontarget species include: restricting the malathion bait spray treatments to coffee and fruit plantations, handling isolated medfly infestations by ground spraying host plants, and spraying in calm conditions with large droplets to reduce drift. Since the beginning of the Guatemala MOSCAMED program, the amount of malathion used in malathion bait spray ground applications has been reduced 50%; the amount of malathion used in the bait spray applied by aircraft has been reduced 80% (Roger Valenzuela, Guatemala MOSCAMED, personal communication 1988).

Malathion bait spraying may still be fairly intensive in some locations during medfly outbreaks. A given 1 km^2 area may receive eight ground applications made at approximately weekly intervals. If outbreaks recur, the area may receive eight more applications within a 2-3 month period for a total of 16 applications in one year (see Part III, B.1.b.). Further, in three CICP EIA team observations of fixed wing aircraft spraying by MOSCAMED, the rate of bait spray discharge averaged 1.5 liters/ha or about 50% more than targeted by MOSCAMED. In four observations of helicopter sprayings, the rate of bait spray discharge averaged 1.12 liters/ha or about 10% more than targeted by MOSCAMED (see PART III, B.1.a.-b.).

The CICP EIA team evaluated the impact of malathion bait spraying (Nu-lure plus malathion at the Guatemala MOSCAMED standard rate) by fixed winged aircraft to a coffee plantation (see Appendix 4, E1). Three sampling methods, sweep nets, mantas, and pitfall traps, were used to estimate arthropods in control and treated plots. Mylar sheets were used to quantify the level of malathion bait spray falling in the sampling areas. No significant differences were found in the number of individuals, species, orders, or families or species diversity with increasing dose of malathion bait spray regardless of sampling method.

Mortality recorded in the malathion sprayed field represented a very small proportion of total nontarget arthropod fauna present. To obtain estimates of the diversity and abundance of the total fauna, coffee trees were selected at random and treated with a pyrethroid insecticide; pyrethroid insecticides kill a wide range of arthropods and provide very fast killing ("knockdown") action. Mantas (0.6 in diameter cloth devices) were suspended from treated trees to catch the falling arthropods. The average number (per manta) of individuals, species, orders, and families of nontarget arthropods knocked from pyrethroid treated coffee trees were 25.0, 13.3, 7.3, and 9.9, respectively; equivalent values for coffee trees receiving the malathion bait spray were 2.7, 2.2, 1.7, and 1.7, respectively.

These results were similar to results of CICP EIA experiments to assess effects of malathion bait spray applied by helicopter by MOSCAMED. Where high dosage ground spraying (3.3 kg a.i. malathion/ha) of coffee trees at Finca Las Nubes killed an average of 30.3 species and 62.5 individuals per manta (see Table IV-6), normal MOSCAMED helicopter spraying never exceeded an average of 11 species and 31 individuals (data not presented but obtained in the same experiment summarized in Tables IV-3-5).

Table IV-6. Impact of malathion bait spray (MBS) applied by ground applicator at high dosages (3.3 kg malathion a.i./ha) on arthropods inhibiting a coffee plantation at Finca Las Nubes, Guatemala 1988 (see Appendix 4, E1 for procedures)

Parameter	Mean no. arthropods per hanging manta 2 days after treatment[a]	
	MBS	Control
No. species	30.3a	4.2b
No. individuals	62.5a	4.6b
No. samples	15	5

[a] Control and MBS are significantly different at 5% level using student t test

(4) Impact on Microorganisms

No data on the impact of malathion bait spray on microorganisms are available for Guatemala. Some data are available from other areas. Shiau et al. (1980) showed that malathion affected *Bacillus subtillis* and *Salomonella typhimurrium*. The chemical "gave only a slight if any mutagenic activity" with *Salmonella*, but was a "weaker" mutagen for *B. subtillis*. The results on DNA-damaging activity were inconclusive.

The relevance of these results to field populations of microorganisms is unclear. The CICP EIA analysis did not include studies to determine the impact of malathion bait spray on microorganisms.

(5) Impact on Wild Vertebrates

No information on the impact of malathion bait spray on wild vertebrates is available for Guatemala. The following analysis for this section is based on studies in other areas.

(a) Impact on Wild Birds

Studies on subacute effects indicate that malathion's potential hazard to birds is low (APHIS 1984). The subacute oral toxicity of malathion to some bird species is shown in Table IV-7. Risk to birds from the MOSCAMED program, if significant, would be more likely to arise through malathion's destruction of the food supply of insectivorous (insect feeding) species.

Table IV-7. Subacute oral toxicity of malathion to birds

Species	5 day LC_{50} (ppm)
Bobtail quail	3,497
Japanese quail	2,128
Mallard duck	5,000
Ring-necked pheasant	4,320

Source: EPA (1975)

APHIS-Universidad de San Carlos (1984) detected malathion residues in some insects and other arthropods collected from the Guatemala MOSCAMED eradication zone. The malathion residue ranged from 61.5 ppm to 149 ppm and averaged 61.5 ppm.

Guatemala has a rich bird fauna (see PART II, B.1.). At least three migrant families of birds are completely insectivorous and many of their members reside in plantation habitats (second growth vegetation and forest edges) (Land 1970, Peterson and Chalif 1973). However, data are not available from studies in Guatemala to allow judgement on the potential impact of malathion bait spraying on birds in these habitats. Also, the malathion bait spray that MOSCAMED applies is only one of several sources of pesticides in Guatemala's coffee plantations (see PART II, C.1.)

(b) Impact on Wild Mammals

APHIS (1984) concluded the following about malathion's effects on wild mammals, "most species of small mammals exposed to dosage rates required for insect control tolerate the insecticide rather well. Effects on wildlife outside the target areas appear to be minimal. Malathion has a favorable safety margin between target pests on one hand and host and nontarget terrestrial animals on the other." However, there are no data available on malathion's impact on mammals in Guatemala.

In an Ohio, U.S. woodlot, a high dose of malathion (about 365 g a.i./ha, compared to 111.8-181.2 g a.i./ha reported in Guatemala MOSCAMED's spraying) applied as a water spray reduced populations of the white-footed mouse (Peromyscus) and striped chipmunks (Tamias) by 40-45%. The reduction was not due to lethality but, rather, to reduced productivity and survival. There were no reductions in short-tailed shrews (Blarina), large animals such as raccoons, or amphibians and reptiles inhabiting the woodlot (Brown 1978). Earlier, Rudd and Genelly (1956) noted

the following about malathion's effects on wildlife: "no reports of loss from the use of malathion." They added that "From a wildlife stand point, it can be recommended as a substitute for highly toxic chemicals..." As with birds, adverse impact on mammals, if it occurs at all, is more likely to result from chemical destruction of food (insects) of insectivorous mammals rather than from direct toxicity.

(c) Impact on other Wild Vertebrates

Data on sensitivity and patterns of mortality in *Anolis* lizards from exposure to malathion resembled data from comparable studies with birds and mammals. Brain cholinesterase activity was related to dose; 50% inhibition was associated with death, and 40% inhibition indicated sublethal exposure (Hall and Clark 1982).

(6) Impact on Soil Ecosystem Biota

In a review of the effects of malathion on soil ecosystems, APHIS (1984) reported only one laboratory study that indicated a strong inhibitory or toxic effect on soil biota. In that study, malathion caused complete inhibition of *Nitrosomas* sp., a nitrogen-fixing bacteria (Garretson and San Clements 1968). Soil inhabitants showed no significant changes in population densities as a result of aerial spraying of malathion (Giles 1970).

The CICP EIA team conducted studies to determine the impact of malathion bait spray, applied by helicopter at the Guatemala MOSCAMED standard rate, on soil invertebrates in coffee plantations (see Appendix 4, E1). The spray consisted of malathion, protein hydrolysate, and molasses. No statistically significant differences between sprayed and unsprayed coffee were found in number of species, families, or individuals or species diversity of soil arthropods in two trials (Table IV-8). Trial 1 was in a coffee plantation about 1,540 m in elevation; trial 2 was in a coffee plantation about 1,700-1,045 m in elevation.

Table IV-8. Impact of malathion bait spray (MBS) applied by helicopter on soil arthropods inhabiting coffee plantations at Finca Las Nubas (see Appendix 4, E1 for procedures).

Parameter	Mean no. arthropods per soil sample[a]			
	Trial 1[b]		Trial 2[c]	
	Control	MBS	Control	MBS
No. species	4.17	5.83	7.17	8.33
No. families	4.00	5.50	7.17	7.17
No. individuals	4.83	7.00	11.00	11.20
S-W Function[d]	1.34	1.71	1.82	1.97

[a] Six 136 cc soil samples from the top 2-3 cm of soil for control and MBS in each trial

[b] No significant differences between control and MBS, of any pair, at 5% level using Student t test

[c] No significant differences between control and MBS, of any pair, at 5% level using Student t test

[d] Shannon-Weaver Function (see Appendix 1)

(7) Impact on Native Plants

Malathion bait spray in the Guatemala MOSCAMED program is directed only at crop plants. However, a variety of native plants coexist with or occur near the sprayed crops. Among these may be orchids.

Orchid sexual propagation is entirely dependent on pollinators. Most of the pollinators are insects, often one or two species closely associated with a particular orchid species or group. *Lycaste virginalis* and *Cattleya skinneri*, two endangered orchid species, are both pollinated by bees (Margaret and Michael Dix, Universidad del Valle, personal communication 1988).

CICP EIA team interviews indicated that some people believe MOSCAMAD's malathion bait spraying is harmful to the orchid pollinators or causes phytotoxicity to the orchid plants. However, the team did not see existing data or generate new data on the direct or indirect effects of malathion bait spraying on orchids.

The CICP EIA team did evaluate phytotoxic effects of malathion bait spray on five native plant species. Ricinus communis, Yucca elephantipis, and "capulin del Monte," a tree species in the family Compositae showed no apparent leaf damage. The tree showed persistent green spots from the spray on naturally yellowing leaves. Leaves of Dracaena showed no apparent damage, but when held to sunlight exhibited a translucency where spray droplets had been. This small sample does not allow any generalizations about phytotoxicity of the bait spray to native nontarget plants. However, it indicates that leaves of some species show changes when treated with the bait spray. The significance of the changes is unclear.

b. Impact on Agroecosystems

(1) Impact on Crop Plants

Some cardamon growers have expressed the opinion that MOSCAMED spraying has interfered with cardamon production by harming pollinators (Guatemala Association of Cardamon Producers, personal communication 1988). In Guatemala, cardamon is often grown adjacent to coffee or intercropped with it. Flowering lasts from February through July/August. Parameswar et al. (1979) showed that 92% of the pollination in cardamon in India was by honey bees. CICP EIA team observations indicate that honey bees are important in cardamon pollination in Guatemala also. Observations in an intercropped coffee-cardamon plantation near Coatepeque (see Appendix 4, 01) showed honey bees to be the most numerous pollinators of cardamon. Frequency of honey bee visits decrease with increasing distance from honey bee hives. Trigona spp., other solitary bees (unidentified), and a hummingbird (Lodiggesia mirabilis) visited cardamon flowers also.

CICP EIA team interviews indicated that farmers who intercrop coffee with cacao or cardamon generally believe that MOSCAMED spraying kills bees and reduces pollination in both cacao and cardamon, with a subsequent loss in yield. However, the CICP EIA team did not locate scientific data to make conclusions concerning the impact of malathion bait spray on cardamon or cacao yields.

Guatemala MOSCAMED denies that there is any phytotoxicity problem in coffee resulting from malathion bait spraying (Roger Valenzuela, Guatemala MOSCAMED, personal communication 1988). Nevertheless, CICP EIA surveys indicated that many farmers in Guatemala associate phytotoxicity in coffee with aerial and ground applications of malathion bait spray. These reports were received in interviews or written surveys. Leaf and flower drop and burning were commonly reported for coffee and also citrus. However, data are unavailable to substantiate such opinions.

The CICP EIA team studied the effect of malathion bait spray on three cultivated species: a Musa sp. (banana or plantain), cardamon, and coffee. Cardamon showed no apparent leaf damage. Young, developing leaves of Musa were burned severely, but the long term effects (i.e., on growth or yield) of damage to the young leaves or effects of bait spray on mature leaves were not determined. The effects on coffee were less clear; after application, many sprayed leaves dropped. Some young coffee leaves displayed obvious burn spots; others were not affected.

(2) Impact on Biological Control

Malathion is toxic to a wide range of arthropod biological control agents as discussed in B.1.a.(2) and reported by APHIS (Ketron 1980). From studies in California, U.S., Ehler and Endicott (1984) reported: "in general, concentrations of malathion bait sufficient to kill most adult parasites tested were less toxic to the pest species tested" (See Table IV-1). Cohen et al. (1987) showed that comparatively less malathion is required to kill insect parasitoids than insect pests.

The potential therefore exists for Guatemala MOSCAMED malathion spraying to disrupt naturally occurring biological control in crops of treated areas. However, presently there are no organized efforts to exploit biological control in crops in the treated areas.

Ehler and Endicott (1984) conducted field studies in California, U.S. to assess the impact of malathion bait spray on insect pests known to be under biological control. Conclusions were as follows: (1) secondary outbreaks of olive scale and black scale were attributed to parasitoid destruction, (2) outbreak of brown soft scale was "possibly" due to destruction of parasitoids and/or pesticide stimulation of scale fecundity, and (3) outbreaks of black scale were attributed to destruction of parasitoids.

During the Mexican medfly eradication program (Ortiz et al. 1987), farmers complained about secondary outbreaks of coffee mealybugs (Pseudococcus sp.), coffee leaf miner (Leucoptera coffella), and lepidopterous larvae (caterpillars) that defoliated coffee shade trees. The Instituto Tecnologico y de Estudios Superiores de Monterrey, through support from APHIS, investigated malathion bait spray's effects on these organisms. However, results did not include records of previous pest incidence and detailed biological and ecological information about the species concerned (USDA-APHIS 1986). They were therefore inconclusive.

Similarly, Guatemala coffee farmers have blamed medfly spraying for increases of coffee leafminer, coffee borer (Hypotenemus hampei), "roya del cafe" (Hemileia vastatrix), red

spider mite (Oligonychus sp.), and, especially, caterpillars (Hemicerus spp.) attacking shade trees. However, sporadic outbreaks of pests such as the coffee leafminer occurred long before the Guatemala MOSCAMED program began. Alvarado (1939) noted that violent outbreaks occurred, followed by a period of 2-3 years in which the pest disappeared.

(3) Domestic Animals

Malathion is registered for the control of various arthropod pests that attack cattle, horses, sheep, cats, dogs, chickens, ducks, geese, and turkeys. Domestic animals that might be exposed to malathion bait spray in the Guatemala MOSCAMED program are mostly pigs, chickens, and dogs around homes, on coffee plantations, or small farms. Most Malathion bait spraying is not done in areas of human habitation where most livestock are found. Fruit destruction and sterile male releases are used for medfly control in these areas. Thus, there appears to be very small, if any, hazard to livestock.

c. Impact on Biodiversity

Section 119 of the Foreign Assistance Act requires that A.I.D. and other U.S. government agencies act responsibly to protect and conserve biological diversity in development assistance programs.

Any chemical pesticide has the potential to reduce biodiversity (an ecological term to reflect richness in species of biotic life forms). It is inevitable that if the number of an abundant species declines there will be some repercussion on other species (Dempster 1975). Most concerns over biodiversity revolve around changes in endemic or endangered species.

Published data from countries other than Guatemala, and data collected by the CICP EIA team in Guatemala, show that malathion bait spray may affect a wide range of species. What is not clear are the long term implications of medfly spraying on species abundance and diversity and ecosystem stability.

Although attractive and intuitively appealing, the direct approach of investigating the influence of malathion bait spray on biodiversity is experimentally difficult, and data must be collected systematically over a long period. Without such data, which do not exist for Guatemala, definitive conclusions cannot be drawn.

d. Impact on Sensitive Ecological Areas

Some ecologically sensitive and protected areas (existing or proposed) lie within or next to Guatemala MOSCAMED work zones (see PART II, C.2.).

Guatemala MOSCAMED maintains medfly traps in protected and ecologically sensitive areas such as Lake Atitlán National Park, Rio Samala watershed (protected by the Instituto Nacional Forestal), and bordering volcanic forests proposed for protection near San Marcos. The policy is not to use malathion bait spray in such areas according to Franz Hentze (Guatemala MOSCAMED, personal communication 1988). Human error, drift, and complex habitat patterns are likely to account for whatever chemical treatment of protected and ecologically sensitive areas does take place.

Helicopters are used to apply malathion bait spray selectively in broken terrain and where coffee and forest form a patchwork pattern. Where more exact targeting is required, ground spraying is used.

e. Impact on Natural Aquatic Ecosystems and Aquaculture

Guatemala's primary coffee and fruit growing areas, infested with the medfly, overlap the country's major river basins and watersheds and are interlaced with small rivers and streams.

There have been no substantiated fish kills or other problems in aquatic habitat due to Guatemala MOSCAMED's malathion bait spraying. However, MOSCAMED has not routinely monitored aquatic habitats in sprayed areas. Small streams in coffee plantations would appear to be the aquatic habitats most at risk. Two water samples taken from a stream in a coffee plantation after aerial spraying with malathion bait showed malathion residues of 0.46 and 4.6 ppb. Water samples from open containers (tubs, about 30-38 liters) placed in the coffee plantation being sprayed showed malathion residues of 4.02 to 174.21 ppb (CICP EIA team data, see Appendix 4, E2 for procedures and B.1.e.(5) for related information).

The Peace Corps and the Dirección Técnica Pesca y Acuicultura of the Ministry of Agriculture have been helping small farmers establish 800-1,000 m2 fish ponds, which are not traditional in Guatemala. Approximately 100 fish ponds around Retalhuleu and Coatepeque and 15 near Coban are in areas where MOSCAMED carries out aerial spraying. Fish species stocked in the ponds include Tilapia, carp (Cyprinus), and the native fish "guapote" (Cichlasoma managuense).

Saltwater shrimp farms in Guatemala are concentrated in brackish estuarine areas along the Pacific coast between Ocos and Champerico, which are a great distance from MOSCAMED operations. At least one government fish hatchery, at Los Brillantes farm near Retalhuleu, Guatemala is in the MOSCAMED aerial spray zone.

As a policy, MOSCAMED uses balloons to mark the presence of ponds, which are avoided by spray planes. The CICP EIA team observed that the MOSCAMED crew in charge of aerial spraying did not use balloons to mark off ponds of a government fish hatchery near Retalhuleu, Guatemala (Los Brillantes farm). However, CICP EIA team interviews with the fish hatchery's aquaculture manager, Daniel Saldana, indicated that the ponds had not been sprayed (personal communications 1988).

For sections (1)-(4) no Guatemala specific data are available.

(1) Impact on Aquatic Flora

Malathion may inhibit the photosynthetic process of some phytoplankton and other aquatic plants (APHIS 1984). However, according to APHIS (1984), "no adverse effects of fogging or aerosol applications to a salt marsh have been noted for salt marsh plants or for aquatic plants in general." Algae metabolize malathion quickly, and the degradation products reportedly are not harmful to the aquatic environment (Mulla and Mian 1981).

(2) Impact on Aquatic Microorganisms

Degradation of malathion in the aquatic environment is rapid and facilitated partially by bacteria. There are limited data available on the effects of malathion on aquatic microorganisms. Generalizations about the effects therefore cannot be made.

(3) Impact on Aquatic Arthropods and Annelids

According to APHIS (1984), aerial applications of malathion have been implicated in population reductions of the aquatic insect orders Collembola, Plecoptera, and Ephemeroptera and dipteran families Chironomidae, Ceratopogonidae, Sciaridae, and Empididae. Because various factors (e.g., water flow rates, pH, and environmental interactions) may affect sensitivity of a particular aquatic organism to pesticides, it is difficult to predict the extent of any population reductions.

The toxicities of malathion to aquatic arthropods and benthic invertebrates are presented in Tables IV-9 and IV-10.

Table IV-9. Acute toxicities of malathion to aquatic arthropods

Organisms	Malathion		
	Toxicity parameter	Exposure	Dose/ concen- tration
Insecta			
Mayfly nymphs-*Baetis* sp.	LC_{50}	48 hr.	6 ug/l, 21 C
Hexagenia sp.	TLm	24 hr.	0.63 mgl 22-24 C
Stonefly-*Claassenia sabulosa*	LC_{50}	96 hr.	2.8 ug/l, 14.4 C
Pteronarcys californica	LC_{50}	48 hr.	20 ug/l, 21 C
		96 hr.	10 ug/l, 15.5 C
Pteronarcella badia	LC_{50}	96 hr.	1.1 ug/l, 15.5 C
Caddisfly-*Hydropsyche* sp.	TLm	24 hr.	0.012 mg/l, 22-24 C
Hydrophilid beetle	LC_{100}	24 hr.	0.06 mg/l
Crustacea			
Water flea-*Daphnia pulex*	EC_{50}[a]	48 hr.	2 ug/l, 21 C
		48 hr.	1.8 ug/l, 15.5 C
Simocephalus serrulatus	EC_{50}[a]	48 hr.	3 ug/l, 21 C
		--	0.37 ug/l, 15.5 C
Freswater amphipod-*Gammarus lacustris*	LC_{50}	96 hr.	1 mg/l, 21 C
Grass shrimp-*Palaemonetes vulgaris*	LC_{50}	96 hr.	82 ug/l, 20 C
P. pugio	LC_{50}	--	32 ug/l
Penaeid shrimp-*Penaeus aztecus*	LC_{50}	48 hr.	5 mg/l
Sand shrimp-*Crangon septemspinosa*	LC_{50}	96 hr.	33 ug/l, 20 C
Hermit crab-*Pagurus longicarpus*	LC_{50}	--	83 ug/l, 20 C
Juvenile mud crab-*Rhithropanopeus harrisii*	LC_{99}	--	20 ug/l
Juvenile blue crab-*Callinectes sapidus*	LC_{67}	--	20 ug/l

[a] Immobilization

Source: Adapted from Mulla and Mian (1981)

Table IV-10. LC_{50} of malathion for benthic invertebrates

Species	Temperature (oF)	Time (hr.)	Value
Stonefiles			
Pteronarcys californica	60	24	35
	60	48	20
Acroneuria pacifica	52-53	48	12
Pteronarcella badia	60	24	10
	60	48	60
Classenia sabulosa	60	24	13
	60	48	6
Caddisflies			
Arctopsyche grandis	51-54	96	32
Hydropsyche californica	51-54	96	22.5
Mayflies			
Ephemerella grandis	48-50	96	100
Baetis sp.	70	48	6
Amphipods			
Gammarus lacustris	70	24	3.8
	70	48	1.8

Source: EPA (1975)

An aerial application of malathion water spray (about 365 g/ha a.i. malathion) over a broadleaf forest in Ohio, U.S. greatly decreased the stream insect fauna, but their numbers recovered soon after treatment (Brown 1978).

(4) Impact on Aquatic Molluscs

APHIS (1984) concluded that malathion used at practical application rates poses few, if any, hazards to most groups of molluscs studied. In a study by Davis and Hidu (1969), malathion was characterized as one of the insecticides least likely to be lethal to oysters and clams.

(5) Impact on Aquatic Vertebrates

The toxicity of malathion to fish has been widely studied, and large differences in sensitivity among species have been documented. Tables IV-11 and IV-12 list toxicities of malathion to various species. Pesticidal effects on a particular fish species depend on many factors including the length of exposure to the pesticide, temperature, pH, turbidity, and salinity (APHIS 1984). Various attempts have been made to develop guidelines for determining "safe" concentration levels. Two guidelines mentioned by APHIS are 0.1 times the 96-hour threshold limit (TL_m) (Burdick 1967) and 0.4 times the 96-hour TL_m (Edwards and Brown 1966).

Table IV-11. Acute toxicities of malathion to various fish species

Organism	Malathion		
	Toxicity parameter	Exposure	Dose/ concentration
Bluegill-*Lepomis macrochirus*	EC_{50}	48 hr.	0.086 ppm, 24 C
Rainbow trout-*Salmo gairdneri*	EC_{50}	48 hr.	0.079 ppm, 13 C
Channel catfish-*Ictalurus punctatus*	EC_{50}	48 hr.	8.9 ppm, 24 C
	TL_m	96 hr.	13.05 ppm
Fathead minnow-*Pimephales promelas*	TL_m	96 hr.	12.5 ppm
	TL_m	---	22 ppm
Fall chinook salmon	LC_{50}	---	0.10 ppm
Spot-*Leiostomus xanthurus*	EC_{50}	48 hr.	0.55 ppm
Sheepshead minnow-*Cyprinodon variegatus*	LC_{50}	24 hr.	0.30 ppm
Striped bass-*Marone saxatilis*	LC_{50}	96 hr.	0.039 ppm
Banded killifish-*Fundulus diphanus*	LC_{50}	96 hr.	0.240 ppm
Pumpkin seed-*Lepomis gibbosus*	LC_{50}	96 hr.	0.48 ppm
White perch-*Roccus americanus*	LC_{50}	96 hr.	1.10 ppm
American eel-*Anguilla rostrata*	LC_{50}	96 hr.	0.5 ppm
Carp-*Cyprinus carpio*	LC_{50}	96 hr.	1.9 ppm
Guppy-*Lebistes reticulatus*	LC_{50}	96 hr.	1.2 ppm
Mosquitofish-*Gambusia affinis*	LC_{40}	72 hr.	0.05 ppm

Source: Adapted from Mulla and Mian (1981)

Table IV-12. TLm of malathion for fish

	hr.	ppm
Black bullhead	96	12.9
Bluegill	48	0.12
Carp	48	10.0
Cirrhina mrigala	48	7.0
Danio sp.	48	13.5
Fathead minnow	48	24.0
Goldfish	96	10.7
Green sunfish	48	0.70[a]
Guppy	48	0.88
Labeo rohita	48	8.0
L. fimbreatus	48	8.5
Largemouth bass	48	0.28[a]
Rainbow trout	96	0.17
Tilapia	48	5-8.3

[a] 20% emulsifiable concentrate

Source: EPA (1975)

Overall, "malathion appears to have a moderate level of toxicity to some species of fish. Species such as carp may tolerate this insecticide at the normal rate of application in mosquito control, whereas others may suffer moderate to high mortality (striped bass, mosquito fish)" (APHIS 1984). McEwan and Stephenson (1979) cited studies with bluegills and channel catfish from ponds that received four applications of malathion at 0.02 and 0.002 ppm during an 11 week period. No abnormal pathology in blood, brain, spinal cord, eye, gill, heart, kidney, liver, gall bladder, or pancreas could be found. On the other hand, Steiner et al. (1961) reported mortality of small fish, belonging to tropical fish breeders, in water less that 7.5 cm deep treated with malathion.

The CICP EIA team conducted studies (see Appendix 4, E2) to determine impact of malathion bait spraying in a coffee plantation on tadpoles (*Bufo* sp.) and minnows (*Profundulus* sp.). The tadpoles and minnows were held in 38 liter open tubs filled with water from one of several nearby streams. Post treatment residues of malathion water in the open tubs ranged from 4.02 to 174.21 ppb. Analysis of water in two controls (water from the same stream, held in covered tubs during treatment) showed malathion residues of 1.77 and 7.34 ppb indicating pre-treatment contamination. No mortality or signs of intoxication were revealed in the tadpoles or minnows, and malathion or malaxon (by product of malathion, see Appendix 5) residues were not detected in the organisms (detection limit 1.6 ppb).

Analysis of water from a second stream in the coffee plantation, before spraying, showed no detectable malathion or malaxon residues (detection limit 0.10 g/liter). However, levels of 0.46 and 4.60 ppb were detected in post spray water samples.

In view of the variation in sensitivity, native Guatemala species of fish and other aquatic vertebrates would have to be tested for malathion sensitivity before the effects of malathion applications could be predicted with confidence. Once the 96-hr. TL_m is known, "safe" levels could be calculated.

2. Human Health Impacts

This section discusses only human health impacts of malathion. Another potential health concern, risk to MOSCAMED workers in turbelent areas, is discussed in D.2.

a. Immediate Effects

Based on rat toxicity data, it appears that inhalation of malathion poses the greatest toxic risk of the three normal exposure routes--oral, dermal, and inhalation (see Appendix 5).

CICP EIA team observations (see PART III, B.1.a.) showed that the aerially applied malathion bait spray droplets ranged from 1 to 5.0 mm in diameter. Droplets in this size range are not likely to be drawn past the external nares and "cannot possibly reach the pulmonary alveoli" (Kahn 1981). The vapor pressure of malathion is low (0.0004 millimeter of mercury at 30 C), so the inhalation vapor dose would be extremely small.

At Guatemala MOSCAMED's targeted aerial application of malathion bait spray, about 11 mg/m^2 active ingredient of malathion is applied. This quantity is equivalent to about 1/6,000 of the acute oral LD_{50} (see Appendix 1 for definition) or 1/17,000 of the acute dermal LD_{50} for a person weighing 50 kg. Ground applications average about 18 mg/m^2, or about 1/3,666 of the oral LD_{50}) for a person weighing 50 kg. Even when the application rate is 50% more than the MOSCAMED targeted rate (see PART III, 1.a. for information on range in application rates), the malathion bait spraying operation would present very low risks.

For comparison, malathion is used against leaf miners in coffee at a rate of 369 mg/m^2, which is 21 times higher than Guatemala MOSCAMED's highest application rate. Two other pesticides used in coffee in Guatemala, aldicarb (acute oral LD_{50} = 1 mg/kg) and paraquat (acute oral LD_{50} = 150 mg ion/kg), pose a much greater risk that malathion (acute oral LD_{50} = 1,375 mg/kg) does.

The major health risks of malathion to Guatemala MOSCAMED workers appears to be associated with mixing, loading, and ground

application. CICP EIA team inspections of MOSCAMED facilities, field operations, and interviews with workers showed that safety equipment and apparel (face masks, boots, gloves, and overalls) are in short supply. Only 27% of MOSCAMED workers in charge of malathion bait spraying reported using masks, 14% boots, 23% gloves, and 20% overalls. Workers in several parts of Guatemala reported that use of pesticides without safety equipment or apparel frequently resulted in headaches and sometimes nausea, vomiting, and dizziness.

During inspections of MOSCAMED aerial operations, the CICP EIA team observed workers with hands, forearms, and feet wet from malathion bait, and on a number of occasions, technical malathion. Spills and dermal contamination resulted from mixing operations. Workers without gloves were observed removing and cleaning spray nozzles that had become clogged with bait spray.

A physician working for the CICP EIA team examined 140 Guatemala MOSCAMED workers for symptoms of health effects related to pesticides. Seven of the workers reported symptoms commonly observed in patients with confirmed clinical pesticide poisoning; of these, five were malathion bait spray ground applicators. Medical histories indicated that roughly half of the 140 workers had at one time experienced clinical symptoms consistent with, but not necessarily related to, pesticide overexposure. Some of these symptoms, however, may also be related to stress, fatigue, rapid temperature changes, or malnutrition (John Davies, University of Miami, personal communication 1988).

In addition, the 140 workers were tested for blood plasma cholinesterase levels. When absorbed through the skin, ingested, or inhaled in sufficient quantity, malathion inhibits cholinesterase in humans. Cholinesterase is an enzyme necessary for normal nerve transmission; when sufficiently inhibited by organophosphate or carbamate insecticides, the signs and symptoms of cholinergic poisoning will appear. Cholinesterase activity is determined by measuring levels of the enzyme in red blood cells or blood plasma; these levels correlate well with levels of cholinesterase in the nervous system. Sufficiently lowered levels of cholinesterase indicate malathion poisoning.

Mild symptoms of malathion poisoning are usually apparent when the cholinesterase is inhibited 50% or more; with moderate to severe poisoning, cholinesterase will be inhibited 80 to 90%. However, manifestation of symptoms depends more on rate of fall in cholinesterase activity than the absolute level of activity reached. Workers may exhibit 70 to 80% inhibition of both red blood cell and blood plasma cholinesterase enzymes after several weeks of moderate exposure and still not exhibit cholinergic symptoms. On the other hand, a previously unexposed individual may develop symptoms suddenly (John Davies, University of Miami, personal communication 1988)

Ninety-eight percent of the 140 MOSCAMED workers tested by the CICP EIA team for blood plasma cholinesterase levels were within normal limits (Figure IV-1). Of the three workers (2%) who exhibited undesirable cholinesterase inhibition, one was a ground applicator of malathion bait spray, one was a fruit stripper, and one had a MOSCAMED job that would not have exposed him to pesticides. It is possible that any of the workers either sustained exposures to other organophosphate insecticides in the area or suffered from malnutrition (John E. Davies, University of Miami School of Medicine, personal communication 1988).

A second cholinesterase survey was conducted in 15 MOSCAMED workers who were mixing malathion bait spray and loading it into the aircraft. After 3 weeks of this work, six of the 15 workers exhibited a 10 to 22% decline in the cholinesterase level compared to the individual pre-exposure baselines. None of the workers exhibited clinical signs of poisoning. However, the post-exposure cholinesterase levels confirmed that the workers had been exposed to undesirable levels of malathion and emphasized the need for use of protective clothing.

