AN ENVIRONMENTAL PROFILE OF GUATEMALA

Assessment of Environmental Problems and Short- and Long-Term Strategies for Problem Solution

Prepared for:

Agency for International Development

U.S. Department of State

By:

Institute of Ecology

University of Georgia

Athens, Georgia 30602

May 1981

DRAFT ENVIRONMENTAL PROFILE

ON

GUATEMALA

PHASE II

PREPARED BY
INSTITUTE OF ECOLOGY
UNIVERSITY OF GEORGIA
ATHENS, GEORGIA
30602

National Park Service Contract No. CX-0001-0-0004
in cooperation with U.S. Man and the Biosphere Secretariat
Department of State, Washington, D. C.

Funded by A.I.D., Office of Science and Technology under
SA/TOA 1-77

MAY 1981

This study was performed by the Institute of Ecology at the University of Georgia under contract to the Agency for International Development and the National Park Service. The authors of this report, listed alphabetically, are:

James L. Cooley

Edward G. Farnworth

Don R. Hoy

Carl F. Jordan

Typing was provided by Gladys Russell

THE UNITED STATES NATIONAL COMMITTEE FOR MAN AND THE BIOSPHERE
Department of State, IO/UCS
WASHINGTON, D.C. 2052

An Introductory Note on Draft Environmental Profiles:

The attached draft environmental report has been prepared under a contract between the U.S. Agency for International Development (A.I.D.), Office of Science and Technology (DS/ST) and the U.S. Man and the Biosphere (MAB) Program. It is a preliminary review of information available in the United States on the status of the environment and the natural resources of the identified country and is one of a series of similar studies now underway on countries which receive U.S. bilateral assistance.

This report is the first step in a process to develop better information for the A.I.D. Mission, for host country officials, and others on the environmental situation in specific countries and begins to identify the most critical areas of concern. A more comprehensive study may be undertaken in each country by Regional Bureaus and/or A.I.D. Missions. These would involve local scientists in a more detailed examination of the actual situations as well as a better definition of issues, problems and priorities. Such "Phase II" studies would provide substance for the Agency's Country Development Strategy Statements as well as justifications for program initiatives in the areas of environment and natural resources.

Comments on the attached draft report would be welcomed by USMAB and DS/ST and should be addressed to either:

Jim Corson
AID/MAB Project
Department of State
Room 410, SA-5
Washington, D.C. 20520

OR

Molly Kux
Office of Forestry & Natural Resource
U.S. A.I.D.
Washington, D.C. 20523

TABLE OF CONTENTS

LIST OF PLATES

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1 Objectives and Scope

The Republic of Guatemala is a developing nation which is facing a severe test in the next twenty years. The country must continue to develop to support its rapidly expanding population, but it also must preserve its natural environmental support systems that are its major resources. Like many developing countries in Latin America, environmental degradation in Guatemala is extensive, yet controllable. The expanding population's needs for additional land and forest products have caused degradation to land and water resources. Without sound development planning that includes ecological considerations and without programs to restore already damaged areas, the long-term costs to the renewable natural resources of the country will be high.

A number of reports (e.g., Bovay Engineering, Inc. 1973, Library of Congress 1979, Goodland and Pollard 1974, Goodland and Tillman 1975) have described Guatemala's resources in detail and have elaborated on the environmental problems associated with development. These reports have pointed out the nature of the environmental problems, but have not presented workable short-term and long-term plans to reduce, repair or prevent environmental damage during development. These reports usually do not state that natural ecosystems are providing free work for man and that man should couple his development to natural systems to take advantage of the free service. If natural systems are abused, then the free services are lost and long-term costs are far greater than the initial costs of sound use and conservation.

The major aim of this "Environmental Profile" is to develop short-term and long-term recommendations for projects and programs that can be feasibly implemented. These suggestions are applicable not only to Guatemala, but to most other countries in Central America because the problems throughout the isthmus are similar.

This survey is specifically designed to

- define the environmental problems,
- assemble in a definitive document information, analysis and data on environmental problems, and
- develop an analytical framework and action recommendations that will provide short-term and long-term solutions to these problems.

In order to approach the objectives stated above, it is also necessary to include:

- the relationship between environmental problems and development objectives,
- an analysis of existing national policies, institutions and programs for dealing with environmental problems, and
- constraints to dealing with environmental problems.

With these considerations available there is then the opportunity for:

- feasible strategy options for the public and private sector.
- projects on environmental protection and improvement for the 1980s.

This environmental report represents a blending of the ideas of Guatemalan professionals and the University of Georgia Institute of Ecology team regarding the type of actions that are both feasible and important.

1.2 Methodology

In December 1979, a team of scientists from the Institute of Ecology, University of Georgia, visited Guatemala to prepare the groundwork for an "Environmental Profile of Guatemala." During the visit, team members interviewed many professionals in Guatemala who were concerned with environmental problems and further familiarized themselves with information already published on the subject. (See the Appendix for a list of people and institutions visited and publications consulted.)

As a result of these background investigations, it was clear that the environmental problems had been identified relatively clearly by the AID mission and the Government of Guatemala. We concluded that the major contribution should be a series of recommendations for actions that would help solve some of the problems. Team members made several visits to Guatemala early in 1980 with the goal of developing a series of action recommendations. The group traveled throughout Guatemala, viewed environmental problems in the field and consulted local specialists about these problems. Our team and most of the Guatemalans consulted agreed that it would be best to make a series of specific recommendations for projects which had a good probability of being carried out rather than to list all of the problem areas where action is necessary.

1.3 Environmental Characteristics and Resources

The information developed in this section has been extracted primarily from the Library of Congress 1979 draft environmental report on Guatemala. This information is provided to develop the national environmental conditions in which the development problems occur.

1.3.1 Physiography, Climate and Rainfall

Guatemala lies entirely within the Tropical Zone, but its climate is influenced both by the Temperate Zone to the north and by its predominantly mountainous topography. The country is traversed by the Sierra Madre Range, which runs from Mexico southeastward to El Salvador and Honduras, dividing the country into four landforms: 1) the Peten Lowlands of the north, covering about a third of the country; 2) the Pacific Lowlands, reaching inland from the ocean to a distance of 16 to 56 km; 3) the Caribbean Lowlands, lying between the lowlands of Belize to the north and those of Honduras to the south, extending inland from the coastal plain along three stream valleys; and 4) the Central and Western Highlands, varying between 158 and 242 km in width, comprising the largest landform.

Twenty-one volcanoes, some still active, occur in the Central Highlands. Earthquakes are frequent in the southern part of the country, the major fault zone being some 240 km from Guatemala City to Puerto Barrios in the Montagua Valley.

The climate of the country is directly influenced by the topography. Temperature varies with altitude. Three temperature zones are generally recognized. The coastal lowlands and the northern department of Peten, where mean daily temperature maxima are from 30-35°C, comprise a zone from sea level to about 1000 m called the "tierra caliente." The "tierra templada" is found at altitudes between 1000 to 1900 m, with mean annual temperatures as low as 18°C in the upper levels. The "tierra fria" is the area of upper altitudes, where mean annual temperatures range from 18 to 5°C. The "tierra fria" is subject to greater seasonal and daily variations in temperatures than are the coastal areas. At the highest levels, e.g., Mont Tajumulco in the Department of San Marcos, 4220 m, freezing temperatures may occur even during the generally warmer dry season.

Rainfall also varies considerably throughout the country (Fig. 1). Most areas of the country experience both dry and wet seasons that vary in length and intensity. The dry season lasts about six months, with the driest period from December through March. The rainy season begins around April in the lowlands and usually in May in the Central Highlands.

Rainfall levels increase between the Pacific Ocean and the mountains ranging from about 1500 mm at San Jose on the coast to as high as 4000 mm along the southern mountain slopes. The highest yearly levels of precipitation are reported at stations in El Quiche, Suchitepequez, and San Marcos, all of which are on the southern slopes of the Central Highlands. Rainfall tends to be somewhat lower on the northern and eastern sides of the mountain divide except for the lowlands of the Chixoy River basin where rainfall may be 6 m annually. In some areas (e.g., Quetzaltenango, Quiche, Solola, San Marcos, Suchitepequez departments), wet season rainfall is torrential and may be 50 mm per month.

Evapotranspiration potential varies throughout the country. Evaporation during the November to April dry season is greatest along the Pacific Coast (over 1000 mm) and least in areas of the Western Highlands (less than 750 mm). In the Peten and in the Caribbean coastal plain potential evapotranspiration ranges between 900 and 950 mm (Instituto Geografico Nacional 1976).

Rainfall patterns tend to limit agricultural development. For example, the wide seasonal variation in rainfall on the South Coast makes it difficult to maintain stable feed levels for dairy and beef cattle. Also, the long dry season in the Highlands reduces the carrying capacity of upland pastures. Heavy rainfall following long dry seasons aggravates soil erosion in some areas.

1.3.2 Forest Resources

The forests are rich and diverse in Guatemala. The richness and diversity are a result of various climatic, physiographic, and soil

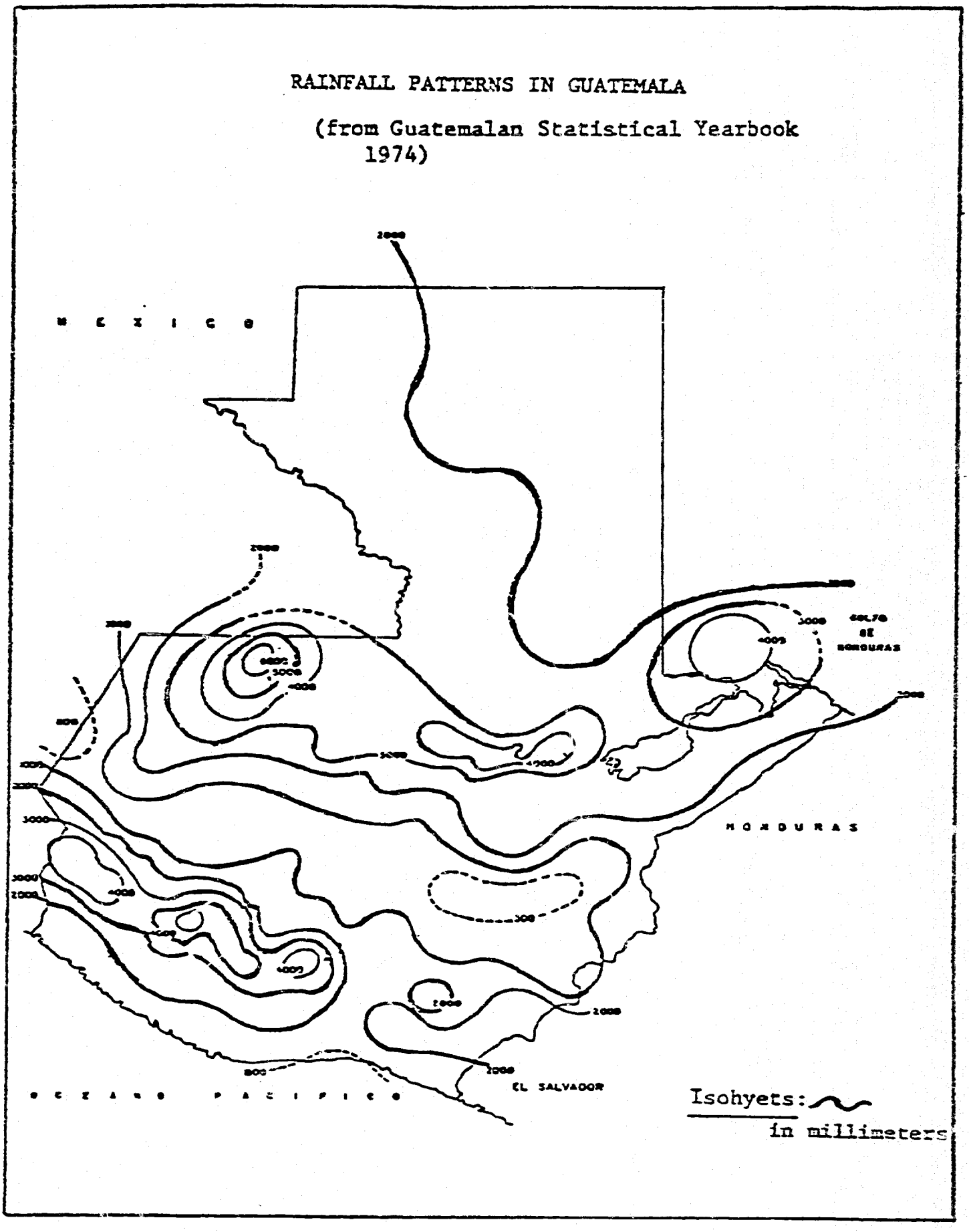


Figure 1. Rainfall patterns in Guatemala.

conditions that have produced possibly the most diversified plant growth of any country in Central America. The country's forests are estimated to contain 16 species of coniferous and 450 species of broadleaved trees. Several forest zones can be identified.