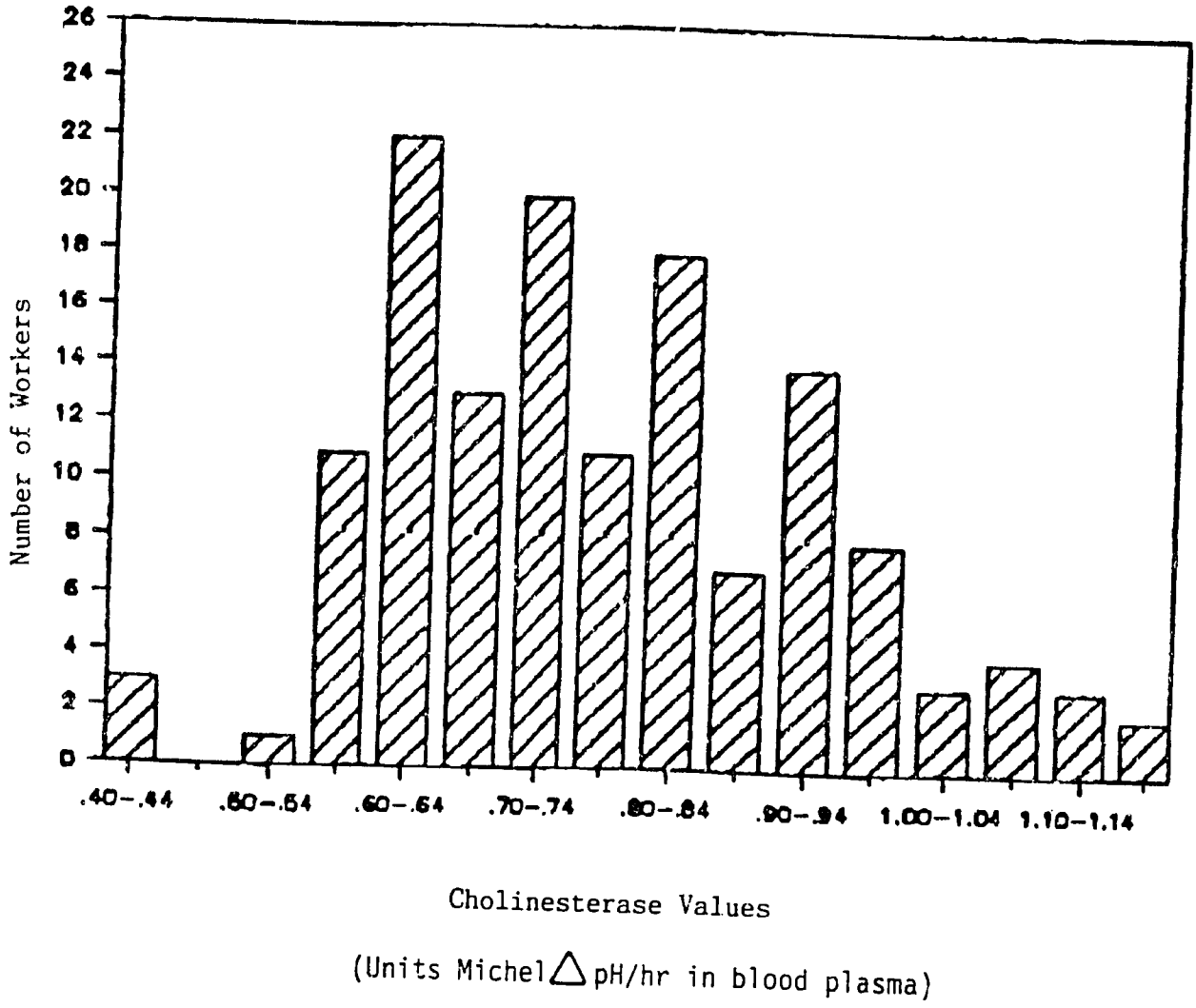

Figure IV-1. Blood plasma cholinesterase levels in 140 MOSCAMED workers

(1) Effects on Allergies

Milby and Epstein (1964) tested allergic contact sensitivity to malathion. A 10% solution of malathion sometimes produced contact sensitization and reactions were strong. Persons highly allergic to the pesticide reacted to solutions as low as 0.99% malathion.

Milby and Epstein (1964) also tested malathion sensitivity in mosquito abatement workers and poultry growers. A skin sensitivity test using a 1% solution of malathion elicited positive reactions in 3% of the mosquito control workers and 4.7% of the poultry growers. Workers handling and applying malathion without proper safety equipment and knowledge of safe use are at risk to allergic reactions. Guatemala MOSCAMED workers interviewed by the CICP EIA team did not complain of rashes or skin reactions but did complain because there were inadequate supplies of safety equipment to reduce exposure to the insecticide.

(2) Effects on Eye Disorders

EPA classifies malathion as a minor eye irritant and places it in the Agency's Toxicity Category III. Accidental contamination of eyes can result in minor eye irritation (see Appendix 5).

b. Delayed Effects

No delayed human health effects have been documented for malathion. Laboratory studies of malathion's effects on oncogenicity, teratogenicity, and mutagenicity are reviewed in Appendix 5.

Grether et al. (1986) investigated the association between congenital anomalies and low birth weight and in-utero exposure to malathion applied as a protein bait spray to control medfly in California during a 14 month span in 1981 and 1982. The authors found no relation to birth weight and malathion exposure or evidence that malathion caused birth anomalies.

c. Psychological Impact

CICP EIA team surveys of 118 Guatemala MOSCAMED workers who apply or mix malathion indicated that a substantial number fear health risks from the chemical. When asked if there was anything dangerous about their job, 59% stated that malathion was dangerous. Informal interviews of MOSCAMED workers indicated that some viewed malathion as more hazardous than pesticides such as dieldrin, aldrin, and aldicarb. Discussions with workers and MOSCAMED personnel indicate that in some areas of Guatemala, workers' perception of malathion's toxicity was influenced by

MOSCAMED supervisors. The supervisors apparently stressed the potential danger of malathion without explaining the danger relative to other pesticides.

CICP EIA team interviews with 476 community leaders indicated that: 24% think MOSCAMED activities are harmful to health, 25% do not, and the remainder are unsure. It appears that MOSCAMED public information campaigns have not adequately informed the public or allayed their fears or suspicions. Anecdotal evidence from CICP EIA team interviews showed that the public perceives the following human health effects to be attributed to malathion bait spraying: headaches, nausea, vomiting, dizziness, and death. CICP EIA team interviewers in the Pacific coastal region heard the rumor that malathion had been banned in the U.S. and that supplies were being "dumped" in Guatemala.

d. Impact on Drinking Water

Of major concern in any large scale program using pesticides is the risk of contaminating surface and ground water used for drinking. Water can be contaminated by direct application to water surfaces, through runoff, or by percolation through soil substrate into ground water. Some ground water contamination from seepage of DDT and other pesticides has been reported from the Pacific agricultural areas of Guatemala (USDI 1984).

The University of San Carlos in 1986 monitored malathion residues in surface water in agricultural areas receiving MOSCAMED aerial applications of malathion bait spray. Of the 45 water samples taken, 44 showed residues less than 0.1 ppm malathion (based on malathion water residue data in an unpublished, undated University of San Carlos report). (See B.1.e. and B.1.e.(5) for discussion of CICP EIA team results from water analysis.)

In the Guatemala MOSCAMED treatment areas, some drinking water may come from small ponds or roof top catchment basins. The following is a worst case scenario for malathion contamination in a small pond associated with MOSCAMED spraying: (1) assume a pond surface of 100 m^2, (2) assume 1,000 liters of water in the pond, (3) assume the entire pond was sprayed aerially with the standard MOSCAMED aerial treatment dosage (111.8 g a.i. malathion/ha); the pond would receive a total of 1,118 g a.i. malathion, (4) the pond's water would therefore contain 1,118 mg a.i. malathion/liter or 1,118 x 106 ppb of water, (5) assume no degradation of the malathion, and (6) assume a child weighing 10 kg drank 1 liter of water. Then the consumed dose would be 0.1118 mg/kg.

The calculated intake in this worst case scenario is less than 1/5,000 of the lowest published lethal dose to humans. The

1,118 x 10^6 ppb of malathion is 6,417.5 times greater than the 174.2 ppb CICP's EIA team detected in the most heavily contaminated tub of water in coffee sprayed with malathion bait spray (see B.1.e.). Public health is unlikely to be affected through drinking water from treated areas.

e. Risk to Workers in Turbulent Areas

Politically sensitive areas at present are primarily in MOSCAMED Zones A, B, and C (see D.2.) which have only sporadic outbreaks of medflies. However, rapid changes in the political situation in Guatemala or neighboring countries could affect the program and should be continuously monitored.

3. Socioeconomic Impacts

a. Impact on Agricultural Productivity/Diversity

Malathion bait spray is used in conjunction with other medfly control tactics (sterile medfly releases, quarantines, and fruit destruction). The spray's impact on agricultural productivity and diversity therefore cannot be separated from effects of the other tactics.

The major medfly host crops in Guatemala and those receiving the most malathion bait spray in the MOSCAMED program are coffee, mango, orange, pear, peach, and apple. Table IV-13 shows amounts and values of these crops in 1987. (PART IV, A.8.-9. discusses the effects of medfly and related fruit flies on these crops and potential economic benefits and costs of medfly eradication.)

Table IV-13. Production and wholesale value of commercially important crops attacked by medfly (Guatemala, 1987)

Crop	1987 Production (metric tons)	1987 Wholesale ($U.S. value)
Coffee	179,400	384,333,702
Mango	19,441	7,484,785
Orange	86,711	13,180,072
Pear	1,565	220,665
Peach	7,880	5,586,920
Apple	13,600	8,921,600

Source: ANACAFE

Direccion General de Estadistica, Agricultural Census for 1979

SEPRA, S.A. (1987) Estimates for 40% of the main pear, peach, and apple growing regions and extrapolation to rest of country for these crops

Interviews with wholesale market brokers and ECOTECNIA, Consultores Asociador projections based on 1979 Agricultural Census for oranges and mangoes

INDECA (National Agricultural Marketing Institute) for wholesale prices

As discussed in B.1.b.(1) some cardamon growers have expressed the opinion that MOSCAMED spraying has intefered with cardamon production. Cardamon growers have recently experienced other problems as a result of overproduction in the global market. Prices for "green" cardamon dropped from U.S. $3.27/kg in 1986 to U.S. $1.70/kg in 1988. Guatemala farmers have therefore planted less cardamon; the area in cardamon was 35,000 ha in 1985 but only 17,500 ha in 1987 (Table IV-14). Supply is decreasing in response to market conditions, and future demand is unknown.

Table IV-14. Cardamon planted area and selling prices (Guatemala, 1985-1988)

Year	Planted area (ha)	Selling price ($U.S./kg)
1985	35,000	n.a.
1986	24,500	3.58
1987	17,500	2.78
1988	n.a.	1.70

SOURCE: Guatemala Cardamon Commission

APROCAR (Cardamon Producers Association)

CARDACAFE

Gremial de Exportadores de Cardamomo (Cardamon Exporters Guild)

b. Impact on Tourism/Recreation

The most popular tourist areas in Guatemala are by order of importance: Guatemala City, Antigua Guatemala, Lake Atitlan, Chichicastenango, Rio Dulce, Tikal, Quetzaltenango, and Huehuetenango (INGUAT, personal communication 1988).

The current MOSCAMED malathion bait spray program does not appear to affect either international tourism or recreation of Guatemalans substantially. Tikal and Lake Atitlán are biologically sensitive areas and not subject to malathion bait applications (Roger Valenzuela, Guatemala MOSCAMED, personal communication 1988). The malathion bait applications are normally not made in urban areas either.

c. Impact on Finishes of Motor Vehicles

Aerial application of malathion bait spray may damage lacquer finish automobile paints if the spray bait droplets are not washed off (USDA-APHIS 1985).

However, vehicle density in the MOSCAMED spray area is very low. In 1986, 69% of all vehicles in Guatemala were registered in Guatemala City (Ministry of Public Finance, personal communication 1988). Although there may be some automobile damage resulting from the malathion bait spraying in Guatemala, potential for damage is small since MOSCAMED avoids aerial

applications of malathion bait spray in urban areas (see PART III, B.1.a.).

d. Impact on Rural Population

MOSCAMED directly targets information to Guatemala's community leaders, such as mayors and agricultural representatives, as well as the general public (MOSCAMED Operations Unit Manual 1987). However, CICP EIA team surveys determined that the information campaign has not been effective in making key leaders understand program activities (Tables IV-15 and 16). These individuals influence public education, and especially in rural communities, opinion and therefore should be aware of and understand MOSCAMED operations in their municipality.

Table IV-15. Percent of key rural leaders, within each zone, who believe MOSCAMED has engaged in aerial malathion spraying in their municipality (based on 410 responses)

ZONE	YES %	NO %	DON'T KNOW %
A	23	58	19
B	9	62	29
C	23	68	9
D	37	49	14
E	7	57	36

Table IV-16. Percent of key rural leaders, within each zone, who believe MOSCAMED has engaged in ground malathion spraying in their municipality (based on 410 responses)

ZONE	YES %	NO %	DON'T KNOW %
A	41	46	13
B	41	35	24
C	29	63	8
D	54	37	9
E	30	45	25

CICP EIA team surveys were sent to mayors and agricultural representatives throughout Guatemala (see Appendix 4, S1). Information from these surveys reflects local level of understanding and opinions about the MOSCAMED program. Data in Tables IV-15 to 18 correspond to the MOSCAMED work zones (A-medfly free; B-post eradication; C-eradication; D-pre eradication; E-infested, see PART VI, A.).

The results in the tables are based on responses to questionnaires sent to mayors and/or agricultural representatives in 172 (58%) of Guatemala's 299 rural counties.

Table IV-17. Percent of key rural leaders, within each zone, who believe that MOSCAMED should initiate aerial malathion spraying malathion spraying in their municipality (based on 410 responses)

ZONE	YES %	NO %	DON'T KNOW %
A	18	32	50
B	9	35	56
C	13	48	39
D	24	49	27
E	8	25	67

Table IV-18. Percent of Key rural leaders, within each zone, who believe MOSCAMED should initiate ground malathion spraying in their municipality (based on 410 responses)

ZONE	YES %	NO %	DON'T KNOW %
A	57	16	27
B	41	18	41
C	36	40	24
D	60	20	20
E	40	8	52

Guatemala MOSCAMED's public information campaign has emphasized information campaigns in Zones A, B, and C where both aerial and ground based spraying has been most prevalent. Results show that in Zone B, 29% of respondents do not know if MOSCAMED has engaged in aerial spraying (Table IV-15) and 24% are unsure if MOSCAMED has had ground based malathion spraying in their municipality (Table IV-16). Also, MOSCAMED has only conducted limited aerial spraying in Zones A and D; the "yes" responses for aerial spraying in these zones appear high (Tables IV-15 and 16). MOSCAMED has not initiated any control operations in Zone E; therefore, the "yes" responses of 7% (Table IV-15) for aerial application and 30% for ground spraying (Table IV-16) are incorrect. Such a misunderstanding could create problems as the eradication program proceeds, since negative perceptions of spray operations other than MOSCAMED's could be erroneously attributed to the MOSCAMED program.

Tables IV-17 and IV-18 show the percentage of key leaders in each zone who believe MOSCAMED should initiate aerial or ground malathion spraying in their municipality. These responses reflect the opinions of influential rural residents and should provide an indication of the degree of potential resistance to initiation of MOSCAMED spraying operations. Potential resistance to initiation of aerial spraying is greater than resistance to initiation of ground spraying. In zone D, the next area where eradication efforts would be initiated, the potential resistance to aerial spraying is more than twice the resistance to ground spraying. CICP EIA team informal interviews to clarify these results indicate that ground spraying is perceived to have fewer human health and environmental risks than aerial spraying has.

In each zone, at least twice as many leaders felt that ground spraying, and not aerial spraying, should be initiated (see Tables IV-17 and 18).

The greatest support (24%) for initiating aerial spray operations was in Zone D (Table IV-17). This response by 24% of the respondents was considerably lower than the lowest "yes" responses (60% in Zone D and 40% in Zone E) for ground spraying (Table IV-18).

Comments of mayors and other key leaders and interviews with rural residents indicate the following concerns over malathion bait spraying: (1) human health and animal illnesses, (2) yield reductions of agricultural crops, attributed primarily to "bee kills" and reduced pollination, or from the spray "drying or burning" the plants, and (3) general environmental damage.

e. Impact on Urban Population

Malathion bait spray is not applied by aircraft in urban areas although it may be applied in outlying rural areas of some

municipalities (Roger Valenzuela, Guatemala MOSCAMED, personal communication 1988).

Resistance to the MOSCAMED program should theoretically be higher in urban than in rural areas. The operations are visible to far greater numbers in the urban areas. Also, the urban areas have a higher education level and considerably more attention is paid to mass media.

The data in Table IV-19 are based on responses from 66 key leaders in 19 (61%) of Guatemala's urban areas. Because of the small sample size, results are presented for data of all zones combined.

Urban leaders offer potentially greater resistance to aerial application of malathion bait spray than ground application. Despite extensive publicity about the MOSCAMED program in urban areas and improved access to information, many leaders in urban areas lack opinions or information about the program.

Table IV-19. Percent of key urban leaders who believe that MOSCAMED has engaged in or should initiate aerial or ground malathion spraying in their municipality (based on 66 responses)

	YES %	NO %	DON'T KNOW %
Has engaged			
Aerial	15	67	18
Ground	35	50	15
Should initiate			
Aerial	21	30	49
Ground	42	17	41

f. Impact on Public Health and Livestock Health Programs

In Guatemala, malathion has been used since 1974 for controlling *Aedes aegypti*, the mosquito vector of dengue fever. Other chemicals, including the organophosphate fenitrothion, are presently being used instead. Malathion has not yet been used to control the *Anopheles* mosquitoes that transmit malaria in

Guatemala. Theoretically, MOSCAMED spraying could precipitate malathion resistance in malaria mosquitos in areas where resistance does not already occur, thus depriving public health programs of a potentially useful alternative insecticide. However, the spraying is unlikely to impinge significantly on Anopheles control. The dosage is too low to kill Anopheles mosquitoes, the mosquitoes do not rest in tree canopies, and broken terrain and high elevation coffee plantations are not major breeding areas. Perhaps equally important is public resistance to the noxious smell of malathion sprays applied inside homes to kill Anopheles. For this reason, malathion has been rejected for malaria mosquito control to date (Carlos Aguilar Murillo, Servicio Nacional de Erradicacion de la Malaria, personal communication 1988).

There are only two other human disease vector control programs in Guatemala. Temephos (Abate) is applied to streams in the San Vincente Pacaya area of Escuintla to control the Simulium blackfly vector of filaria worms (Onchocerciasis), and DDT or fenthion is sprayed in houses to control the bug vector (Triatoma) of Chagas disease in small areas outside of the MOSCAMED treatment zone. MOSCAMED activities would not be expected to interfere with these programs.

The only organized veterinary pest control effort in Guatemala is the USDA sponsored screwworm fly (Cochliomyia hominivorax) eradication program (Programa de Erradicacion del Gusano Barrenador del Ganado). The program depends on the release of sterile male screwworm flies to suppress wild populations. Releases were to begin in Petén in April 1988, in the western part of Guatemala in July 1988, and in remaining areas in late 1988. Roger Valenzuela (Guatemala MOSCAMED, personal communication 1988) reported that the cattle and coffee zones do not overlap, so that malathion bait spraying should not interfere with sterile screwworm fly releases.

C. STERILE INSECT TECHNIQUE

1. Ecological Impacts

a. Impact on Evolution of "Superflies"

There is some concern that partially irradiated, partially fertile female medflies, produced as a result of improper sterilization, are a potential source of new genetic variants.

Scientists in several countries have been irradiating and sterilizing fruit flies for years in an attempt to produce mutants, including those resistant to insecticides (Anonymous 1983). The resistant mutants have not appeared, although this is always a possibility.

b. Impact on Competitive Displacement and Secondary Pest Outbreaks

Shortly after the oriental fruit fly, Dacus dorsalis (Hendel) entered Hawaii, medfly populations declined. Nishida et al. (1985) concluded that the oriental fruit fly displaced the medfly and occupied much of the niche that the latter previously occupied. Laboratory studies confirmed the ability of the oriental fruit fly to suppress medfly development when both species infest a host (Keiser et al. 1974). Other reports indicate that medfly populations are reduced in the presence of Dacus tryoni in Australia and Anastrepha striata in Mexico and Central America (Christenson and Foote 1960).

In situations where the medfly, fruit flies of the genus Anastrepha, and fruit fly relatives (Euxesta spp. in the family Otitidae) compete for the same fruit hosts in Guatemala, the sterile medfly releases would reduce competition of medflies for those hosts. However, even if other fruit flies increased to fill the empty niche, it is unclear if the overall impact on fruit would be higher, lower, or the same.

The CICP EIA team analyzed data of 18,734 fruit samples (1987 data provided by Guatemala MOSCAMED) to determine the relation between medfly and Anastrepha infestations. The fruits produced 96,669 (94.6% of the total) Anastrepha larvae and 5,521 (5.4% of the total) medfly larvae or about 17 times more Anastrepha than medflies.

Of 31,511 fruit fly larvae from fruit sampled in MOSCAMED Zones A and B where medfly densities are very low (see PART VI, A.), 99.8% were Anastrepha. Of 79,696 larvae from fruit sampled in Zone E where medfly densities are high, 93.2% were Anastrepha.

Plant health and medfly experts in Costa Rica report that Anastrepha has competed with, and to some degree, displaced the medfly in some crops in some areas of Costa Rica (Francisco Morales, OIRSA Costa Rica; Juan Jose May Montero, Director of Plant Health, Costa Rica; Herman Camacho, University of Costa Rica; personal communications 1988). Out of 4,126 fruit fly larvae Jirón and Hedstrom (1988) found in 446 fruit collections in Costa Rica, 3,932 (95.3%) were Anastrepha spp. and 194 (4.7%) were medflies.

c. Impact on Nontarget Organisms

A potential effect of sterile medfly releases on nontarget organisms would be changes due to released medflies as a temporary food source for insectivorous animals, such as ants. These insectivores reportedly feed on sterile medflies while the flies are still in the release bags, or after they emerge from the bags according to CICP EIA team interviews. The effect

theoretically could be harmful if, for example, it diluted predator pressure on pests or changed the reproductive output of the insectivores. The overall effect, however, should be short term and minimal.

d. Impact of Accidently Released Fertile Medflies

Accidental release of unsterilized medflies from the rearing laboratory, or the inadvertent release of fertile medflies, could cause a medfly population increase. However, Guatemala MOSCAMED is cognizant of the potential problem and security measures (e.g., using double doors in rearing room, sterilizing old rearing medium from which immature medflies have developed, placing Trimedlure baited traps in the facility) are used to prevent releases (Franz Hentze, Guatemala MOSCAMED, personal communication 1988).

e. Impact of Release Bags

The sterile medfly release bags are biodegradable and therefore should not have any lasting presence or appreciable negative effects in the environment.

2. Human Health Impacts

The released medflies would not be expected to interfere with human health.

See D.2. for discussion of risk to MOSCAMED workers in turbulent areas.

3. Socioeconomic Impacts

a. Impact of Fruit Losses from Oviposition Damage ("Stings")

Oviposition "stings" by released sterile female medflies may scar the fruit and thus reduce marketable quality (McDonald and McInnis 1985). Also, in the process of oviposition, females may introduce into their host fruit microorganisms which enable larvae to utilize fruit tissues. The development of these microorganisms cause fruit rot or produce unpleasant odors (Gibson 1970, Waikwa 1979).

Cosmetic appearance of fruit is not a vital concern of fruit markets in Guatemala; whereas, in the U.S. it is of primary importance. A high degree of variation exists in quality of fruits sold in Guatemala. CICP EIA team surveys in over 50 markets in towns and cities in Guatemala did not identify any vendors who were aware of problems caused by medfly stings. No vendors could provide information on price differentials or the existence of stung fruit; virtually all commented on loss due to

"larvae," but they did not know what kind they were. Domestic sales of fruits are not likely affected by oviposition damage from sterile female medflies.

The CICP EIA team interviewed Guatemala's two largest mango exporters, whose exports to Europe account for 40% of exportable mangoes. Neither exporter knew that the sterile medfly stings could affect cosmetic appearance of mangoes or had experienced problems with buyers rejecting the exported mangoes (Edgar Barillas and Tirso Cordova, mango growers, personal communications 1988).

b. Impact on Human Population

The majority of recent sterile fly releases have been in Zones B and C with some releases in Zone A and minimal releases in Zone D and none in Zone E. Table IV-20 shows perceptions of key rural leaders about sterile fly releases. In Zone B, where the sterile releases were highest, nearly one quarter of key rural leaders reported uncertainty when asked if releases were underway. A "yes" response rate of 67% in Zone E is very high given the low level of releases. A "yes" response of 26% in Zone E shows that a better public awareness program is needed.

Table IV-20. Percent of key rural leaders with each zone who believe MOSCAMED has released sterile medflies in their Municipality (based on 410 responses)

ZONE	YES %	NO %	DON'T KNOW %
A	27	54	19
B	41	35	24
C	41	48	11
D	67	23	10
E	26	44	30

As shown in Table IV-21, 18% of key urban leaders were unsure if MOSCAMED was conducting releases in their municipality.

Table IV-21. Percent of key urban leaders who believe MOSCAMED has released sterile medflies in their municipality (based on 66 responses)

YES %	NO %	DON'T KNOW %
38	44	18

The table is based on responses of 66 key leaders representing 61% of the urban municipalities.

Table IV-22 shows that with the exception of Zones C and D potential resistance to initiating sterile medfly release is relatively small. In most areas of Guatemala, the percentage of key leaders who are in favor or uncertain about initiating releases is high. Therefore, an adequate public education campaign could probably minimize resistance to the sterile medfly releases.

Table IV-22. Percent of key rural leaders within each zone who believe MOSCAMED should initiate sterile medfly release in their municipality (based on 410 responses)

ZONE	YES %	NO %	DON'T KNOW %
A	37	12	51
B	38	12	50
C	31	36	33
D	49	25	26
E	39	8	53

Informal CICP EIA team field surveys suggested that opposition to sterile medfly release is isolated, although several people interviewed thought that sterile medflies are disease vectors, bite like mosquitoes, or attack fish and infect them with worms. In the Coatepeque region, where the MOSCAMED program has been controversial, there were several independent reports that residents watch for airplanes to drop bags of

sterile medflies which they bury or burn. Some farmers interviewed stated that they did not know why these bags were thrown on their property, and when questioned indicated that they believed the flies were fertile and would damage their fruit.

CICP EIA team surveys showed that potential opposition to sterile fly releases in urban areas was 18% (Table IV-23). The majority of key leaders were in favor of or uncertain about the benefits of sterile fly releases. In one urban area, informal CICP EIA team interviews in five restaurants showed that owners blamed the flies in their restaurants on MOSCAMED. Upon examination, the flies turned out to be common houseflies.

Table IV-23. Percent of key urban leaders who believe MOSCAMED should initiate sterile medfly releases in their municipality (based on 66 responses)

YES %	NO %	DON'T KNOW %
35	18	47

Informal field interviews and survey results presented above indicate that there is less potential resistance to SIT than to chemical control.

D. SPRAY AND STERILE MEDFLY RELEASE AIRCRAFT

1. Ecological Impacts

Presence of MOSCAMED aircraft could frighten animals, but the CICP EIA team found no evidence that it would have a major harmful effect. Field interviews indicated that helicopter propwash has occasionally knocked down maize and vegetable plants in some farms. However, total damage would not likely be major.

2. Human Health Impacts

Presently in five regions of Guatemala (Figure IV-2), MOSCAMED worker safety may be endangered because of illegal trade and criminal transit routes, drug production, and processing (marijuana and poppies), or political turmoil. Politically sensitive areas are mostly in Zones A, B, and C which have only sporadic outbreaks of medflies. However, rapid changes in the political situation in Guatemala or neighboring countries could affect the program and must be continuously monitored.

At various times, MOSCAMED has had to cease activities in some of the areas shown in Figure IV-2. Area 1 of the figure in the Petén, bordering Belize, is an illegal trade and criminal transit route. Stolen and illegal goods are often passed along the many small roads and rivers between Guatemala and Belize. MOSCAMED has halted virtually all monitoring activities in this area. Area 2 of Figure IV-2, near Tacaná, is a drug production and trade site. MOSCAMED workers entering that area have been threatened and monitoring activities have been limited. Area 3 of Figure IV-2 supports guerilla activity and may also have some illicit trade. Because the MOSCAMED program is known to and generally accepted by rebel groups, some work continues in these areas (Edward Stubbs and Roger Valenzuela, APHIS and Guatemala MOSCAMED, respectively, personal communication 1988; CICP EIA field interviews).

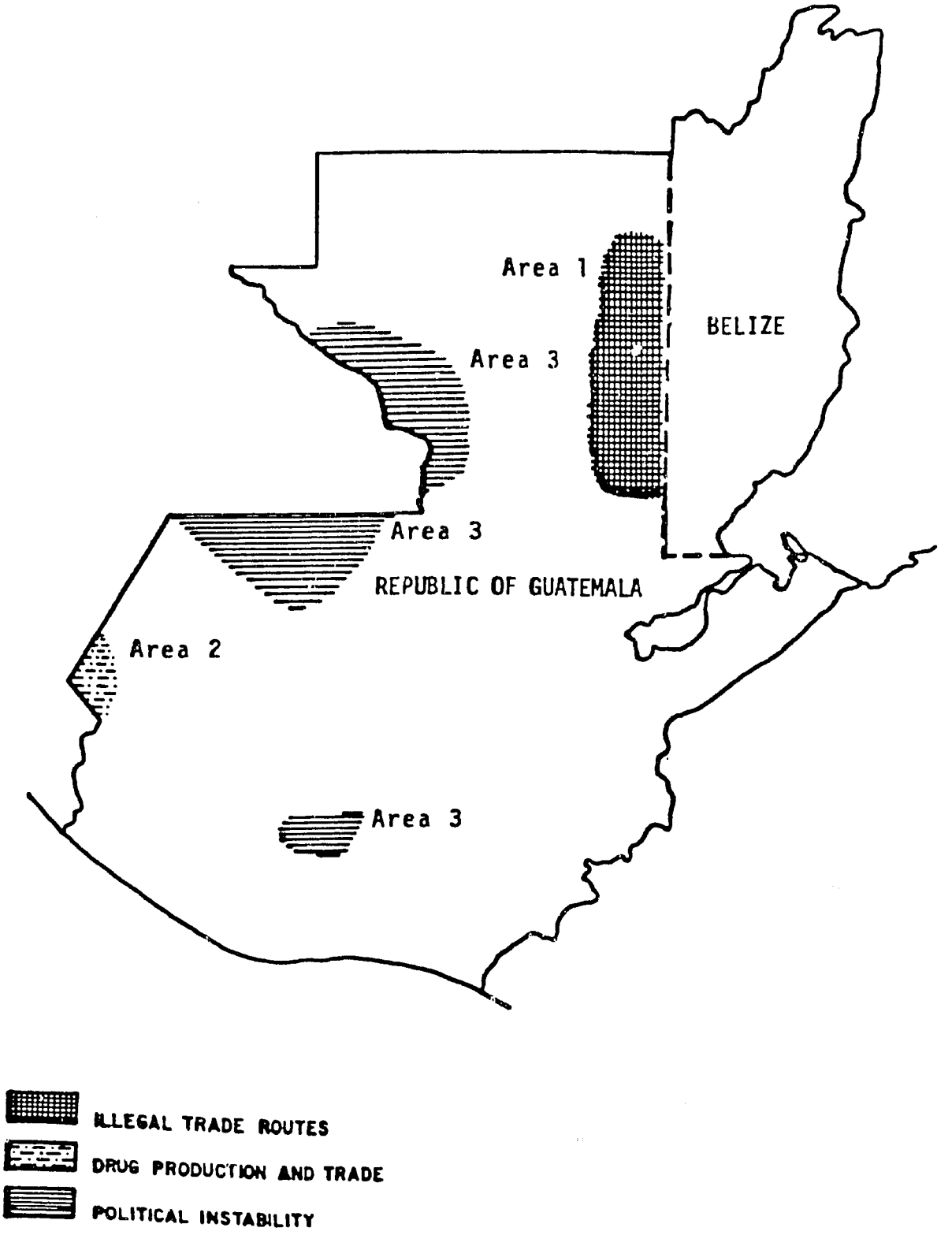

Figure IV-2. Potentially sensitive areas to Guatemala MOSCAMED workers, June 1988. The number and location of these areas are subject to rapid change.

3. Socioeconomic Impacts

Informal CICP EIA team interviews and observations indicate that rural residents may fear aircraft, especially helicopters, believing that helicopters are used for military operations. Helicopter noise was blamed in these limited interviews for reducing egg production in chickens, scaring cows, which affected milk quality, and knocking down field crops. Residents indicated that they preferred airplanes to helicopters because airplanes are less noisy and intrusive.

E. MONITORING

1. Ecological Impacts

a. Impact on Natural Ecosystems

The Guatemala MOSCAMED program uses about 30,000 medfly traps per year for monitoring, and some of the traps are located in natural ecosystems. MOSCAMED workers servicing the traps may cause some physical disturbance in certain natural ecosystems. In addition, the workers take fruit samples from wild hosts (e.g., caimito or star apple and guava) of the medfly in these natural areas. However, the CICP EIA team could find no reports of major disturbances.

b. Impact on Nontarget Organisms

Beroza et al. (1975) evaluated the toxicity of eight insect attractants including trimedlure. Trimedlure was tested for acute oral and aerosol inhalation toxicity to rats and for acute dermal toxicity, eye irritation, and primary skin irritation to rabbits. It was also tested for toxicity to rainbow trout and bluegill sunfish. Beroza et al. (1975) concluded that trimedlure had a "low order of toxicity" and "in the small amounts that will normally be required in field work, the use of these chemicals should present no environmental problems from a toxicological standpoint."

Various insects become entangled in the adhesive on the medfly traps and die, whether they are attracted to the trimedlure or simply caught accidentally. Sticky traps of various types are often used to survey insects, including parasitoids (Weseloh 1981). Burk (1982) reported catching *Euphasiopteryx ochracea*, a tachinid parasitoid of *Gryllus rubens*, on surfaces of Caribbean fruit fly traps that had been coated with a sticky surface. The CICP EIA team could find no documented evidence that medfly traps have eliminated nontarget species or caused ecological disturbances.

2. Human Health Impacts

See D.2. for discussion of turbulent areas in Guatemala.