In the Pacific Coastal Zone, mangroves dominate lagoons inland from the shore. The coastal plain beyond the shore is predominantly savanna, interspersed with semideciduous forests. Further inland, tropical semideciduous forests cover the foothills and lower slopes of the Highlands, while at heights of from 600 to 1500 m there are remnants of the once extensive tropical broadleaf forest among coffee plantations.

In the Highlands there are traces of the once extensive pine and oak forests that covered the hills before much of the land was cleared for subsistence agriculture. The major trees in the area of the Chixoy Development Project in the Western Highlands include three types of pine (Pinus oocarpa, P. montezumae, and P. pseudostrobus), three types of oak (Quercus peduncularis, Q. acatenangensis, and Q. brachystachys), one Malpighiaceae (Byrsonima crassifolia) and one Dilleniaceae (Curatella americana) (Goodland and Pollard 1974). The Guatemalan fir (Abies guatemalensis), endangered because of its extensive use in religious ceremonies, grows only in the high-mountain wet forests of the Highlands between 1700-3500 m.

Along the Caribbean Coast, with the exception of plantation areas such as in the Motagua River Valley, tropical broadleaf evergreen rain forests are found.

The most densely forested area of Guatemala is the northern department of El Peten which comprises about one-third of Guatemala. An estimated 80% of the hardwoods of the country grow there. Some lowland rain forest occurs in the southern part of the department, but most of the area is dominated by tropical evergreen seasonal forest. In the northern areas, in the vicinity of Tikal, an upland forest of mahogany (Swietenia macrophylla), Spanish cedar (Cedrela odorata), ceiba (Bombax ellipiticum)--the Guatemalan national tree, zapote (Manilkara achras), ramon (Brosinum alicastrum), and various palms are found. There is also a rare, small area of pine forest near the northeast corner of Tikal National Park. In poorly drained areas (bajo), there are dense, almost impenetrable forests of logwood (Haematoxylum campechianum) and other low spiny leguminous species. Between these areas and the upland forests are found spiny escoba palm (Cryosophilia argentea) and the botan palm (Sabal morrissiana). Cleared upland forest regenerates into fast-growing Cecropia. In the southern parts of the department, there are small savanna areas with pine forests (Pinus caribaea), among which grow oaks, palms, and sedges.

Estimates of the extent of the forest resource of Guatemala vary widely. The most recently issued FAO statistics place it at 64,000 km^2 or some 59% of the total land area of the country. The Guatemalan Association for the Defense of the Environment estimated in 1978 that only 36,100 km^2 or about 33% of Guatemala is still forested, while Walter Mittak, an FAO consultant, estimated it at 36.3% in 1975. Whatever the actual percentage of forest land, however, it is clear from most sources that increasing and uncontrolled loss of forests is a problem of major concern in Guatemala.

Wadsworth (1971) indicated that about 2,650,000 ha (approximately 55%) of the forest land of Guatemala were accessible and under exploitation for timber or fuelwood. Wadsworth also cites figures indicating that if soil capabilities, climatic and topographic factors are considered, about 6,330,000 ha (approximately 59%) of Guatemala are unsuitable for crop or forage agriculture. Of this 6,330,000 ha, 3,180,000 ha (approximately 50%) are suitable for timber production, while the remaining 3,150,000 ha should be reserved as protective forest cover, serving for soil and water conservation as well as for wildlife habitat.

Most of the broadleaved (non-coniferous) hardwoods suitable for exploitation are in the Peten and Transversal regions while conifers are found chiefly in the southwestern mountains. There are about 300 species of tropical, subtropical, and temperate varieties of wood capable of being exploited. Recent commercial exploitation of wood has been concentrated in the Peten and the Transversal del Norte. The government plans to increase accessibility to the Peten department by constructing roads and ports to serve this area. These actions will considerably increase logging and wood production. There are also plans to establish sawmills and a veneer cutting plant.

Recent statistics on forest roundwood removal and export and on lumber production and export are shown in Table 1. Roundwood removal continues to increase but export of this product is decreasing. The same phenomenon is occurring for sawnwood production and export. This trend indicates a greater utilization of forest products internally and a possible reduction of export capital. Increased expansion of lumbering in the Peten and Transversal may shift this trend back to more export gains if the government wishes to use forest products to increase foreign income. The high use of coniferous forests for fuelwood indicates a high population pressure in this resource. Approximately 90% of the wood use in Guatemala is for firewood.

Construction materials, such as veneer sheets and plywood (about 23,000 m^3 in 1974), printing and writing paper (about 12,000 MT in 1974), and other paper products such as construction paper and wrapping and packaging paper (about 16,000 MT in 1974), are produced in Guatemala. These products have increased by as much as a factor of two or three since the mid-1960s. Other important forest products are chicle, the base for chewing gum, derived from the zapote tree in Peten, vanilla, sarsparilla, medicinal barks and herbs, camphor, cinnamon, oil-bearing palms, tannin, and bamboo.

Forest resources are managed by two organizations: 1) Instituto Nacional Forestal (INAFOR) which was established by law in 1974 and is the government agency responsible for forests throughout most of Guatemala, and 2) Empressa Nacional de Fomento y Desarrollo Economico del Peten (FYDEP), which includes forest management as one of its responsibilities in the development of the Peten Department.

1.3.3 Soil Resources

Guatemala has many different soil types which vary considerably in fertility. Wadsworth (1971) cites studies indicating that if soil capabilities, climatic, and topographic factors are taken into account,

Table 1. Roundwood removal and sawnwood production from Guatemalan forests. Table adapted from Library of Congress report (1979). Information from FAO Yearbook of Forest Products (1975).

	Broadleaved Trees			Coniferous Trees			Total		
	1964	1974	1975	1964	1974	1975	1964	1974	1975
1. Roundwood Removal									
a. Sawlogs, veneer logs, railway tie logs	58*	168	87	286	236	449	344	404	536
b. Other industrial wood	-	-	-	8	27	10	8	27	10
c. Fuelwood	600	900	900	3294	4220	4220	3894	5120	5120
TOTALS	658	1068	987	3588	4483	4679	4246	5551	5666
2. Sawnwood Production	25	59	44	110	144	225	135	211	269
3. Wood Export									
a. Roundwood (Broadleaved plus coniferous)							1	8	7
b. Sawnwood	7	16	10	7	50	28	14	66	38

* all values x 1000 m^3

about 63,000 km^2 (approximately 59%) of Guatemala are unsuited for crop or forage agriculture. A 1970 study of the Peten states that about 85% of the department is covered with shallow clayish, poorly drained soils which are highly susceptible to erosion when the now dominant forest cover is removed. This fact could and should restrict colonization efforts aimed at sustained agricultural production, but should encourage attempts for sustained forestry management projects.

Wylie (1970) describes about 10 general soil types for Guatemala. The Pacific coast slopes and plains are dominated by alluvial, humic gley and grumusol soils. Alluvial soils are fertile and well drained, with a loam or silt loam surface and a fine sandy loam subsoil. Humic gley soils of the Pacific plains are poorly drained and usually too wet for cultivation. Proper drainage is necessary to bring them into production. Grumusols occur along the Pacific coast and in some parts of Peten. These soils, which are difficult to manage since they are sticky when wet and very hard when dry, could be productive if good management techniques were employed.

Andosenic soils are found mostly in the mountainous areas of the Central Highlands. These soils, derived from volcanic ash, are moderately fertile with loamy surfaces and subsoils containing slightly more clay than the surface soil. Subject to erosion on the steep slopes, these soils are intensely cultivated on the more gentle slopes. Reddish-brown lateric soils are deep, well-drained, and friable, and are the most productive soils in the country. However, they are restricted to small areas in the Eastern Central Highlands and southwest sectors of the country. Red-yellow podzolic soils are less productive than the reddish-brown lateric soils and occur in a few areas in central Guatemala. They respond well to fertilization. Lithosolic soils dominate the mountains and steep slopes of central Guatemala. These soils are largely forested and have little farming potential.

The northern portion of the country, the Peten and Transversal, is dominated by terra rosa (red clay) and rendzina (black or dark brown clays) soils. These soils are shallow but have high surface organic matter. Humic gleys, grumusols, and red-yellow podosols are interspersed throughout the Transversal and Peten.

Acid fibrous peat, interspersed with low ridges of beach sand, is found in the area northeast of Puerto Barrios along the Gulf of Honduras. These areas have little agricultural potential. Terra rosas, humic gleys and lithosols are also found in this Caribbean area.

1.3.4. Water Resources

Many rivers, most arising in the Central Highlands, drain Guatemala. Seventeen major river basins flow toward the Pacific draining 26,344 km^2, approximately 24% of the land area of Guatemala. Four river basins, two of which (Rio Dulce and Rio Motagua) consist of two or more sub-basins, flow toward the Caribbean and drain about 30,743 km^2, about 28.5% of the land area. Two major river basins, the Grijala, consisting of 3 subbasins, and the Usumacinta, consisting of 7 subbasins, flow toward the Gulf of Mexico, draining 50,803 km^2 or about 47.1% of the country.

Guatemala has many thousands of kilometers of rivers. The river complex formed by the Chixoy and Negro, the Salinas, and the Usumacinta is 728 km long; the Rio Motagua flows 486 km from its source in the El Quiche department to the Caribbean. Only about 260 km of rivers are navigable year-round, with 730 km being navigable during the wet season. The Motagua is navigable along about 192 km of its length; it is the only major inland route formed by the Lake Izabal-Dulce River system which empties into the Bay of Amatique on the Gulf of Honduras. Deforestation-caused-siltation in the Rio Motagua has reduced discharge volume by half in the past 20 years.

The hydroelectric potential of Guatemala is estimated to be about 4,000 megawatts, but only about 20% of this potential is now being realized. The rivers flowing from the mountains to the Pacific have high hydroelectric potential. All are located on a fault line or volcanic zone. Seven new hydroelectric projects are at various stages of completion (Goodland and Tillman 1975). A major hydropower project on the Rio Chixoy will produce 125 megawatts of power.

Rivers serve as a source of water for irrigation, but Guatemala's irrigation potential has been underutilized. Irrigated land accounts for only about 4% of the total farmed land dedicated to both harvest and permanent crops. Government irrigation efforts, conducted under the Division of Water Resources of the Ministry of Agriculture, have been concentrated mainly in the Motagua River Valley. The country is presently planning to develop its irrigation potential in conjunction with hydroelectric projects (Goodland and Tillman 1975).

Guatemala has about twenty lakes of various sizes. The largest are Lake Atitlan, 130 km^2, and Lake Izabal, 589.6 km^2. Lake Atitlan, about 100 km southwest of Guatemala City, is situated amid spectacular volcanic peaks. It is renowned for its clear waters and abundant wildlife. It is the home of the Atitlan Grebe, (Podilymbus gigas), a rare flightless waterbird occurring nowhere else in the world. Lake Amatitlan, a smaller lake about 20 km south of Guatemala City, has suffered significant degradation.

Lake Atitlan is a center for tourism. Hotels and tourists resorts are presently concentrated at Panajachel on the northern shore. Construction of six large scale apartment towers at Panajachel and four similar structures on the opposite shore of the lake is planned. These buildings will have the adverse effect of bringing to this still relatively unspoiled lake thousands of people and their sewage. Lake Amatitlan, because of its proximity to Guatemala City, has already degraded due to many vacation homes with their frequently inadequate sanitary facilities.

Little groundwater data are available. It has recently been estimated that about 60-70% of the 160 million liters of drinking water consumed daily in Guatemala City comes from groundwater sources. The actual amount of groundwater consumed may be higher because this estimate fails to account for a large but unknown number of unregistered wells. This heavy demand plus water loss related to deforestation in the area is reported to be leading to a permanent decrease in the groundwater supply.

A recent survey of the water resources of Guatemala stated that only about 3% of Guatemala's abundant water resources was currently being used (UNESCO 1976). Problems, however, arise from the geographical distribution of these resources in relation to water-demanding activities. In the Guatemala Valley, for example, the water supply limit has nearly been reached. Furthermore, estimates suggest that by the beginning of the 21st century total demand will be equal to the average runoff of the country and that a considerable part of the hydroelectric resources will be used.