3. Socioeconomic Impacts

a. Impact on Human Population

The following information was derived from informal interviews by the CICP EIA team with MOSCAMED workers at three of the regional operations centers and residents in the centers' regions. In each of the three regions, at least one MOSCAMED worker involved in monitoring activities stated that residents sometimes thought the traps prevented trees from becoming infested with medflies. The workers said that residents were more cooperative if the program and function of the traps were first explained. Formal CICP EIA team surveys of 113 MOSCAMED workers in charge of trapping showed that only 19% of the workers believed that the public they contact understand why the traps are used.

In CICP EIA team interviews with key leaders in rural areas, over half of the respondents in each of Zones A-D knew that trapping was underway. Uncertainty was greatest (15%) in Zone B. Respondents in Zone E were confused (33% said MOSCAMED had traps, and 24% were unsure). In urban areas, 14% of 66 key leaders were unsure if trapping took place in their municipality.

b. Impact of Vandalism to MOSCAMED Property

MOSCAMED estimates that 2-3% of the traps are intentionally destroyed each month (Roger Valenzuela, Guatemala MOSCAMED, personal communication 1988). Vandalism is especially high along new trapping routes or where aerial spraying operations are underway. CICP EIA team informal surveys with residents suggest that vandalism may occur when the traps are placed on the owner's property without permission or a MOSCAMED worker has offended the resident. Residents indicated that some traps may be destroyed by nonresidents.

F. MEDFLY REARING FACILITY

1. Ecological Impacts

Day-Glo Blaze Orange (see Appendix 5) is used to mark sterile medflies that are released. This pigment has been used to mark insects for many years (Turner and Gerhardt 1965). The small amount entering the Guatemala environment on the sterile medflies is unlikely to have a harmful impact.

The equipment used to irradiate fruit flies and the facility within which it is kept are inspected by the appropriate

Guatemalan government agency twice or three times per year. The items addressed by the inspection are specified by Guatemalan law. No danger of leakage due to natural disasters (including earthquakes) are anticipated unless the structural integrity of the unit itself is damaged. The possibility of radiation is very remote. However, there presently is no plan of action for emergency situations (based on correspondence with Raul Pineda, General Commission on Nuclear Energy 1988).

2. Human Health Impacts

The Day-Glo Blaze Orange pigment used to mark sterile medflies in the rearing facility at San Miguel Petapa is moderately toxic if inhaled (see Appendix 5). During inspections made by the CICP EIA team, workers applying Day-Glo to the medfly pupae wore paper filter masks. During examination by the CICP EIA physician, workers using the Day-Glo pigment retained visible (under ultraviolet light) residues over their bodies, including ears and nostrils.

Paper masks were not worn in the tumbling area of the rearing facility where medfly larvae are separated from food media. The airborne media may present respiratory problems to workers not wearing the masks. Guatemala MOSCAMED is currently installing a system of air filter ducts which is supposed to reduce the airborne media (Franz Hentze, personal communication 1988).

3. Socioeconomic Impacts

The San Miguel Petapa rearing facility has an estimated replacement value of U.S. $2.4 million. Operating and administrative expenses for the facility are U.S. $800,000. Assuming a U.S. $240,000 depreciation charge, the yearly expenses are over U.S. $1.0 million (Franz Hentze, Guatemala MOSCAMED, personal communication 1988).

G. REGULATORY CONTROLS

1. Ecological Impacts

a. Impact of Medfly Host Reduction

The wild hosts caimito, guava, and other fruits are often heavily infested with medfly. The plants' fruits are destroyed as a measure to reduce the pest. The CICP EIA team was unable to determine ecological impacts of the destructive action.

b. Impact of Burying Confiscated Fruits

Burying confiscated fruit, if done properly, should have the positive impact of fertilizing and adding organic material to soil.

c. Impact of Pesticides

Guatemala MOSCAMED quarantine stations are situated outside of ecologically sensitive areas, and relatively small amounts of toxicants are liberated from them into the environment. The CICP EIA team could find no evidence that the liberated toxicants are causing ecological damage.

2. Human Health Impacts

a. Impact of Vehicle Treatment

Guatemala MOSCAMED's policy is to treat vehicles passing through quarantine stations into medfly free areas with d-phenothrin. This pyrethroid insecticide has a relatively low toxicity and is the only insecticide approved by Guatemala MOSCAMED for this use (Franz Hentze, Guatemala MOSCAMED, personal communication 1988). However, CICP EIA team inspections at quarantine stations and interviews with MOSCAMED workers revealed that d-phenothrin was rarely used. Instead, the quarantine stations used various formulations of dichlorvos and propoxur. D-phenothrin, dichlorvos, and propoxur have been approved for use in Guatemala by the Ministry of Agriculture and Food in accordance with Guatemala's pesticide law; see PART IV, H.1. (Mario Gaytàn, Ministry of Agriculture and Food, personal communication 1988).

Dichlorvos is a poor choice for quarantine treatment to vehicles because of high toxicity (see Appendix 5). Also, the compound has recently been found to be a carcinogen. Use of the material at MOSCAMED quarantine stations could seriously affect the health of applicators and people passing through the quarantine stations.

Propoxur is also a poor choice for vehicle fumigation because of high toxicity. It is 100 times more acutely toxic than d-phenothrin (see Appendix 5).

According to Franz Hentze, Director of Guatemala MOSCAMED (personal communication 1988), all uses of propoxur and dichlorvos were discontinued shortly after the CICP EIA inspections in April 1988 and use of d-phenothrin was reinstated. On June 6, 1988, CICP EIA team members inspected three MOSCAMED quarantine stations and determined that only 2% d-phenothrin was being used to treat vehicles.

The CICP EIA team tested blood plasma cholinesterase levels in 25 Guatemala MOSCAMED employees working at the quarantine stations. All workers showed cholinesterase levels within normal limits.

Quarantine workers sometimes treat the vehicles with the occupants inside or allow reentry into the vehicles immediately after treatment. These practices increase the chances of exposure to nonacceptable levels of pesticides.

b. Impact of Methyl Bromide Fumigation

Guatemala MOSCAMED uses the fumigant methyl bromide to treat fruit at the quarantine stations (see PART III, D.2.b.). Fruit is placed in a chamber at the quarantine station and fumigated at a rate of 0.77 kg/10,000 m^3 for 2 1/2-4 hr. depending on the fruit species and air temperature. At the conclusion of the fumigation period, the chamber is cleared of methyl bromide gas by running an exhaust fan for 1 hr.

Methyl bromide has been approved for use in Guatemala by the Ministry of Agriculture and Food in accordance with Guatemala's pesticide law; see PART IV, H.1. (Mario Gaytán, Ministry of Agriculture and Food, personal communication 1988).

Methyl bromide is highly toxic to humans (see Appendix 5). In low concentrations, neither taste nor odor is detected, but in high concentrations a sweetish odor may be detected. Animal experimentation and clinical observation show that quite large doses may be tolerated for brief periods of time. This fact, along with the lack of odor, tends to make even some experienced individuals careless when handling the material (from Dow Chemical, U.S.A., n.d., methyl bromide fact sheet).

The CICP EIA team observed workers at one Guatemala MOSCAMED station playing cards in the chamber used to fumigate fruit with methyl bromide. At another station, CICP EIA team members discovered that workers sleep in the chambers at night. At another station, the CICP EIA team learned that handling the fruit to be fumigated (putting the fruit into the chamber and removing it) requires the help of two MOSCAMED workers, yet the station had only one respirator. The worker without the respirator wrapped a handkerchief around his nose and mouth before entering the fumigation chamber. At another station, the CICP EIA team observed that instructions for replacement cartridges for the respirators were only in English. Although anecdotal, these reports indicate that methyl bromide fumigation at quarantine stations presents potentially serious health problems for the workers.

Methyl bromide fumigation should pose no risk to the general public if managed properly.

3. Socioeconomic Impacts

a. Impact on Trading

Routes from the Pacific Coast to Quetzaltenango and to Coatepeque are the trading routes most seriously affected by quarantine stations. An estimated maximum of 80 (average = 18.8) metric tons of fruit passes through the quarantine station between the Pacific Coast and Quetzaltenango per week. An estimated maximum of 1.7 (average = 0.5) metric tons of fruit passes through the quarantine station between Coatepeque and the rest of the Pacific Coast to the east. The service rate for fumigation at quarantine stations is 3-6 hr. Average loads are 5 metric tons/truck (Franz Hentze, Guatemala MOSCAMED, personal communication 1988).

It is unlikely that time spent at quarantine stations presently represents a significant cost to truckers. Guatemalan truck drivers are used to frequent roadblocks due to army and police search activities, lengthy road repairs, fallen bridges, landslides, and accidents. Small dining rooms and food stands have sprouted at most quarantine stations. Drivers often have something to eat while loads are fumigated.

CICP EIA team interviews with residents and MOSCAMED officials indicated that alternate routes are sometimes used to bypass quarantine stations at Zunil, Los Encuentros, and Huehuetenango. Examination of road maps in Guatemala shows alternate trading routes that could be used to circumvent additional quarantine stations. No information is available on the volume of fruit transported via the alternate routes.

Guatemala City is presently infested with medfly. Once it becomes a medfly free area, the quarantine disruption of trading could be a major problem. Depending on the "shape" of the noneradicated zone, Guatemala City-bound fruit from the north, the northeast, and the southeast would have to pass quarantine stations. Depending on the fruits eventually subjected to quarantines, long queues could form at stations between Guatemala City and Puerto Barrios, Guatemala and Escuintla, and Guatemala City and Jutiapa. Problems could be especially acute during periods of harvest of major medfly host fruits or during holidays.

b. Economic Impact of Fruit Confiscation

Guatemala MOSCAMED estimates that a total of 114 metric tons of all kinds of fruit are confiscated by quarantine workers every year (Franz Hentze, personal communication 1988). At an average price of U.S. $274 per metric ton, the total value of this confiscated fruit would be U.S. $31,236.

c. Public Resentment at Quarantine Stations

CICP EIA team interviews with Guatemala MOSCAMED quarantine station workers indicated that the search and fruit confiscation procedures at the stations provoke an adversarial relationship. Workers at Los Encuentros, Las Victorias, Zunil, San Julian, and Chiyuc indicated that at least once each week, a situation arose where they felt endangered. Of 91 quarantine workers surveyed by the CICP EIA team, only 18% felt that the public understands the MOSCAMED program. When asked if there was anything dangerous about their job, 26% of the quarantine workers responded that lack of security at the quarantine station was the most serious problem.

CICP EIA team observations indicated that people are often unwilling to exit vehicles that are to be fumigated. Some women complained about having to disturb their sleeping children and losing their seats. Both women and men felt the quarantines were an inconvenience. Some of the Guatemala MOSCAMED quarantine workers told the CICP EIA team that they sometimes used the d-phenothrin sprayers, even if they lack chemicals, as a means of getting people to leave vehicles to be searched for fruit.

Public resentment over confiscated goods is reflected in the MOSCAMED worker's concerns about their safety. Anecdotal evidence and observations at quarantine stations by CICP EIA team members provided some evidence to support workers' concerns: Some vehicle owners failed to open the vehicles or submit their personal belongings for inspection; some vehicles refused to stop at the quarantine stations; some occupants of vehicles swore at the MOSCAMED workers; and the CICP EIA team witnessed at least one physical attack on a MOSCAMED worker (by a stopped vehicle's occupant). Anecdotal information from two carloads of tourists indicated that the tourists thought they were about to be robbed as they approached the quarantine stations at night. Lack of uniforms to identify the stations' workers with MOSCAMED and small or obscurely placed signs led to this perception.

d. Cost of Fruit Destruction

Guatemala MOSCAMED estimates that it strips 2,866 metric tons of fruit from trees each year as a regulatory control measure (Franz Hentze, Guatemala MOSCAMED, personal communication 1988; see PART III, D.3. for a description of the regulatory measures). At an average wholesale price of the U.S. $274 per metric ton, total value of the destroyed fruit would be U.S. $0.53 million assuming two-thirds of it is marketable at the same prices.

4. Political Impacts

a. Impact in Guatemala

The quarantine stations are perceived as a form of government control or harassment. Preferential treatment is given to specific groups: the military is rarely inspected, and private passenger cars, especially expensive ones, are often not inspected (based on CICP EIA team observations).

b. Impact on Relations With Neighboring Countries

If Guatemala became medfly free, quarantine stations would have to be set up at Guatemala's international ports at Puerto Barrios, Santo Tomas de Castilla, and Puerto Quetzal; Guatemala-Honduras and Guatemala-El Salvador borders; and the Guatemala City airport. OIRSA plant protection quarantines are already operating at all Central American borders, but they do not inspect or treat for the medfly. Additional requirements for the medfly quarantines would constrain movement in and out of Guatemala. The most significant impact would likely be on international flights originating in medfly infested countries and landing in Guatemala City. The CICP EIA team gathered no information to indicate that the international quarantine requirement would be expected to constrain relations with neighboring countries.

H. LAWS AFFECTING THE MOSCAMED PROGRAM

1. Guatemala Legal Requirements

CICP recruited a Guatemala environmental lawyer, Lic. Rolando Alfaro A., to assess Guatemala laws affecting the EIA and pesticide use in Guatemala. The following is a translation of the exact wording of Lic. Alfaro's assessment submitted to CICP in Spanish:

a. Guatemalan Legal Requirements and EIA and Pesticide Use Rules

Guatemala has environmental legislation that is included in different laws. Juridical norms with environmental effects are included from the general principles of the Constitution to the administration arrangements of the different authorities. It must be understood clearly that until this moment in none of the text of these laws does the legislator worry about including the necessary mechanisms to address the control of the negative effects of contamination to the Guatemalan population.[a]

Nevertheless, based on the Political Constitution of May 31, 1985 and as something with transcendental relevance, results the call for a specific national environmental regulation. It is

called the Mark Law, Frame or Organic Law of the Environment. This constitutional norm is contained in Article 97; its text states: "The State, the municipalities and the inhabitants of the national territory are obligated to participate in the social, economic, and technical development to prevent environmental contamination and to maintain the ecological equilibrium. The necessary norms will be dictated to guarantee that the use and taking advantage of the fauna, flora, land, and water will be rational, avoiding waste."[b]

On the other hand at this moment there does not exist a specific law for the "Evaluation of the Environmental Impact of Large Projects or Works," nor does Guatemala have a regulation that shows the requirements of this in the law compared to the environment. At the same time the Law of Protection and Improvement of the Environment in Article 8 states that: "For all project, work, industry, or other kind of activity that by its characteristics can produce deterioration of the renewable or non-renewable natural resources to the environment, or introduce harmful or obvious modifications to the countryside and the cultural resources of the national patrimony, a study evaluating the environmental impact will be necessary before its development, to be performed by technicians in the field and approved by the National Environmental Commission."

Furthermore, in Article 25 (subsection m) of the Guatemala Environmental Law it stipulates that the Functions of the Technical Consultants: "To recommend and supervise the studies evaluating the environmental impact to people, companies, or public or private institutions to determine the best options that permit sustained development."[c]

In relation to the Guatemalan management in disposition of pesticides, there only exists the "Regulator Law of Importation, Formulation, Storage, Transportation, Selling, and Use of Pesticides (Decree 43-74 of the Congress of the Republic)" and its regulation does not implicate any contradiction with the scientific analysis of the EIA of the Mediterranean fruit fly.

In conclusion, since there does not exist any regulation nor specific legislation that indicates the requirements for the studies of EIAs in Guatemala for programs like the eradication of the Mediterranean fruit fly, except as indicated in Article 8 of the Law of Protection and Improvement of the Environment as mentioned above, approval by the National Environmental Commission should be requested. After the study is completed by the CICP EIA technical team, the recommendations should be dictated to fulfill the requirements of the MOSCAMED Program.

b. Identify Deficiencies in the EIA Document of the MOSCAMED Program and to Present the Actions to Correct Them:

The document of the study, in its legal parts, has some aspects that must be added to especially in citing Guatemala dispositions whose norms have environmental effects for the MOSCAMED program such as: Fumigation Law (Law Decree No. 375).

In the Article 4 it states that "Individual or Juridical persons dedicated to aerial fumigation and combating pests must strictly comply with the norms dictated by competent authorities with the purpose of preserving the health, and life of the persons on the flight and the land in their service without complying with the Guatemala Institute for Social Security Dispositions." And Article 5 states: "Individual or Juridical persons dedicated to aerial fumigation and combating pests must provide the necessary means and the special equipment required to perform the technical examination of the pilots they contract."

Article 24 states that: "It is prohibited to carry additional passengers or people not directly involved in the aerial operation aboard aircraft performing fumigation and combating pests."

Also prohibited by Article 29 of the Fumigation Law is "The use of insecticides not authorized by the Ministry of Agriculture and Public Health and Social Welfare is prohibited. These institutions must issue the corresponding norms for the use of the same. In any case, the companies that operate aircraft for use in the type of work that is mentioned in this Decree, will be pecuniary liable for damages to persons or goods by the incorrect application of chemical substances."

Finally, among sanctions that are stated by the law: "The immediate suspension for the infractions commited by the Ministry of Communications and Public Works through the General Administration of Civil Aeronautics, of the authorizations, licenses, flight certificates and validation that have been issued for the purpose of aerial fumigation and combating pests that does not include other sanctions that result from the unlawful act committed."[d]

And within the special protection that must be given to the workers in Programs like MOSCAMED, the General Regulation on Hygiene and Security in Work of the Guatemalan Institute of Social Security states in its Article 94 (subsection f) that the "managers are obligated to provide the workers with, depending on the type of work: Suits or special equipment for the work, when health and the physical integrity of the worker is in danger..."[e]

c. Recommendations (by Lic. Ronald Alfaro A.)

(1) Request the National Environmental Commission to give its approval to the study evaluating the EIA of the MOSCAMED program.

(2) That the National Environmental Commission show the steps for eradicating the Mediterranean fruit fly after analyzing the study of the EIA.

(3) Establish the activities that can be developed for the eradication of agricultural pests, like the Mediterranean fruit fly, by issuing a law on Evaluations of the Environmental Impact of Projects and Works and its regulation.

(4) Suggest to the competent authorities that they issue simple environmental laws and regulations with the purpose of reaching sustained development.

(5) That the authorities and people with relations to the MOSCAMED Program insure that the workers use personal protection equipment in transporting and storaging the pesticides.

d. Bibliographic Notes

a. Rolando Alfaro. Legislación Ambiental y Reglamentación Actual y Programada. En Perfil Ambiental de la República de Guatemala. URL - AID 1984, p. 154.

b. Rolando Alfaro Arellano. Introducción al Derecho Ambiental Guatemalteco. Ambiente y recursos naturales. Revista de Derecho, Poli'tica y Administración. Editorial LA LEY. Buenos Aires, Argentina, Enero - Marzo 1987 - VOL. IV No. 1. p. 41.

c. ley de Protección y Mejoramiento del Medio Ambiente (Decreto 68-86, del Congreso de la República). En Leyes emitidas durante el ano de 1986, Ministerio de Gobernación de Guatemala; Tipografia Nacional, 16 de Julio de 1987, pp. 103-206.

d. Consejo Nacional de Planificación Económica. Recopilación de la Legislación Agraria y de Pesca. Guatemala: Tipografía Nacional 1986, p. 625-630.

e. Instituto Guatemalteco de Seguridad Social. Dpto. de Medicina Preventiva, Sección de Seguridad e Higiene. Reglamento General sobre Higiene y Seguridad en el Trabajo. Guatemala, julio de 1975.

2. International Laws

a. Laws Regulating Pesticides in Imported Food

Countries that import commodities from Guatemala may have laws to prohibit the importation of food crops with some pesticide residues. In the U.S., the Federal Food, Drug, and Cosmetic Act (FFDCA) governs pesticide residue levels in imported food. FFDCA prohibits the importation of food crops into the U.S. treated with methyl bromide unless tolerances have been established. Treatment with malathion, if used on those crops for which registered, and applied according to the manufacturer's label, is not prohibited by FFDCA. Some countries that import food crops from Guatemala do not prohibit importation of fruits treated with methyl bromide, and none that the CICP EIA team could determine prohibit malathion treatment.

b. U.S. Foreign Assistance Act, Section 119

The Foreign Assistance Act, Section 119 (g) (8) requires A.I.D. to ".....ensure that ongoing and proposed actions by the Agency do not inadvertently endanger wildlife species or their critical habitats, harm protected areas, or have other adverse impacts on biological diversity." The suggested mitigative measures in PART V include procedures to reduce recognizable adverse impacts per the Section 119 requirement.

PART V

MITIGATIVE MEASURES

PART IV reviewed the potentially adverse impacts of the Guatemala MOSCAMED eradication program on the ecological, human, and socioeconomic environment. All of the impacts reviewed are listed in Table V-1, in one of two categories:

A - No impact or negligibly adverse impact identified.

B - Adverse impact identified or insufficient information available to dismiss potential importance.

Table V-1. Potentially adverse impacts of Guatemala MOSCAMED eradication program on the ecological, human, and socioeconomic environment for the purpose of identifying mitigative measures

Control tactic and potential impacts	Category A No impact or negligible impact	Category B Adverse impact or insufficient information to dismiss importance
MALATHION BAIT SPRAY		
A. Ecological Impacts		
Impact on Naturally occurring Nontarget organisms		
* Honey bees and other pollinators		*
* Natural enemies		*
* Other invertebrates		*
* Microorganisms	*	
* Wild vertebrates		
-Birds		*
-Mammals		*
-Other vertebrates		*
* Soil ecosystem biota	*	
* Native plants		*
Impact on Agroecosystems		
* Crop plants		*
* Biological control		*
* Livestock	*	
Impact on Biodiversity		*
Impact on Sensitive Ecological Areas		*
Impact on Natural Aquatic Ecosystems and Aquaculture		
* Aquatic Flora	*	
* Aquatic microorganisms	*	
* Aquatic arthropods and annelids		*
* Aquatic mollusks	*	
* Aquatic vertebrates	*	

Control tactic and potential impacts	Category A No impact or negligible impact	Category B Adverse impact or insufficient information to dismiss importance
MALATHION BAIT SPRAY (cont.)		
B. Human Health Impacts		
Cholinesterase Inhibition		
* General population	*	
* MOSCAMED applicators/ mixers		*
Allergies		
* General population	*	
* MOSCAMED applicators/ mixers		*
Eye Disorders		
* General population	*	
* MOSCAMED applicators/ mixers		*
Delayed Effects (cancer,etc.)		
* General population	*	
* MOSCAMED applicators/ mixers	*	
Psychological Impact		
* General population		*
* MOSCAMED applicators/ mixers		*
Drinking Water	*	
Risk to MOSCAMED Workers in Turbulent Areas		*

Control tactic and potential impacts	Category A No impact or negligible impact	Category B Adverse impact or insufficient information to dismiss importance
MALATHION BAIT SPRAY (cont.)		
C. Socioeconomic Impacts		
Agricultural Productivity/ Diversity	*	
Tourism/Recreation	*	
Finishes on Motor Vehicles	*	
Impact on Rural Population		*
Impact on Urban Population		*
Public Health/Livestock Health Programs	*	
STERILE INSECT TECHNIQUE		
A. Ecological Impacts		
Evolution of "Superflies"	*	
Competitive Displacement and Secondary Pest Out-breaks	*	
Nontarget Organisms	*	
Accidentally Released Fertile Medflies	*	
Release Bags	*	
B. Human Health Impacts	*	
C. Socioeconomic Impacts		
Impact of Fruit Losses from Oviposition Damage ("Stings")	*	

Control tactic and potential impacts	Category A No impact or negligible impact	Category B Adverse impact or insufficient information to dismiss importance
STERILE INSECT TECHNIQUE (cont.)		
C. Socioeconomic Impacts (cont.)		
Impact on Human Population		*
SPRAY AND STERILE MEDFLY RELEASE AIRCRAFT		
A. Ecological Impacts	*	
B. Human Health Impacts		*
C. Socioeconomic Impacts		*
MONITORING		
A. Ecological Impacts		
Natural Ecosystems	*	
Nontarget Organisms	*	
B. Human Health Impacts		
Risks to Workers in Turbulent Areas		*
C. Socioeconomic Impacts		
Impact on Human Population		*
Vandalism to MOSCAMED Property		*

Control tactic and potential impacts	Category A No impact or negligible impact	Category B Adverse impact or insufficient information to dismiss importance
MEDFLY REARING FACILITY		
A. Ecological Impacts	*	
B. Human Health Impacts		*
C. Socioeconomic Impacts	*	
REGULATORY CONTROLS		
A. Ecological Impacts		
Medfly Host Reduction		*
Burying Confiscated Fruits	*	
Pesticides	*	
B. Human Health Impacts		
Vehicle Treatment		*
Methyl Bromide Fumigation		*
C. Socioeconomic Impacts		
Trading		*
Economic Impact of Fruit Confiscation		*
Public Resentment at Quarantine Stations		*

Control tactic and potential impacts	Category A No impact or negligible impact	Category B Adverse impact or insufficient information to dismiss importance
REGULATORY CONTROLS (cont.)		
D. Political Impacts		
Impact in Guatemala	*	
Impact on Relations with Neighboring Countries	*	

The purpose of PART V is to identify measures, if known, for mitigating (reducing) the risks of impacts in Category B of Table V-1. Some of the impacts cannot be avoided, even when mitigative measures are used, and will also be identified if possible.

A. MALATHION BAIT SPRAY

1. Ecological Impacts

a. Naturally Occurring Nontarget Organisms

(1) Honey Bees and Other Pollinators

See PART IV, B.1.a.(1) for discussion of impacts.

(a) Suggested Mitigative Measures

Guatemala MOSCAMED recommends the following procedures to reduce the harmful effects of malathion bait spray to honey bees:

* Apply aerial spray in alternate strips (see PART III, B.1.a.)
* Use large malathion bait spray droplets and low application dosages of malathion
* Warn beekeepers 7 days in advance of plans for spraying in a given area
* Have beekeepers confine their bees in hives covered with burlap during the day of application

* Provide beekeepers with technical assistance, burlap to cover the hives, sugar (which the beekeepers mix with water as food for confined bees), genetically selected improved queen bees, and an equivalent of 1 day's salary for each 25 hives if the beekeepers comply with MOSCAMED procedures to protect their colonies

* Avoid treatment to coffee when in bloom

* Leave a 1 km^2 buffer (untreated) zone around apiaries with 20 or more hives. Suspend brightly colored helium balloons, that pilots of the spray aircraft can easily see, to mark the buffer zones.

The above measures, except for use of burlap which needs to be investigated before it can be recommended, should be enforced.

The following additional actions should be taken:

* Sponsor research and monitoring to quantify the impact of malathion bait spray relative to other impacts (Africanization, tracheal mites, poor bee management, American foulbrood, and other factors) that affect honey bee mortality and honey production in Guatemala

* Sponsor research to quantify impact of malathion bait spray on pollinators of cardamon and wild orchids

* Develop education and information programs to inform beekeepers of overall problems affecting bee culture and honey production (diseases, tracheal mites, Africanization, and pesticides) and steps they can take to reduce the problems.

(b) Unavoidable Impact

Even with mitigative measures, malathion bait spray will kill some honey bees and wild pollinators.

(2) Natural Enemies

See PART IV, B.1.a.(2) for discussion of impacts.

(a) Suggested Mitigative Measures

* Use lowest per hectare dosages of malathion possible and largest spray bait droplets acceptable

* Apply malathion bait aerial spray in alternate strips (see PART III, B.1.a.)

* To reduce the problem of drift, avoid spraying when winds are 10 km/hr. or more, raining, or when rain is apparent, or the trees are wet with dew

* Restrict treatment to coffee and medfly cultivated host fruit crops; avoid use of malathion bait spray within 100 m of any nontarget crops or uncultivated areas.

(b) Unavoidable Impact

Although the mitigative measures will reduce the risks, malathion bait spray will kill some natural enemies.

(3) Other Invertebrates

See PART IV, B.1.a.(3) for discussion of impacts.

(a) Suggested Mitigative Measures

* Same as for natural enemies, A.1.a.(2)(a).

(b) Unavoidable Impacts

Same as for natural enemies, A.1.a.(2)(b).

(4) Wild Vertebrates

See PART IV, B.1.a.(5)(a)-(c) for discussion of impacts on birds, mammals, and other vertebrates.

(a) Suggested Mitigative Measures

* Use mitigative measures shown for A.1.a.(2)(a), A.1.b.(1)(a), and A.1.d.(1).

(b) Unavoidable Impact

Insufficient information is available to predict unavoidable impacts.

(5) Native Plants

See PART IV, B.1.a.(7) for discussion of impacts.

(a) Suggested Mitigative Measures

* Restrict treatment to coffee and cultivated medfly host fruit crops; avoid use of malathion bait spray within 100 m of any nontarget plants

* Also, use mitigative measure shown for A.1.d.(1).

(b) Unavoidable Impact

Insufficient information is available to predict unavoidable impacts.

b. Agroecosystems

(1) Crop Plants

The potentially adverse impacts to crop plants include destruction of pollinators and problems of phytotoxicity; see PART IV, B.1.b.(1).

(a) Suggested Mitigative Measures

* Follow directions on malathion's label on ways to avoid problems of phytotoxicity on specific crops

* Sponsor research to quantify impact of malathion bait spray on wild pollinators including those of cardamon, see A.1.a.(1)(a), and on the phytotoxicity to cultivated and noncultivated plants

* Sponsor research to quantify impact of malathion on malathion bait spray phytotoxicity of cultivated and noncultivated plants; see Part IV, B.1.b.(1).

(b) Unavoidable Impact

Destruction of some pollinators is probably unavoidable. Problems of crop phytotoxicity would be expected only if malathion bait spray contacted crop plants sensitive to it, or if errors in mixing and formulation occurred.

(2) Biological Control

See PART IV, B.1.b.(2) for discussion of impacts.

(a) Mitigative Measures

* Use same measures in A.1.a.(2)(a).

(b) Unavoidable Impacts

The unavoidable impacts would be the same as discussed for A.1.a.(2)(b).

c. Biodiversity

This section addresses the concerns of 22 CFR 216.5 and Sections 117 and 119 of the U.S. Foreign Assistance Act.

See PART IV, B.1.c. for discussion of impacts.

(1) Suggested Mitigative Measures

* Use all of the measures in A.1.a.(1)(a), A.1.a.(2)(a), A.1.a.(4)(a), A.1.a.(5)(a), and A.1.b.(1)(a).

(2) Unavoidable Impacts

If mitigative measures are used, malathion bait spray will still destroy some nontarget insects, spiders, and other invertebrates. Other impacts cannot be predicted.

d. Sensitive Ecological Areas

See PART IV, 1.d. for discussion of impacts.

(1) Suggested Mitigative Measures

* Guatemala MOSCAMED should provide all staff in charge of planning and implementing the malathion bait spray operations with maps that accurately show locations and borders of all protected and ecologically sensitive areas

* Guatemala MOSCAMED should adopt and strictly enforce a policy to forbid use of malathion bait spray in any of the protected and ecologically sensitive areas

* Guatemala MOSCAMED should request the National Commission on Environment to monitor the medfly eradication operations in areas near the protected and ecologically sensitive areas.

Under Section 119 of the Foreign Assistance Act, the Administrator of A.I.D. is required to review the A.I.D. requirement to "ensure that...actions by the Agency do not inadvertently endanger wildlife species or their critical habitats, harm protected areas, or have other adverse impacts on biological diversity."

(2) Unavoidable Impact

Unavoidable impacts cannot be predicted.

e. Natural Aquatic Ecosystems and Aquaculture

See PART IV, B.1.e. for discussion of impacts.

(1) Suggested Mitigative Measures

Guatemala MOSCAMED recommends the following procedures to reduce harm to aquatic systems; these procedures should be enforced:

* Avoid contamination of aquatic systems with malathion bait spray when washing out malathion bait sprayers or containers

* Leave buffer (untreated) zones of 250 m around standing bodies of water larger than 50 m in diameter; for rivers, use a 1 km buffer on each side when fixed wing aircraft are used and a 100 m buffer on each side when helicopters are used. Use brightly colored helium balloons, that the spray pilots can easily see, to mark the buffer zones.

The following additional measures should be taken:

* Guatemala MOSCAMED, in consultation with the National Commission on Environment, should establish and enforce guidelines for protecting small streams commonly found in coffee plantations from malathion bait spray.

(2) Unavoidable Impacts

To what degree the impacts are unavoidable is uncertain.

2. Human Health Impacts

See PART IV, B.2. for discussion of impacts.

a. Immediate Effects

See PART IV, B.2.a. for discussions of the immediate effects (i.e., cholinesterase depression, effects on eyes, allergies) of malathion bait spray.

(1) Mitigative Measures

* All Guatemala MOSCAMED pesticide applicators and other workers regularly exposed to pesticides (mixers, loaders, airplanes flaggers, fruit strippers) should be trained in safe use of pesticides (including proper storage, transportation, application, disposal, emergency procedures, and use of safety equipment and apparel)

* Guatemala MOSCAMED should provide workers pesticide safety equipment and clothing. Pesticide applicators and other workers regularly exposed to pesticides should wear long sleeved shirts, long pants, a cap, and footgear

* Rubber or neoprene gloves should be worn during mixing and loading

* Soap and water should be available to mixers, loaders, and applicators at all times

* Pesticide applicators and other workers exposed to pesticides should be regularly monitored by MOSCAMED for cholinesterase depression and other pesticide effects to prevent illness and identify inadequate pesticide handling practices. Workers with recurring symptoms of allergies, skin disorders, or other problems related to malathion bait spraying should be assigned to MOSCAMED jobs that do not require exposure to pesticides

* Use radio and other mass media tools, as well as close coordination with key leaders, to give advance notification of spray applications in a given area

* Pesticides should be stored properly and kept locked in facilities designated only for that purpose. Only supervisors should have access to keys.

(2) Unavoidable Impact

If mitigative measures are strictly enforced, the immediate health effects of malathion should be minimal, barring unforseen accidents, e.g., spills of technical malathion around workers. However, some workers may be allergic to the material and exhibit allergic responses even if mitigative measures are used.

b. Psychological Impact

See PART IV, B.2.c. for discussion of impacts.

(1) Suggested Mitigative Measures

For Guatemala MOSCAMED workers:

* MOSCAMED supervisors should enforce all training and safety measures in A.2.a.(1). Also, the supervisors should emphasize that while malathion is potentially dangerous, it is relatively safe when compared to some pesticides, and if used properly with appropriate precautionary measures, most risks can be avoided.

For the general population:

* MOSCAMED should develop a public education and information program that explains the purpose of malathion bait spraying. The program should emphasize that while malathion is potentially dangerous, it is relatively safe when compared to some pesticides, and proper use in the MOSCAMED program should not cause harm to the general population or their livestock. The program should include key rural and urban leaders as well as agricultural representatives, clergy (Catholic, Protestant, and Evangelic, etc.), town officials, local storekeepers, schoolteachers, rural health workers, etc.

* To increase understanding and decrease resistance to the program, all public education activities should emphasize a continuous process of monitoring, evaluation, and feedback about program activities at the local level, as well as specify foreseeable time

* Malathion bait spray should not be applied without the consent of property owners.

(2) Unavoidable Risk

Use of the suggested mitigative measures should reduce but not completely eliminate psychological impacts associated with use of malathion bait spray.

c. Risk to MOSCAMED Workers in Turbulent Areas

See PART IV, B.2.e. and D.2. for discussion of the risks.

(1) Suggested Mitigative Measures

* A comprehensive public relations and education program is the most effective way to reduce risks in turbulent areas. If the general public and politically active groups understand the MOSCAMED program objectives and procedures, many problems can be avoided

* MOSCAMED workers working in turbulent areas should wear distinctive, nonmilitary uniforms and carry identification cards that clearly show their affiliation with MOSCAMED

* MOSCAMED should regularly monitor the potentially turbulent areas and begin new public relations campaigns when turbulence increases.

(2) Unavoidable Impact

Even with the best public relations campaign and the other suggested mitigative measures in place, some risk is unavoidable.

3. Socioeconomic Impacts

a. Impact on Rural and Urban Populations

See PART IV, B.3.d.-e. for discussion of impacts.

(1) Mitigative Measures

* A rigorous public relations and education program should be developed to explain why malathion bait spray is needed and its benefits. An explanation of the relative low hazard of the material, compared to other pesticides with which the people may be familiar, should be part of the education program

* Coordination with groups who are differentially affected by the Guatemala MOSCAMED program (e.g., beekeepers, cardamon producers, coffee producers) should be improved.

(2) Unavoidable Impact

The best public relations and education program would not be expected to eliminate all of the impact.

B. STERILE INSECT TECHNIQUE

1. Ecological Impacts

No adverse impacts or only negligibly adverse impacts were identified (See PART IV, C.1.).

2. Human Health Impacts

The only human health impacts identified (PART IV, C.2.) were related to the medfly rearing facility (see F.1. below).

3. Socioeconomic Impacts

See PART IV, C.3. for discussion of impacts.

a. Suggested Mitigative Measures

* To reduce misconceptions about the released sterile medflies, a public relations campaign should be developed to stress that the released medflies are beneficial and will cause no harm to humans, crops, livestock, or other human resources

* In urban areas especially, residents and people in charge of business such as restaurants should be taught to differentiate released sterile medflies from common houseflies.

b. Unavoidable Impact

A public relations and education campaign would reduce the public's misconception about the released sterile medflies but not completely eliminate it.

C. SPRAY AND STERILE MEDFLY RELEASE AIRCRAFT

1. Ecological Impacts

No adverse or only negligibly adverse impacts were identified (see PART IV, D.1.).

2. Human Health Impacts

The only human health impact identified was the potential risk to Guatemala MOSCAMED aircraft and pilots in politically sensitive or other turbulent areas (see PART IV, D.2.).

a. Suggested Mitigative Measures

* MOSCAMED should use the radio and other mass media tools to provide advance notice of plans to use aircraft in an area and the purpose

* When terrain permits MOSCAMED should use fixed wing aircraft instead of helicopters in areas where there have been major complaints or problems with helicopters

* Mitigative measures in A.2.b.(1) (for the general population) and A.2.c.(1) are also suggested.

b. Unavoidable Impact

Use of the mitigative measures will not guarantee the safety of all workers.

3. Socioeconomic Impacts

See PART IV, D.3. for discussion of impact.

a. Impact on Human Population

(1) Suggested Mitigative Measures

* Measures in A.2.b.(1), for the general population, and A.2.c.(1) are suggested.

(2) Unavoidable Impact

Some, but an unknown, level of impact is unavoidable.

D. MONITORING

1. Ecological Impacts

No adverse or only negligibly adverse impacts were identified (see PART IV, E.1.).

2. Human Health Impacts

a. Risk to Workers in Turbulent Areas

See PART IV, E.2.a. for a discussion of the risks.

(1) Mitigative Measures

* The MOSCAMED monitors should carry identification to show their affiliation with the MOSCAMED program and wear uniforms (e.g., bright shirt or hat with a MOSCAMED logo)

* MOSCAMED monitors should not enter private property without permission of the owner

* See A.2.c.(1) for additional mitigative measures.

(2) Unavoidable Impact

The mitigative measures should reduce but not entirely eliminate the risks.

3. Socioeconomic Impacts

a. Impact on Human Population

The CICP EIA team determined that the general population may not understand why medfly traps are used (see PART IV, E.3.a.).

(1) Suggested Mitigative Measures

* The public relations and education program should explain why the traps are used and stress that the MOSCAMED eradication effort cannot be successful without them.

(2) Unavoidable Impact

A public relations and education program would increase understanding of the traps and reduce misconceptions about them, but some people would continue to have misconceptions.

b. Impact on Vandalism

See PART IV, E.3.b. for a discussion of vandalism to the traps.

(1) Suggested Mitigative Measures

* A comprehensive public relations and education program is the most effective way to reduce vandalism.

(2) Unavoidable Risk

Some vandalism is unavoidable.

E. MEDFLY REARING FACILITY

1. Human Health Impacts

A potential health problem in the medfly rearing facility at San Miguel Petapa results when workers separating medfly larvae from diet media do not wear paper filter masks. Inhalation of airborne media may cause respiratory ailments. Another potential problem is worker exposure to the Day-Glo pigment residues (see PART IV, F.2.).

a. Suggested Mitigative Measures

* All MOSCAMED employees working in the medfly larvae separation rooms should wear paper filter masks. Appropriate air filters and ducts should be installed to reduce airborne media in the work areas
* MOSCAMED should seek advice from medical authorities on appropriate masks for minimizing risks from Day-Glo exposure.

b. Unavoidable Impact

Installing appropriate air filtering systems and wearing appropriate masks should reduce most health risks.

F. REGULATORY CONTROLS

1. Ecological Impacts

a. Medfly Host Destruction

Fruits of caimito, wild guava, and other wild medfly hosts are destroyed in the field as a regulatory measure to reduce medfly populations (see PART IV, G.1.a.). The CICP EIA did not determine the ecological impact of this practice.

(1) Suggested Mitigative Measure

* The only known mitigative measure is to stop the practice of destroying fruit of the wild species. However, discontinuation of the practice may interfere with the regulatory program.

(2) Unavoidable Impact

The adverse impact, if destroying the fruit does indeed result in an adverse impact, may not be avoidable in a medfly eradication program.

2. Human Health Impacts

a. Impact of Pesticides

The CICP EIA team observed a number of potentially serious human health risks at Guatemala MOSCAMED quarantine stations (see PART IV, G.2.). Procedural changes and use of safer chemicals are needed to reduce the risks.

(1) Suggested Mitigative Measures

For vehicle treatment:

* Vehicle fumigants containing dichlorvos and propoxur should not be used; instead, d-phenothrin should be used

* Vehicles should always be vacated before being treated

* Occupants should not be allowed to re-enter vehicles treated with d-phenothrin for a period of time specified by the chemical manufacturer; Guatemala MOSCAMED should obtain and enforce the manufacturer's guidelines concerning safe re-entry time.

For fumigation of medfly host material:

* Only MOSCAMED employees properly trained in fumigation procedures and safety should be allowed to perform the fumigation tasks

* Quarantine station workers entering a fumigation chamber should use respirators approved for use around methyl bromide

* Instructions that explain the proper procedures for fumigation and use of fumigation safety equipment should be available in Spanish at every quarantine station

* The quarantine operations should be inspected regularly. Following inspection, the inspector should submit a written report to Guatemala MOSCAMED's Director to verify that the inspection was made and indicate needs for making the operations effective and safe.

For all quarantine station workers:

* All quarantine station workers should be required to take the training and use the precautionary safety measures in A.2.a.(1).

* Each quarantine station should provide pesticide safety equipment and have soap and water available for all workers. Guatemala MOSCAMED should develop emergency procedures in case of pesticide accidents (e.g., spills, fire).

(2) Unavoidable Impact

If the mitigative measures are used, and barring unforseen accidents (chemical spills, fires, faulty equipment, etc.), most serious impacts can be avoided. However, a certain percentage of MOSCAMED workers and persons passing through the quarantine facilities may be allergic to the vehicle fumigants and might be expected to exhibit an allergic response upon exposure.

b. Public Resentment at Quarantine Stations

See PART IV, G.3.c. for discussion of impacts.

(1) Suggested Mitigative Measures

* Guatemala MOSCAMED should clearly identify the purpose of the MOSCAMED program at airports, quarantine facilities, hotels, and recreational and cultural areas

where tourists visit. Increased public relations, especially for non-Spanish speaking tourists, should be targeted at the quarantine stations and ports of entry where tourists may be delayed and inconvenienced by the inspections and treatment

* Quarantine stations should be clearly marked, with large signs indicating what they are and where they are, several kilometers before reaching them

* Security should be provided at quarantine stations

* Workers should be provided with bright, highly visible uniforms which clearly distinguish them.

(2) Unavoidable Impact

Some resentment and confrontations are unavoidable.

3. Socioeconomic Impacts

a. Disruption of Trading

See PART IV, G.3.a. for discussion of impacts.

If the MOSCAMED eradication effort proceeded east, and Guatemala City became a medfly free area but was still flanked to the east by infested areas, the potential for disruption in fruit trading would increase. Long queues of trucks could form at quarantine stations between Guatemala City and the major fruit centers of Puerto Barrios, Escuintla, and Jutiapa. The disruptions could be especially acute during certain times of the year.

(1) Mitigative Measures

* MOSCAMED should determine the best way for the eradication effort to proceed across Guatemala so as to be least disruptive to trade. One possible way to minimize the disruptions would be to advance the eradication effort in a manner of a closing fan with Guatemala City in the center, at least until Escuintla and Puerto Barrios fell well within the medfly free zone. Another possibility would be to postpone the eradication effort in the Guatemala City area until the rest of Guatemala was medfly free.

(2) Unavoidable Impact

Even with the best plan for minimizing disruption of trading, some disruption is unavoidable.

b. Economic Impact of and Resentment Over Fruit Confiscation and Destruction

See PART IV, G.3.b.-d. for discussion of impacts.

(1) Suggested Mitigative Measure

* MOSCAMED should study the feasibility of manufacturing fruit candy and preserves from confiscated fruit and giving them to the persons from whom the fruits are confiscated

* MOSCAMED should periodically update its information on medfly fruit hosts (species and varieties of given species, ripening characteristics, etc.) in relation to medfly infestation patterns and use this information in developing fruit destruction procedures that cause the least losses to farmers

* When possible, olotes (corn cobs impregnated with malathion bait) should be used instead of fruit destruction

* When fruit destruction is necessary, MOSCAMED should compensate for the fruit destroyed.

(2) Unavoidable Impact

Some would probably continue to resent the confiscation and fruit destruction and refuse to accept mitigative measures.

PART VI

COMPARISONS OF MEDFLY ERADICATION AND ALTERNATIVE COURSES OF ACTION

Part VI compares requirements, benefits, and limitations of medfly eradication and three alternative courses of action: nonchemical pest management, creation of a stable barrier in Mesoamerica to prevent northern spread of the medfly, and no action. In the contract awarded to CICP to conduct the EIA, A.I.D. specified that the contractor should make these comparisons. Goals and medfly control tactics of the four programs to be compared are as follows:

PROGRAM ONE: MEDFLY ERADICATION

Goal: To eradicate the medfly from all of Guatemala

Control Tactics: Malathion bait spray, release of sterile medflies, fruit destruction, and regulatory procedures (including pesticides and fumigants in quarantine programs)

PROGRAM TWO: STABLE BARRIER

Goal: To create and maintain a permanent medfly suppression barrier that deters northern spread toward Mexico and the U.S.

Control Tactics: Malathion bait spray, release of sterile medflies, fruit destruction, and regulatory procedures (including pesticides and fumigants in quarantine programs)

PROGRAM THREE: MANAGEMENT OF MEDFLY USING NONCHEMICAL METHODS

Goal: To manage the medfly in Guatemala without using chemical pesticides

Control Tactics: Release of sterile medflies, cultural practices, biological control, and nonchemical regulatory treatments

PROGRAM FOUR: NO ACTION

Goal: To terminate the current MOSCAMED eradication program and not replace it with any of the above strategies

Control Tactics: None

The information presented is based on interviews with medfly experts, government officials, and others, the published literature, and unpublished reports. Much of the information presented for program one is based on MOSCAMED (1987, 1988), Ortiz et al. (1987), Hentze and Mata (1987), and discussions with Franz Hentze, Director of Guatemala MOSCAMED.

A. PROGRAM ONE (MEDFLY ERADICATION)

Program one would attempt to eradicate the medfly from all of Guatemala based on the existing MOSCAMED eradication strategy, using one of three time-based options. Options one, two, and three differ in the amount of time (4, 5, and 6 years, respectively) and costs (see A.9.) required for the eradication effort to progress across all of Guatemala. The strategy for all options assumes that the eradication effort would begin at a time when medfly populations were at 1987 levels. Costs and other requirements represented for the various options are based on calculations presented in the MOSCAMED (1987) document (see PART VI, A.10. for discussion of developments in medfly infestations since 1987).

Figure VI-1 shows how the eradication effort would progress across Guatemala each year under the different options of program one.

MOSCAMED personnel claim that it would be possible to eradicate the medfly from Guatemala in a 4- or 5-year period if sufficient numbers of sterile medflies were available and assumptions in A.10. were met. However, at present it would be difficult to proceed with option one (4 years) because of problems in producing sufficient numbers of the sterile insects (Franz Hentze, Guatemala MOSCAMED, personal communication 1988).

MOSCAMED has partitioned Guatemala into five zones to show status of medfly eradication at a given time:

Medfly free (Zone A): an area free of medflies, based on trapping and fruit sampling, and not close to medfly infested areas

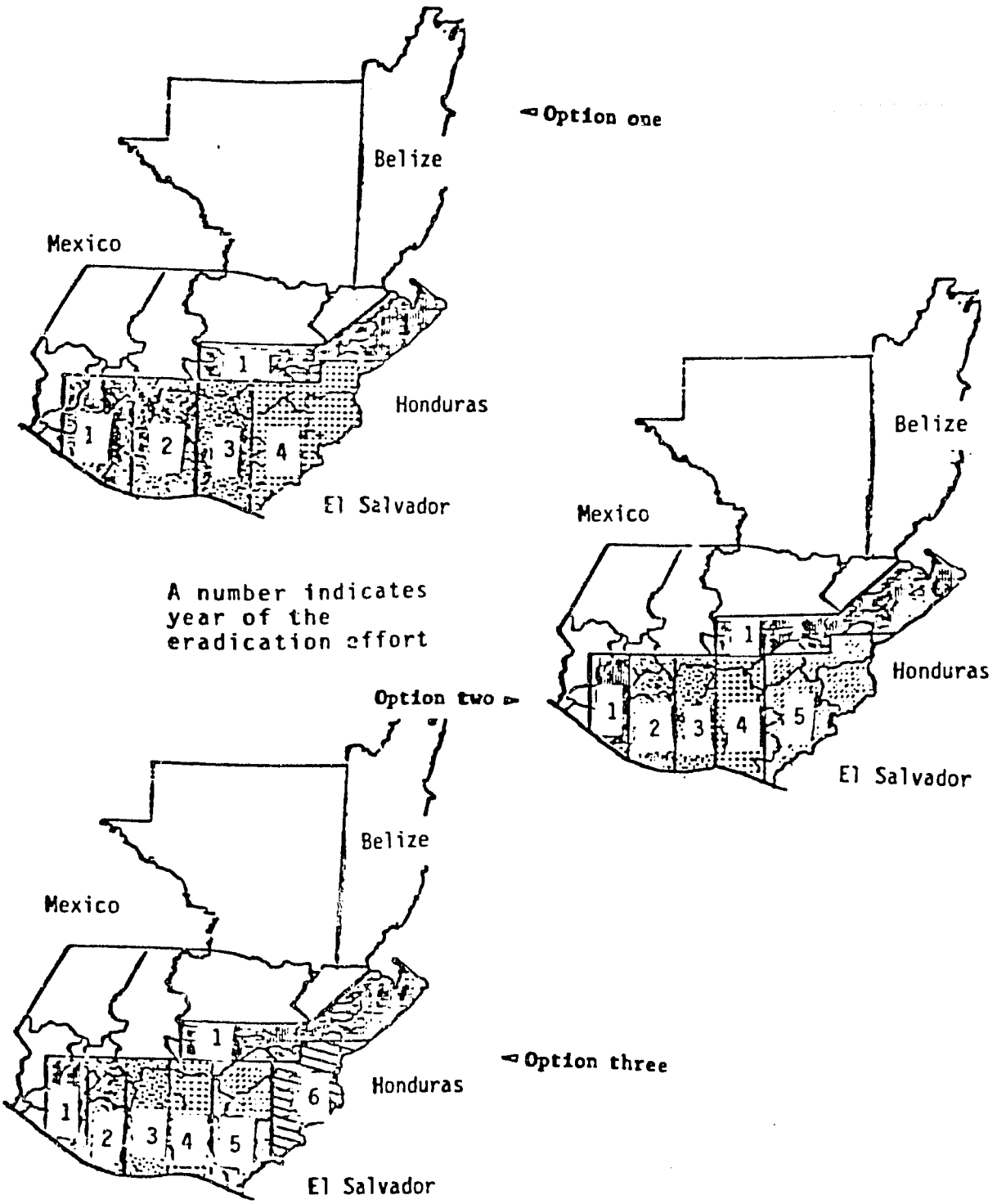

Figure VI-1. Progression of medfly eradication by year for the three options of program one

Post eradication (Zone B): an area where the medfly has been eradicated but close to areas infested with the species

Eradication (Zone C): an area where eradication measures are being used

Pre eradication (Zone D): a medfly infested area where extensive monitoring is being carried out in preparation for eradication

Infested (Zone E): any area where no eradication measures have been taken and which is probably infested with medflies.

In addition, a buffer zone 10 km wide is maintained between the eradication zone (C) and pre eradication zone (D).

Figure VI-2 shows the location of the various zones in 1987.

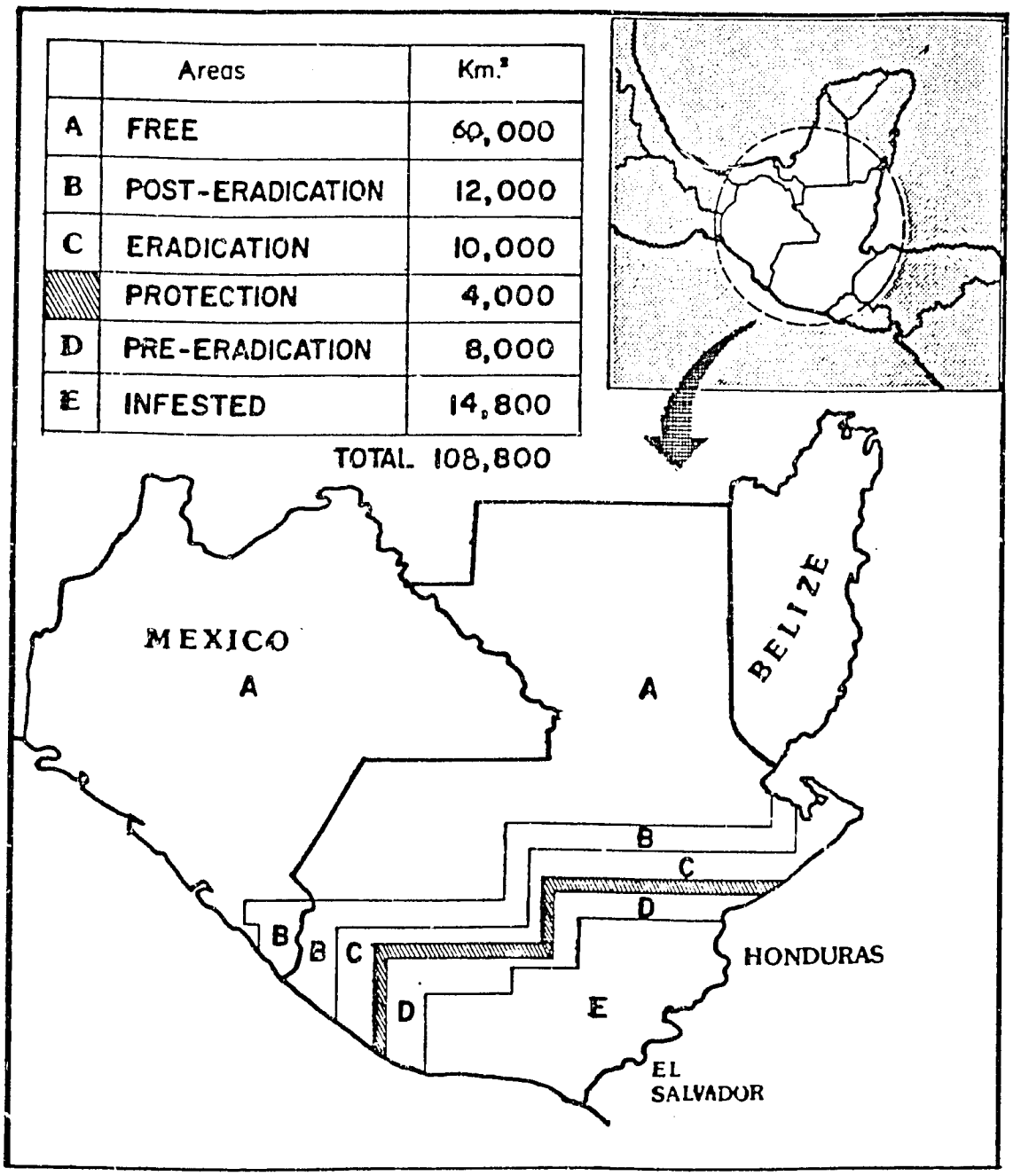

Figure VI-2. Status of medfly eradication in Guatemala in 1987 (MOSCAMED 1987)

1. Control Tactics

a. Malathion Bait Spray

Program one would use malathion bait spray to reduce the medfly populations to the low levels required for successful application of the sterile insect technique. The bait spray would be applied both as an aerial strip spray and as a ground spray using the malathion-bait mixtures, application equipment, and application intervals described in PART III, B.1. Olotes would be used in some areas considered off limits for aerial or ground spraying (around villages and towns, near ecologically sensitive areas, etc.).

Table VI-1 estimates the land area in hectares that would receive aerial and ground treatments of malathion bait spray in the different options of program one.

b. Sterile Insect Technique

The sterile insect technique (see PART III, A.) works best when directed at low density medfly populations. Malathion bait spray would normally b used to achieve this low density requirement in program one. However, in certain conditions, (e.g., in sensitive ecological areas, in areas where medfly infestations were naturally low, and in towns and cities) the sterile insect technique might be used alone or in combination with the olotes.

Table VI-1. Estimated hectares (1,000s) to be treated with malathion bait spray in program one

Option	Appl. tech.	Yr. one	Yr. two	Yr. three	Yr. four	Yr. five	Yr. six	Total
One	Aerial	100	150	150	75			475
	Ground	15	15	20	17			67
	Total	**115**	**165**	**170**	**92**			**542**
Two	Aerial	75	75	75	150	75		450
	Ground	20	15	20	20	17		92
	Total	**95**	**90**	**95**	**170**	**92**		**542**
Three	Aerial	75	50	75	100	40	40	380
	Ground	20	13	20	18	14	14	99
	Total	**95**	**63**	**95**	**118**	**54**	**54**	**479**

Source: MOSCAMED (1987)

The sterile medflies would be secured from rearing facilities at San Miguel Petapa, Guatemala and Metapa de Dominguez, Mexico (see PART III, A.3.). Table VI-2 estimates the number of sterile medflies needed to achieve eradication in the different options of program one.

Table VI-2. Estimated number of sterile medflies (millions) needed per week in program one

Option	Yr. one	Yr. two	Yr. three	Yr. four	Yr. five	Yr. six	Total
One	400	500	600	600			2,100
Two	400	450	500	500	600		2,450
Three	400	450	500	500	550	550	2,950

Source: MOSCAMED (1987)

c. Fruit Destruction

Stripping and destroying medfly infested or medfly susceptible fruit is done during quarantine periods when spot infestations of the medfly are detected (see Part III, D.3.).

Destruction of fruits would be emphasized in the medfly free and post eradication zones in program one. All medfly susceptible fruits found within 1 km^2 of a medfly infestation (confirmed by trapping or fruit sampling) would be collected and buried or burned. Estimated tons of fruit destroyed as a means to reduce medfly populations in program one are shown in Table VI-3.

Table VI-3. Estimated tons of fruit destroyed to reduce medfly populations in program one

Option	Yr. one	Yr. two	Yr. three	Yr. four	Yr. five	Yr. six	Total
One	2	2.5	1	3			8.5
Two	2	2.0	2	3	3.0		12.0
Three	2	2.0	2	3	1.5	1.5	12.0

Source: MOSCAMED (1987)

2. Quarantine Stations

Program one would depend heavily on the success of quarantines discussed in PART III, D. Quarantine stations would be maintained along motor vehicle routes, at borders between Guatemala and neighboring countries, and at air- and sea-ports. The quarantines would be enforced during the eradication effort and then continued indefinitely as needed to keep medflies from reinfesting previously uninfested areas or areas where they had been eradicated.

Permanent quarantine locations in Guatemala would likely be maintained at the following locations: Retalhuleu, Zunil, María Tecún, Zacualpa, San Cristóbal Verapaz, Cobán Highway Chisec, Cobán Highway, Fray Bartolomé de las Casas, Cahaboncito, La Cumbre, La Ruidosa, Mariscos, Livingston, Puerto Barrios, and Melchor de Mencos.

Traffic entering the quarantine stations would be stopped and inspected for the presence of potential medfly host material. All potential host fruits and vegetables would be confiscated and buried, burned, or fumigated. Commercial fruits and vegetables, if determined to be potential medfly hosts, would be fumigated before continuing into medfly free areas. As an added precaution, d-phenothrin would be applied in automobiles, trucks, and buses entering quarantined areas to kill any adult medflies.

The present regulatory program at Petén and Poptún airports and El Estor water port at Lake Izabal would be continued (see PART III, D.1.). In addition, after the medfly had been eradicated in the Guatemala City area, quarantine programs would be instituted at the Guatemala City Airport to inspect international flights arriving from medfly infested areas.

3. Public Education/Relations Campaign

Effective education and public relations are integral to the success of medfly eradication. Guatemala MOSCAMED's current public education/relations campaign, shown below, should be continued, but expanded to be more effective:

Eradication Zone		Focus of Public Education/Relations
A	-	General maintenance and awareness of program, emphasizing detection and maintenance of eradication status. Mass media such as radio, pamphlets, posters, and cooperation from local authorities.
B	-	Similar emphasis to Zone A activities but greater attention to the importance of quarantine, monitoring, and sterile fly releases, with occasional spot spraying. Reliance on mass media, but greater emphasis on personal contact.
C	-	Most active education public relations program designed to inform public of spraying, quarantines, sterile medfly releases, cultural controls, and detection. Aggressive information campaign which uses mass media but emphasizes personal contact to obtain citizen consent and participation.
D&E	-	Information on preliminary activities to prepare for action, such as monitoring, identification of apiaries, etc. Minimal mass media or direct contact.

4. Medfly Monitoring

A minimum detection trapping array would consist of from one Jackson trap (see PART III, G.) per km^2 to one Jackson trap per 4 km^2 depending on the zone and medfly density (Hentze and Mata 1987). The traps would be baited every 2 to 8 weeks, depending on the bait formulation, and checked every 1 or 2 weeks.

Fruit sampling would consist of regularly collecting fruits and vegetables known to host medflies. Part of the samples would be dissected to determine the presence of immature medflies and part would be held in cages in the laboratory and observed for emerging medfly adults or parasitoids.

Table VI-4 estimates the number of traps and fruit samples needed in program one.

Table VI-4. Estimated number of traps and fruit samples needed in program one (data in 1,000s)

Option		Yr. one	Yr. two	Yr. three	Yr. four	Yr. five	Yr. six	Total
One								
	Traps	35	40.0	45	45.0			165
	Frt. samp.	5	6.5	8	9.5			29
Two								
	Traps	33	35.0	40	45.0	45.0		198
	Frt. samp.	4	4.0	6	7.5	9.5		31
Three								
	Traps	33	35.0	38	43.0	45.0	50	244
	Frt. samp.	4	5.0	6	7.5	8.5	9	40

Source: MOSCAMED (1987)

Medfly trapping and fruit sampling would be continued as long as there was a potential threat of new medfly introductions.

5. Monitoring Pesticide Use and Impacts

Pesticide use and impact on human health and environment should be monitored on a continuous basis in program one. According to USDA-APHIS (1982), the pesticide monitoring in a medfly eradication scheme should include:

a. Using Dye Cards to Monitor Aerial Bait Application

* Droplet size information
* Droplet distribution information
* Bait deposition information
* Determination of wind drift
* Verification of spray block boundaries
* Identification of missed areas.

b. Sampling to Evaluate Effect on Environmental Components

* Water sampling to detect insecticide levels through direct application, leaching, and runoff

* Soil sampling to determine insecticide levels and residues

* Foliage sampling to identify residues

* Biological organism sampling to determine impact of insecticides

* Air sampling to determine the presence of pesticides in respirable air.

In the past, Guatemala MOSCAMED has periodically determined the presence of malathion residues on soil, nontarget organisms, etc.

Pesticide effects on human health should also be monitored. The monitoring should check cholinesterase levels in MOSCAMED's pesticide applicators and others working around pesticides. Guatemala MOSCAMED has not previously monitored for human health effects.

6. Measure of Success

Eradication of the medfly species from all or any one area of Guatemala would be judged successful if no wild medflies were detected by medfly traps, fruit samples, or other methods in one year of intensive sampling (see PART III, G.) after the eradication measures were stopped.

7. Project Personnel

a. Requirements

Approximately 1,900 workers, the number Guatemala MOSCAMED had on its payroll in early 1987, are needed to marshall the eradication effort in Guatemala. The May 1988 work force of 1,000 is inadequate to carry out the proposed eradication program (Franz Hentze, Guatemala MOSCAMED, personal communication 1988).

In 1987, Guatemala MOSCAMED's Operations Unit had seven Regional Operations Centers (ROC) and two laboratories that received and released sterile medflies. Division of labor differs in a given work zone, even within ROCs, depending on the medfly control tactics used, etc. Each of the ROCs is subdivided into four units with field personnel (permanent plus temporary) partitioned into the following work categories: monitoring (36%); control (chemical control, 31%, SIT, 2%, quarantine, 14%); and technical assistance and administration (17%). The organization of the Operations Unit and the location of the ROCs would change as the eradication effort progressed. Although the number of ROCs has recently been reduced to five, the eradication effort would best be achieved using the organization which existed in early 1987.

b. Training

Presently most positions in MOSCAMED utilize a system of on-the-job training to prepare workers for the jobs they will undertake. There is a strict job hierarchy which stresses internal promotion of workers at all levels within the program, although it is tailored with special advantages for professional staff. This system assumes that workers who have mastered an area will be able to accept increasing responsibility and expanded duties. Training, at all levels, is the responsibility of the immediate supervisor. In some cases, the public relations specialists will meet with groups of newly hired personnel to give orientation to the program.

The present system of training would be continued in program one.

8. Potential Program Benefits

Medfly eradication benefits would fall in four categories: (1) elimination of crop losses inflicted by medfly, (2) relaxing export constraints to countries that restrict products from medfly infested areas, (3) aggregate benefits (political and human capital benefits) such as improving international cooperation linkages and providing training for program workers, and (4) direct program benefits, such as providing jobs. The first three are permanent benefits. The fourth benefit would continue only while the eradication program was in progress.

a. Reduction in Crop Losses

The medfly's major commercial crop hosts in Guatemala are coffee, throughout its entire growing range; mangoes and oranges, especially in areas south of the coffee area; and apples, peaches, and pears, principally to the north of the coffee areas (Figure VI-3). In addition, the medfly attacks a range of crops of lesser commercial importance (Table VI-5).