1.3.5 Wildlife and Fisheries Resources

Central America has been in the center of extensive migrations of northern and southern animal species. Major interchanges of fauna have occurred throughout recent geological time. Guatemala with its diverse habitats has also been a center of evolution of new flora and fauna. Guatemala now has a rich fauna of more than 600 bird species, more than 200 species of reptiles and amphibians, 250 species of mammals and 28 game animal species (Bovay Engineering, Inc. 1973).

Guatemala has a diverse mammal fauna representing the southern limit for some species that are typically North American and the northern limit for others that are typically South America. Some smaller species, such as Anthony's spiny pocket mouse (Liomys anthonyi), the big deer mouse (Peromyscus grandis), and the Guatemala vole (Microtus guatemalensis), are endemic to Guatemala and occur nowhere else in the world. Many of the larger mammals are among those listed as rare and endemic by the International Union for the Conservation of Nature (IUCN) (Table 2). There are over twenty species of bats, six species of squirrels, oppossums, shrew anteaters, gophers, a large variety of mice and rats, foxes, raccoons, weasels, skunks, mountain lions, peccaries, and manatees. Mountain lions, peccaries and manatees are rapidly being depleted.

Colorful and exotic birdlife abounds in Guatemala. Of particular interest is the resplendent Quetzal, the national bird of Guatemala, which is found principally in the montane forests of Quetzaltenango, Huehuetenango, El Quiche, Alta Verapaz, and Baja Verapaz. Lake Atitlan is the home of the endemic Atitlan Grebe. The total world Atitlan Grebe population is entirely in Guatemala and has been estimated at 90 to 100 individuals. Other birds of particular interest are the Horned Guan which inhabits the high forest of northwestern and central Guatemala and the Brown Pelican which is found on both the Atlantic and Pacific Coasts but which has disappeared from Lake Atitlan. These birds, particularly the Quetzal and the Atitlan Grebe, are valuable national resources.

Reptilian and amphibian life is also plentiful; 107 species of reptiles, including frogs, turtles, crocodiles, lizards, and snakes, have been found in the Peten alone. Among endangered reptiles are Morelet's crocodile (Crocodylus moreletti), which is protected by the 1970 Hunting Law, and species of turtles.

Fish vary in quantity in the rivers of Guatemala. Goodland and Pollard (1974), for example, found that most of the Chixoy River in the area designated for joint hydroelectric and irrigation development was

Table 2. Guatemalan animals considered rare or endangered (From Library of Congress 1979 report).

Scientific name	Common Spanish name	Common English name
	REPTILIA	
Crocodylus moreletti*/**	Lagarto del Peten	Morelet's Crocodile
	AVES	
Pharomachrus mocinno*/**	Quetzal	Resplendent Quetzal
Podilymbus gigas*/**	Poc de Atitlan/ Zambullidor	Atitlan Grebe
Oreophasis derbianus*/**	Faisan de cuerno/ Pavo de cacho	Horned Guan
Pelecanus occidentalis*/**	Pelicano Pardo	Brown Pelican
Burhinus bistriatus	Peretete	Thick Knees
	MAMMALIA	
Myrmecophaga tridactyla*	Oso Homiguero	Giant Anteater
Tapirus bairdii*/**	Danta	Central American Tapir
Felis onca*	Tigre	Jaguar
Felis pardalis*/**	Tigrina	Ocelot
Felis weidii*/**	Tigrillo	Margay
Trichechus manatus*/**	Manati	Manatee
Odocoileus virginianus	Venado	White-tailed Deer
Mazama americana	Cabrito	Brocket Deer
Tamandua tetradacyla	Oso Colmenero	Tamandua
Ateles geoffroyi	Mico	Spider Monkey
Alouatta villosa	Mono Zaraguate	Howler Monkey
Lutra annectens	Perro de Agua	Otter

* Species included in the IUCN Red Data Book of Endangered Species
** Species in the U.S. Fish and Wildlife Service's List of Endangered and Threatened Wildlife and Plants (1980)

unusually deficient in fish. Other rivers such as the Polochic serve as sources of fish, but fishing in the inland waters of Guatemala is primarily subsistence level.

Only Lake Atitlan has been an important focus of fishing activities, principally because of the freshwater crabs which have been an important component of the diet of local inhabitants. Native fish stocks of the lake and the rare Atitlan Grebe were seriously threatened by largemouth bass (Micropterus salmoides) introduced into the lake in September 1958 and again in June 1960. Fingerlings of the bass grew rapidly and competed so successfully with native species of both birds and fish for food that the crab industry slumped and populations of native fish and other aquatic life dropped drastically. There have been attempts to rectify this situation through the introduction of other fish species and the reintroduction of nearly exterminated species such as the pescadito (Poeciliopsis gracilis and Poecilia sphenops). Goodland and Tillman (1975) list about 22 "important" indigenous freshwater fish species and seven introduced species of fish.

Guatemalan coastal waters are rich in fish. The waters of the Pacific Coast provide abundant quantities of shrimp, tuna, snapper, and mackerel. Fisheries resources tend to be underutilized, a circumstance traced largely to a lack of interest or a lack of skills and capital on the part of Guatemalans in either fish or fishing. Local markets throughout large areas of the country do not have large offerings of fish products (Goodland and Tillman 1975). Commercial fishing operations are limited to coastal areas, particularly along the Pacific Ocean, where commercial quantities of large pink and white shrimp occur. Shrimp production in recent years has been adversely affected by migratory changes in the shrimp banks of the Pacific Coast which have led to large portions of the shrimping fleet either being laid up or forced to operate in other locations. Exports of fish, crustaceans, and molluscs as reported for 1971 amounted to 2,787,200 pounds valued at 2,479,000 Quetzals.

Recent studies of the nation's hydroelectric plans have recommended the promotion of fisheries development in the reservoirs created by such projects, including the careful introduction of exotic species such as tilapia, carp, and bass. A fishing cooperative in the Santa Rosa department plans to set up several fish farms to protect certain species from extinction and develop other species.

1.4 Population, Development, Environment--The Problems.

The fundamental economic and social problem of Guatemala is the rapidly increasing population pressure, i.e., the degree to which strain is placed upon the environment as the result of people demands on resources.

For most of Guatemala's human history, a nearly static balance has existed between the nation's natural resource demands and the ability of the environment to supply these demands. Not only were levels of demand limited, but also the number of people was small. However, the balance between population and resources changed during the past 80 years. Guatemala's population has grown rapidly, increasing from about 1.5

million in 1900 to an estimated 6.8 million in 1980, with 12.2 million people projected for 2000 (Library of Congress 1979). The annual growth rate is 3.3%, giving a 22 year doubling time. The age structure of the population shows a broad base of young people with approximately 45% of the population under 15 years old (Fig. 2). Even if the growth rate decreases, the numbers of new individuals added to the population annually will continue to be high for many years.

Guatemala's population is divided into two ethnic groups, Indian, with 41% of the population and Ladino, with 59% of the population. The Indians are confined mainly to the Central and Western Highlands where they exist predominantly as subsistence farmers and craftsmen. The Ladino group is composed of westernized Indians and people of mixed race. This group is mainly found in urban areas and controls most of the economic, social and religious affairs of the country.

The urban population of Guatemala has increased in the past decades and now accounts for 36% of the total population. In 1973 the urban population was 1.07 million and was expected to rise to 1.4 million in 1980 and to 3.0 million by 2000. Most of the urban population is in Guatemala City. A 30% increase in the city's population in 10 years has led to degradation in water and air quality in the city.

Almost all of Guatemala, except the sparsely populated north, suffers adversely from population pressure. The population density for the entire country was 59.6 individuals per square kilometer in 1976. However, the density for arable land was 142.9 individuals per square kilometer. The population is most concentrated in the Central and Western Highlands in the departments of Guatemala, Solala, Totonicapan, Quezaltenango and San Marcos (Fig. 3). However, the greatest percentage increase in population is the Peten department, an area of new lumber development and colonization. In the Central and Western Highlands, there is insufficient land for even subsistence agriculture. Individuals with insufficient land must resort to a variety of activities for support, e.g., seasonal migration to the coffee area for the harvest season and to the South Coast to work on cotton farms, permanent migration to the sparsely settled north and to urban centers, intensification of agriculture and the use of commercial fertilizers, and clearing of sloping forested land and its conversion along with pastureland to cropland.

The net result of some of these practices has been deforestation and forest deterioration as a result of exploitation for wood and for agricultural land. This has resulted in wildlife destruction and decline, excessive soil erosion and depletion. Runoff from deforested land has resulted in stream siltation and contamination by fertilizers. Also, streams have been contaminated by raw sewage dumping from towns and individual farms.

All of these problems, as well as others, are intimately interrelated and are reflections of the region's socio-cultural and economic patterns. Environmental damage that has occurred so far is serious but controllable. Each day that passes without remedial action increases the costs and compounds the difficulty of reversing or significantly

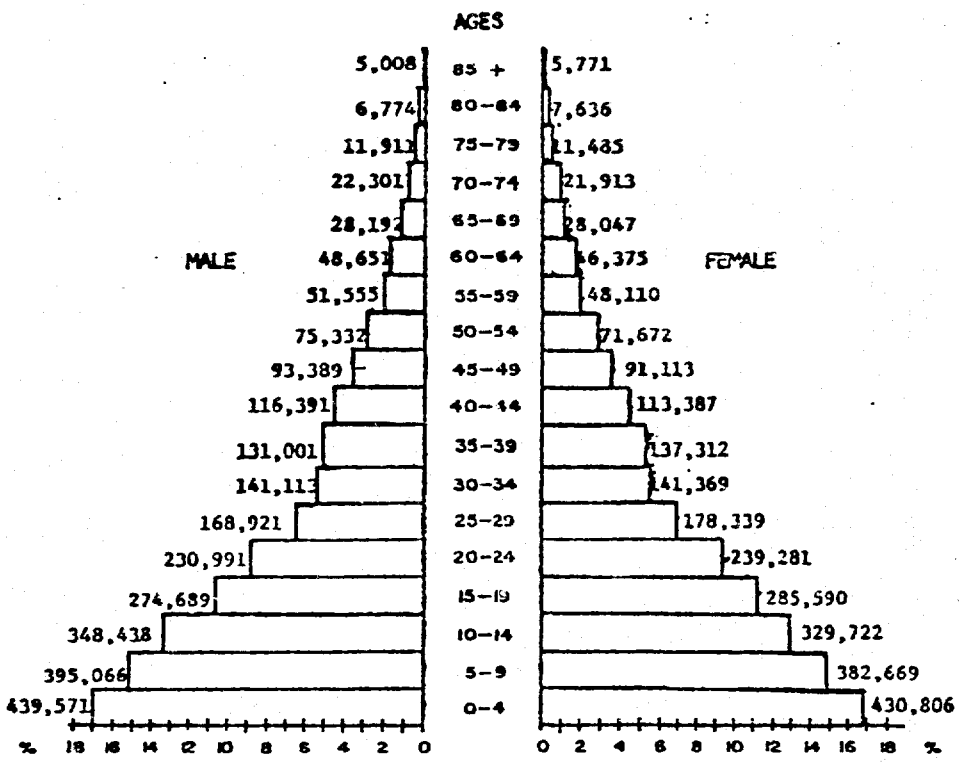
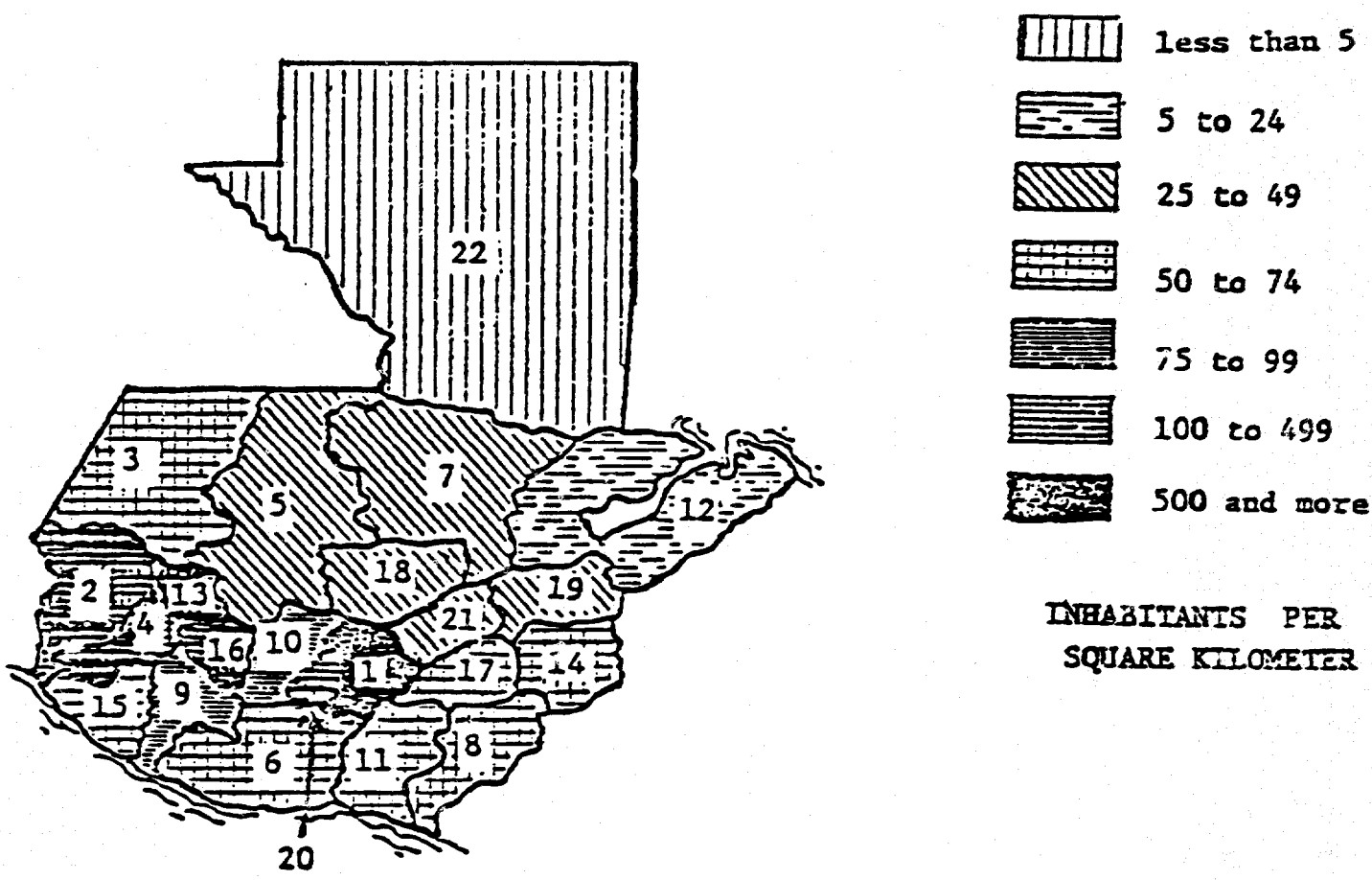


Figure 2. Population pyramid based on the 1973 Census. (Library of Congress 1979).



Department	Area (sq. km)	Pop. (1973)	% of pop.	% increase since 1964
1. Guatemala	2,126	1,127,845	21.6	38.6
2. San Marcos	3,791	388,100	7.4	16.8
3. Huehuetenango	7,400	368,807	7.1	28.5
4. Quezaltenango	1,951	311,613	6.0	15.9
5. Quiche	8,378	300,641	5.8	21.3
6. Escuintla	4,384	300,140	5.7	11.2
7. Alta Verapaz	8,686	276,370	5.3	6.3
8. Jutiapa	3,219	231,005	4.4	16.1
9. Suchitepequez	2,510	212,017	4.1	13.8
10. Chimaltenango	1,979	193,557	3.7	18.2
11. Santa Rosa	2,955	176,198	3.3	13.3
12. Izabal	9,038	170,864	3.3	49.4
13. Totonicapan	1,061	166,622	3.2	19.3
14. Chiquimula	2,376	158,146	3.0	4.6
15. Retalhuleu	1,856	133,993	2.5	9.1
16. Solola	1,061	126,884	2.4	16.6
17. Jalapa	2,063	118,103	2.3	20.5
18. Baja Verapaz	3,124	106,909	2.0	11.8
19. Zacapa	2,690	106,726	2.0	11.2
20. Sacatepequez	465	99,710	1.9	23.9
21. El Progreso	1,922	73,176	1.4	9.7
22. Peten	35,854	64,503	1.2	141.4
GUATEMALA	108,889	5,211,929	100.0	21.6

Figure 3. Population concentration by department (Library of Congress 1979).

modifying the damage. Yet like so many other nations Guatemala's priority projects revolve around economic and social development leaving few funds and little effort available for environmental protection. This may be partially based on the concept that the natural environment should be conquered and the erroneous belief that renewable natural resources are inexhaustible.

The idea that economic development and environmental well-being can be separated or that the environment can be ignored without causing economic development problems is an impediment to long-term solutions. Long-term ecological solutions are difficult to implement when a country is faced with the realities of malnutrition, unemployment and underemployment, and growing population. Short-term, 5-10 year, economic growth projects are politically more expedient and are superficially more attractive than less clear-cut, long-term programs.

Any successful plan to protect the environment or reduce environmental degradation must recognize that a) economic and social development projects receive the highest priorities, and b) environmental concerns are not perceived as important to many leaders and citizens. An environmental program, therefore, should have economically stimulating benefits. For example, one of the most critical pollution problems results from dumping raw sewage in natural waterways. A benefit-cost analysis could show that it is more economical to treat the sewage than to spend large sums to purify contaminated water for household and industrial uses.

With these general considerations in mind we next develop a more detailed statement of the environmental problems of deforestation, soil erosion, wildlife decline, water quality degradation, agrochemical and pesticide problems, urban and industrial problems, air quality degradation and noise pollution, and coastal zone impacts. We then proceed to the relationship between environmental problems and developmental objectives, a discussion of existing national policies, institutions and programs for dealing with environmental problems, constraints to dealing with environmental problems, and conclude with the long and short-term recommendations.

2. ASSESSMENT OF ENVIRONMENTAL PROBLEMS

2.1 Watershed Deforestation and Associated Soil Erosion

2.1.1 Deforestation

Growth of human populations continues to increase and demands for agricultural land by these additional people are increasing. The demand for land has led to burning of forests and fields, resulting in a major reduction in flora and fauna, increased soil erosion and possibly climatic changes.

South of latitude 15°30'N only about 20% of the original biota remains or approximately 10,000 km^2 of habitat (Bovay Engineering, Inc. 1973). The greatest landscape alterations have occurred in the central, western and Pacific regions of the country where a dense and increasing

population demands more agricultural land. Destruction throughout the Central Highlands is at a critical point. Many wildlife species are at critically low levels and many plant and animal species have become extinct or are on the verge of extinction. These losses constitute an extinction of valuable genetic stock whose potential may not have been realized.

Forest loss has been severe. Trees suitable for industry and exploitation, e.g., mahogany, cedar, white oak, have decreased because the ecological zone suitable for their propagation and growth is the area in which increased cultivation has the highest priority. The lack of good timber has resulted in the closing of many small sawmills.

Conifers, an important timber source in the Central and Western Highlands, are subjected to severe commercial exploitation. In 1973, 99.5 million board feet were cut, the equivalent of 250,000 trees. Currently, a severe pine beetle (Dendroctonus) infestation is destroying many pines. Although this infestation may be only a severe repetition of a naturally recurring cycle, by December 1978, 200,000 ha had been affected.

Another major cause of forest loss is the increasing demand for firewood, Guatemala's chief energy source. More than 90% of the wood cut in Guatemala is used for firewood. In all heavily populated areas, particularly in the Central and Western Highlands, the demand is high for firewood for domestic cooking and heating, firing brick- and lime-kilns, coffee dryers and bakery ovens. Estimates indicate that about 600,000 rural families use firewood for cooking which accounts for about 1.8 million trees cut per year (Library of Congress 1979).

The rate of deforestation is uncertain and various reports conflict. The U.S. Agency for International Development (AID) estimated 30-50% of the forest resources of the country has been destroyed since 1950 (AID 1979). Other sources suggest 33% of the forest resources lost in the last 10 years (ICAITI 1978); 65% of the forests destroyed since the beginning of the century (INAFOR); 64.7% of the country forested in 1950 and only 36.3% forested in 1975 (FAO); rate of loss of forests is 60,000 ha per year (FAO); and only 36,100 km^2 of the former 96,368 km^2 of forest remain (Guatemalan Association for the Defense of the Environment). Although they differ, these figures underscore the critical deforestation problem.

2.1.2 Atlantic Watershed Problems

Extensive forest conversion has taken place in the basins of the Motagua, Sarstún and Polochic Rivers and in the watersheds surrounding Lake Izabal. Agricultural and mining development in the Rio Polochic Basin and along the shores of Lake Izabal has caused considerable soil loss from erosion and associated stream sedimentation. Large forested areas have been converted to pastures for cattle farming. This practice has resulted in pollution and sedimentation in small streams that feed the lake. The Motagua watershed has been subjected to severe forest conversion, which has resulted in its streams and main stem being highly sedimented. The Motagua is the most contaminated river in the region due to sewage from Guatemala City and deforestation.

Extensive burning in the dry season associated with the clearing of forests has caused temporary ash contamination in some watersheds along Lake Izabal. The heavy influx of excessive ash and organic matter is flushed into the streams by the first heavy rains of the wet season. This has resulted in depressed oxygen concentrations in streams due to increased biochemical oxygen demand from decomposing ash and organic matter. This phenomenon was particularly severe in the Polochic watershed in 1975 when numerous fish, primarily bottom feeders such as catfish, were killed along the western shore of Lake Izabal. Low oxygen concentrations and fish kills from ash influx are recent recurring problems.

Soil erosion has silted many rivers. The Motagua River has had its flow reduced by 50% over the past 20 years as a result of silt deposits (Library of Congress 1979).

2.1.3 Central and Western Highlands Watershed Problems

The extensive deforestation of the Highlands is a direct result of the expanding population's need for land for cropping and for fuelwood. The Ladino population has contributed to the severe land conversion through exploitation of wood and conversion of land to agriculture, housing and commercial use. The Indian population has had a long tradition of understanding of nature's carrying capacity and in the past has practiced conservation. The Indians, working in village or sub-village groups, constructed terraces, planted and cultivated on the contour of the hills, reserved steeply sloped land for forests, and replaced soil nutrients by fallowing, green manuring and by carrying silt from low areas to the upper slopes. Recently the strong Indian cultures have been partially destroyed through increased population on restricted land and through outside influences. Terracing has declined and more steeply sloped land has been cleared for cropping. Population pressure has forced many Indian groups onto marginal land. In order to survive, these people must clear forests on steep slopes in order to provide subsistence cropping areas.

The majority of the deforested land is in the steeply sloped Highlands where denuded areas are susceptible to extensive erosion. Large scale conversion to primarily agricultural land use has resulted in severe soil erosion, soil nutrient depletion, siltation of streams, reduction of water holding capacity of soils, increased susceptibility to flooding and drought effects, drying up of springs used as water supply points, loss of fuel for cooking, and loss of raw materials for tools and many forms of handicrafts.

Soil erosion in the Highlands has removed several hundred hectares of land from productive use through the removal of surface soil layers. Although the soils of the Central and Western Highlands are the moderately fertile andosols of volcanic origin, they are highly erodable on steep slopes because they are primarily unconsolidated volcanic ash. Most of the Central Guatemalan region is dominated by mountains and steep slopes with strong lithosolic soils which are readily eroded when cleared. Soil losses in the Western Highlands have been estimated from 5 to 35 tons per hectare annually in areas without soil conservation practices. In the Xaya-Pixcaya watershed about 267 ha of soil are lost

annually. If this soil loss rate continues the watershed could be depleted in 15 years (AID 1979).

Soil nutrient depletion is characteristic in areas of intensive agricultural use. Erosion removes nutrient stocks by removing soil and leads to rapid leaching of remaining nutrients. Terracing helps reduce soil loss, but too little terracing is employed in the Highlands.

Soil erosion in the Lake Atitlan basin results from intensive and extensive agriculture on very steep slopes. Total solids during the wet season in two rivers flowing into the lake were 468 and 693 mg/l (mean annual concentration for 1969 to 1972) (Instituto Geografico Nacional 1976). Forest clearing in this watershed has accelerated since these measurements were taken and the total solids in rivers and streams entering the lake have increased. Agrochemical use may also be threatening Lake Atitlan. The potential exists for accelerated eutrophication from chemical fertilizers washed into the lake through runoff and erosion. Reforestation of the entire Lake Atitlan watershed has been suggested to prevent further deterioration to the lake (Bovay Engineering Inc. 1973).

2.1.4 Pacific Coastal Watershed Problems

Almost complete deforestation of the Pacific coastal plain has been accomplished in the past 30 years. In 1940 this coastal area was almost totally forested. The area is now the major agricultural exporting region of the country, producing cotton, sugar cane, bananas and cattle. Erosion, although no longer a major problem as it was during deforestation, occurs in the cotton areas where clear cultivation techniques are employed. The extent of soil inputs into streams is not known. Soil nutrient depletion as a result of cropping is high and nutrients are replaced through costly commercial fertilizers.