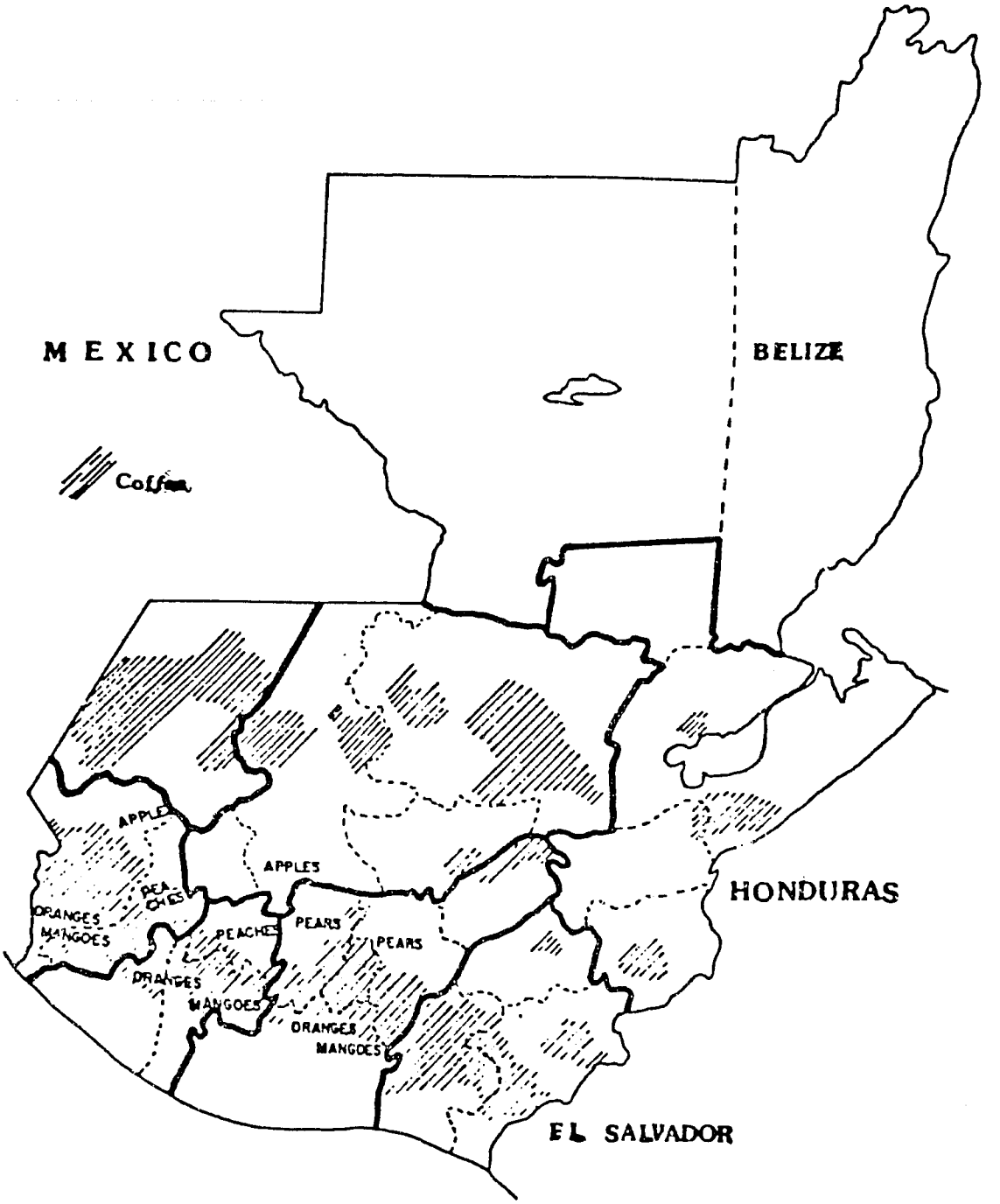

Figure VI-3. Distribution of primary commercial crops in Guatemala attacked by the medfly

Table VI-5. Medfly infestation levels in crops of lesser commercial importance (Guatemala 1987)

Crop	No. Fruit samples analyzed	No. Fruit samples infested	% Fruit samples infested
Camito (Star apple) (*Chrysophillum cainito* L.)	744	25	3.4
Bitter orange (*Citrus aurantium* L.)	20,377	116	0.6
Tangerine (*Citrus reticulata* Blanco)	5,229	111	2.1
Guavas (*Psidium guajava* L.)	7,199	95	1.3
Grapefruit (*Citrus paradisi*)	7,221	6	0.1
Tangerine lemon (*Citrus* sp.)	6,053	20	0.3
Tropical almond (*Terminalia catappa*)	1,248	22	1.8
Sapote sapodilla (*Achras zapota*)	4	0	0.0
Loquat (*Eriobotrya japonica*)	250	2	0.8
Rose apple (*Eugenia sapote*)	297	11	3.7
White sapote (*Casimiroa sapote*)	900	1	0.1
Hog plum (*Spondias purpurea*)	1,051	2	0.2

Source: Data were calculated by CICP EIA team based on MOSCAMED records from its seven ROCs

Table VI-6 shows the relation in production and value of the five most important commercial fruit hosts of the medfly in Guatemala and medfly infestation levels in 1987. (Medfly infestation levels in commercial crops of lesser importance for 1987 are shown in Table VI-5.)

Table VI-6. Production and value of the five most important medfly commercial fruit hosts and medfly infestation levels (Guatemala 1987)

Crop	1987 production (metric tons)	1987 wholesale value ($U.S.)	No.Fruit samples analyzed	No.Fruit samples infested	% Fruit samples infested
Mango	19,441	7,484,785	6,169	21	0.3
Orange	86,711	13,180,072	8,498	101	1.2
Pear	1,565	220,665	2,858	111	3.9
Peach	7,880	5,586,920	575	28	4.9
Apple	13,600	8,921,600	634	5	0.8

Source: Dirección General de Estadistica, Agricultural Census for 1979

SEPRA, S.A. 1987 estimates for 40% of the main pear, peach, and apple growing regions and extrapolation to the rest of the country for these crops

Interviews with wholesale market brokers and ECOTECNIA, Consultores Asociados projections based on 1979 agricultural census for mangoes and oranges

INDECA (National Agricultural Marketing Institute) for wholesale prices

Data on medfly infestation were calculated by CICP EIA team based on MOSCAMED records from its seven ROCS

Interpretation of the medfly infestation data in Tables VI-5 and VI-6 requires an understanding of MOSCAMED's fruit sampling procedures. One MOSCAMED fruit sample (approximately 1 kg) may contain several fruits of a given species. Average fruit numbers are as follows: oranges, 9/kg; apples, 14/kg; mangos, 9/kg; peaches, 20/kg; and pears, 14/kg. A positive find of one or more

medfly larvae in one sample is recorded as if all the fruits in the sample are infested, even though they rarely are. Therefore, the percentage infestation levels in the tables overestimate actual infestation.

The major commercial fruit crop hosts of medfly in Guatemala (mango, orange, pear, peach, and apple) are also attacked by Anastrepha fruit flies and other fruit flies (Euxesta). Table VI-7 estimates the losses (metric tons of fruit and $U.S.) that the entire fruit fly complex caused to these fruit crops in 1987. The fruit fly infestation data used to estimate losses were based on MOSCAMED records (from seven ROCs). Fruit losses were calculated by first converting each individual sample to its equivalent in number of fruit units, using regional fruit weight averages provided by MOSCAMED. Then larval infestations per sample were divided by average number of larvae per fruit species to obtain estimates of percent infested fruit.

Table VI-7 shows that medfly is a more important pest of pear and peach but Anastrepha and fruit fly relatives (Euxesta) clearly cause more losses than medfly does in the other crops.

Anastrepha has a number of economically important species. The Anastrepha complex reduces crop yields in Guatemala. Further, it prevents the export of fruits it attacks to the U.S. since the complex contains species that the U.S. quarantines.

Table VI-7. Estimates of losses to five major commercial fruit crops caused by medfly, *Anastrepha*, and fruit fly relatives (Guatemala 1987)

	Medfly	*Anastrepha*	Other fruit flies[a]
		Losses in metric tons	
Mango	138.7	10,233.2	1,669.4
Orange	365.8	11,597.1	3,664.3
Pear	328.4	0.0	9.0
Peach	405.7	214.2	129.8
Apple	0.0	162.7	35.3
		Losses in $U.S.	
Mango	53,412	3,939,780	642,706
Orange	55,608	1,762,754	556,981
Pear	46,301	0	1,276
Peach	287,627	151,867	92,040
Apple	8	106,857	23,230
Total	442,956	5,961,258	1,316,233

[a]Primarily *Euxesta*

Source: CICP EIA team, based on MOSCAMED records of fruit fly infestations

Coffee is the most important medfly host in Guatemala. However, there is no firm evidence that the medfly causes serious economic losses in coffee. The female medfly deposits her eggs in ripe coffee berries (yellow-green to yellow-red stages) after the grain (harvestable portion) has already developed. Waikwa (1979) reported that 40% of coffee berries with medfly oviposition punctures dropped prematurely. However, CICP EIA team calculations using Waikwa's (1979) data indicate that premature drop in coffee berries artificially infested with medfly was only 5.9% higher than drop in uninfested berries. Besides, Waikwa's (1979) experiment had certain limitations: he only exposed 500 berries to the medfly; the entire experiment spanned a period of only 31 days; and he did not account for natural fruit (berry) drop unrelated to medfly infestation.

Medfly losses to coffee in Latin America have been estimated at 2.0-2.5%: Nicaragua, 2% (César Estrada, Plant Protection Office Head, personal communication 1988); Mexico, 2.5% (Jesús Reyes, Mexico MOSCAMED, personal communication 1988); and FAO Plant

Protection Office for Latin America, 2.0% (Mario Vaughan, personal communication 1988). All of these estimates were based on opinions and not actual data.

The CICP EIA team developed a technique to assess medfly damage to coffee in Guatemala that is described in Appendix 4 (Experiment E7). However, there was insufficient time to subject the technique to a rigorous test in the field. One year or more would be needed to obtain medfly loss data in the field.

Because coffee is such an important crop in Guatemala, just a small loss by medfly could amount to large sums of money. In 1987, Guatemala's coffee harvest was estimated at U.S. $384,334,702. A 2% loss of this would have amounted to U.S. $7.7 million annually.

However, coffee growers (Robert Toledo and Gunther Herman, personal communication 1988) and technicians (Bernard Decazy, PROMECAFE; Manuel Castro and Eduardo Carrillo, ANACAFE; personal communications 1988) in Guatemala state that the medfly causes no noticeable reduction in coffee yields. CICP EIA team surveys showed that coffee growers and technicians in El Salvador, Honduras, and Costa Rica do not consider medfly to be an important economic pest of coffee (René Josa, FAO/El Salvador medfly program, El Salvador; Eliseo Navaro, Ministry of Agriculture, Plant Protection Office, El Salvador; Fausto Rodriguez, OIRSA, Honduras; Evaristo Morales, OIRSA, Costa Rica; Carlos Enrique Fernández, PROMECAFE, Costa Rica; Victor Pérez, CAFESA, Costa Rica; personal communications 1988). The Central American coffee grower is faced with more important problems (e.g., prices, labor, taxes, political instability, the possibility of agrarian reforms, and other pests) than the medfly.

b. Relaxing Export Constraints

According to Robert Spaide (APHIS, personal communication 1988), the following crops in Guatemala are prohibited entry into the U.S. because of the medfly: green pepper, papaya, genip, cactus fruit, naranjillo, ethrog, breadfruit, mangosteen, ceriman, dates, and litchi. None is considered to be a host of *Anastrepha* and could be allowed entry into the U.S. if the medfly was eliminated from Guatemala.

Of these crops, green peppers and papayas have had the greatest export potential up to now. The U.S. imported 18,791 metric tons of green peppers (value U.S. $7,238,000) and 4,284 metric tons of papayas (value U.S. $5,035,000) in 1985/1986. Prospects for export of dates also look promising although Guatemala does not presently produce them (U.S. Department of Commerce, TSUSA: Imports, Commodity by Country, 1984).

Dominican Republic, a country with geographical and agricultural conditions similar to Guatemala's but with a more

developed plant protection program (and no medfly), exported 4,690 metric tons of green peppers (value U.S. $1.5 million) and 162 metric tons of papayas (value U.S. $69,000) to the United States in 1984 (U.S. Department of Commerce, TSUSA: Imports, Commodity by Country, 1984).

Elimination of the medfly from Guatemala would probably be an incentive for Guatemala exporters to seek U.S. markets, especially for green pepper and papaya. ECOTECNIA (1985) estimated that this new export market would amount to U.S. $1.5 million per year (based on 1985 prices) for Guatemalan exporters.

c. Aggregate Benefits

The aggregate benefits include political and human capital gains.

MOSCAMED has strengthened Guatemala-Mexico relationships in agriculture. It has stimulated regular exchange of information and regular visits between officials and technicians of the two countries. Mexico contributes a large number of sterile medflies to the Guatemala MOSCAMED program. Continuation of the cooperative medfly eradication effort has political value in strengthening relations between the two countries.

Human capital benefits must also be considered. Guatemala MOSCAMED has provided training in medfly control for numerous Guatemalans. These individuals represent a valuable resource. Their training and experience have contributed to increasing Guatemala's overall capacity in pest management.

d. Direct Program Benefits

MOSCAMED has benefited Guatemala directly by creating employment. In May 1988, the MOSCAMED program employed 1,000 Guatemalans, about half the number it employed in early 1987 (see A.7.a.). Benefits from employment, which include a multiplier effect, would continue to accrue as long as the eradication program existed.

Wage effects are equal to wages paid in the MOSCAMED program, times multiplier, plus wages paid minus average wages in comparable activities, times the multiplier (Gerald Carlson, North Carolina State University, personaL communication 1988). This can be stated thus:

$$WE = (WP * U * M) + (WP - CW) * M$$

WE = wage effects; WP = wages paid by MOSCAMED;
U = unemployment rate; M = national multiplier;
CW = wages that are paid in comparable activities.

From January 1987 to February 1988, Guatemala MOSCAMED paid an average of U.S. $208,098 in monthly wages; this amounted to a yearly total of U.S. $2,497,183. Average wages paid for somewhat similar work, based on Labor Ministry figures, would have been about 72% this amount, or U.S. $1,797.972. The multiplier estimated by the Bank of Guatemala is 2.98. Estimated yearly employment benefits from the Guatemala MOSCAMED program were about U.S. $3,021,910. Similar benefits would be expected every year of the eradication effort, assuming wage levels, unemployment rates, and multiplier effects stayed constant.

9. Estimated Costs

Costs of eradication would be both direct and indirect. Direct costs would be costs needed to run the program. Indirect or "external" costs would be costs such as fruit stripping.

Tables VI-8, VI-9, and VI-10 present direct cost estimates for options one, two, and three of program one and include costs of sterile medflies to be contributed by Mexico.

Table VI-8. Direct program costs under option one (4-year eradication plan) of program one, in U.S. $1,000

Cost Category	Year 1	Year 2	Year 3	Year 4	**Total**
1. Trapping	700	800	900	900	**3,300**
2. Fruit sampling	300	390	480	570	**1,740**
3. Aerial chem contr.	1,000	1,500	1,500	750	**4,750**
4. Ground chem. contr.	960	960	1,280	1,090	**4,290**
5. Fruit destruction	120	150	180	180	**630**
6. Regulatory control	240	240	240	160	**880**
7. Sterile fly releases	400	500	600	600	**2,100**
8. Sterile fly production (Guatemala)	800	1,000	1,000	1,000	**3,800**
9. Sterile fly contributions (from Mexico)	800	1,000	1,400	1,400	**4,600**
10. Technical support	300	410	500	300	**1,510**
11. Management	400	450	450	450	**1,750**
12. Unforeseen (10%)	602	740	853	740	**2,935**
Total	**6,622**	**8,140**	**9,383**	**8,140**	**32,285**

Sources:
- Items 1-8, 10, and 11 from MOSCAMED 1987
- Item 9 estimated by CICP on the basis of Guatemala medfly rearing costs
- Item 12 estimated by CICP
- All values in constant dollars of 1987 and assuming an exchange rate of Q.2.50 per U.S. $1.00

Note:
- Public education, monitoring, and mitigative measure costs are not included due to lack of information on specific program design

Table VI-9. Direct program costs under option two (5-year eradication plan) of program one, in U.S. $1,000

Cost Category	Year 1	Year 2	Year 3	Year 4	Year 5	**Total**
1. Trapping	660	700	760	900	900	**3,920**
2. Fruit sampling	240	300	360	450	570	**1,920**
3. Aerial chem. contr.	750	750	750	1,500	750	**4,500**
4. Ground chem. contr.	960	960	960	1,280	1,090	**5,250**
5. Fruit destruction	120	120	120	180	180	**720**
6. Regulatory control	240	240	240	240	160	**1,120**
7. Sterile fly releases	400	450	500	500	600	**2,450**
8. Sterile fly production (Guatemala)	800	800	1,000	1,000	1,000	**4,600**
9. Sterile fly contributions (from Mexico)	800	1,000	1,000	1,000	1,400	**5,200**
10. Technical support	300	300	350	500	300	**1,750**
11. Management	400	400	450	450	450	**2,150**
12. Unforeseen(10%)	567	602	649	800	740	**3,358**
Total	**6,237**	**6,622**	**7,139**	**8,800**	**8,140**	**36,938**

Sources:
- Items 1-8, 10, and 11 from MOSCAMED (1987)
- Item 9 estimates by CICP on the basis of Guatemala medfly rearing costs
- Item 12 estimated by CICP
- All values in constant dollars of 1987 and assuming an exchange rate of Q.2.50 per U.S. $1.00

Note:
- Public education, monitoring, and mitigative measure costs are not included due to lack of information on specific program design

Table VI-10. Direct program costs under option three (6-year eradication plan) of program one, in U.S $1,000

Cost Category	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	**Total**
1. Trapping	660	700	760	860	900	1,000	**4,880**
2. Fruit sampling	240	300	360	450	510	540	**2,400**
3. Aerial chem. contr.	750	500	750	1,000	400	400	**3,800**
4. Ground chem. contr.	960	830	960	1,050	890	890	**5,580**
5. Fruit destruction	120	120	120	180	90	90	**720**
6. Regulatory contr.	240	240	240	240	190	160	**1,310**
7. Sterile fly releases	400	450	500	500	550	550	**2,950**
8. Sterile fly production (Guatemala)	800	800	1,000	800	1,000	1,000	**5,400**
9. Sterile fly contributions (from Mexico)	800	1,000	1,000	1,200	1,200	1,200	**6,400**
10. Technical support	300	300	350	500	300	300	**2,050**
11. Management	400	400	450	450	450	450	**2,600**
12. Unforeseen(10%)	567	564	649	723	648	658	**3,809**
Total	**6,237**	**6,204**	**7,139**	**7,953**	**7,128**	**7,238**	**41,899**

Sources:
- Items 1-8 10, and 11 from MOSCAMED (1987)
- Item 9 estimated by CICP on the basis of Guatemala medfly rearing costs
- Item 12 estimated by CICP
- All values in constant dollars of 1987 and assuming an exchange rate of Q.2.50 per U.S. $1.00

Note:
- Public education, monitoring and mitigative measure costs are not included due to lack of information on specific program design

Of external costs, only regulatory control costs (fruit confiscation and destruction) could be quantified and were estimated at U.S. $544,346 for 1987. These costs would increase as the MOSCAMED program spread into larger areas, but to what extent cannot be predicted.

As an eradication program proceeded east through Guatemala, movement of fruit from medfly infested to medfly free areas would increase and so would the need for quarantines and their associated external costs. Presently, most fruit produced in the medfly infested area is consumed in that area. Therefore, disruptions in trade patterns are small. A major increase would occur when Guatemala City, the country's major consumer of fruit, was liberated from medflies. Costs due to trucking delays would increase, as traffic lines formed at quarantine stations. As delays became more serious, parallel service facilities might be needed. These costs would have to be borne throughout the entire eradication campaign.

Under option two (5-year eradication plan), indirect costs would be borne for one more year (5 versus 4 years) than they would be in option one (4-year eradication plan). Some reductions would take place as a consequence of reduced pesticide use each year, but on the whole, indirect costs could be 20% greater under option two.

Option three (6-year eradication plan) would take 50% more time than option one would, which means that indirect costs would be increased almost proportionally. Pesticide use per year would be less, but overall use would increase under option three. Indirect costs under option three might be 40% higher than indirect costs under option one.

Both direct and indirect costs would be reduced significantly under option one.

Total costs of option one are estimated at U.S. $32.3 million; option two U.S. $36.9 million; and option three U.S. $41.9 million. Estimated indirect costs of option one would be 80-88% smaller than in option two and 67-77% smaller than in option three, depending on whether cost or time proportions are used. Estimated indirect costs in option two would be between 80-88% smaller than in option three. In addition, unless the medfly is also eradicated from El Salvador and Honduras, an estimated U.S. $6.87 million would be needed annually to maintain a medfly barrier at the Guatemala-El Salvador-Honduras border (see B.8.).

10. Technological Limitations

Successful medfly eradication would depend on many factors. For program one to achieve successful country wide eradication, the following assumptions must be met (these assumptions were used to derive estimates of insecticide use, sterile medfly requirements, personnel needs, costs, etc., presented for the various options):

* Medfly control technology and knowledge of its use is sufficient to achieve eradication

* The eradication technology would provide consistent results with no loss of effectiveness

* Medfly populations at the beginning of the eradication effort (i.e., at the beginning of the 4, 5, or 6 year effort, depending on the option chosen) would not exceed the levels of 1987 or occur in areas not infested in 1987

* Any unforeseen problems resulting from budget cuts, inconsistent releases of funds, inclement weather, earthquakes, political disturbances, workers strikes, etc., would not delay completion of the eradication effort

* Monitoring and education programs would help meet all needs required for success

* The quarantine program would prevent reinfestation of medfly free zones

* Prices for program inputs and resources, and prices for crops saved, would remain the same

* At the end of the program neighboring countries to the south of Guatemala would have to undertake an eradication effort or Guatemala would have to maintain a long term barrier at its border to prevent reinfestation.

In 1988, the medfly free and post eradication zones were reinfested and reached levels similar to those of 3 years earlier. Guatemala MOSCAMED blamed the increases on its inability to carry out the full scale eradication program needed because of: (1) AID's freeze on use of PL 480 funds until this EIA is completed; (2) decline in value of Mexican peso and delays in receiving Mexican funds; (3) directive by U.S. Congress to limit the medfly control activities; and (4) limited disbursement of funds from APHIS. (APHIS disbursement of funds was consistent with the continuing resolution allocation of U.S. $1.9 million.

Once the budget allocation was approved, in late January 1988, disbursements were made at revised levels. Robert Spaide, APHIS, personal communication 1988.) Strikes by labor unions, drastic personnel reductions, and low morale among employees have accompanied the reduced eradication effort. (MOSCAMED 1987, 1988; Franz Hentze, Guatemala MOSCAMED, personal communication 1988). Bureaucratic and institutional problems such as these can seriously limit the effectiveness of an eradication effort.

Another serious limitation to the eradication effort is the quarantine program. Curbing all movement of medfly infested fruits and vegetables into medfly free zones is probably not possible as long as other Central and South American countries are infested with medflies. The U.S. quarantine program has not been able to keep the medfly out of the U.S. mainland. The medfly has entered the U.S. mainland many times despite a very intensive and costly APHIS vigilance at all international airports and seaports (USDA-APHIS 1985).

Eradication of the medfly from Guatemala and for that matter, all of Mexico and Central America, will not eliminate the threat of the insect entering the U.S. Guatemala is currently responsible for only a small percentage of the total medflies intercepted at the U.S. mainland ports (see Table VI-11).

Table VI-11. Medfly interceptions at U.S. mainland ports 1977-1988

Origin	Number interceptions	% of total
Africa	3	.32
Algeria	2	.21
Argentina	8	.86
Azores	20	2.15
Bahrain Island	1	.11
Bolivia	2	.21
Brazil	23	2.47
Central America	1	.11
Colombia	4	.43
Costa Rica	11	1.18
Cyprus	7	.75
Ecuador	5	.54
Egypt	13	1.40
El Salvador	11	1.18
Europe	3	.32
France	8	.86
Ghana	10	1.07
Gibraltar	1	.11
Greece	50	5.37
Guatemala	12	1.29
Hawaii	183	19.65
Honduras	1	.11
Iran	3	.32
Israel	59	6.34
Italy	190	20.41
Jordan	12	1.29
Kuwait	1	.11
Lebanon	11	1.18
Liberia	4	.43
Libya	2	.21
Madagascar	1	.11
Madeira Islands	2	.21
Malta	1	.11
Mexico	1	.11
Middle East	1	.11
Morocco	1	.11
Nigeria	10	1.07
Oman	1	.11
Pakistan	1	.11
Panama	3	.32
Peru	14	1.50
Portugal	162	17.40
Qatar	1	.11
Saudi Arabia	3	.32

Origin	Number interceptions	% of total
Sierra Leone	4	.43
South Africa	1	.11
South America	2	.21
Spain	20	2.15
Syria	1	.11
Thailand	1	.11
Tunisia	2	.21
United Kingdom	1	.11
Unknown	28	3.00
Venezuela	5	.54
Yugoslavia	2	.21
Zambia	1	.11
TOTAL	931	99.99

Source: APHIS computer database on medfly interceptions at U.S. ports, supplied by Robert Spaide 1988

Finally, if the medfly were eradicated in Guatemala, the farmers would still be confronted with Anastrepha. This complex of fruit flies attacks some of the same fruits as the medfly. If Guatemala were free of medfly, it still could not export these fruits to the U.S.

B. PROGRAM TWO (STABLE BARRIER ALTERNATIVE)

1. Barrier Concept

Program two would attempt to create and maintain a permanent Mesoamerican medfly barrier to deter northern spread of the insect. The barrier would consist of two parallel zones--the southeastern "eradication zone" and the northwestern "high risk zone"--extending across Mexico (barrier one) or Guatemala (barriers two and three) shown in Figure IV-4.

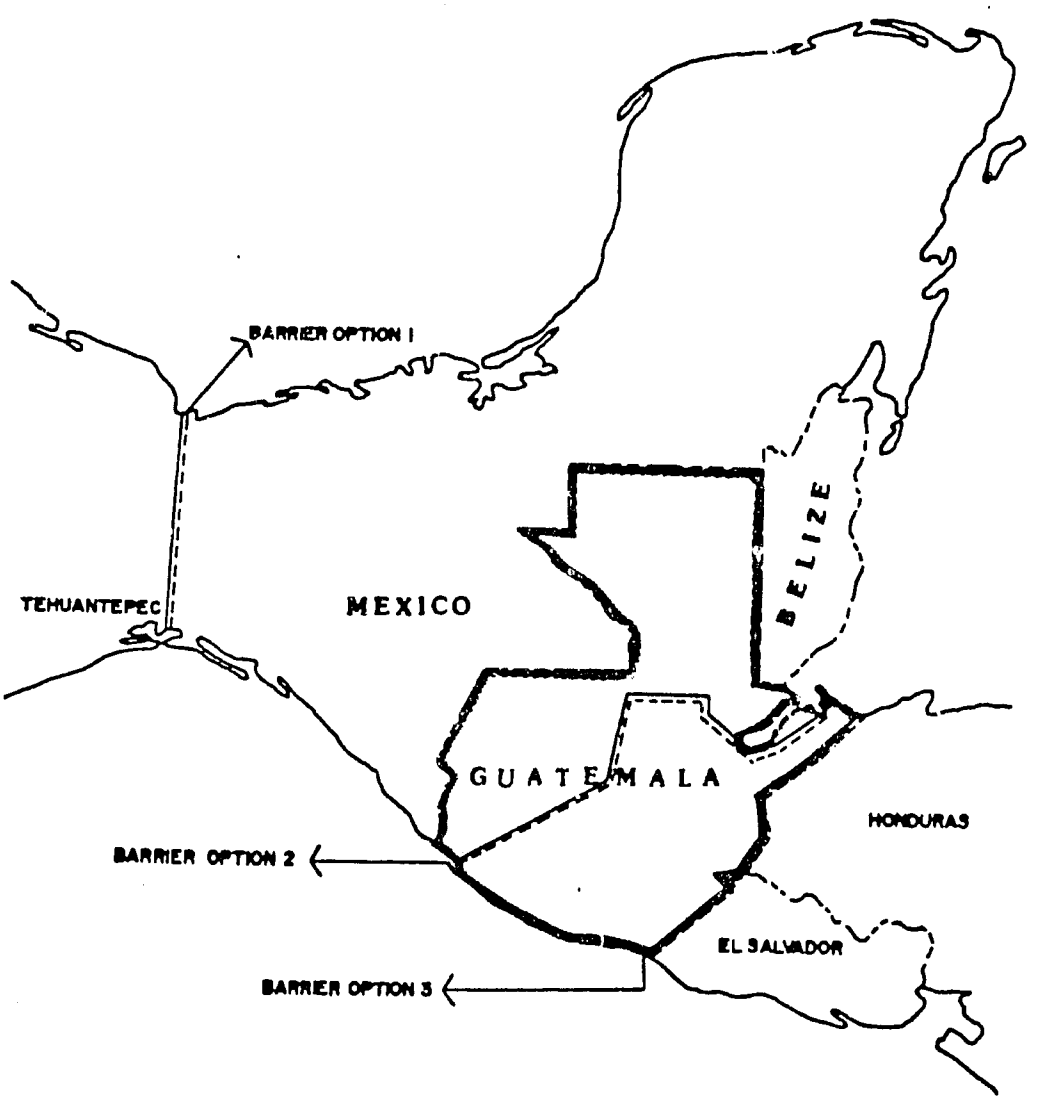

Figure VI-4. Location of three barriers proposed to deter northern spread of the medfly

The eradication zone would receive ground and aerial applications of malathion bait spray, high density releases of sterile medflies, intensive medfly monitoring, and fruit destruction aimed toward complete annihilation of the medfly. The zone would be 30-km wide. Thirty kilometers is proposed since this is twice the estimated maximum distance an adult medfly can travel during its life time, if assisted by wind, according to Gutiérrez Samperio (1976), although dispersal estimates vary.

The high risk zone, abutting the eradication band to the north, would be 75-km wide in an area where the medfly had been eradicated or had not previously existed. It essentially would be treated the same way the post eradication zone (see PART III, A.) is now treated in the MOSCAMED program since it would be close to infested areas and highly susceptible to medfly invasion. Actions in the high risk zone would include rigorous monitoring (medfly trapping and fruit sampling) and selective use of malathion bait spray and sterile males to eliminate any medfly infestations detected.

2. Proposed Barrier Locations

Choice of location of the stable barrier would depend on numerous factors, including: (1) status of medfly and organized efforts to eradicate it, (2) geography and topography, (3) logistics, including access by control and survey crews, etc., (4) medfly host abundance, (5) crops saved and lost, (6) climate, and (7) location of environmentally fragile or protected areas. The three barrier locations below are presented for purposes of allowing relative comparisons of the locations. The CICP EIA team did not make detailed studies of the potential environment, human, or social impacts of any one barrier location.

a. Barrier One (Isthmus of Tehuantepec)

The Isthmus of Tehuantepec barrier would extend from just slightly south of the town Tehuantepec on the Pacific coast to the town Coatzacoalcos on the Atlantic coast (a distance of approximately 210 km). This area is approximately 325 km northwest of Guatemala. It is approximately 275 km north of the area in Chiapas, Mexico infested by the medfly prior to the eradication effort of Mexico MOSCAMED. The medfly did not infest the area between Tehuantepec and Coatzacoalcos any time before or during the Mexico MOSCAMED eradication efforts.

b. Barrier Two (mid-Guatemala)

The mid-Guatemala barrier, which would essentially encompass the present Guatemala MOSCAMED eradication zone (see PART III, A.), would aim at confining the medfly to the area it presently occupies in Guatemala.

c. Barrier Three (Southern Guatemala Border)

The southeastern Guatemala border barrier would run the entire length of the southern Guatemalan border abutting El Salvador and Honduras.

Table VI-12 provides the length and area of the three proposed medfly barriers.

Table VI-12. Characteristics of the three proposed medfly barriers

	Barrier: One (Tehuantepec)	Two (Mid-Guat.)	Three (So. Guat. Border)
Eradication Zone (barrier proper)			
Length (km)	210	479	326
Area (1,000 ha)	600	1,437	978
High Risk Zone			
Area (1,000 ha)	1,968	4,400	3,500

3. Control Tactics

Two types of suppression strategies would be utilized in the barrier: continuous suppression and outbreak suppression, respectively, in the eradication and high risk zones.

a. Continuous Suppression in Eradication Zone

(1) Monitoring: One Jackson medfly trap per 1-4 km^2, with weekly inspections; one fruit sample (average 0.5 kg) per km^2 per week.

(2) Malathion bait spray: Aerial strip spray as described for program one (A.1.a.). Supplementary ground application and use of the corncob baits (olotes), as described for program one (A.1.a.), when aerial applications were impractical (i.e., during rainy season, on small farms, and in villages).

(3) Sterile insect technique: An average of 2,500 sterile medflies released per hectare per week. Actual number would depend on the quality of flies being released.

(4) Fruit destruction: As described for program one (A.1.c.).

b. Outbreak Suppression in High Risk Zone

(1) Monitoring: One or more medfly traps per square kilometer, inspected weekly; from 10-20 fruit samples (average 0.5 kg) per km^2.

(2) Malathion bait spray: Selective ground or aerial applications, as appropriate.

(3) Sterile insect technique: Ground and aerial releases, as appropriate.

(4) Fruit destruction: As described for program one (A.1.c.).

4. Regulatory Control Requirements

Effective quarantine programs would be essential to the medfly barrier. Both the southern and northern boundaries of the eradication zone would need to be guarded heavily by quarantine inspections and treatment stations. All traffic and commodities entering the eradication zone from the south and all traffic and commodities exiting (either from the eradication zone or the high risk zone) for points north would be subjected to inspection and treatment. The materials and procedures used in the quarantine program would be the same as for program one (see A.2.).

5. Public Education/Relations Campaign

Residents in the barrier zone would continually be subject to all control techniques, yet would receive minimal benefits. Controversy about the health effects of repeated malathion bait spray, the intrusiveness of monitoring and detection activities, losses due to fruit destruction, and time loss and aggravation from quarantine facilities are among the objections that residents would have to locating a stable barrier near them. The public education and relations needs for the stable barrier alternative would differ considerably from a program that progressed in geographical increments.

a. Affected Population

All residents in the barrier zone and persons who frequently traveled across the barrier would be regularly affected. Special

education and public relation campaigns should be developed for such groups. Tourists, especially at overland border crossings, should be advised of the program before reaching quarantine stations. Others, such as truck drivers, should be identified a, treated as potential special groups.

b. Participation

The public should be involved in selecting the barrier site. Public input into site selection would reduce resentment and mitigate opposition.

c. Timing

A public information program should address the stable barrier alternative before its location is determined. Early discussion of the location of quarantine facilities is particularly important. Patterns or alternate routes selected may make sense in maintaining the barrier, but may seriously disrupt traffic flows.