Coastal mangrove forests are exploited for firewood. Mangrove wood is also supplied to the tanning industry in El Salvador. Pressure on this resource is critical; the mangrove forests now comprise only 8% of the 1954 area. This ecosystem should be protected because it supports coastal fisheries as a pollutant scrubber, land retainer, nutrient supplier and shelter for juvenile fish.

2.1.5 Northern Region Problems

The Transversal del Norte and Peten recently have begun to feel the pressure of modern exploitation. Deforestation in these areas is primarily for wood products by major lumber operations and conversion of land to agriculture through slash and burn techniques.

The Peten is the most densely forested area of Guatemala containing an estimated 80% of the hardwoods of the country. The Peten also has the most suitable hardwoods for exploitation. Tropical evergreen seasonal forests are found over most of the region, with tropical rain forest in the southern portion and in major areas of the Transversal.

The Government plans to make the Peten and the Transversal more accessible to exploitation by constructing roads and ports to serve the

area. This plan will accelerate logging operations and open the area to colonization. Sawmills and a veneer cutting plant are planned for the area.

Colonization is coupled with increased commercial logging in these areas. The increased population density in the Highlands has encouraged development of colonization schemes to move people from the Highlands to the northern lowlands. Many of these schemes are agricultural projects that lack sufficient scientific information to assure their success. Both social and environmental problems may result from these colonization projects. In most areas the soils are not suitable for sustained agriculture and may rapidly lose fertility. Traditional slash and burn agricultural practices will require longer fallow periods to restore fertility. This will require increased forest conversion to agriculture to sustain the colonists. Sustained production forestry programs for the colonists may be a better use for this area.

The potential for serious destruction of the forests of the Transversal and Peten departments is real. Lumber and land exist there and are envisioned as a method for foreign exchange and for relief of social problems in the high population concentrations of the Highlands. Settlement of the area is imminent, but a sustained yield forestry concept for the colonists would be a better approach than agriculture, especially in the heavy rainfall areas of the Transversal.

2.2 Water Quantity and Quality

2.2.1 Drinking Water Supply and Quality

Drinking water supply is inadequate. Only about 40% of the population has either piped water or easy access to other safe water sources (Fig. 4). Only about 80% of the water need in Guatemala City is satisfied. High leakage is found in the water distribution system and illegal taps and leaky connections are common. The leakage and low pressure could result in serious public health problems.

Guatemala City relies on groundwater for much of its water supply. Groundwater quality is not well monitored in the Guatemala City basin, but should be. Water treatment plants in the city, deriving most of their supply from wells, have interrupted withdrawals as a result of inadequate supply and function only about 12 hr per day. The discontinuous function is believed to adversely affect water quality (Library of Congress 1979).

Drinking water quality is generally poor and is the source of much of the disease which afflicts Guatemalans, especially in rural areas. Although the number of individuals served by water supply and sewer systems has increased in recent years, the proportion of the population served has either remained the same, increased slightly, or decreased for the total urban population with access to safe water supply (Fig. 4).

In areas heavily impacted by the 1976 earthquake, extensive damage to water supply systems occurred. Seventy-five urban water systems were partially or totally destroyed and about 240 rural localities were damaged. The waterworks in Guatemala City suffered extensive damage,

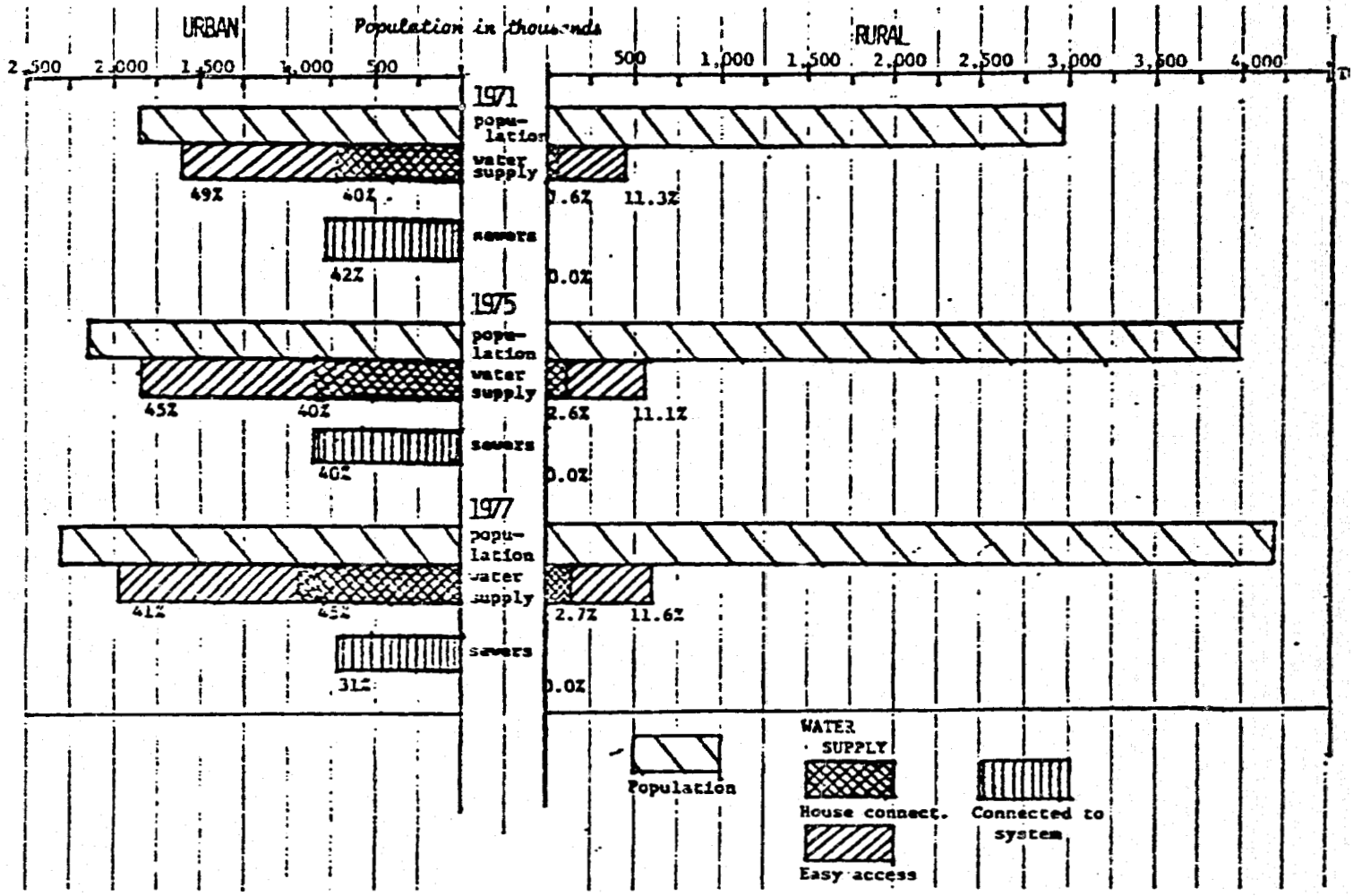


Figure 4. Urban and rural populations served by water supply and sewage systems, 1971, 1975 and 1977 (From Library of Congress 1979).

and fecal contamination of water supplies became a threat because of possible cross connection of water and sewer lines (Library of Congress 1979).

2.2.2 Wastewater Treatment

Only three sewage treatment plants are located in Guatemala with none in or around Guatemala City. Only 11-14% of the population of the country has been served by sewers throughout the 1970s. Guatemala City has a main sewage collection system for storm water and domestic sewage but does not have a sewage treatment system. Sewage is dumped directly into streams and rivers. Consequently, streams and rivers of the Pacific and Atlantic watersheds in the vicinity of Guatemala City are polluted.

This practice not only affects fish resources in the area, but presents a significant health hazard to rural populations downstream from Guatemala City and downstream from other urban centers. Rural streams are used for washing and bathing. Lack of sanitary facilities, potable water and washing and bathing in polluted streams results in gastroenteritis, other diarrheal diseases and skin infections. Enteritis and diarrheal disorders are high especially among children 1-5 yr old. These maladies result in debilitation and high infant mortality (Library of Congress 1979).

2.2.3 Water Quality Degradation

One major cause of water quality degradation is sedimentation. The deforestation of watersheds throughout the country, but especially on the steep slopes of the Central and Western Highlands, has resulted in severe erosion and soil loss. Sediment imports into streams and rivers have resulted in reduction of bottom organisms that are fish food, loss of fish resources, reduction in depth of streams, increased flooding from stream size reduction, reduction in navigability of rivers and streams, and damage to estuarine organisms. Deforestation causes changes in the hydrologic regime of streams and rivers. Flow and discharge patterns are altered; watershed runoff is more rapid, hence rivers rise faster and flow rates increase during heavy rainfall. This phenomenon frequently results in more flooding and more devastating floods.

Hydroelectric projects add to degradation of water quality when the vegetative cover is removed from watershed slopes. Erosion rates are high in the area of the Chixoy Hydroelectric Project and sediment yields of 760 m^3 of soil per year per square kilometer of watershed have been estimated. Without adequate revegetation or natural regeneration of plantings to conserve soil, the reservoir will fill in rapidly.

The Villa Lobos basin south of Guatemala City is almost completely deforested. The sediment yield to Lake Amatitlan is 1170 m^2 of soil per year per square kilometer of watershed. Also, a poorly functioning sewage treatment plant along a stream that empties into Lake Amatitlan further degrades water quality in this lake which is also impacted by extensive vacation development homes along its shore. High sediment loads also are found in the Maria Linda, La Paz, Somalá, Coyolate and Achiquate River basins.

Lake Izabal has been impacted by sediment input as a result of severe deforestation and mining operations (Section 2.1.2). Lake Atitlan, the most beautiful lake in the country, is under severe pressure from sediment inputs from agricultural development on the steep slopes of its basin, from fertilizers and pesticides associated with agriculture, and from the rapid tourist development around the lake and its associated wastes which are dumped untreated into the lake.

Water quality in the Pacific coastal zone is degraded by agricultural chemicals, primarily pesticides. The cotton cultivation in this zone is carried out with multiple pesticide and herbicide applications. Much of this aerially applied material drifts or runs off into waterways. Impact is extensive on human health through direct poisoning or debilitation and on fisheries resources in collecting streams and in the estuaries. These problems are amplified in section 2.4.

2.3 Wildlife and Fisheries Problems

2.3.1 Wildlife Pressures

Animal populations are declining in many areas of the country with many species near extinction. This acceleration in natural extinction rates and species loss is a result of natural habitat destruction, contamination of terrestrial and aquatic habitats by pesticides, agrichemicals, toxic substances, and human and animal waste. Also, overexploitation due to reckless hunting has reduced game animals; crocodiles, ocelots and jaguars have been exploited for their skins.

The resplendant Quetzal, Guatemala's national bird, has been subjected to increasing pressure primarily as a result of habitat destruction but also from exploitation for stuffed skins. Road construction associated with hydroelectric projects is a potential threat to the Quetzals (Goodland and Tilman 1975). The principal Quetzal habitat is the montane forests of Quezaltenango, Huehuetenango, El Quiche, Alta Verapaz and Baja Verapaz departments. A small preserve has been provided in the cloud forest of Volcan Atitlan; a second reserve under the supervision of the National University is in Baja Verapaz. However, these reserves are not adequate to preserve an adequate population of this bird.

The Atitlan Grebe has been threatened repeatedly and its numbers have diminished to about 100 individuals. The habitat of this bird has been disturbed by tourists in motorboats and the grebe has been preyed upon by the introduced largemouth bass. Fluctuations in water level caused by a proposed hydroelectric project may disturb the vegetation on which the grebe depends for successful nesting. A campaign to save the grebe, in conjunction with protection afforded the bird under the 1970 Hunting Law, has been reported to have been successful in restoring and preserving its nesting habitat (Goodland and Tillman 1979).

The next areas to be severely affected will be the Transversal and Peten. Pressure on wildlife is increasing due to logging operations and human settlement expansion with associated slash and burn agriculture practices.

Coastal birds have been and continue to be affected by agrichemicals and pesticides. Small reserves of natural forests have provided habitat for birds and other animals. These areas should be preserved, especially with the eventual need for the coastal agricultural industry to adopt integrated pest management programs.