Special public relations campaigns may be necessary at certain times during the year: prior to spraying, during holiday periods, etc.

d. Scope

Residents of barrier zones should have detailed information about the chemicals used, possible effects, symptoms from over-exposure, spraying patterns, effects of the bait spray, etc. Greater understanding will lead to increased acceptance of the barrier control tactics. A mass media public relations campaign should be instituted for the general population most affected by quarantines; travel from south to north would be quarantined, therefore a strong campaign should be conducted south of the barrier. Broad coverage is especially important prior to holidays, when traffic is heaviest, for the quarantine operations to be effective.

e. Dissemination

Systems to disseminate information in major Guatemalan languages where the barrier will be located is essential. A high degree of personal contact, in addition to mass media, is necessary. Special groups such as tourists should be targeted in appropriate ways. Large tourist groups (e.g., buses) in transit through barrier zones should have a verbal explanation of regulatory activities before arriving at quarantine stations.

f. Monitoring and Evaluation

Residents' reactions to all phases of control operations should be monitored and concerns continually identified and addressed. The public's cooperation, especially with regulatory controls, is essential for a barrier to be effective.

6. Project Personnel

a. Requirements

Fewer personnel would probably be needed to execute a stable barrier program than an eradication program. While detection activities would be extensive, control operations would be limited to a more specific range requiring less staff. However, because of the importance of quarantines, quarantine personnel would be expected to increase. A well trained cadre of quarantine personnel would have to be maintained and their work schedules changed to three 8 hr. shifts.

Other personnel needs would depend on the specific medfly barrier selected.

b. Training

Quarantine personnel should be trained to be effective managers and to deal with conflicts at the quarantine stations. Inspections need to be rigorous to ensure the best possible protection of the barrier. Workers in charge of fumigation and vehicle treatment should be trained initially, periodically evaluated, and given updated training on pesticide use and safety.

7. Potential Program Benefits

Stable barrier benefits of program two fall into the same categories as for program one (see A.8.).

Crop and pest control savings would be greater for the Guatemala border barrier option (three) than the other options. Medfly losses in mangoes, oranges, peaches, apples, pears, and other medfly hosts (tangerines, guavas, caimitos, bitter oranges, grapefruits, wild almonds, and others) would cease in the border barrier option. Medfly inflicted losses in commercial crops are estimated at U.S. $0.43 million (see A.8.a. and Table VI-7).

Export benefits would probably accrue in the border barrier (three) but not in the mid-Guatemala option (two). USDA's export policies would apply to the "buffer" zones adjacent to medfly barriers (zones from which no exports of restricted medfly hosts to the U.S. are allowed, due to proximity to medfly infested areas). Exports to the U.S. from the buffer zones may not be

allowed. (Edward Stubbs and Patrick Gomes, APHIS Guatemala, personal communication 1988). The CICP EIA team estimated that commercial fruit saved in the medfly liberated area would have a value of U.S. $71,000 for the mid-Guatemala barrier option.

A buffer zone would eliminate a percentage of the potential export benefits. Guatemala is only 250 km wide on the Pacific side; a 25 km buffer adjacent to the border barrier would reduce 10% of the export benefits. A 200 km buffer would reduce export benefits to 20% of total. A buffer of more than 75 km would eliminate all benefits from the Zacapa valley area. A buffer of 150 km would eliminate all benefits from the Salama-San Jeronimo region as well.

Export benefits would be smaller in program two (medfly barrier) than in program one (medfly eradication). Under the mid-Guatemala option, the benefits would tend to disappear completely if USDA established a buffer zone for export compliance.

Aggregate benefits (political and human capital) would accrue under all options of program two. In fact, because the barrier is a permanent proposition, potential aggregate benefits are largest under program two. Guatemala would continue its cooperative program with Mexico. In addition, Guatemala would continue to realize benefits from personnel trained in the MOSCAMED program. The personnel could work on the barrier maintenance permanently.

Employment benefits would also accrue to Guatemala permanently under the two Guatemala options. These benefits are estimated, as in the eradication alternative, at about U.S. $3.0 million per year, assuming labor costs in the barrier alternatives are approximately the same.

8. Estimated Costs

Cost are divided into two categories: direct and indirect. Direct costs fall in two categories: an "investment" cost, or what it would cost to create the barrier; and an "operating" cost, or what it would cost to permanently maintain the barrier.

Investment costs for the Isthmus of Tehuantepec and mid-Guatemala barriers would be practically zero; because of the Guatemala MOSCAMED program, the barrier is basically already in place. Investment costs for the border barrier would be eradication costs for Guatemala, estimated at U.S. $32.3 million in four years (Table VI-13). Longer-term cost estimates are not available.

Table VI-13. Annual operating costs for stable barrier options two and three (U.S. $1,000)

Item	Barrier: One (Tehuantepec)	Two (Mid-Guat.)	Three (So. Guat. Border)
1. Trapping and surveillance	421	800	800
2. Fruit destruction	137	260	260
3. Malathion bait sprays	263	500	300
4. Sterile fly rearing (Guatemala)	526	1,000	1,000
5. Sterile fly release	421	800	400
6. Regulatory Controls	126	240	160
7. Public Communications	106	200	200
8. Management	158	300	250
9. Sterile fly rearing (Mexico)	1,842	3,500	3,500
Total	**4,000**	**7,600**	**6,870**

Source: Guatemala MOSCAMED (Franz Hentze, APHIS personal communication 1988)

Public communication costs were based on Guatemala MOSCAMED's current costs in this category

Barrier one costs estimated by CICP EIA team

Costs are estimated at U.S. $4.0 million for the Isthmus of Tehuantepec barrier (Jesús Reyes, Mexico MOSCAMED, personal communication 1988). This barrier would be the least costly of the three proposed barriers because it is the shortest (210 km) and the range of potential crops is smaller.

The main cost limitation under both Guatemala barrier locations is that operating costs would have to be borne permanently, or at least until Honduras and El Salvador began their own eradication program and eliminated the medfly from Guatemala border areas.

External costs (harm to the environment and human health, etc.) would have to be borne permanently under all barrier options. The same kind of external costs discussed in Part IV would be expected with any of the three options.

9. Possible Technological Limitations

The same kinds of limitations discussed for program one apply here (see A.10.).

10. Pesticide Monitoring

Pesticide use and impact on human health and environment would be monitored on a continuous basis in program two. Monitoring would take place inside the full length of the barrier. Limited sampling should also take place outside the barrier to measure pesticide impacts in the environment and for comparison.

11. Measure of Success

A barrier would be considered successful if the medfly did not move north beyond the high risk zone (criteria proposed by CICP EIA team based on consultations with various medfly control experts).

C. PROGRAM THREE (NONCHEMICAL PEST MANAGEMENT)

Program three would attempt to manage (not eradicate) the medfly in Guatemala using nonchemical tactics. The program would use a combination of nonchemical tactics to keep the medfly to acceptable levels. The program would proceed using one of three options.

1. Program Options

a. Option One: Nonchemical Pest Management Barrier

The nonchemical barrier option would attempt to keep the medfly at 1987 levels in the medfly free and post eradication zones (see A.). In other words, this is a barrier option similar to the barrier alternative proposed for program two (see B.) except it would exclude all pesticides. All uses of pesticides (both field and quarantine station uses) would be stopped and replaced with nonchemical methods.

The methods would include release of sterile medflies, all available cultural controls (see PART III, C.), biological control agents (see PART III, E.2.), and all available nonchemical regulatory controls (stripping and confiscating and burning or burying fruit, and U.S. approved nonchemical postharvest quarantine methods, e.g., hot water treatment, that

may become available). In addition, the same medfly monitoring procedures of program one (see A.4.) would be used.

b. Option Two: Crop Specific Pest Management

This option would restrict the management effort to major non-coffee medfly hosts with good commercial potential and high susceptibility to medfly attack: pear and peach. The objective would be to keep field infestations of medfly to a minimum in these crops.

The methods would include release of sterile medflies, all available cultural controls (see PART III, C.), biological control agents (see PART III, E.2.), and all available nonchemical regulatory controls (stripping and confiscating and burning or burying fruit, and U.S. approved nonchemical postharvest quarantine methods, e.g., hot water treatment, that may be available. In addition, the medfly monitoring procedures of program one (see A.4.) would be used.

Management of medfly under option two would not attempt to contain the medfly within Guatemala; Mexico would be required to use the sterile medflies it presently donates in maintaining its own barrier. Guatemala does not produce sufficient numbers of sterile medflies to carry out a Guatemala wide SIT attack on medfly in coffee. However, medfly losses to coffee are very low or nonexistent in this crop (see A.8.a.), so the bulk of sterile medflies would be used against medfly in the other crops (primarily pear and peach) and not coffee.

c. Option Three: Combination Nonchemical Barrier and Crop Specific Pest Management

Option three is a combination of the first two options. The option would attempt to maintain a medfly free barrier and also protect the major crops identified in option two.

The methods would include release of sterile medflies, all available cultural controls (see PART III, C.), biological control agents (see PART III, E.2.), and all available nonchemical regulatory controls (stripping and confiscating and burning or burying fruit, and U.S. approved nonchemical postharvest quarantine methods, e.g., hot water treatment, that may become available). In addition, the same medfly monitoring procedures of program one (see A.4.) would be used.

The sterile medflies from Mexico would be needed as long as the barrier was maintained.

2. Control Tactics

a. Sterile Insect Technique

SIT would be the primary medfly suppression tactic in all three program options. The sterile flies should be released at a ratio (sterile flies:wild flies) of 200:1 or more if enough flies were available. However, evaluation of the relationship between trap catches and the density of wild populations in Guatemala is necessary to insure the effectiveness of released sterile flies. The releases would begin when medfly populations were at the lowest seasonal levels (toward end of the rainy season). The greatest demand for the sterile medflies would be in two primary coffee growing areas: in the Pacific piedmont, from the Mexican border to Mazatenango; and the area around Cobán and the Polochic watershed. In option one, up to a billion medflies per week would be required. In option two, the program would use whatever numbers Guatemala could produce (currently 200 million flies per week). In option three the requirement for sterile medflies would be greatest, up to 1.2 billion per week, the maximum number that the Guatemala and Mexico facilities combined can produce. To achieve maximum production, Mexico would need to invest over U.S. $0.4 million in renovating equipment. Then, Mexico would need to invest U.S. $0.15 million more per year than present for personnel (Jesús Reyes, Mexico MOSCAMED, personal communication 1988).

Under options one and three, Mexico MOSCAMED might want to continue to contribute sterile medflies, that is if Mexico accepted the barrier concept as being effective. There would be little incentive for Mexico MOSCAMED to contribute the sterile insects under option two.

Regardless of option, the sterile medfly requirement would be significantly greater than current needs and might exceed Guatemala's and Mexico's present capability combined. Although the Mexico rearing facility is designed to produce 1 billion sterile medflies per week, present production is about half this (see PART III, A.3.).

b. Cultural Practices

Cultural control (See PART III, C.) would be a primary method of medfly suppression in all three options.

c. Research Needs

A significant factor constraining the nonchemical management strategy is lack of understanding of medfly behavior and population dynamics in Guatemala. Lack of Guatemala experience with some of the potentially effective nonchemical methods (e.g., parasitoids and pathogens) further constrains the nonchemical

management strategy. A new research program to obtain information on medfly behavior and find effective new nonchemical methods is needed. Further, guidelines on economic thresholds must be developed to show when medfly control is needed on various crops and when it is not.

3. Regulatory Control

Maintaining an effective quarantine program would be essential in all program options. However, where program one would use methyl bromide and d-phenothrin for quarantine treatment, program three would depend on nonchemical methods. Presently, nonchemical methods include stripping (from fruit trees) and confiscating (from persons passing through quarantine stations) and burning or burying fruit. Other nonchemical methods such as use of U.S. approved hot water treatment would be used if they became available.

4. Medfly Monitoring

The two methods of medfly monitoring, trapping and fruit sampling, would be used in this program. Monitoring in the medfly free and post eradication zones in program options one and three would be identical to monitoring described in these zones in program one (A.4.).

5. Public Education and Relations

Nonchemical control methods require greater public participation than any of the other control methods. Education is particularly important since new cultural practices must be widely adopted for nonchemical management to succeed. Farmers must clearly see program benefits before they intensify labor for fruit stripping, field sanitation, and other cultural practices. The public must have a clear idea that the released sterile medflies are not a health hazard to people or animals. Finally, strong cooperation with quarantines is important for program success.

a. Affected Population

Residents living in control zones and travellers passing through quarantines will be affected. Both broad based mass media and extensive contact with individual farmers should be used to alter cultural practices.

b. Participation

Special training programs to advise farmers on altered cultural practices, with regular followup, are necessary. Participation of the local population should be planned so as to minimize demands on their time during peak labor periods.

Special contact should also emphasize farmers who will suffer substantial losses from altered farming practices such as fruit stripping. Crop specific programs can emphasize direct contact with producers. Broader based nonchemical control programs must involve the general public.

c. Timing

Many aspects of nonchemical control programs cannot be rapidly implemented. Therefore, public education should be initiated as early as possible to prepare the public for these activities.

d. Scope

The scope of public education must be sufficiently broad to explain the basic rationale of all nonchemical control methods, especially the sterile insect technique and cultural controls. Farmer participation will be much greater if farmers understand what they are being asked to do, why, and the results anticipated. Broad based campaigns should explain the purpose of quarantines and fruits to be confiscated.

e. Dissemination

Mass media techniques, especially radio, can increase the public's awareness of the program. Programs should be developed to capitalize on all opportunities for using mass media.

f. Monitoring and Evaluation

While participation may be high in the initial phases of the program, lack of visible progress may lead people to conclude that the program is not working. An effective monitoring and evaluation program can detect changes in perceptions and help to mitigate their impact.

6. Measures of Success or Failure

The program would be considered successful if the medfly did not move north beyond the high risk zone under options one and three (criteria proposed by CICP EIA team based on discussion with various medfly control experts). There are no criteria for evaluating success and failure under option two since economic thresholds are not available for medfly on different crops (theoretically, marginal control expenditures would equal marginal crop returns).

7. Project Personnel

a. Requirements

Program three would need more personnel than any of the programs. The component of the program emphasizing cultural controls would require a significant increase in operations personnel. Further, an effective public education staff would be essential. Exact personnel needs are not presently known, however.

b. Training

Training of professional staff would be necessary for a nonchemical control program emphasizing SIT. The expanded rearing facility, medfly release program, and research to improve rearing will require a cadre of expertise presently unavailable. A formal training program for staff involved in rearing and releasing is essential.

The cultural control program would have to assure that workers received adequate training to assist farmers with agricultural questions or problems or to refer them to appropriate authorities (e.g., agricultural extension agents). Otherwise, the program would be jeopardized by negative farmer reactions and lack of cooperation.

8. Program Benefits

The potential unique benefit of program three, when compared to either program one or two, is that it would eliminate the threat (both real and perceived) associated with chemical pesticides. All program options offer this potential benefit. Other potential benefits are as follows:

a. Option One: Nonchemical Pest Management Barrier

The benefits would essentially be the same as for program two, option two (mid-Guatemala barrier; see B.7.) providing the nonchemical barrier was effective.

b. Option Two: Crop Specific Pest Management

The benefits cannot be assessed because the level of crop protection expected by sterile releases and cultural practices in commercially important crops is not known.

c. Option Three: Combination Nonchemical Barrier and Crop Specific Pest Management

The benefits would be the same as for option one, plus whatever benefits would be derived from option two.

9. Program Costs

a. Option One

Program costs would be similar to those of program two, option two (mid-Guatemala barrier) minus the pesticide-related costs plus increased sterile insect production and release costs.

b. Option Two

Program costs would be roughly similar to those of the mid-Guatemala barrier minus pesticide related costs.

c. Option Three

It is not possible to appraise these costs due to lack of information on requirements for sterile medflies.

10. Technological Limitations

A major nonchemical program as proposed here has not been previously launched against the medfly. Therefore, the results cannot be realistically predicted.

A significant constraint to the nonchemical alternative relates to lack of understanding of the medfly's behavior and population dynamics in Guatemala. Quantitative information on the insect's seasonal distribution and abundance in various hosts and habitats, naturally occurring biological control, and flight characteristics is limited. Without this information, it is impossible to design the most effective pest management program.

A second significant constraint relates to limited information on the effectiveness of the nonchemical methods used alone and in various combinations.

D. PROGRAM FOUR (NO ACTION)

In the no action program, the Guatemala MOSCAMED medfly eradication program would be terminated and not replaced by any of the alternatives. Guatemala MOSCAMED would discharge all workers. All physical assets accumulated in the MOSCAMED program would be reclaimed by USDA-APHIS and Mexico under the current agreement, unless donated to the Guatemala government. If they stayed in Guatemala, the vehicles, laboratory equipment, and office equipment could be transferred to other programs. Perhaps the most difficult problem in reallocating the physical assets would relate to the medfly rearing facility at San Miguel Petapa.

Termination of the Guatemala MOSCAMED program would result in Guatemala severing its medfly eradication agreement with Mexico and the U.S. If Guatemala abandoned the effort, Mexico

likely would establish a medfly barrier at the Isthmus of Tehuantepec. According to Mexico MOSCAMED estimates, crop losses could still be an estimated U.S. $5-10 million per year from regions southeast of the barrier. The estimated cost of a barrier at Tehuantepec would be U.S. $4.0 million per year, according to Mexico MOSCAMED (Jesús Reyes, Mexico, MOSCAMED, personal communication 1988).

Mexico might have financial difficulty maintaining a barrier permanently without U.S. support, although Mexican Agricultural Ministry officials have stated their solid commitment to keeping Mexico free of Medfly (Franz Hentze, Guatemala MOSCAMED reporting on a personal conversation he had with Mexican officials in 1988).

1. Potential Benefits

Guatemala would receive the following benefits if the medfly eradication program were abandoned:

* Reduction in external costs
* Relocation of some MOSCAMED personnel currently tied to medfly control to other jobs. This could be viewed as the equivalent of "training" benefits
* Liberation of some MOSCAMED funds for other purposes.

The greatest physical asset of the MOSCAMED program is the medfly rearing facility. It is valued at an estimated U.S. $2.4 million. Another important asset would be the MOSCAMED vehicles, estimated at about U.S. $400,000. Including laboratory and office equipment, total value of physical assets to be relocated following termination of the MOSCAMED program would not exceed U.S. $3.0 million. According to the current MOSCAMED agreement, the assets belong to the governments of U.S. and Mexico.

Indirect costs now associated with the MOSCAMED program would end as soon as the program stopped.

MOSCAMED employs about 1,000 people (May 1988). A substantial portion of them have been trained in different aspects of pest management. Once discharged, many if not most, would seek jobs unrelated to their training and experience. Some would secure related jobs in pest management in the public or private sectors. Their new employers would benefit from the training and experience the workers received while previously employed by MOSCAMED.

2. Potential Costs

Costs of the no action program would fall in four categories:

a. Crop Loss

If the MOSCAMED program were terminated, Guatemala would annually incur an estimated U.S. $0.43 million in medfly crop losses to mango, orange, apple, pear, and peach (see A.8.a. and Table VI-7). Some growers would control the medfly themselves.

b. Export Disincentives

Export constraints would continue to represent another cost category to the extent that they do today (see A.8.b.).

c. Political and Human Costs

The political costs of program four would probably be small. Both Guatemala and Mexico perceive the U.S. as being the most important player in decision making regarding medfly programs. Therefore, if the Guatemala MOSCAMED program were terminated, there probably would be no political repercussions in Guatemala-Mexico relations. However, interaction between agricultural, plant health, and medfly personnel in U.S., Mexico, and Guatemala would decrease, with an uncertain effect on other international cooperative programs.

There would be a significant human capital cost if MOSCAMED were terminated. It is unlikely that more than a few trained MOSCAMED personnel would find jobs as lucrative as they now have or where their expertise in fruit fly control would be as fully utilized.

Last, Guatemala would no longer obtain employment benefits (about U.S.$3.0 million per year) from the MOSCAMED program.

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APPENDIX 1

GLOSSARY, ACRONYMS, AND ABBREVIATIONS

Abate	An organophosphate insecticide
Acaricidal	Lethal to mites and ticks
Acaricide	A pesticide that controls mites and ticks; miticide
Acceptable daily intake	The level of pesticide residue that may be consumed each day over the course of an average human life span without appreciable risk (ADI)
Acetylcholinesterase	An enzyme essential to the proper functioning of animal nervous systems; cholinesterase
Acute dermal LD_{50}	The dose of a substance absorbed through the skin that kills 50% of a population of test animals; usually expressed in milligrams of pesticides, etc., per kilogram of body weight of test animals; the lower the LD_{50}, the more poisonous the pesticide
Acute oral LD_{50}	The dose of a substance ingested by mouth that kills 50% of a population of test animals; usually expressed in milligrams of pesticides, etc., per kilogram of body weight of test animals; the lower the LD_{50}, the more poisonous the pesticide
ADI	Acceptable daily intake
Aerial release	Release of sterile medflies from aircraft flown through the medfly target area
Africanization	The take over of honey bee hives by Africanized bees, which are difficult to manage and low honey producers, using current management practices
AGRICOLA	USDA-National Agricultural Library data base
Agroecosystem	The ecological community together with the physical environment present in an agricultural unit

a.i.	Active ingredient
A.I.D.	United States Agency for International Development
Aldicarb	Systemic insecticide, acaricide, and nematicide belonging to the Carbamate class of pesticides
Aldrin	An organochlorine (chlorinated hydrocarbon) insecticide
American foulbrood	A serious disease of honey bees caused by Bacillus larvae
ANACAFE	Asociación Nacional Del Cafe
Anastrepha	The genus of a group of fruit flies related to the medfly and attacking many of the same plant hosts
Annelids	A phylum of worms comprising earthworms, leeches, various marine worms, etc., characterized by their ringed or segmented bodies
Anopheles	Important genus of mosquito whose larvae inhabit wet, vegetation rich areas and whose adults vector malaria; the adult appears to stand on its head when in the resting position
APHIS	Animal and Plant Health Inspection Service (of USDA)
Apiary	A collection of hives or colonies of bees kept for their honey
Apparel	Clothing
Aquaculture	The culture and harvesting of aquatic organisms such as fish or shrimp for commercial purposes
Arthropoda	A phylum of animals characterized by jointed limbs and a segmented, shell-like external covering; it includes insects, crustaceans, spiders, and mites; arthropods
Attractant	A substance that lures (attracts) an organism

Barrier	A set of actions to prevent the movements of organisms beyond a given location
Bioaccumulation	The increasing concentration of a pesticide (or other chemical) in organisms based on their position in the food chain; biomagnification
Biodiversity	The richness of species of organisms or biotic life forms
Biological control	The use of natural enemies (predators, parasites, or disease agents) to control pests
Boric acid	An inorganic compound used as a fungicide, a herbicide, and an insecticide; also known as boracic acid and orthoboric acid
bw	Body weight
C	Degrees celsius
CAB	Commonwealth Agricultural Bureaux
CAFESA	A private Costa Rican coffee cooperative company
Carcinogenicity	The cancer causing potential of a substance
Ceratitis capitata (Wiedemann)	Mediterranean fruit fly; medfly
Cesium	A silver white, soft ductile metal element that is the most electropositive known and that is used especially in photoelectric cells
CFR	Code of Federal Regulations
Chagus disease	A trypanosome disease of man and rodents vectored by South American assasin bugs in the family Reduviidae
Chemosterilants	Chemicals which are either eaten or absorbed through the insect cuticle and cause sterility

Cholinergic poisoning	Poisoning accompanying inhibition of the enzyme acetylcholinesterase (= cholinesterase)
Cholinesterase	See acetylcholinesterase
Cholinesterase inhibitor	A chemical, such as an organophosphate or carbamate pesticide, that inhibits or damages the enzyme acetylcholinesterase (= cholinesterase) necessary for proper nerve function
CICP	Consortium for International Crop Protection
CIES	Centro de Investigaciones Ecologia del Sureste
cl	Centiliter
cm	Centimeter
CNS	Central nervous system
Cobalt-60	A heavy radioactive isotope of cobalt with mass number equal to 60, used as a source for gamma rays
Colony	A localized population of bees inhabiting a territory (e.g. hive) in close association
Combi-fly	Genetically manipulated fly which exhibits a combination of induced and inherited sterility
Competitive displacement	One species replacing another in a particular ecological niche through superior competition for resources
Conditional lethal genes	Dominant genes which govern characters that have deleterious effects under certain conditions but not under others
Conveyances	Vehicles at quarantine stations
Crop diversification	Increasing the variety of crops currently cultivated
Cu	Cubic

Cultural controls	Crop management and other practices that make the environment less favorable for pests, e.g., field sanitation, crop rotation, diversification, harvesting practices, time of planting, trap crops
Cythion	One of the trade names of malathion
Day degrees	Cumulative measure of temperatures above a developmental threshold used to predict developmental times of medflies and their activity
Day-Glo	A brightly colored powdery substance used to mark sterile medflies
DDVP	2, 2- Dichlorovinyl dimethyl phosphate (insecticide)
Delayed effects	Effects caused by a pesticide which occur later in time or are farther removed in distance
Dermal LD_{50}	See acute dermal LD_{50}
Diazinon	An organophosphate insecticide
Dichlorvos	Name for the insecticide DDVP
Dieldrin	An organochlorine (chlorinated hydrocarbon) insecticide
Diversified crops	In Guatemala, crops other than traditional crops (maize, coffee, sugar cane, etc.) that have been introduced and/or exploited for export or domestic markets
DNA	Deoxyribonucleic acid; functions in the transfer of genetic information
d-phenothrin	Synthetic pyrethroid insecticide used in treating conveyances (vehicles) at quarantine stations
EC	Emulsifiable concentrate; a formulation of pesticide that is soluble in water

Economic threshold	The pest density, or amount of plant damage, at which costs of control equal crop returns
Ecosystem	An ecological community together with its physical environment
EDB	Ethylene dibromide (fumigant)
EEG	Electroencephalography
e.g.	For example
EIA	Environmental Impact Analysis
EMG	Electromyography
Emulsifiable concentrate	A pesticide formulation; produced by dissolving the toxicant and an emulsifying agent in an organic solvent
Endangered species	A species in danger of extinction
Endemic species	A species restricted to a particular geographic area
EPA	Environmental Protection Agency (U.S.)
Eradication	Complete elimination of a pest species from a given area
Export crop	A crop grown to sell in another country
F	Degrees fahrenheit
Family	A group of related plants or animals forming a category ranking above a genus and below an order; comprising several to many genera
FAO	Food and Agriculture Organization of the United Nations
FDA	Food and Drug Administration
FEMA GRAS	Food Essential Manufacturer's Association Generally Regarded as Safe

Fenthion	An organophosphate insecticide
FFDCA	Federal Food, Drug, and Cosmetic Act
Fixed wing aircraft	Spray airplane with two stationary wings, contrasted to a helicopter
Fruit	The reproductive body of a seed plant, and here, includes all fruit tree and vegetable hosts of medfly; coffee berries are included in the definition
Fruit stripping	Removal of infested fruit by hand picking to reduce medfly populations
ft.	Foot
Fumigant	A volatile substance whose vapor kills insects and other pests
g	Gram
Gamma rays	A high energy photon emitted spontaneously by a radioactive substance
Genetic manipulation	Release of gentically altered males for mating with wild populations to produce less vigorous offspring
Genus	A category between the family and the species comprising structurally or phylogenetically related species; designated by a Latin capitalized singular noun
Guatemala MOSCAMED	The Guatemala component of the MOSCAMED medfly eradication program
ha	Hectare
Habitat	The place where an organism lives
Hg	Mercury
Honeydew	A sugary deposit secreted on the leaves of plants usually by aphids or scale insects

hr.	Hour
ICAITI	Instituto Centroamericano de Investigación y Tecnologia Industrial
i.e.	That is
IICA	Interamerican Institute for Cooperation on Agriculture/Instituto Interamericano de Cooperacion para la Agricultura
Immediate effects	Effects caused by exposure to a pesticide which occur at the same time and place
INAFOR	Instituto Nacional Forestal
INGUAT	Instituto Quatemalteco de Turismo
Integrated pest management	Use of a variety of biological, cultural, and chemical control methods in a cohesive management scheme designed to maintain pest populations at levels below those causing economic injury (IPM)
IPM	Integrated pest management
Isochromosome	A chromosome with identical arms believed to be derived from a telocentric chromosome by fusion of two daughter chromosomes
IUCN	International Union for Conservation of Nature and Natural Resources
Jackson trap	Medfly trap that contains a synthetic lure, baited with the attractant trimedlure; used for medfly monitoring
kg	Kilogram
km	Kilometer
Krad	A measure of gamma radiation (1,000 rad)

Kromecote cards	Small paper cards coated with a dye to detect spray droplets; used to evaluate aerial bait spray applications for droplet size, distribution, etc.
l	Liter
Label signal words	Descriptive human hazard words established by the EPA and assigned according to the EPA toxicity category of a particular product: caution, warning, danger or danger/poison.
Larva	The immature, wingless form of an insect; alters chiefly in size while passing through several molts and is finally transformed into a pupa from which the adult emerges
Lat.	Latitude
LC_{50}	Abbreviation denoting mean lethal concentration, rather than median lethal doze as in the use of LD_{50} (see LD_{50})
LD_{50}	Abbreviation of median lethal doze, MLD. It indicates a dose of a substance that kills 50% of a population of test animals; usually expressed in milligrams of pesticide per kilograms of body weight. The lower the LD_{50}, the more poisonous the chemical.
LD_{Lo}	Lowest published lethal dose
Long.	Longitude
LUCAM	Laboratorio Unificado de Control de Alimentos y Medicamentos
Lucathion	One of the trade names of malathion
m	Meter
Malaoxon	Oxygen analog of malathion which is a much more potent cholinesterase inhibitor than the parent compound

Malathion	An organophosphate insecticide-acaricide
Malathion bait spray	Spray mixture containing a bait protein hydrolysate, a feeding stimulant, and the toxicant malathion
Manta	Circular cloth trapping device hung from trees to catch insects and other arthropods
Mask	A device worn over the face to prevent inhalation of toxic substances and/or eye injury
MB	Methyl bromide
MBS	Malathion bait spray
Medfly	Mediterranean fruit fly; Ceratitis capitata (Wiedemann)
Medfly outbreaks	Appearance of medflies in medfly free, post eradication, and eradication zones in Guatemala MOSCAMED program (see Zone A, Zone B, Zone C)
Methyl bromide	A fumigant used in fruit and vegetable fumigation at quarantine stations and ports of entry
Metric ton	A unit of 1,000 kilograms
Mexico MOSCAMED	The Mexico component of the MOSCAMED medfly eradication program
mg	Milligram
min.	Minute
Mitigative measure	Action taken to avoid, reduce, minimize, repair, or compensate for an adverse environmental impact
ml	Milliliter
mm	Millimeter

Monitoring	Continuous sampling of medflies, natural enemies, pesticide residues, etc., during an eradication or pest management program
MOSCAMED	U.S.-Mexico-Guatemala organization responsible for eradicating the medfly from Mexico and Guatemala
Multiplier effect	An expansion of income resulting from increase in investment or expenditure in a given area
Mutagenicity	The degree to which a compound can cause a biological mutation
Mylar sheets	Plastic sheets used in determining the amount of pesticide, etc., falling in a given area
n.a.	Not available
NAP	Normal atmospheric pressure
Natural enemies	Predators, parasites, and microorganisms that cause the death of pests; biological control agents
NCI	National Cancer Institute
n.d.	Not dated (no date)
Nematodes	Roundworms; insect-specific parasitic nematodes are a potential control tactic for medflies
ng	Nanogram
Niche	The position or functional status of an organism within its community and ecosystem
NIOSH	National Institute for Occupational Safety and Health (U.S.)
Nitrosomas sp.	Genus of soil and water bacteria which convert ammonia to nitrites and nitrites to nitrates
No.	Number

No Effect Level (NOEL)	Also the No Observable Effect Level; the pesticide dosage that causes no observable harm to test animals in chronic toxicity tests
NOEL	No observable effect level or no effect level
Nontarget organisms	Those organisms (species) that are not the focus of control efforts
Nosema apis	Causal agent of Nosema disease of adult honey bees
Nosema disease	Serious disease affecting adult honey bees caused by *Nosema apis*
NT_{50}	Neurotoxic dose to 50% of test organisms
NTP	National Toxicology Program
Nu-lure	Protein bait; see protein hydrolysate
Octanol-water partition coefficient	A measure of the tendency for a compound to accumulate in an organic substance relative to water
OIRSA	Organismo Internacional Regional de Sanidad Agropecuaria/International Regional Animal and Plant Health Organization
Oko	Formulation of dichlorvos, propoxur, kerosene, and citronella used to treat inside of vehicles to kill adult medflies
Olotes	A preparation of malathion bait spray mixed with corncobs, and using a cotton wick containing the trimedlure attractant; used to attract and kill medflies
Oncogenicity	A measure of the tendency of a compound to cause tumors
Order	A category of classification ranking above the family level and below the class level

Organophosphate	A class of pesticides derived from phosphoric acid esters
OSHA	Occupational Safety and Health Administration (U.S.)
OSHA standard	A minimal standard of pesticide safety for the work place established by the U.S. Occupational Safety and Health Administration
Ovipositor	Egg-laying structure of female insects; used by medfly to insert eggs into fruits or vegetables
Paraquat	A contact herbicide and dessicant
Parasite (parasitoid)	An organism that grows and feeds in or on a host; often used in biological control program to suppress pest populations
pH	Potential of Hydrogen (a measure of acidity or alkalinity)
Pheromone	A chemical substance given off by one individual that causes a specific reaction by other individuals of the same species, such as sex attractants
Pitfall trap	A container (e.g., a can) sunk in the ground with its top at ground level, used to catch insects and other arthropods that fall in and are unable to escape; used primarily to catch insects that do not fly
Pollen	A mass of microspores in a seed plant usually appearing as a fine dust; bees use the material as food for their young
Pollinator	An agent (e.g. bee) which places pollen on the stigma of a flower from the stamen of another flower and thereby ensures pollination
ppb	Parts per billion

ppm	Parts per million
Predator	An organism that lives by preying on animals (prey); often used in biological control programs to suppress pest populations
Probit	A unit of measurement of statistical probability based on deviations from the mean of a normal distribution
PROMECAFE	Proyecto Regional Centroamericano de Mejoramiento del Cultivo del Café
Propolis	A reddish resinous cement collected by bees from plants, used to stop up crevices in the hives, strengthen the cells, etc.
Propoxur	2-(1-Methylethoxy) phenol methylcarbamate; insecticide with fast knockdown
Propwash	Downward air turbulence created by aircraft (especially helicopter) propellers
Protein hydrolysate	Feeding stimulant for medflies and other fruit flies (furnishes nutrients necessary for sexual maturation) which is used in combination with malathion in malathion bait spray; Nu-lure
Pupa	The stage between the larva and adult of an insect; a medfly pupa is known as a puparium
Pyrethroid	Synthetic compounds related to the pyrethrins which are chemicals found in flowers that possess insecticidal properties; provide rapid killing action against insects

Quarantines	Actions to prevent entry of pest species into protected areas; restrictions on production, movement of plants or plant products, animals or animal products, or other material, or people's normal activity, in order to control the spread of a pest
Respirator	A device worn over the nose and mouth to prevent inhalation of toxic substances
ROC	Regional Operations Center (operations unit of Guatemala MOSCAMED)
ROCAP	A.I.D.'s Regional Office for Central American Programs
rpm	Revolutions per minute
Safety equipment	Face masks, goggles, respirators, etc. to reduce exposure to and risks from pesticides
Safety apparel	Clothing (coveralls, hat, boots, gloves, etc.) to reduce exposure to and risks from pesticides
Screwworm fly	A species of blow fly which lays its eggs in the wounds or nostrils of animal hosts and whose larvae attack living tissue; an important southern pest of domestic animals
Secondary pest outbreak	Flare-up of potentially harmful nontarget organisms to pest status following use of pesticide against other pest organisms
-SH	Sulfhydro groups
Shannon-Weaver Function	An index of species diversity, derived from a mathematical formula, used to predict the species of the next individual collected
<u>Simulium</u>	Genus of the insects known as blackflies that act as vectors of onchocerciasis, a disease caused by a filarial worm

SIT	See sterile insect technique
Socioeconomic	Sociological and economic factors considered together
Soil treatment	See chemical soil treatments
Sp.	One species
Species	A category ranking below the genus level, comprising related organisms capable of interbreeding; designated by a latin binomial
Spp.	Two species or more
Sterile insect technique	The release of sterilized medflies into infested areas where they mate with wild medflies; no offspring result from these matings and field populations decline (SIT)
Sticky trap	A trap coated with an adhesive substance used to catch insects and other arthropods
"Superflies"	Theoretical genetic variant pest medflies resulting from the release of partially irradiated, partially fertile female flies into the natural environment
Sweep net	A strong cloth net (e.g., muslin) used with a sweeping motion to collect insects on the ground and on low vegetation
Technical material	The pesticide chemical in its pure manufactured form before formulation into a wettable powder, emulsifiable concentrate, etc. - usually contains 95-100% of the active ingredient
Temephos	Trade name for Abate.
Temperature dependent	Varying with temperature; the life cycle of medflies varies in length depending on temperature
Tephritidae	Also called Trypetidae; the family of flies (Diptera) to which medflies belong; tephritids.