2.3.2 Fisheries Impacts

The damage to inland fisheries has been in areas where watershed conservation has not been practiced. Forest destruction on steep slopes results in soil erosion which places heavy silt and sediment loads in streams. This silt and soil damages fish directly through physiological impact and reduces feeding, breeding and nesting. This is common in the Atlantic lowland areas and in the Highlands.

Lake fisheries have been disrupted through the introduction of largemouth bass in Lake Atitlan. This predator multiplied rapidly and out-competed native fish for habitat and food. It also affected the food supply of a freshwater crab that is utilized by local people and commercially exploited.

Coastal fisheries are affected directly by siltation, agrichemicals, and pesticides or through impact to their invertebrate food sources from these agents. Destruction of mangrove forest has affected near shore fisheries.

2.4 Pesticide Use and Misuse

2.4.1 Pesticide Use in Central America and Guatemala

Pesticide use in Central America has been associated primarily with cotton cultivation. Cotton has been grown in the region since the beginning of this century, but heavy applications of pesticides were not administered until the 1950s. The advent of organochloride insecticides in the early 1950s provided new control for cotton pests, but also caused new problems.

DDT, BHC, and toxaphene, at the rate of eight applications per season, were used in the early 1950s. Later, organophosphorous insecticides were introduced. The increased use of pesticides, however, was accompanied by an increase in the number of harmful species reaching pest levels from two in the 1950s to eight in the 1960s. In the 1960s new organosynthetic pesticides, many of them not approved for sale in the country of production, appeared on Central American markets and were used in various combinations in cotton farming. By this time the number of applications per season had increased to 28. DDT, dieldrin, toxaphene, methyl parathion, ethyl parathion, and endrin were used most extensively. As old pests were brought under control, new pests appeared. As pesticide use increased, it reached 50% of production costs in some areas. In Guatemala total use of pesticides increased about 130% between 1972 and 1975 and cotton pesticide use increased about 60% for that period (ICAITI 1976).

2.4.2 Problems With Pesticide Use

Detrimental environmental effects traceable to overuse of pesticides are a major problem throughout the entire Central American region. Pesticide related problems have been called the most critical problems in Central America because of short-term public health impacts, long-term ecological balance problems, and high costs associated with these problems.

Pesticide problems have occurred because of pesticide drift during aerial application, which is often used where direct local application would be more efficient. Large quantities of pesticides applied from the air settle on neighboring fields rather than on the crops being treated. Soil erosion in areas after heavy pesticide application also contributes to pesticide movement, leading to contamination of water bodies, especially rivers and estuaries. Pesticides are transmitted in food chains and affect not only wildlife but also foods consumed by humans. Pesticides also pollute water sources, rivers, and estuarine zones that have traditionally been important as sources of fish and seafood.

An UNEP and ICAITI study (ICAITI 1976) showed that contamination levels were highest in animals and animal products and lowest in water. The study showed a definite correlation between cotton cultivation and pesticide levels in milk, meat and other foods, as well as in human blood and fat tissue. Contamination in Guatemala is highest in the major cotton growing areas of the departments of Retalhuleu, Escuintla, and Suchitepequez.

Milk and meat from Guatemala cotton areas have high levels of pesticide residues. In a 1975 to 1976 survey, milk samples from dairy cows in the cotton growing areas showed pesticide levels that reflected seasonal pesticide use and that averaged 4.52 ppm, 90 times higher than the United States allowable limit. Meat contamination occurs in areas where pesticides drift to grazing areas, when drinking water is contaminated or when cattle eat cotton stalks. Residues in the meat are stored by human consumers. Meat is rejected from the export market because of residue levels which exceed tolerance standards set by importing countries, but is often sold in Guatemala City markets.

Pesticide related human health problems are extensive in the cotton growing areas of the Pacific coastal plain. As cotton production increases, population also increases and living and sanitary conditions do not keep up with the rapid growth rate. Pesticide poisoning, increased incidences of malaria, and sub-clinical, but possibly debilitating, levels of pesticide in body tissue are problems. Direct poisonings, although decreasing, are still a serious problem, especially from the organophosphate, parathion.

Increases in malaria have resulted from the resistance of the anopheles mosquito to sustained use of DDT and its associated chlorinated hydrocarbons to control cotton pests. Natural selection of resistant individuals to the pesticides has produced populations of mosquitoes that are resistant to the full suite of DDT-related pesticides. Guatemalan malaria rates are strongly correlated with the amount of land

planted in cotton and the need for increased pesticide application for each crop. Substitute pesticides, such as propoxur, have not reduced the malaria incidence rate but have arrested further increases in the rate.

Chlorinated hydrocarbon residues in human tissues are 6.8 times greater in cotton growing areas residents than in urban dwellers. Average levels of accumulation as high as 520 ppb have been found in tissues of people in cotton areas.

2.4.3 Possible Solutions to Misuse

Pesticide control has been given little serious attention in any Central American country. However, in 1978 a Regional Seminar in the Use and Management of Pesticides was held in Guatemala City. Also a new law regulating pesticides has been in effect in Guatemala since 1974. There must be more serious attention to developing methods for reducing the number of applications of insecticides, substituting insecticides that have fewer environmental and human health effects, and controlling the methods of application. Technology and methodology have been developed to integrate the use of insecticides into predator, parasite and disease techniques for insect control and cultural and genetic methods of control. It is important to begin integrated pest management projects as soon as possible to help ameliorate the adverse side effects and to help reduce the direct pest management cost and the cost to natural environments.

2.5 Coastal Zone

Guatemala has over 400 km of coastline, with 320 km along the Pacific coast. Black sand beaches, lagoons where mangroves grow, and shallow offshore waters characterize the Pacific Coast. The black volcanic sand beaches are tourist attractions. Future development of hotels and condominiums is planned. The port of San José, the second largest maritime port in the country, handling about 50% of the country's imports and some of its coffee exports, is located on the Pacific Coast.

Approximately 100 miles of coastline are found along the Atlantic Coast. The Bay of Amatique (10 miles wide and 25 miles long) provides a sheltered area in which are found the country's major ports, Puerto Barrios, and Matias de Galvez and Livingston. Most of Guatemala's foreign trade goes through Puerto Barrios and Santo Tomas de Castilla (Matias de Galvez).

Port development, shipping and tourist development have not had major environmental impacts on coastal resources. The major problems have come from deforestation associated with agricultural development on both coasts and pesticide problems in the Pacific Coast.

The development of the Pacific coastal plains for extensive agriculture, particularly cotton, has resulted in early soil losses and water quality degradation from erosion following deforestation. Current and recent intensive cotton management practices, primarily heavy insecticide use, have caused degradation of streams and estuaries, affecting

invertebrates and fish. Pesticide poisoning of birds, mammals and people, once a major problem, has decreased somewhat but is still serious. Pesticide residues in milk, beef and wild animals are still high and body tissue residues in humans are greater than in non-agricultural areas (See Section 2.4).

Increasing populations, as agriculture expands in both coastal zones, are resulting in heavy pressure on remaining forests for fuelwood and on the faunal resources associated with these forests. Removal of mangroves for fuelwood on the Pacific Coast has reduced this valuable free-service resource drastically. The mangroves coastal protection and water cleansing and nutrient supplying capabilities are decreasing rapidly.

Sediment and pesticide impacts on inshore and estuarine fisheries have been severe. Sediment from cotton fields entering streams from erosional runoff has reduced invertebrate animal food supplies for fish in streams and estuaries. Pesticides have impacted these resources directly or debilitated them.

Protection of remaining mangrove forests is necessary, but substitute fuelwood sources must be provided. Integrated pest management programs to reduce cotton spraying intensity and soil conservation projects are also needed.

2.6 Urban/Industrial

The urban/industrial problems of the country are centered in Guatemala City where the population is most concentrated. Guatemala City has the largest population in the country with all the remaining cities have less than 10% of Guatemala City's population. As a result Guatemala City has severe water quality problems, an emerging air quality problem, solid waste disposal difficulties and a minor noise problem. Other growing cities have or will have their problems of water and solid waste disposal and to a lesser extent the noise and air impacts.

2.6.1 Water Quality

Water quality in Guatemala City has been described in Section 2.2. Water quality problems are those of drinking water degradation because of inadequate groundwater monitoring and drinking water supply treatment. Contamination of streams and rivers around the city is caused by untreated sewage discharge and leakage of water through improper solid waste disposal into streams and possibly groundwater. Disruption of the sewage collection and water supply systems during the 1976 earthquake resulted in water quality problems.

2.6.2 Solid Waste

Solid waste disposal is a municipal responsibility, although residential areas in Guatemala City, for example, are served by private companies. The central dump for Guatemala City is located in the downtown area, whe e it gives off a foul penetrating odor. This dump serves for all types of wastes (garbage, industrial wastes, hospital wastes, and toxic wastes) and has no base sealing and no drainage water control

(Library of Congress 1979). Water quality monitoring of the seepage water should be performed.

2.6.3 Air Quality

Throughout most of Guatemala air quality is high. Only in Guatemala City is there a potential problem. Air quality is deteriorating, however quality is not as bad as some major cities. Air quality will continue to degrade and eventually will impose severe limitations on quality of life in the city. At present there are no effluent limitations on industry or transportation and no ambient air quality standards have been set. The Government of Guatemala does have the authority to regulate air pollution for industrial sources.

2.6.4 Noise

Noise problems are minor throughout the country. The only appreciable noise disturbance appears to be airplane take-offs directly over the city causing elevated noise levels at all times of day. People living beneath this departure pathway may have hearing reduction and psychological stress (Library of Congress 1979).

3. RELATIONSHIP BETWEEN ENVIRONMENTAL PROBLEMS AND DEVELOPMENT OBJECTIVES

The relationship between the environment and human use of the environment is both complex and little understood. If one assumes a "pristine" environment as most desirable and that anything less results in environmental degradation, then any development program causes environmental degradation. It must be realized that all development programs change the environment. Guatemala's basic development objectives are optimal use of the nation's human and physical resources, higher income levels and employment, and improvement of living conditions and levels of living. Such broadly stated objectives have little meaning, but one point clearly stands out: the development objectives are economic in nature and call for increased production. The danger is that increased production will be attempted without adequate environmental safeguards.

There is abundant evidence that environmental concerns are not considered either by public officials or private citizens when economic opportunities are assessed. One official stated that

> "even today many of the people do not consider environmental degradation a problem. They believe the wind and rain will carry away air pollutants and that when the rain comes it flushes away pesticides, fertilizers, and sewage so that any pollution problem is only temporary."

Another stated

> "The government has never done much for the environment, partly out of ignorance."

Other comments from both government officials and private sector leaders demonstrate the relative lack of concern for the environment when such concern may impinge on economic development objectives. For example,

> "One of the biggest problems is that the government has encouraged industrialization without concern for the environment;"
>
> "Planning has been mainly economic with very little ecological focus;"
>
> "It must be shown that a reduction in environmental degradation is of benefit;"

and finally,

> "One must remember that Guatemala is a poor country and highest priorities will go to economic and infrastructural needs."

It is clear that the erroneous belief exists that renewable natural resources are inexhaustible and that the lessons of man coupled to his environment and the environment providing free service are not obvious or understood.

There are several reasons why environmental degradation has received little attention. First, for much of Guatemala's history environmental degradation was of little significance. The population lived primarily by agricultural pursuits with only the best land and land least susceptible to depletion and erosion being used. In fact land use was extensive except for the Western Highlands and there the traditional Indian land-conserving practices of irrigation, terraces, and contouring were widely used. Man in that region was truly coupled to the natural environment. Improved health care, sanitation, and production, however, led to increasing population pressure and to gradually increasing yet hardly perceptible environmental degradation. Over the last 50-60 years significant environmental damage has occurred; only now is there the beginnings of an awareness that such damage must be halted.

A second reason that environmental degradation has received little attention is that the costs of such degradation are difficult to determine precisely and only recently have techniques been available to estimate these environmental costs. Degradation has both short- and long-term implications and aesthetic as well as social, economic, and political aspects. Take, for example, the case of sewage. Apparently only three sewage treatment plants are located in Guatemala with none in or around the area of Guatemala City. The city's sewage is consequently dumped untreated into streams and rivers that flow to both the Atlantic and Pacific Oceans. Not only is domestic sewage so dumped, but also industrial wastes and even wastes from hospitals. The latter poses an especially significant health danger. The impact of dumping raw sewage is manifold and includes the following considerations:

- Increases the cost of water treatment for human domestic use. The greater the pollution level and the more diverse the pollutants the more difficult and costly is the treatment;
- Makes water unsuitable for industrial use;

- Reduces the usefulness for crop irrigation;
- Reduces recreational value of water as, for example, Lake Atitlan and Lake Amatitlan;
- Causes the growth of undesirable biological life;
- Kills fish and other aquatic life;
- Lowers land use and monetary values of land along water courses;
- Produces a general effect such as causing water to appear aesthetically undesirable or to smell. Water that appears polluted is never fully used resulting in underutilization of an important resource;
- Causes the spread of disease in human and animal populations who drink the water or who consume life forms grown by using the water. Gastroenteritis and other similar health problems are endemic in Guatemala and such illnesses are commonly associated with consumption of contaminated water and food.

The impact of allowing untreated sewage to be deposited in the national waterways is not impossible to measure but all the costs are difficult to assess. The cost of downstream water treatment is high and disease and illness in downstream areas are significant. The general unpleasantness of sewage odors and downstream appearance along with other factors is one reason why the larger cities of the country such as Guatemala City are the receptors of many migrants who place an ever increasing drain on the city's resources to provide minimal public services.

A third reason why environmental degradation has received little attention is that it impacts the nation's socio-economic groups differently. In essence it is the poor who are most affected. They live and work in the most contaminated areas and do not have the financial means and often the knowledge to protect themselves. Again the example of raw sewage illustrates this variable impact. Downstream from population clusters the polluted streams are used by the rural poor as drinking and cooking water sources, washing sites both personally and for clothing, as watering places for domestic animals, and in some cases for irrigation of cropland. In contrast the wealthier citizens of the country live in the larger urban places and have access to bottled water for drinking and cooking, treated tap water for washing and personal hygiene. They are not exposed to disease-ridden plants and animals. Thus, the burden of environmental degradations falls on those who have the fewest resources to combat the problem. Wealthier groups are able to insulate themselves from significant contamination and are leaders in the social, economic, and political circles. As noted earlier many of these leaders fail to recognize the danger and extent of environmental degradation since it does not affect them directly. The World Health Organization, however, "considers that provision of a safe and convenient water supply is the single most important activity that could be undertaken to improve the health of people living in rural areas."

Other forms of environmental degradation also impact the poor more than other groups. It is the rural poor who most suffer the effects of constant insecticide spraying of Pacific Coast cotton. They are exposed to those insecticides in several ways:

- By working in the fields when spraying is done;
- By having their homes along the periphery of sprayed fields;
- By using insecticide contaminated streams as a water source; and
- By consuming fish and other foods from insecticide-laden sources.

It is the rural poor who suffer directly and most from the damages of soil erosion and depletion and associated deforestation. These problems are greatest in the areas of minifundios. Many minifundistas recognize the causes and dangers of deforestation and soil erosion and depletion but are powerless to combat the problems. It is the urban poor who suffer most the damages of air and industrial pollution since they live in the immediate environs of the pollution source. In short, the poor, both urban and rural, are most exposed to environmental degradation, suffer most from its effects, and yet have the fewest resources to combat the situation from either the preventive or curative standpoint.

There is a strong positive correlation between poverty and environmental problems. As noted above, it is the poor who are most directly affected by pollution and degradation. It is the poor who suffer most from the effects of diseases resulting from contaminated water supply. Diseases such as typhoid, bacillary dysentery, Chagas' disease and onchocerciasis have been directly traced to water supplies contaminated by sewage. Diseased workers are less productive than their healthy counterparts, have higher rates of absenteeism and partly as a consequence earn lower wages. A part of their limited income must be used for medicines further reducing their effective income.

Environmental degradation and poverty represent a classic example of circular causation with a downward spiral. The only effective way to break this spiral is to infuse a change into the system. One viable change would be to improve the health of the poor by reducing adverse environmental conditions. The problem is, however, that both environmental damage is increasing in seriousness and the number of rural and urban poor is growing rapidly. More people can mean more environmental degradation. The stage is now set for significant future problems if remedial action is not begun immediately. Perhaps the motto should be "Desarrollo Sin Destruccion."

4. ANALYSIS OF EXISTING NATIONAL POLICIES, INSTITUTIONS AND PROGRAMS FOR DEALING WITH ENVIRONMENTAL PROBLEMS

A great diversity of private and governmental groups and agencies are directly or tangentially involved in environmental problems. Since we lack total knowledge of the interactions of these groups, we will present the situation as it appears to us, with lack of political bias.

In an attempt to be thorough and demonstrative, we present a listing of the government and private groups involved in environmental considerations and then show how agencies are involved in the major environmental problems of Guatemala. The majority of the information on environmentally associated organizations is extracted from the 1979 Library of Congress draft environmental report.

4.1 Organizations Concerned with Environmental and Natural Resources--Government Agencies

A widespread lack of institutional authority, capacity, and financial resources is a major constraint on more effective environmental control programs in Central America as a whole, and in Guatemala in particular (UNEP 1976). Rational planning and implementation of natural resources development programs are severely hampered by the large number of government agencies with diverse responsibilities in environment. To remedy this situation the National Economic Planning Council recommended creation of a centralized and autonomous institution to integrate the responsibilities of planning and execution of a natural resources program. Other serious constraints are the low numbers of trained technicians required for work such as the operation of remote sensing equipment, and the lack of the data so necessary for effective programs. Even the most complete study, the National Economic Planning Council's Preliminary Inventory of Renewable Natural Resources of Guatemala, is reported to suffer from a lack of data gathered in a coordinated, integrated, and continuous manner.

4.1.1 Ministerial Commission Charged with the Conservation and Improvement of the Human Environment

The Commission was established by a Resolution of May 3, 1973 and is comprised of representatives of the Ministries of Government, Communications and Public Works, Agriculture, External Affairs, National Defense, Education, Economics, Finance, Public Health and Social Assistance, and Labor and Social Planning. The Commission is authorized to establish technical groups for planning and implementation of activities dealing with conservation and improvement of the human environment. The decisions of such groups are subject to the Commission's approval. The Commission is also authorized to establish the measures it deems necessary to resolve the problems of environmental contamination.

4.1.2 Ministry of Agriculture

Two major departments of the Ministry of Agriculture provide environmental expertise: the Direccion General de Servicios Agricolas (DIGESA) and the Instituto de Ciencia y Technologia Agricolas (ICTA).

The Department of Renewable Natural Resources (DIRENARE), a department of DIGESA, has a Water Resources and a Faunal Division. In 1972 the Division of Water Resources was granted control of all state waters. It is charged with conducting studies relating to all aspects of water quality and use, regulating all national waters, both groundwater and surface waters, organizing irrigation projects, and developing water conservation policy. The Faunal Division has the general responsibility for wildlife and fisheries. The Division has the chief responsibility for enforcing the 1970 Hunting Law and issuing hunting and fishing permits.

Also associated with DIRENARE is the Dirreccion de Ensenanza y Capacitacion Agricolas (DECA)--Directorate of Agricultural Education and Training. The Directorate is responsible for agricultural education and

training programs at the basic, middle and higher levels. The Directorate also is responsible for 3 rural normal schools and 248 rural primary schools. DECA operates the Instituto Tecnico de Agricultura (ITA) (Agricultural Technical Institute); graduates of ITA are considered Agronomy Specialists (Perito Agronomo). The ITA in 1977-78 granted 83 scholarships to the Faculty of Agronomy and 15 to the Veterinary Faculty.

The Instituto de Ciencia y Tecnologia Agricolas (ICTA) (Institute of Agricultural Science and Technology) is responsible for promoting the use of agricultural technology with the general aim of increasing agricultural production. Its activities include the identification of new varieties of plants and experimentation with their use in Guatemala.

4.1.3 National Forestry Institute (INAFOR)

The National Forestry Institute was established by decree in 1974 by incorporating part of the Ministry of Agriculture and the Instituto Nacional de Transformacion Agraria (INTA). INAFOR is responsible for forest inventory, reforestration, forest management programs and parks. Its jurisdiction does not include the Peten department where most of the countries forests are located and where the new pressure is being applied. The National Company for the Development of the Peten (FYDEP) is responsible for the Peten.

Specifically INAFOR obligations are to: implement the Forestry Law and other pertinent statutes; plan and execute a national forestry plan; conduct a forest inventory; carry out ecological zoning of the country; establish a National Forestry Register; carry out programs of aforestation and reforestation to restore the natural resources of the country and increase forest production; cooperate with INDE (National Electrification Institute) and other institutions in the conservation and improvement of hydrological basins; plan and execute forest management programs, including marketing of forest products and industries based on them; deal with export of wood and wood products; supply educational funds for the formation of human resources in the forestry area; administer national parks in conjunction with the Guatemalan Tourist Institute and the Institute of Anthropology; and study and collaborate in programs designed to avoid environmental contamination and to promote ecological balance.

INAFOR is actively involved in seed and seedling distribution for aforestation and reforestation and is conducting reforestation work. The Institute has also conducted a forest inventory of the northwest high plateau and the east central areas of the country; produced a land use map, a potential land use map, and a map of reforestation priorities; introduced measures to combat the pine beetle infestation; and is developing and promoting forest cooperatives.

4.1.4 National Institute for Agrarian Transformation (INTA)

INTA is the state land reform agency. It oversees programs designed to provide the landless with government land or with other unused agricultural land and with housing, technical assistance, and credit necessary to undertake agricultural operations.

4.1.5 National Institute of Agricultural Commerce (INDECA)

INDECA is an autonomous, decentralized state agency charged with marketing, price stabilization, and supply of agriculture products.

4.1.6 National Company for the Development of the Peten (FYDEP)

FYDEP is responsible for the Peten, the northeastern department which occupies one-third of Guatemala and contains most of its tropical forests. FYDEP was established in 1959 with the goal of developing roads, agriculture, and industry and is in charge of plans to colonize and develop large tracts of forest land. FYDEP operates a small-scale cedar and mahogany reforestation experiment and is engaged in planting white pine, cedar, citronella, and zapote.

4.1.7 Ministry of Public Works and Communications

The Ministry of Public Works and Communications in Guatemala City has four sub-units that are involved in environmental matters.

The Instituto Nacional de Electrificacion (INDE) is the agency concerned with the development of the hydroelectric potential of the country. It operates a network of river level monitoring stations and has commissioned at least two environmental impact assessments of hydroelectric projects (see Goodland and Tillman 1975; Goodland and Pollard 1974).

The Department of Aqueducts and Sewerage is located in Guatemala City and has jurisdiction over water supply and sewage collecting systems.

The Instituto Geografico Nacional (IGN) has three divisions that are involved in natural resource planning and identification. The Division de Geologia has prepared a geological map. The Division Geografica has prepared studies to determine the location of possible national reserves. Also, a study was carried out in association with the University of Oregon on environmental protection legislation. It has prepared a plan for the restoration of Lake Amatitlan, including a study of the problems of the Lake and its basin, and a study on the adaptability of species in the region of Lake Amatitlan.

The Division de Investigacion de Recursos de Agua (Water Resources Investigations Division) and its Departmento de Agua Superficial (Department of Surface Waters) are sub-units of the National Institute of Geography.

The Instituto de Sismología, Vulcanología, Meteorología y Hidrología was created in 1976 to administer the geological areas associated with earthquakes, volcanos, meteorology and hydrology.

4.1.8 Ministry of Public Health and Social Assistance

The major areas of environmental, resource and population concerns in public health are incorporated under the Direccion General de Servicios de Salud. The Subdirectorate for Technical and Nomative Affairs

includes the Division of Maternal, Child and Family Health and provides some education in planning. The Division of Environmental Health has responsibility for regulation of drinking water quality and regulation of waste water discharges into surface and sub-surface water. It has the responsibility for operating the air pollution monitoring station in Guatemala City under the Pan American Air Pollution Monitoring Network (REDPANAIRE) which monitors dust fall, total suspended particulates, and sulfur dioxide and the authority to regulate air pollution from industrial sources. Also under its jurisdiction is the setting of noise standards to protect health of workers.

4.1.9 Secretariat of Mining, Hydrocarbons and Nuclear Energy

The Secretariat of Mining, Hydrocarbons and Nuclear Energy is responsible for mineral development in Guatemala. The General Directorate of Statistics is responsible for the population census and for publishing statistics on weather, agriculture, health, industry and the economy.

4.1.10 National Economic Planning Council

The National Economic Planning Council is the chief planning office of Guatemala. As part of its general charge to formulate a national policy for the conservation and management of renewable natural resources, the Council in 1972 prepared a preliminary inventory of renewable natural resources in Guatemala. The Council has given high priority to natural resources conservation and development in the 1979-1982 development plan. This Council is obviously an important and powerful group in the country.

4.1.11 Local Government

Guatemala is organized into 22 departments each of which is headed by a governor. The departments have 327 municipal governments with elected governing bodies each headed by a mayor.