Teratogenicity	A measure of a compound's tendency to cause physical birth defects in the offspring of exposed pregnant females
Threatened species	Any species of fish, wildlife, or plant listed as threatened of existence
Threshold Limit Value	Airborne concentrations of substances to which it is believed workers may be exposed day after day without adverse effect, as adopted by the American Conference of Governmental Industrial Hygienists; TLV, also TL
TLm	Tolerance level median
Tlm96	Tolerance level median after 96 hours
TLV	Threshold limit value
Tolerances	Safe pesticide residues permitted on harvested products
Toxicity Category	Four categories used to indicate the potential hazard of pesticides; Category I uses the signal words Danger and Poison to signify highly toxic compounds (acute oral LD_{50} mg/kg), Category II uses the word Warning to signify moderately toxic compounds (acute oral LD_{50} 50-500 mg/kg), Category III uses the word Caution to signify slightly toxic compounds (acute oral LD_{50} 500-5,000 mg/kg), and Category IV uses the word Caution and must state "Keep Out Of The Reach Of Children" (acute oral $LD_{50} > 5,000$ mg/kg)
Tracheal mites	Parasitic mites, *Acarapis woodi*, that infest honey bees' trachea (air conveying tube in the bees' respiratory system) and shorten adult bee longevity and reduce the amount of nectar and pollen they collect
Trade name	Trade-marked name of a pesticide, formulation, or other product

Translocation homozygotes	Up to 20% of the offspring from two balanced translocation (equal exchange of parts between non-homologous chromosomes) heterozygote parents will be viable but will inherit sterility from their parents to some extent
Trimedlure	Synthetic lure for medfly traps used in monitoring
TWA	Time weighted average
ug	Microgram
ULV	Ultra low volume; a low volume spray, 4.8 liters or less per hectare, undiluted liquid pesticide
U.S.	United States of America
U.S.A.I.D.	United States Agency for International Development
U.S.C.	United States Code
USDA	United States Department of Agriculture
WHO	World Health Organization of the United Nations
Zone A	Medfly free zone in Guatemala MOSCAMED program area
Zone B	Post eradication zone in Guatemala MOSCAMED program area where the medfly has been eradicated
Zone C	An area in Guatemala MOSCAMED program where medfly eradication measures are being used
Zone D	Pre eradication zone in Guatemala MOSCAMED program where extensive medfly monitoring is being carried out in preparation for eradication
Zone E	Medfly infested areas in Guatemala where no eradication measures have been taken

APPENDIX 2

EIA CONTRIBUTORS

CICP EIA TEAM AND U.S AND GUATEMALAN CONSULTANTS/CONTRACTORS ASSISTING IN THE EIA STUDIES AND DOCUMENT DEVELOPEMNT

Name	Description of Work
CICP EIA Team	
Mr. Jim Murphrey	Team Leader - Coordinated EIA work in Guatemala and managed U.S.A.I.D./ Guatemala Contract with IICA
Dr. Dale Bottrell	Contract Manager - Coordinated overall technical work of EIA and managed A.I.D./W contract for CICP
Dr. Katrina Eadie	Sociologist - Coordinated all sociological studies
Dr. Pedro Barbosa	Ecologist - Coordinated all ecological studies
Mr. Lawrence Pinto	Environmentalist - Coordinated preparation of preliminary EIA drafts and pesticide monitoring and impact studies
Lic. Eduardo Villagrán	Economist - Coordinated all economic studies
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Miss Flora Hernández	Word Processor-Administrative Asst.
Mrs. Claudia de Wilhelm	Secretary-Administrative Asst.
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Mr. Bruce Mann	Chemist - Advised on procedures for monitoring pesticide residues in environment and humans
Ms. Polly Hoppin	Public health specialist - Assisted in analyzing data in sociological survey

Dr. Gerald Carlson	Economist - Assisted in planning the economic evaluations and statistical analysis of economic data
Dr. David Williams	Ecologist - Assisted in evaluating medfly trap effectiveness, effect of malathion on nontarget organisms, and medfly predation
Ms. Melanie Odlum	Apiculturist - Assisted in studies on impact of malathion on honey bees and other pollinators
Dr. Patricia Matteson	Entomologist - Assisted with analysis of interactions of MOSCAMED pesticide use patterns with sensitive ecological areas and endangered fauna and flora
Dr. Steven Stewart	Sociologist - Assisted in socioeconomic surveys
Dr. Larry Douglass	Biostatistician - Assisted in analysis of experiments to determine environmental impacts of medfly tactics

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Ing. Mario Gerardo Fernández	Assisted with surveys to assess medfly effect on fruits
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LUCAM Laboratory/ Marit de Campos	Analyzed blood samples taken by Dr. Arreaga to determine cholinesterase levels
Ing. Hector Lobos	Interviews with MOSCAMED workers in the Cobán area

Universidad de San Carlos/School of Pharmacy	Diagnosed diseases in honey bees from field studies
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APPENDIX 3

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PUBLIC BRIEFING MEETINGS

The first briefing meeting was held February 18, 1988 at the Guatemala Fiesta Hotel in Guatemala City. One hundred twenty nine (129) invitations were sent to people representing one hundred fourteen (114) public and private organizations that had interest in the Guatemala medfly Environmental Impact Analysis. The purpose of this Briefing Meeting was to provide information about the MOSCAMED program and to inform participants of the scope of EIA and planned procedures for gathering and evaluating information.

The invitation list was developed by the CICP-EIA team in collaboration with U.S.A.I.D., Guatemala and Guatemalan National Environmental Commission. A.I.D., Washington D.C., announced the meeting in the U.S. Federal Register.

Seventy-nine (79) people representing fifty-one (51) organizations attended the meeting. Participants were invited to submit written observations and suggestions relative to the EIA. The written comments were received and made available to the CICP EIA team for use in developing the EIA document.

The second public meeting was held May 26, 1988 at the Guatemala Fiesta Hotel in Guatemala City. One hundred seventy (170) invitations, with copies of preliminary EIA findings, were sent to representatives of ninety-one (91) organizations. The invitation list was practically the same as for the earlier public briefing meeting with some modifications and additions suggested by the National Commission on Environment and other environmental organizations. Ninety-three (93) people representing forty-two (42) organizations attended the meeting. The purpose of the meeting was for the CICP-EIA team to present preliminary impacts identified in the EIA, to allow participants to ask questions of the CICP-EIA team, and to explain plans, procedures and schedule for completion of the EIA. The meeting was transcribed in both Spanish and English languages. The transcription of the meeting, including the question and answer session, was made available to the CICP-EIA team for use in further development of the EIA document.

APPENDIX 4

EXPERIMENTS, SURVEYS, AND OBSERVATIONS CONDUCTED FOR THE EIA

Experiment: E1

Objective: To determine the impact of malathion bait spray on nontarget arthropods and estimate the total resident arthropod fauna

Investigators: Hugo Arriaza, Pedro Barbosa, Mario Enriquez, Ronald Estrada, Delia Nunez, Larry Pinto, Luis Reyes, and David Williams

Period of Field Activity: March 3-5, 1988; April 8-15, 1988

Procedure:

1. Site and Treatment

   a. Two coffee plantation sites, one site about 1,700 - 1,845 m; another site above 1,500 m and two montane forest sites (at about 1,200 m) were selected near the Finca Las Nubes, north of San Francisco Zapotitlán, Suchitepequez. Malathion bait spray (a formulation containing protein and molasses) was applied by helicopter in alternate strips. The total area of application was about 20 ha. Randomly selected trees were sprayed with ground sprayers using malathion bait spray; arthropods subsequently killed by the spray were collected using mantas. The latter provided an approximation of total arthropod fauna.

   b. Sites were selected in the San Francisco Miramar near Coatepeque (treated) and El Destierro (control) near Retalhuleu. Treatment areas received regular MOSCAMED fixed wing aircraft applications of malathion bait spray. Two sprays were applied, each a week apart. Randomly selected trees were sprayed with ground sprayers using a pyrethroid insecticide and the arthropods killed by the spray were collected using mantas. The latter provided an approximation of total arthropod fauna.

2. Evaluation Criteria

   a. Sticky yellow traps, 50-100 m apart, were mounted on cardboard, 1 m above ground and set in along transect. Ten traps were used per site. Pitfall traps were also used and consisted of 17 cm diameter plastic funnels placed level to ground surface and emptying into a container. One light

trap was placed in each site. Data comparisons involved the Shannon-Weaver Function and comparisons of number of species, number of families, and number of individuals.

b. Three sampling methods were used: (1) pit fall traps (as described above) placed every 40 m along 3 transects within the spray swaths and in the control site; (2) Mantas (0.6 m diameter circular cloth devices hung in trees to capture falling insects) were arranged in a fashion similar to (1); and (3) sweep net samples made in groups of 50 sweeps at designated points along each transect. Samples were taken 24 hr. before spraying and 48 hr. after each spray. The amount of malathion bait spray deposited was determined by placing mylar sheets every 10 m along three parallel transits of 700 m within spray swaths. These sheets were collected 1 hr. after spray and given to ICAITI for quantitative analysis. Kromecote paper cards were used to determine the distribution of drops and drop size. Cards were placed each 10 m along three parallel 700 m transects within spray swaths.

c. Malathion bait feeding stations (open containers with small amounts of bait spray) were placed in untreated areas; records were kept on visits by ants and other ground foraging invertebrates.

Experiment: E2

Objective: To determine the impact of malathion bait spray on nontarget aquatic vertebrates

Investigators: Ronald Estrada and Byron Izquierdo

Period of Field Activity: April 7-28, 1988

Procedures:

1. Sites and Treatments

Experiments were conducted in the San Francisco Miramar farm near Coatepeque. Fifteen containers (38 l tubs) with locally collected minnows (Profundulus sp.) and tadpoles (Bufo sp.) were placed in the field 24 hr. before each malathion bait spray application by fixed wing aircraft. Three of the containers were covered on each treatment date and used as controls.

2. Evaluation Criteria

Morbidity and mortality of the vertebrates were assessed 4 hr. after spray. Samples of the water in each container were analyzed for malathion residues by ICAITI. The test animals were killed after the second spray application and their tissues analyzed for malathion residues by ICAITI.

Experiment: E3

Objective: To determine the impact of malathion bait spray on honey bees

Investigators: Jorge A. Aguirre Kish and Melanie Odlum

Period of Field Activity: March 3-5, 1988; April 7-28, 1988

Procedure:

1. Site and Treatment

   a. Initial experiments were conducted in early March in the Las Nubes farm (treated) north of San Francisco Zapotitlán, Suchitepequez and Las Margaritas farm (control). Malathion bait spray was applied by helicopter to about 20 ha in alternate strips.

   b. Subsequent experiments were conducted in San Francisco Miramar (treated) and El Destierro (control) farms. Treated sites were sprayed with malathion bait spray using fixed wing aircraft.

2. Evaluation Criteria

   a. Five strong and five weak colonies of honey bees (based on number of frames and amount nectar and pollen reserves) were selected in each site. Flight activity of foraging bees was monitored before and after the spray for a period of 3 days. In addition, the attraction of honey bees to malathion bait spray in containers 2 m from hives was evaluated. Finally, a survey was conducted of bee colonies in order to assess the extent of tracheal mites, disease, degree of Africanization, crowding, and general colony management.

   b. Ten strong and 10 weak colonies were selected for evaluation in treated and control sites. Mantas (12) were placed outside the hive entrance to assess mortality. Five weak and five strong hives were covered following MOSCAMED recommendations in the treated and in the control site. Surveys were also conducted to determine the degree of Africanization in apiaries.

Experiment: E4

Objective: To determine influence of rainfall on malathion bait spray and its components

Investigators: Hugo Arriaza and Larry Pinto

Period of Field Activity: April 8-15, 1988

Procedure:

1. The Treatments and Procedures

The formulations (applied by backpack sprayer) assessed were: (1) protein plus malathion (57%) plus water at a 3:1:96 ratio; (2) protein plus malathion (95%) in a 9:1 ratio; and (3) molasses diluted in water (2:1) plus malathion (57%) plus starch (4%) in a 30:15:55 ratio. Records were kept on rainfall. Rainfall was artificially simulated when it did not fall naturally. The strength of artificial rain used was either 2.5 mm or 5 mm of water per square meter applied from a height of 2 m. Twenty coffee plants were used for each bait type, for a total of 60 sample plants.

2. Evaluation Criteria

The presence of bait on leaves or the proportion of drops remaining after treatment were the factors evaluated after natural rains or artificial watering of leaves.

Experiment: E5

Objective: To determine if MOSCAMED workers are experiencing health effects from use of pesticides

Investigator: Heriberto Arreaga Nowell

Period of Field Activity: March, April 1988

Procedures:

1. The Medfly Program's Operations Centers in the Southwest and North of the country were visited in order to observe operations and to inform the directors of both Centers of the study. To select the target group for study, the directors were asked to provide a general list of workers indicating their current occupation, date of entry, and work area.

   A group of workers having no direct contract with malathion and a group having direct contact with the pesticide were chosen at random from this list. Forty-three workers were selected in the Cobán area and 70 in the Coatepeque area. The latter number was subsequently increased to 97 in order to evaluate the degree to which aerial spraying affects the ground support personnel.

2. At the Coatepeque Operations Center, the laboratory technicians selected did not agree to participate in the study since they considered it unnecessary. Instead workers in charge of backpack sprayer operations and inspectors at the Las Mercedes quarantine station were used.

3. To determine cholinesterase levels, a blood sample (6-7 cm) was taken from each of the workers with Vacutainer tubes. The blood was centrifuged at 1,500 rpm for four minutes in order to obtain the plasma. The samples were labeled and kept in iceboxes containing four bottles of previously-frozen propylene glycol. All samples were processed at the Unified Food Control Laboratory through the Reinhold method, and results were expressed in Michel units.

4. After the blood samples were obtained, the workers were questioned regarding the characteristics of their work, hours of exposure, handling of chemical substances, observance of hygiene habits, use of protective equipment, and symptoms suggestive of a current or past, slight or moderate intoxication. Further, they

were given a physical examination of which a record was made.

Experiment: E6

Objective: To establish medfly, Anastrepha spp. and other fruit fly infestation records in samples taken by the MOSCAMED program

Investigators: Mario Fernandez and Eduardo Villagran

Period of Field Activity: February 15-April 15, 1988

Procedure:

1. Medfly detection centers in San Antonio Suchitepequez, Coatepeque, Huehuetenango, Cobán, Morales, and Sacatepequez were visited to search their files and obtain the following statistics:

   * Municipality where sample was taken
   * Weight of sample
   * Week in which sample was obtained
   * Number of medfly, Anastrepha spp., and other fruit fly larvae found in sample
   * Average weight of fruit
   * Average number of larva found per fruit.

   Data were collected, tabulated, and fed into a computer, where a specially designed program calculated total number of individual fruits sampled and total number of individual fruits infested with fly larva. A total of 18,734 samples of mango (6,169), orange (8,498), apple (634), peach (575), and pear (2,858) were obtained and processed.

Experiment: E7

Objective: To develop technique to estimate medfly damage in coffee

Investigators: Diego Sanz-Agero and Eduardo Villagran

Period of Field Activity: February 25-April 15, 1988

Procedure:

1. Four coffee farms that still had berries on trees were selected taking into account their distance to Guatemala City and potential variation in their levels of medfly infestation. In each, 16 neighboring trees were selected at random in the plantation. The ground beneath them was covered with screen. Jackson traps were set in the vicinity of the experiment plot. Records were kept of rain, unusual winds, and pest attack. Fallen berries were collected periodically and taken to MOSCAMED laboratories for analysis to detect presence of medfly larvae. Harvest was at the same time as the rest of the plantation. Harvested berries were also taken to MOSCAMED laboratories for analysis. Medfly trap data were reviewed weekly.

Survey: S1

Objective: To determine the success of MOSCAMED's public information campaign by assessing the knowledge and opinions of community leaders about the MOSCAMED program.

Investigators: Katrina Eadie

Period of Field Activities: February 2-May 18,1988

Procedure:

1. The survey asked respondents to indicate which of the MOSCAMED program control tactics, (e.g. aerial and ground spraying, sterile fly release, quarantines, traps, etc.) had been used in their community. Respondents were also asked for their community's opinions about the effects of MOSCAMED activities on health, yield of agricultural crops, and if the program was of benefit to Guatemala. Key leaders could indicate activities which they believed MOSCAMED should initiate in their municipality. Space was made available for comments. Responses reflect the opinions of local community leaders or their perception of the level of awareness or the community opinion which prevails.

   Questionnaires were sent to each of the 330 municipal mayors throughout Guatemala, along with an envelope for responses. Follow up telegrams were mailed to increase the response rate, which was 31%. The same questionnaires were distributed to two agricultural representatives. These agricultural representatives are elected by communities to receive short-term agricultural training and to promote agricultural development in rural communities. A response rate of 57% was obtained. The combined sample represented 58% of the municipalities in Guatemala. Results were analyzed for the different subgroups (mayors vs. agricultural representatives, rural vs. urban, and for each of the MOSCAMED work Zones A-E.

   The following municipalities in Guatemala were represented in this survey:

Acatenango
Aguacatán
Amatitlán
A sunción Mita
Barillas
Cabanas
Cajolá
Camotan
Cantel
Cobán
Comapa
Concepción
Chiquirichapa
Concepción las Minas
Conguaco
Cubulco
Chahal
Chiché

Chichicastenango
Chinautla
Chinique
Chiquimula
Chisec
Dolores
El Asintal
El Chol
El Estor
El Jícaro
El Palmar
El Tumbador
Escuintla
Esquipulas
Esquipulas Palo Gordo
Estanzuela
Fraijanes
Fray Bartolomé de Las Casas
Granados
Gualán
Guanagazapa
Guastatoya
Guazacapán
Huitán
Huité
Ipala
Ixcán
Iztapa
Jacaltenango
Jalpatagua
Jocotán
Jutiapa
La Esperanza
La Gomera
La Libertad Huehuetenango
La Libertad Petén
Lanquín
La Reforma
La Unión
Livingston
Los Amates
Magdalena Milpas Altas
Malacatancito
Masagua
Mazatenango
Melchor de Mencos
Mixco
Momostenango
Monjas
Morales
Nahualá
Nueva Concepción
Nueva Santa Rosa
Olintepeque
Olopa
Ostuncalco
Pajapita
Palencia
Palestina de Los Altos
Palín
Panajachel
Panzós
Parramos
Patzón
Poptún
Pueblo Nuevo
Puerto Barrios
Purulhá
Quesada
Quezaltenango
Quezaltepeque
Rabinal
Rio Blanco
Rio Bravo
Rio Hondo
Salamá
Salcajá
Samayac
San Agustín Acasaguastlán
San Andrés
San Andrés Sajcabaja
San Andrés Semtabaj
San Andrés Villa Seca
San Antonio La Paz
San Antonio Suchitepéquez
San Bartolo
San Bartolomé Milpas Altas
San Benito
San Bernardino
San Carlos Sija
San Cristobal Cucho
San Cristobal Totonicapán
San Cristobal Verapaz
San Diego
San Francisco La Unión
San Francisco Zapotitlán
San Gabriel
San Jacinto
San Jeronimo
San José Escuintla
San José Petén
San Josén Acatempa
San José del Golfo
San José El Idolo
San José Pinula
San Juan Chamelco
San Juan Ixcoy
San Lorenzo
San Lucas Sacatepéquez
San Luis
San Luis Jilotepeque
San Marcos La Laguna
San Martin Jilotepeque
San Martin Sacatepequez
San Mateo
San Miguel Acatán
San Miguel Duenas
San Miguel Panán
San Miguel Siguilá
San Pablo
San Pedro Ayampuc
San Pedro Carchá
San Pedro La Laguna
San Pedro Pinula
San Raphael Las Flores
San Raimundo
San Sebastian Coatán
San Sebastian Huehuetenango
San Vincente Pacaya
Santa Ana
Santa Apolonia
Santa Bárbara
Santa Catarina Ixtahuacán
Santa Clara La Laguna

Santa Cruz
Santa Cruz Muluá
Santa Cruz Verapaz
Santa Eulalia
Santa Lucía Cotzumalquapa
Santa Lucía La Reforma
Santa Lucía Milpas Altas
Santa Lucia Utatlán
Santa Maria Cahabon
Santa Maria Chiquimula
Santa Maria Visitación
Santa Rosa de Lima
Santo Domingo Suchitepequez
Santo Tomas La Unión
Santiago Sacatepequez
Sayaxché
Sibilia
Sololá
Sumpango
Tecpán Guatemala
Teculutá
Totonicapán
Tucurú
Usumatlán
Villa Nueva
Zacapa
Zacualpa
Zaragoza
Zunil
Zunilito

Survey: S2

Objective: To determine perceptions of MOSCAMED workers about the program

Investigator: Katrina Eadie

Period of Field Activities: January 29-April 29, 1988

Procedure:

1. A survey, asking MOSCAMED workers (all workers, including temporary workers, present at the ROCs were surveyed) eight questions about their work were sent to seven Regional Operations Centers and the medfly rearing facility at San Miguel Petapa. The workers were asked to describe the following about their jobs: the type of work, anything they did not like about it, anything they felt was dangerous, things within the MOSCAMED program which could be improved, their use of pesticides and safety equipment, perception of harm from pesticides, the public's understanding of the MOSCAMED program, and if people are bothered when they are performing MOSCAMED activities. They were advised of the EIA, and told not to put their name on the survey. Those who had difficulty writing were assisted separately.

   The surveys were administered in groups of 10-30 depending on the facilities available. Absenteeism was most prevalent among workers in quarantine stations and those who work far away from the ROCs. Surveys were not administered to Headquarters' staff. The total sample size was 363. The survey was conducted over a period of several months to take advantage of paydays and scheduled meetings. During the 3 month interval, many workers were laid off or fired, in some cases within 2 weeks of when the survey was conducted. MOSCAMED did not have records readily available for the number of employees on the exact day of the survey. The total number of MOSCAMED workers changed during the course of the survey. The response rate, based on the number of workers at the beginning of the project, was about 30%; it was about 40% at the project's conclusion.

Survey: S3

Objective: Supplementary survey to assess public opinion of MOSCAMED program

Investigator: Katrina Eadie

Period of Field Activity: February 2-May 18, 1988

Procedure:

1. The purpose of this survey was to use trusted individuals in each community to assess public opinion and awareness of the MOSCAMED program. This survey provided background information to substantiate the community leaders survey and the informal field surveys. A two part survey (2 pages total) was developed and distributed to the professional evaluation staff of the National Malaria Eradication Service and several of the Catholic Bishops within Guatemala. The purpose of this survey was for trusted clergy and malaria eradication staff to ask the public general questions about the MOSCAMED program as they conducted their daily work. Since both groups are known within their communities, and trusted, it is easy for them to quickly gather general impressions which exist in the community. The first part of the survey highlighted the types of information which they were to ask during their workday. The second part described the format for them to summarize their findings.

   Unfortunately, a health workers' strike prevented the completion of a significant number of surveys. The bishops did not distribute the questionnaires to the clergy within their dioceses until too late. Therefore, the responses summarizing opinions from 29 communities could only be used to substantiate and verify other survey results.

Survey: S4

Objective: Informal field interviews

Investigators: Katrina Eadie, Stephen Stewart (supervising seven Guatemalan interviewers), Hector Lobos

Period of Field Activity: February 2-May 18, 1988

Procedure:

1. This survey relied on interviewing randomly selected Guatemalans in the five MOSCAMED work zones to determine general perceptions and concerns about the program. The seven Guatemalan interviewers were each given a list of towns (6-10 depending on the distance) to visit. The interviewers were asked to engage people at the markets, bus terminals, meeting halls and churches, and other community areas in conversation and ask them about the program. The interviewers also asked questions of people on buses and observed quarantine operations first-hand, as well as reactions before and after. They were provided with forms for each town they visited to summarize both general, as well as extreme, comments and impressions of the MOSCAMED program.

   Stephen Stewart traveled to the Coatepeque region to obtain perceptions of the aerial spray operations. Hector Lobos traveled throughout the Cobán region, interviewing residents in Kekchi to assess their impressions. Finally, the CICP EIA team sociologist traveled extensively throughout the country, in an area bordered by El Salvador on the South, Malacatán to the west, Huehuetenango to Cobán on the north, and Tucurú and El Progreso on the east. Many of those interviews were with farmers and peasants located off of major roads. Eight quarantine stations were visited to observe practices. These surveys provided general information on public perceptions, as well as data on extreme viewpoints, for different groups of individuals throughout Guatemala.

Survey:	S5
Objective:	To establish farmers' perception of medfly damage and to take fruit samples in the area not presently covered by the MOSCAMED program in order to detect the presence of medfly and other fruit flies
Investigators:	Mario Fernández and Eduardo Villagran
Period of Field Activity:	April 15-May 21, 1988

Procedure:

1. The survey considered relative host dispersion, host attractiveness and cultural practices, among other factors. A questionnaire was prepared and tested. It was found in the trials that farmers could not distinguish medfly damage from that of other insects. A decision was made to collect samples from farmers' crops. A total of 116 farmers were interviewed and 81 samples collected. Samples were taken to MOSCAMED laboratories for analysis. Questionnaires were tabulated and data evaluated.

Observation: 01

Objective: To determine the identity and level of activity of pollinators of cardamon

Investigators: Ronald Estrada and Delia Nunez

Period of Field Activity: April 1988

Procedures:

1. Site and Treatment

   Observations were made in coffee/cardamon plantation (San Francisco Miramar farm) near Coatepeque.

2. Evaluation Criteria

   Ten cardamon flowers were observed for 15-30 minutes on several occasions to determine what species visited the flowers. A visit was considered to occur when the individual stood on the flower and went inside to obtain nectar or pollen.

Observation: 02

Objective: To observe MOSCAMED operations at quarantine stations, sterile fly laboratory, and during ground applications of malathion bait spray

Investigators: Pedro Barbosa, Dale Bottrell, Katrina Eadie, Ronald Estrada, Jon Bruce Mann, Larry Pinto, and Heriberto Arreaga Nowell

Period of Field Activity: January-April 1988

Procedure:

1. Quarantine stations: The investigators inspected facilities, pesticides, spray and safety equipment, observed operations, and interviewed workers to determine the pesticides, dosages, and procedures being used for vehicle treatment and fruit and vegetable fumigation. The following MOSCAMED quarantine stations were inspected: La Ruidosa, El Estor, Siguanhá, Chiyuc, La Cumbre, Ojechejel, Los Encuentros, Las Victorias, San Julián, Montúfar, and Zunil.

2. Sterile fly laboratory: The investigators inspected the facility and observed operations to determine if any health or ecological impacts result from operations of the laboratory.

3. Malathion ground applications: The investigators observed MOSCAMED workers mixing and applying malathion bait spray by backpack sprayer in coffee plantations.

Observation: 03

Objective: To observe MOSCAMED aerial spray operations from the air and the ground, evaluate pesticide handling and safety procedures, and determine dosages and droplet-size spectrum of the bait spray.

Investigator: Larry Pinto

Period of Field Activity: April 13-21, 1988

Procedure:

1. The investigator flew as an observer on three fixed wing and four helicopter spray flights in the Coatepeque and Retalhuleu area. Estimates of the dosages of malathion applied were made by determining: (1) the amount of bait spray loaded on the aircraft and applied; (2) the total time of applications (as determined with a stopwatch on the flight); (3) the average speed of the aircraft during spray swaths; (4) the width of the spray swath; and (5) chemical analysis of the bait spray.

   Droplet size of the malathion bait spray was determined for fixed wing aircraft and helicopter applications by measuring droplet diameter on Kromecote paper cards, commercial spray droplet cards, leaves, and other surfaces in the spray areas.

   Mixing and aircraft loading operations were observed before each flight to determine if proper pesticide handling and safety procedures were being followed. MOSCAMED's mitigative measures (such as leaving buffer zones around apiaries and ponds, not spraying nontarget crops, and avoiding coffee plantation whose owners refused permission for treatment) were observed and evaluated.

APPENDIX 5

INFORMATION ON PESTICIDES AND OTHER CHEMICALS

1. Malathion

a. Chemical and Physical Properties

Chemical Name: 0,0-dimethyl phosphorodithioate of diethyl mercaptosuccinate.

Common Name: Malathion

Manufacturer: American Cyanamid

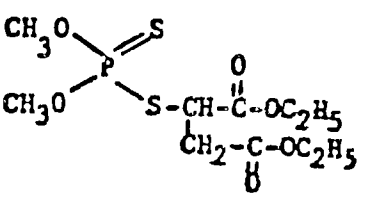
Chemical Abstracts Service Number: 121-75-5

Pesticide Type: Organophosphate

Empirical Formula: $C_{10}H_{19}O_6PS_2$

Molecular Weight: 330.36

Structural Formula:



Physical State: Liquid, may be colorless, yellow, amber, or brown

Odor: Slight mercaptan-like (garlic)

Melting Point: 2.85 C

Boiling Point: 156 to 157 C at 0.7 mm Hg (slight decomposition)

Vapor Pressure: 0.00004 m Hg at 30 C

Specific Gravity: 1.2315 at 25 C

Density: 10.25 lb/gal (1.2 kg/l)

Refractive Index: n^{D25} 1.4985

Viscosity: At 40 C, 17.57 centipoises (0.176 dyne/sec/cm^2)
At 25 C, 36.78 centipoises (0.368 dyne/sec/cm^2)

Flash Point (Tag Open Cup): Greater than 320oF (160 C)

Solubility: In water at 25 C, approximately 145 ppm. Completely soluble in most alcohols, esters, high aromatic solvents, ketones and vegetable oils. Poor solubility in aliphatic hydrocarbons.

Partition coefficients (Dobroski Jr. and Walter n.d.):

Malathion:

Carbon tetrachloride-water	34
Chloroform-water	37
Hexane-water	27
Octanol-water	781

Malaoxon:

Carbon tetrachloride-water	2.9
Chloroform-water	5.8
Hexane-water	0.42

Stability: Stable for an indefinite period of time when stored under the proper conditions. Isomalathion is formed when malathion is stored at elevated temperatures.

Stable to light, but decomposes when heated to boiling.

In solution or in a finely divided form in an aqueous or other liquid medium, malathion is hydrolyzed at a pH higher than 7, but exhibits no appreciable instability at pH 2-7.

Malathion's half-life is 73 minutes at pH 8.9 at 60-65 C. Decomposition is extremely rapid at pH 12 and above (Dobroski Jr. and Walter n.d.).

Corrosion Characteristics: Malathion and concentrated liquid formulations attack iron, tin plate, lead, and copper, and may gel if kept in contact with iron or tin plate.

Label Signal Word: Caution

Classification: General Use

Degradation: Malathion degrades through a number of pathways in the environment. In the soil, malathion breaks down by microbial metabolism, exoenzyme activity, and hydrolysis (Walker and Stojanovic 1973; Kearney and Helling 1969); studies suggest that the degradation is usually rapid (Jenkins et al. 1978). Linsley (1979) found the half-life of malathion in soil to be 0.5 day (see Table 1).

Table 1. Degradation rates for some pesticides in soils expressed as half-life

Compound	Half-life[a] (days)
Diuron	600
Dieldrin	300
DDT	250
Atrazine	130
Diazinon	30
Parathion	10
Malathion	**0.5**

[a] Time for 50% degradation.

Source: Dobroski Jr. and Walter (n.d.)

Paschal and Neville (1976) studied the degradation of malaoxon (malathion's oxygen analog) in silty loam soil and determined that malaoxon's half-life ranged from 3.5 to 7.5 days at a soil pH ranging 8.2 to 6.2. The exoenzyme degradation pathway in soil organic matter is the most important degradation pathway in soils with malathion esterase activity. In soils with small or unsuitable microbial populations, that contain no bound exoenzyme esterase, or that are alkaline, hydrolysis may be an important degradation pathway (Gibson and Burns 1977). As with other organophosphates, malathion is most strongly inactivated in moist, organic soils (Brooks 1980).

Tests have shown that malathion does not penetrate below the surface layer of soil, accumulate in the soil, or translocate in soil water. Biological degradation prevents the displacement of malathion or malaoxon under normal conditions of soil water movement, moderate rainfall, and moderate vegetation (Jenkins et al. 1978).

Reviewing laboratory, field, and monitoring studies on residues and fate of malathion in soil, EPA (1975) concluded that malathion residues in soil are short-lived. Kearney and Helling (1969), in a summary of pesticide persistence data, reported that malathion normally persists in soil for about 1 week.

Malathion breaks down in water through hydrolysis and microbial degradation. Studies indicated that malathion degradation in the aquatic environment is rapid (Walker 1976; Tagatz et al. 1974; Conte and Parker 1971). The microbial degradation of malathion by bacteria in water uses pathways similar to those found in soil bacteria and fungi. However, the major metabolites are not detoxified for nontarget animals, and anti-cholinesterase activity may persist after the parent compound is no longer detectable (Bourquin 1977; APHIS 1984).

Hydrolysis can result in toxic or nontoxic compounds, depending on conditions. Colder water (35oF) favors the formation of acids of malathion which may be more persistent than malathion itself (Wolfe et al. 1977). Hydrolysis under basic pH conditions produces stable malathion monacids which may have adverse impacts on aquatic organisms (Konrad et al. 1969). One basic hydrolysis product, diethyl fumarate, is more toxic to fish than malathion (APHIS 1984), and pronounced synergistic effects between malathion and its primary basic hydrolysis products are possible (Bender 1968).

Table 2 compares the hydrolysis half-lives for a number of insecticides including malathion in a water/ethanol solution. Table 3 compares degradation rates in water of malathion and five other organophosphorus insecticides.

Table 2. Half-lives of insecticides in sterile water/ethanol (99:1) phosphate buffers at 25 3 C

	Half-life (weeks) at indicated pH				
	4.5	5.0	6.0	7.0	8.0
Aldicarb	25	---	38	35	38
Aldicarb sulfoxide	81	---	97	23	3.3
Aldicarb sulfone	160	---	60	11	1.4
Carbaryl	300	---	58	2.0	0.27
Carbofuran	170	690	690	8.2	1.0
Chlorpyrifos	11	11	7.0	4.2	2.7
Cypermethrin	99	---	69	63	50
Diazinon	0.45	2.0	7.8	10	7.7
Ethion	99	63	58	24	8.4
Fensulfothion	59	---	77	87	58
Fonofos	87	50	41	22	6.9
Heptachlor	0.77	0.62	0.64	0.64	0.43
Letophos	350	170	35	5.5	2.3
Malathion	**18**	---	**5.8**	**1.7**	**0.53**
Methomyl	56	---	54	38	20
Oxamyl	300	---	17	1.6	0.20
Parathion	39	43	33	24	15
Phorate	0.55	0.60	0.55	0.57	0.68
Phorate sulfoxide	77	---	46	25	11
Phorate sulfone	27	---	17	8	5
Tebufos	0.29	---	0.28	0.28	0.32
Tebufos sulfoxide	120	---	99	27	8.3
Terbufos sulfone	22	---	19	12	6.2
Trichlorfon	>1,000	---	3.5	0.4	0.13

Source: Dobroski Jr. and Walter (n.d.); adapted from Chapman and Cole (1982)

Table 3. Hydrolytic degradation rates of some organophosphate insecticides at pH 7.4 and 20 C

Compound	Half-life
Phosmet	7.1 hr
Dialifor	14.0 hr
Malathion	**10.5 days**
Dicapthon	29 days
Chlorpyrifos	53 days
Parathion	130 days

Source: Freed et al. (1979)

b. Bioaccumulation

Bioaccumulation is the increase through time of a pesticide's level in the environment through biological concentrations in lipid tissues of organisms. A measure of the tendency of a pesticide to bioaccumulate is its octanol-water partition coefficient. The larger the coefficient, the more likely a pesticide will accumulate in the environment. A comparison of octanol-water partition coefficients for malathion and other pesticides is presented in Table 4.

Table 4. Comparison of octanol-water partition coefficients and bioconcentration factors for several pesticides

Chemical	Octanol-water partition coefficient (Kow)
DDT	960,000
Aroclor 1016	380,200
Chlorpyrifos	97,700
Methoxychlor	47,500
Malathion	**780**
Phosmet	677
Carbaryl	230
Picloram	2

Source: Adapted from Dobroski Jr. and Walter (n.d.)

Based on its relatively low octanol-water partition coefficient of 780, malathion has a low potential for bioaccumulation. Additionally, there is no evidence for long-term accumulation of either malathion or malaoxon in tissues (EPA 1975). However, under certain environmental conditions, malathion's bioaccumulation potential may increase. Bender (1969) studied malathion bioaccumulation in the carp (Cyprinus carpio) in acidic natural waters. When malathion concentration in the water exceeded 7.5 mg/liter, flesh levels reached 42 mg/kg; when exposure was discontinued, malathion levels in the carp fell rapidly (half-life 12 hours).

c. Air Residues

Jenkins et al. (1978) demonstrated that loss of malathion or malaoxon by evaporation from treated soil was not a significant factor in transport of malathion in the environment. Wolfe et al. (1977) suggested that photolysis rates of malathion were too slow to be significant in environmental degradation.

d. Toxicology

Malathion, is a cholinesterase inhibitor. Cholinesterase, or acetylcholinesterase, is an enzyme essential to the proper functioning of animal nervous systems. In an organophosphate intoxicated animal, nerve impulses increasingly race out of

control, and the muscles responding to these uncontrolled nerve stimulations contract in an uncoordinated manner.

However, malathion is not a strong inhibitor of cholinesterase by itself. It requires activation by conversion to its oxygen analog, malaoxon, which as a cholinesterase inhibitor is 10,000 times more potent than the parent compound (NCI 1979b). In mammals, a significant proportion of malathion is hydrolyzed by carboxyesterases into products that do not inhibit cholinesterase. In contrast, a larger proportion of malathion is converted to malaoxon in insects, where carboxyesterase activity is low. This is the basis for malathion's relatively low toxicity to mammals (Murphy 1967) but high toxicity to insects (NCI 1979b).

The major hazard reported for users of malathion is accidental contamination with isomalathion (a toxic impurity) resulting from inadequate manufacture or storage at high temperature. Isomalathion was the key impurity in two formulations of malathion responsible for a malathion poisoning epidemic in Pakistan (Baker et al. 1978; Talcott et al. 1979). Over one hundred persons were poisoned in one incident (J.E. Davies, University of Miami, personal communication 1988).

The acute toxicity to malathion exhibited by various test animals is shown in Table 5. Table 6 compares the rat oral toxicity of malathion with other insecticides.

Table 5. Malathion acute toxicity

Species	Acute toxicity (technical material)
	Oral LD_{50} (mg/kg)
Rat	1,000 (2) - 2,800a
Mouse	720 - 3,330b
Guinea Pig	570c
Mallard duck	1,485c
Adult chickens	greater than 850c
2-3 week chickens	370c
Cat	greater than 500c
Rabbit	1,200d
Sheep	less than 150c
Cattle	200 - 560c
Calves (dairy)	80c
	Dermal LD_{50} (mg/kg)
Rat	greater than 4,444c
Guinea pig	greater than 12,300c
Rabbit	2,400 - 6,150c
	Inhalation LC_{50} (mg/l)
Rat	greater than 60c
Mouse	greater than 15c

Sources: a Worthing (1979)
b Meister et al. (1984)
c EPA (1975)
d NIOSH (1977)

Table 6. Acute oral toxicity of representative insecticides

Insecticide	Rat LD_{50} (kg body weight/mg insecticide)
Parathion	13
Guthion	13
Methyl parathion	14
EPN	36
DDVP	80
Diazinon	108
Carbaryl	850
Malathion (technical grade)	**1,375**
Ronnel	1,250

Source: Gaines (1960)

Kurtz (1977) studied behaviorally conditioned rats that were injected with 25, 50, 100, or 150 mg/kg of malathion. Behavioral changes were observed for rats injected with 50 mg/kg, although blood and brain cholinesterase remained at greater than 90% of control values. Higher dosages produced behavioral and cholinesterase activity changes that did not necessarily coincide, suggesting that low dosages of malathion may disrupt behavior without reducing cholinesterase activity.

Desi and Bakacs (1974) and Desi, et al. (1975) used electromyography (EMG) and electroencephalography (EEG) and behavioral testing on rats fed 1/20 (75 mg/kg bw) and 1/40 (38 mg/kg bw) of the acute LD50 of malathion for 90 days. Conventional toxicological tests were negative and cholinesterase activity did not differ significantly from that of the controls. However, psychophysiological examinations indicated abnormalities within 21 days. Changes appeared in EEG and EMG readings after 90 days of feeding. The relationship between these findings and those of Kurtz (1977) was not apparent, but Kurtz (1977) suggested that the possibility of a link warranted further research.

NIOSH (1977) reported that the lowest published lethal dose (LDLo) of malathion to humans is 857 mg/kg. EPA (1975) quoted a report (Paul 1960) of a lethal dose of 71 mg/kg in a 75-year old man.

Rider et al. (1959) fed one group of five volunteers 16 mg of malathion daily for 88 days with no significant depression of RBC or plasma cholinesterase. Another group was fed 6 mg EPN (a chemical that increases malathion toxicity) daily for 88 days and 8 mg of malathion for the last 44 days of the test with no effect. When fed 42 days more on 6 mg EPN and 16 mg of malathion daily, both groups showed depressed plasma and RBC cholinesterase. However, no toxic signs were detected.

In a malathion inhalation study (Golz 1959), subjects were exposed to malathion air levels of 0.15, 0.6, and 2.4 g of malathion per 28.3 m^3. Some blood cholinesterase suppression was observed, but there were no cholinergic symptoms. No subjects exhibited any significant effects in 84 exposures over 42 consecutive days.

Hayes et al. (1960) found no decrease in blood cholinesterase following dermal applications of 1, 5, and 10% malathion dust applied 5 times weekly for 8 to 16 weeks.

Acceptable Daily Intake (ADI): 0.02 milligram per kilogram

TLm 96: under 1 part per million

OSHA Standard: air TWA = 15 milligrams per cubic meter (skin)

No Effect Level (NOEL): 100 parts per million (rats)

e. Oncogenicity

The National Cancer Institute (NCI) conducted bioassays of malathion for possible carcinogenicity. It was concluded that, under the conditions of the bioassays, there was no clear evidence of the association of carcinogenesis with the administration of malathion or malaoxon (NCI 1979a; NCI 1979b).

The National Toxicology Program (NTP) recently concluded that malathion is not carcinogenic, based on a review of rat bioassays from the NCI tests, reported above. The review was undertaken because of a challenge to the original reading of the bioassay slides. The new review was "blind," and findings were in close agreement with the original readings (P&TCN 1984).

A review of the slides from the malaoxon tests found "equivocal evidence of carcinogenicity" because of thyroid C-cell neoplasms. The conclusion of the NCI study was that malaoxon was not carcinogenic, although C-cell neoplasms were found in the female rats (P&TCN 1984).

f. Teratogenicity

Standard rodent tests for teratogenicity have proved negative, but malathion has caused teratogenic effects when injected into chick embryos (Proctor and Casida 1975). How this relates to potential mammalian teratogenicity is presently unclear (Khera et al. 1978).

g. Mutagenicity

Malathion has been shown to be capable of producing structural alterations of DNA in bacterial systems (Shiau et al. 1980), in calf thymus (Olinski et al. 1980), and in cultures of human lymphocytes (Nicholas et al. 1979, Vachkova-Petrova 1980, Walter et al. 1980).

2. Methyl Bromide

Methyl bromide's insecticidal activity was first reported in 1932, and it was quickly adopted for plant quarantine purposes because many plants, vegetables, and some fruits tolerate concentrations lethal to most insects. It has been a major fumigant for insect and microorganism control in stored products, mills, and for commodities in warehouses, ships, and railway cars. With the loss of ethylene dibromide (EDB) for use in the

U.S. or on commodities imported to the U.S., use of methyl bromide increased in quarantine programs.

Methyl bromide is not as toxic to most insects as EDB is. It penetrates quickly and deeply into sorptive materials and when treatment is concluded it dissipates rapidly (Monro 1972). Methyl bromide is nonflammable and nonexplosive under normal use but will form a flammable mixture when its concentration is at 10-15% in air.

a. Chemical and Physical Properties

Chemical Name: Bromoethane; monobromoethane

Common Name: Methyl Bromide

Manufacturer: Great Lakes Chemical Corp. (Brom-O-Gas, Meth-O-Gas); CMPA (France) (Brom-O-Gaz)

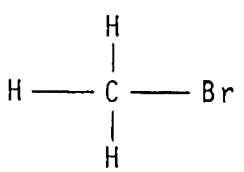
Chemical Abstracts Service (CAS) Number: 74-83-9

Pesticide Type: Brominated hydrocarbon fumigant

Empirical Formula: CH_3Br

Molecular Weight: 94.95

Structural Formula:



Physical State: Colorless gas at normal temperature and pressure; colorless liquid when under pressure or below 3.6 C

Odor: None at low but dangerous concentrations; sweet, musty, or chloroform-like at high concentrations. Malodors may be produced when sulfur-containing compounds are fumigated.

Melting Point: -94 C

Boiling Point: 3.6 C at 760 mm Hg

Vapor Pressure: 1420 mm Hg at 20 C

Specific Gravity: (H_2O = 1) 1.732 at 32 C, 760 mm Hg

Vapor Density: (air = 1) 3.27

Latent Heat of Vaporization: 61.52 cal/g

Flash Point: None

Flammable Limits: 10-15% in air with spark; in presence of aluminum will form aluminum trimethyl, a spontaneously ignitable material.

Solubility: Water = 1.75 g/100 g at 20 C. Freely soluble in alcohol, chloroform, ethers, carbon disulfide, carbon tetrachloride, benzene, esters, ketones, halogenated hydrocarbons, and aromatic hydrocarbons.

Stability: Stable

Corrosion Characteristics: Noncorrosive to most metals when dry. Attacks aluminum and magnesium and their alloys.

Label Signal Word: Danger

Classification: Restricted Use

Degradation: Degraded rapidly in sunlight (Pesticide Manufacturing and Toxic Materials Control Encyclopedia)

b. Toxicology

Methyl bromide is highly toxic to humans (Alexcoff and Kilgore, 1983). Vapor inhalation can cause symptoms from mild bronchitis to respiratory arrest, depending on concentration and time of exposure. Dermal exposure to vapors can result in delayed skin burns. Liquid methyl bromide can severely burn skin and mucous membranes. Direct contact with eyes or eyelids may result in serious injury. Exposure to low concentrations of methyl bromide over a period of time results in a variety of symptoms, most of which are related to the central nervous system. Proper use of personal protection equipment and proper handling practices are necessary to avoid injury.

The toxicity of methyl bromide to various mammals is shown in Table 7.

Table 7. Acute toxicity of methyl bromide

Species	Toxicity
Rat	Acute oral LD_{50} ¼ 100 mg/kg[a] Acute oral LD_{50} 214 mg/kg[b] Acute inhalation LC_{50} 3,120 ppm (15 min.)[a]
Rabbit	Acute inhalation LC_{50} 6,425 ppm (60 min)[c]
Human	Acute inhalation LC_{Lo} 60,000 ppm (2 hrs)[b] Acute vapor toxicity level 220 ppm[c] A single inhalation exposure to 1,000 ppm for 30 to 60 minutes is dangerous to life[d]

Sources: [a] MSDS, Methyl Bromide (1982)
[b] 1988 Farm Chemicals Handbook (1988)
[c] NPCA (1987)
[d] Methyl Bromide - Fact Sheet, Dow Chemical, U.S.A.

Hayes (1982) reviewed the toxicity of methyl bromide to animals and showed that rats and guinea pigs tolerated 250 mg/m3 for 6 months and with normal growth, no symptoms, and no histopathological changes. Higher but nonlethal concentrations produced wild activity, subsiding to muscle tremors in rats and paralysis of the extremities in rabbits and monkeys. Functional disorders disappeared when exposure stopped, and methyl bromide was eliminated rapidly.

In order of frequency, the ssymptoms of poisoning are visual disturbance, slurred speech, numbness of the extremities, mental confusion, hallucinations, tremors, coma, and frequent fainting (GLCC u.d.). Recovery may occur in a few days or hospitalization may be required for many weeks. Complete recovery is the rule, but in rare cases the patient may be left with gross, permanent disability (Hayes 1982).

Symptoms of poisoning generally appear several hours after exposure, but the delay may range from a few minutes to 48 hours (Hayes 1982). Death is usually from circulatory or respiratory failure (Hayes 1982).

Methyl bromide is stored under pressure as a liquid. When released at temperatures above its boiling point of 4.4 C, it evaporates rapidly. However, if methyl bromide is spilled on clothing, gloves, or shoes, it may be held in contact with the skin. Since no sensation is produced by direct contact, the individual may be burned, with blisters commonly appearing after several hours (GLCC n.d.). Dermal exposure may also produce systemic illness (Hayes 1982).

OSHA TLV-TWA: 20 ppm C (skin)

ACGIH TLV-TWA: 15 ppm C (skin)
5 ppm (inhalation)

EPA Fumigation Limit: 5 ppm requires self-contained breathing apparatus (SCBA).

c. Protective Equipment

Avoid tight clothing, jewelry, gloves, and boots. Concentrations of methyl bromide exceeding 5 ppm require a self-contained breathing apparatus (SCBA) or combination air-supplied/SCBA respirator. Goggles or a full face shield should be worn when handling liquid.

3. d-phenothrin

The pyrethroid d-Phenothrin is a nonsystemic residual insecticide effective by contact and as a stomach poison and used to control public health and general pests. About 50% of the usage is for insecticidal treatment of transport vehicles. It consists of a specific combination of isomers (1R -cis- 51186-88-0 and 1R -trans- 26046-85-5 , cis/trans ratio 20:80 m/m) of phenothrin. A solution of 2% d-phenothrin is the insecticide approved for treating vehicles at quarantine stations in eradication and barrier alternatives (Franz Hentze, Guatemala MOSCAMED, personal communication 1988).

a. Chemical and Physical Properties

Chemical Name: 3-phenoxybenzyl(1RS)-d-cis, trans-chrysanthemate

Common Name: d-phenothrin

Manufacturer: Sumitomo Chemical Company

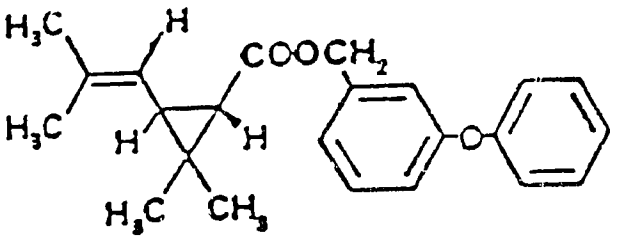
Chemical Abstracts Service Number: 26002-80-2; 51186- 88-0(1R -cis-isomer); 26046-85-5(1R -trans-isomer)

Pesticide type: Pyrethroid

Empirical Formula: $C_{23}H_{26}O_3$

Molecular Weight: 350.5

Structural Formula:



Physical State: Colorless liquid

Vapor Pressure: 1.64 mm Hg at 200 C

Density: d25 1.061

Refractive Index: n^{D25} 1.5482

Solubility: Almost unsoluble in water: 2 mg/l water at 30 C; miscible in mostly organic solvents

Stability: Stable under irradiation, in most organic solvents, and on inorganic mineral diluents.

Label Signal Word: Caution

Classification: General Use

b. Toxicology

The acute toxicity of d-phenothrin to various species is shown in Table 8.

Pyrethroids may cause respiratory irritation or allergic reactions but no information on these effects from d-phenothrin has been found.

Table 8. Acute toxicity of d-phenothrin

Species		Toxicity
Rat	Acute oral LD_{50}	> 10,000 mg/kg
	Acute dermal LD_{50}	> 5,000 mg/kg
	Intraperitoneal LD_{50}	> 10,000 mg/kg
	Subcutaneous LD_{50}	> 10,000 mg/kg
Mouse	Acute oral LD_{50}	> 10,000 mg/kg
Rainbow Trout	Acute LC_{50} 0.0167 mg/l (96 hr.)	

Source: Sumitomo Chemical Company, Ltd. Osaka, Japan

4. Propoxur

Propoxur is a carbamate residual insecticide effective by contact and as a stomach poison. It is characterized by a rapid knockdown, flushing effect, and moderate residual activity of over 2 weeks.

Propoxur has been used by MOSCAMED in the medlfy eradication program for the past year in a spray mixture (Oko) with dichlorvos (1% propoxur and 1% dichlorvos in kerosene) for treating vehicles at quarantine stations. It was not approved for program use and was to be removed from quarantine stations as of April 26, 1988.

a. Chemical and Physical Properties

Chemical Name: 2(1-methylethoxy)phenol methylcarbamate or O-isopropoxyphenyl methylcarbamate

Common Name: Propoxur

Manufacturer: Bayer Chemical Company; Mobay Chemical Company

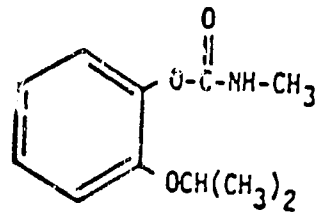
Chemical Abstracts Service Number: 114-26-1

Pesticide Type: Carbamate

Empirical Formula: $C_{11}H_{15}NO_3$

Molecular Weight: 209.27

Structural Formula:



Physical State: White to tan crystalline solid

Odor: Mild chemical

Melting Point: 91 C

Vapor Pressure: 3×10^{-6} mm Hg at 20 C

Flash Point: None

Solubility: Soluble in most polar solvents; solubility in water 0.1-0.2%

Stability: Unstable in alkaline media

Staining: Both water-based and petroleum distillate-based sprays may stain light colored and finished surfaces.

Label Signal Word: Caution

Classification: General Use

b. Toxicology

The acute toxicity of propoxur to various species is shown in Table 9.

Table 9. Acute toxicity of propoxur

Species	Toxicity	
Rat	Acute oral LD_{50}	100 mg/kg
Duck	Acute oral LD_{50}	10 mg/kg
Wild Bird (species unidentified)	Acute oral LD_{50}	4 mg/kg
Rat	Acute dermal LD_{50}	1,000 mg/kg
Rat	Inhalation LD_{50}	1,440 mg/l (1 hr)

Source: NPCA (1987)

ACGIH TLV-TWA: 0.5 mg/m^3

ACGIH TLV-STEL: 2.0 mg/m^3

5. Dichlorvos (DDVP)

Dichlorvos or DDVP is an organophosphate insecticide widely used for control of flies, mosquitoes, gnats, cockroaches, and other nuisance insect pests; pests of stored products; and agricultural crop pests. It acts as a contact and stomach poison and exhibits fumigant activity.

Dichlorvos has been used by MOSCAMED for the past year in the medlfy eradication program in a spray mixture (oko) with propoxur (1% dichlorvos and 1% propoxur in kerosene with citronella) for treating vehicles at quarantine stations. It was not approved for program use and was to be removed from quarantine stations as of April 1988.

The U.S. Environmental Protection Agency (EPA) has recently recommended that dichlorvos be rated as a probable human carcinogen and will require new labeling for all products containing the compound.

a. Chemical and Physical Properties

Chemical Name: 2,2-dichlorovinyl dimethyl phosphate hexahydro-4, 7-methanoindene

Common Name: Dichlorvos, DDVP

Manufacturer: AMVAC Chemical Corp.; SDS Biotech Corp.; Prentiss Drug and Chemical Co.; Dow Chemical Corp.; Kaw Valley; MGK Co.; Denka Chemia B.V.; Kenco Chemical and Mfg.

Corp.; Wesley Industries, Inc.; Fermenta Animal Health; E.I du Pont de Nemours and Co.

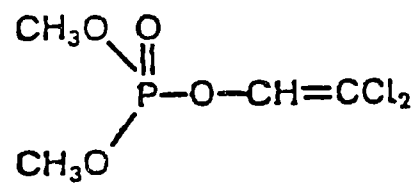
Chemical Abstracts Service Number: 62-73-7

Pesticide Type: Carbamate

Empirical Formula: $C_4H_7Cl_2O_4P$

Molecular Weight: 221.0

Structural Formula:



Physical State: Colorless to light amber liquid

Odor: Slight chemical; pleasant smelling

Boiling Point: 117 C at 10 mm Hg

Vapor Pressure: 0.012 mm Hg at 20 C; 0.032 mm Hg at 32 C; 0.07 mm Hg at 40 C

Specific Gravity: 1.42 at 25 C

Density: 1.65-1.67

Solubility: Slightly soluble in water (1%) and kerosene; readily soluble in most organic solvents. Miscible with most organic solvents and aerosol propellants.

Stability: Stable in the presence of hydrocarbon solvents; undergoes hydrolysis in the presence of water; readily decomposed by strong acids and bases.

Corrosion Characteristics: Corrosive to steel; noncorrosive to stainless steel, aluminum, nickel, Teflon Hastelloy B.

Chemical Relationships: Trichlorfon and naled are chemically related to dichlorvos.

Label Signal Word: Danger/Poison

Classification: General Use (most uses are being reclassified to restricted use as of October 1, 1988)

Degradation: According to EPA (1987), numerous data gaps exist concerning the environmental fate of dichlorvos. Studies indicate that dichlorvos degrades fairly rapidly, with a half-life of 2 to 8 hours in soils ranging in texture from sand to silt. Dichlorvos is highly volatile and residues should dissipate fairly rapidly.

b. Toxicology

Dichlorvos is classified by the U.S. EPA as moderately toxic (Category II) for acute oral exposure and highly toxic (Category I) for acute dermal exposure and acute inhalation. The acute toxicity to dichlorvos exhibited by various test animals is presented in Table 10.

c. Oncogenicity

Dichlorvos is classified by U.S. EPA as a B2 "probable human carcinogen" based on a draft report of a review of two rodent studies. EPA's Scientific Advisory Panel classified dichlorvos as Group C, a "possible human carcinogen."

Table 10. Acute toxicity of dichlorvos

Species	Toxicity
Rat (male)	Acute oral LD_{50} 80 mg/kg
Rat (female)	Acute oral LD_{50} 56 mg/kg
Dog (male)	Acute oral LD_{50} 100-316 mg/kg[a]
Mouse	Acute oral LD_{50} 124 mg/kg[a]
Rabbit	Acute oral LD_{50} 107 mg/kg[b]
Rat (male)	Acute dermal LD_{50} 107 mg/kg
Rat (female)	Acute dermal LD_{50} 75 mg/kg
Rainbow trout	LC_{50} 0.1 ppm (96 hr.)
Striped mullet	LC_{50} 0.23 ppm (96 hr.)
Daphnia pulex	LC_{50} 0.00007 ppm (96 hr.)
Sand Shrimp	LC_{50} 0.004 ppm (96 hr.)
Rat	Acute inhalation LC_{50} >193 mg/m^3

Sources: EPA (1987) except for
[a] Ciba Geigy (1971)
[b] Farm Chemicals Handbook (1988)

d. NOEL (No Observable Effect Level)

Based on a dog feeding study demonstrating increased relative liver weights in males at 32 ppm, and enlargement of liver cells in both sexes at 32 ppm, EPA established the NOEL at 3.2 ppm (EPA 1987).

e. Teratogenicity

Based on a rabbit inhalation teratogenicity study, EPA established a NOEL for embryo/fetotoxicity at 2 ug/l2 (EPA 1987).

f. Mutagenicity

Dichlorvos is a direct-acting mutagen in bacteria, fungi, and mammalian cells *in vitro*. Dichlorvos was negative in micronucleus and sister chromatid exchange assays in mice and negative in repeated dominant lethal assays (EPA 1987).

g. Regulatory Changes

After October 1, 1988, U.S. EPA will require label changes for dichlorvos products. Changes include the following:

* Cancer hazard warning

* Worker protective clothing statement as follows: "Persons who handle this product must wear the following protective clothing: protective suit of one or two pieces covering all parts of the body except head, hands, and feet; chemical resistant gloves; chemical resistant shoes (or chemical resistant shoe coverings or chemical resistant boots); NIOSH or MSHA approved respirator; and a chemical-resistant apron"

* Restricted use classification for end use products except household sprays containing 0.5% or less active ingredients, resin strips, and pet uses.

* Warnings of toxicity to fish, birds, and aquatic invertebrates

* Re-entry time of 48 hours without protective clothing.

6. Kerosene

Kerosene is not an insecticide but a thin volatile oil distilled from petroleum and other hydrocarbons and commonly mixed with insecticides in place of water for applications with thermal foggers and their equipment. MOSCAMED has mixed kerosene with dichlorvos and propoxur for applications to vehicles at quarantine stations. It is not required for use with d-phenothrin.

7. Citronella

Citronella is a volatile, sharp-smelling oil used in perfume, soap, and as an insect repellant. MOSCAMED has used a number of insecticide products (oko) that contain small quantities (0.015, 0.03, and 0.04%) of ciflutrina (citronella).

8. Trimedlure

Trimedlure is not an insecticide but a synthetic attractant used in Jackson traps for monitoring the medfly and in "olotes" for control of medfly in sensitive areas. In Jackson traps, approximately 2 ml of the liquid trimedlure is applied to a cotton wick with an eye dropper, and the wick is placed inside the trap. This compound is not listed in the 4 major chemical databases, in the Registry of Toxic Effects of Chemical Substances, or in the computerized database at Cornell University (SCAMP: Cornell Pesticide Profiles).

a. Chemical and Physical Properties

Trade Name: Trimedlure

Chemical Name: tert-butyl 4(or 5)-chloro-2-methylcyclohexanecarboxylate

Solubility in Water: Insoluble

b. Toxicology

LD_{50} values of trimedlure appear in Table 11.

Beroza et al. (1975) reported the following eye irritant scores for rabbits (Draize scoring system; maximum score of 110): 1 hour = 12, 24 hours = 0, 48 hours = 0, 72 hours = 0. The primary skin irritant score (Draize scoring system; maximum score is 8.0) for rabbits was 1.4.

Table 11. Trimedlure toxicology data

Species	LD_{50} (ppm) 24 Hours	48 Hours	96 Hours
Rainbow Trout	11.5	11.0	9.6
Bluegill	14.7	14.7	12.1
	Acute LD_{50} (mg/kg) (technical material)		
Rat	oral - 4,556 (± 1,136)		
Rabbit	dermal - 2,025		

Source: Beroza et al. (1975)

9. Protein Hydrolysate

The protein hydrolysate used in malathion bait spray in the Guatemala MOSCAMED program is Nu-lure, sold by Miller Chemical and Fertilizer Corporation. Nu-lure insect bait is a proteinaceous liquid, derived from corn and designed for use as an attractant bait in insecticide sprays. It is rich in free amino acids and polypetides which encourage certain insects, especially the penoles, to feed upon the spray residue.

Specific characteristics are as follows:

49% Solids
51% Corn steep liquor
24% Amino acids
6% Nacl
1.4% Ammonium chloride
pH 4.0

10. Day-Glo

Day-Glo is the trademark of a coloring agent added to pigments and dyes to produce a variety of brilliant fluorescent colors. It has been used to mark insects for many years (Turner and Gerhardt 1965). MOSCAMED uses Day-Glo Blaze Orange pigment to mark sterile medflies so that they can be identified as sterile by the glow that appears when monitoring traps are placed under ultraviolet light.

Chemical Abstracts Service Number: 66038-64-0

Toxicity data are shown in Table 12.

Table 12. Toxicity of Day-Glo pigments

		Pigment code		
		A, AX D, T, GT	Q	Z
Acute Oral Toxicity	LD_{50} g/kg	> 16.0	15.4	10.25
Acute Dermal Toxicity	LD_{50} g/kg	> 23.0	10.2	10.25
Acute Dust Inhalation	LC_{50} mg/L air	> 4.4 (4 hours)	4.4	1.1
Eye Irritation		No significant Irritation	Mildly Irritating	Mildly Irritating

Source: Day-Glo (n.d.)