Municipalities have health related responsibilities under the laws establishing their governments and under the Health Code. For example, in Guatemala City these include regulation of bus emissions (smoke), regulation of vehicular noise within the city limits, responsibility for regulating solid wastes under the Health Code, transportation and collection of household wastes, and planning and regulating land use. Despite its responsibilities, Guatemala City lacks an active program for the control of domestic wastewater discharges, which are the single largest source of water pollution in both the Atlantic and Pacific watershed areas.

4.2 Organizations Concerned with Environment and Natural Resources--Non-Governmental and Quasi-Governmental

4.2.1 Conservation Organizations

A number of non-governmental organizations are vocal for conservation efforts and rational development of natural resources in Guatemala and lead the conservation movement in the country. Representatives of

the Association of Friends of the Forest (Associacion Amigos del Bosque), Friends of Nature (Amigos de la Naturaleza), Guatemala Association for the Defense of the Environment (Associacion Guatemalteca Prodefensa del Medio Ambiente), the Association of the Friends of the Nation (Associacion Amigos del Pais) and the Guatemalan Natural History Association participated in the first meeting of the Central American Non-Governmental Conservation Societies in Guatemala City in 1973. This meeting produced a resolution which urged organizations to take action to ensure environmental impact studies of all public projects as well as of those financed by national banks. Irrational use of natural resources was identified as the number one problem affecting the area, and action to influence governments to pursue rational development of such resources was urged.

4.2.2 Institute of Anthropology and History

The Institute is concerned with the preservation of ancient Mayan sites; it assisted Goodland and Tillman (1974) in evaluating environmental impact of hydroelectric projects on such sites.

4.2.3 National Museum of Natural History

The National Museum of Natural History was officially inaugurated in 1950. The Museum has sections dealing with mineralogy, paleontology, and zoology, as well as a herbarium. One of its aims is to "create a public consciousness of the need to know the plants and animals that take part in biologic equilibrium. Such a function is put to practice through exhibits, popular lectures, conferences, publications and promotion of conservation activities."

The Museum publishes "Historia Natural y Pro Natura," a journal which generally features articles about conservation not only in Guatemala but throughout the world. The journal also publishes laws and regulations relevant to the environment and conservation. "Historia Natural y Pro Natura" and its editor, Jorge Ibarra, have led the fight to establish reserves for the Quetzal, the endangered national bird of Guatemala.

4.2.4 Comite Operacion Quetzal

This Committee, which is officially sanctioned by govermental decree, is principally concerned with the prevention of the extinction of the Quetzal. Its purposes are to educate the public of Guatemala and other Central American countries about the gradual extinction of the Quetzal, to give advice on the establishment of national parks and refuges at sites which are presently Quetzal habitats, and to promote reforestation of those species of trees which serve as food for the Quetzal. The Committee conducts campaigns to increase awareness of the scientific and historical importance of the Quetzal and cooperates with international organizations interested in the preservation of avifauna.

4.3 International Organizations and Cooperation

4.3.1 Central American Research Institute for Industry (ICAITI)

ICAITI was founded in 1955 in response to the need for an applied research institution in Central America. It is an independent institution of the governments of the five Central American Republics and is assisted by the United Nations Technical Assistance Administration. Headquartered in Guatemala City, ICAITI has conducted many technical-economic studies and performed applied research on a variety of industrial development subjects.

ICAITI is involved in the environmental effects of development and is a key organization in efforts to develop programs geared to a regional approach to environmental and natural resource problems. In cooperation with the United Nations Environment Program (UNEP), it has carried out research on the environmental and economic effects of pesticide use in Central America (ICAITI 1976). ICAITI's technical staff and laboratories are an excellent resource for carrying out the environmental baseline studies so urgently needed in the region.

4.3.2 International Cooperation

Meetings on environmental problems have been held between Guatemala and other Middle American countries. In late 1974 a meeting was held between representatives of the Guatemalan Ministerial Commission for the Improvement of the Human Environment and the Mexican Sub-secretariat of Environmental Improvement. In June 1978, Guatemala hosted a Regional Seminar in the Use and Management of Pesticides. Guatemala also participates in Pan American Health Organization programs. The Division of Environmental Health operates a station in the Pan American Air Pollution Monitoring Network.

The U.S. Agency for International Development sponsored two important workshops that were held in the 1970s. The first workshop was conducted in 1974 by the University of North Carolina on Environmental Considerations in Less Developed Countries. The second workshop was conducted in 1979 by the University of Oklahoma on Appropriate Technology for Water and Wastewater Treatment in Less Developed Countries. AID also sponsored in 1973-74 the Bovay Engineering, Inc. inventory of the natural resources of Guatemala.

4.4 Advanced Educational Capabilities

The University of San Carlos has three departments that have been and/or currently are active in environmental problems of the country. The College of Physical Sciences and Pharmacy had been operating an air pollution monitoring station up until the time of the earthquake in February 1976, as part of the Pan American Air Pollution Monitoring Network. The college now plans to equip five stations through Pan American World Health Organization funds. The school operates sound survey meters and plans to develop five stations to be used for both air and noise monitoring. These facilities, designed primarily for training, could be important in providing technicians trained in the use of air and noise monitoring equipment (ROCAP 1978).

The regional School of Sanitary Engineering (ERIS), in the Faculty of Engineering, offers postgraduate courses and performs applied research in sanitary engineering. ERIS carried out analytical work on water quality investigations with the University of North Carolina and the Instituto Geografico Nacional in 1969-70 (Weiss 1971a, b, c). This school has the capability to carry out the regional monitoring necessary to assure appropriate water quality standards.

The Department of Botany led the program to establish the Quetzal sanctuary at Purulha Preserve in Baja Verapaz.

4.5 Environmental Monitoring

4.5.1 Air Quality

The Division of Environmental Sanitation of the Ministry of Public Health has been operating a single station as part of the REDPANAIRE monitoring system since 1974 and has plans to reactivate another destroyed by the 1976 earthquake. The health agency is equipped to handle the collection and analysis of samples from a simple type of ambient air sampling network but does not have the technicians to handle a continuous monitoring network at this time (ROCAP 1978).

The Instituto de Sismología, Vulcanología, Meteorología y Hidrología can provide wind direction and velocity, inversions, temperature, humidity, and barometric pressure data. The Institute has no responsibilities for air quality monitoring but its meterological data would be useful in an air pollution control program.

4.5.2 Rainfall and Water Quality

Fifty-five hydrometeorological stations are located throughout the country, twelve of which have the capability of monitoring rainfall, temperature, wind velocity and direction, relative humidity, solar intensity, temperature, humidity, and barometric pressure. An additional forty stations monitor rainfall, temperature, wind direction, and maximum and minimum temperatures. Many of these stations were established by the Proyecto Hidrometeorological Centroamericana (PHC) as a basic network; others were set up by the National Meteorological Observatory.

Eighty-four hydrological stations providing water level and flow data are located along the rivers of Guatemala. Seventy-three of these are the responsibility of INDE and 13 are run by the National Observatory. Thirteen hydrological stations monitor water level in lakes. Seven are run by INDE and 6 by IGN.

Although data on the levels of rivers and lakes are apparently obtained regularly, publication of the data is not regular. Extensive water quality data in Guatemala's lakes and rivers appeared in the publications resulting from water quality investigations conduction in 1969-70 by the University of North Carolina (Weiss, 1971a, b,c). These data cover pH; turbidity; total solids; dissolved solids; hardness; total alkalinity; contents of chloride, calcium, potassium, sodium, and

magnesium; temperature; dissolved oxygen; nitrate-nitrogen; total nitrogen; phosphate; and total phosphorus. Data are also available in the Hydrological Atlas prepared by IGN in 1976.

4.6 Legislation Dealing with Environment and Natural Resources

Many laws and decrees pertain to the environment and natural resources development; it appears that adequate laws are available for sound environmental and resource use. Little information is available on the actual enforcement of this legislation. The implementation and enforcement of pollution control legislation is severely hampered by the absence of standards and emission/effluent limitations, the lack of trained enforcement staff and monitoring equipment, and a lack of commitment and resources on the part of agencies with jurisdiction.

4.6.1 Forest Legislation

The major legislation applicable to forests are those decrees and laws dealing with forest use, reforestation, hunting and protected species.

Forestry law was established by Decree No. 58-74 in 1974. This comprehensive basic forestry law consists of 73 articles divided into 13 chapters dealing with: general provisions; classification of forests; forest production; statistics and trade; forest exploitation; transport of wood; reforestation; forest incentives; taxation; forest offenses, sanctions, and penalties; forestry awards; forestry terminology and transitional provisions. INAFOR is responsible for enforcing this law and for actively prosecuting offenders.

The Emergency Reforestation Law (1978) provides that all reforestation efforts be directed by INAFOR. It states that all municipal governments are to reforest areas within their jurisdiction, the military and convicts are to aid in tree planting, farmers are granted income tax breaks for tree planting and a ten-year territorial tax exemption is granted for growing new forests. The nation's educational system was ordered to establish programs promoting conservation, tree cultivation, and environmental improvement, and to actually plant trees (about 70 trees per student).

The General Hunting Law was established in 1970 by Decree No. 8-70. This legislation has broad application in that it defined hunting categories and rights, established a permit system, established a protected species program, defined penalties of infraction of the law and established provisions for national parks, refuges, reserves and hunting areas. The law essentially declares wild animals the exclusive property of the nation, states that conservation, reproduction and increase in all forms of wildlife is a matter of national emergency, and prohibits introduction of species tending to alter the natural balance. The law is administered through the Division of Flora and Fauna of INAFOR.

4.6.2 Water Resources Legislation

Although provisions dealing with water resources are included under various decrees and laws, there is no single Guatemalan law dealing

comprehensively with this important resource. The diversity of legislation dealing with water resources is stated as one of the important constraints on the execution of water development plants (UNESCO 1976).

The Health Code provides the authority to regulate drinking water and to regulate the discharge of wastewater into surface and sub-surface water to the Division of Environmental Health of the Ministry of Public Health and Social Assistance. Municipalities are given the authority to regulate wastewater discharge within city limits. These provisions are relatively ineffective as exemplified by the lack of an active wastewater control program in Guatemala City.

Chapter 23 of the Agrarian Transformation Law regulates water allocation, aquaducts and irrigation. The National Institute for Agrarian Transformation (INTA) administers the law. The law controls water expropriation, use and regulation of water, priorities for water use and control over water for agricultural development.

Decree No. 1004 of 1953 prohibits the discharge of wastes into waters and is administered by the Ministry of Agriculture and the Ministry of Public Health and Social Assistance. This decree categorically prohibits discharging vegetable or chemical substances, agricultural or industrial wastes or residues, or those species of plants (such as citronella and agave) harmful to fish, livestock, or human health into rivers, streams, springs or lakes. It also prohibits using latrines which do not adequately purify wastes on the banks of water bodies and requires municipalities to conduct studies on treatment of municipal wastes.

Various municipalities govern potable water systems. These are supported by a 1967 resolution which provides the regulation for the operation of rural potable water systems.

4.6.3 Wildlife and Fisheries Legislation

The 1970 Hunting Law provides rules for protecting wildlife from hunting and establishes an endangered species program. The law forbids capturing or hunting insectivorous birds which beautify the countryside and benefit farms and forest areas, songbirds and ornamental birds, nesting birds, birds and other scavenging animals beneficial to public health, resident birds which have a great aesthetic value, certain useful wildlife species which are beneficial to the country and which are not considered to be game animals, animals and reptiles not authorized by this law in specified reserve zones, refuges, national parks and forest reserves, and native animals considered rare or endangered. Rare and endangered animals are listed in Table 2.

Fisheries are not well protected by law. Various decrees and resolutions provide general philosophical intent to protect fish and specific authorization to fish in certain areas.

4.6.4 Pesticides Legislation

Decree 43-74 enacts the law which regulates importation, storage, transportation, sale and use of pesticides. However, we have no

information on the particulars or implications of this law. Other resolutions have banned use of certain dangerous organophosphate insecticides and a 1971 Order (No. SP-A-35-71) established standards for limitation of pesticide residues in meat and edible meat products.

4.6.5 Air Quality Legislation

Article 115 of the Health Code grants the Ministry of Health the authority to regulate air pollution from industrial sources and to prevent nuisances. Authority is granted in very general terms.

Articles 24, 25, and 28 of the Municipal Code grant municipalities the authority to regulate bus exhaust emissions. The municipality of Guatemala City has issued regulations as the Reglamento de Transportes Urbanos para Autobuses 1971. There is no statutory authority for any agency to regulate other vehicle emissions.

Pollution control provisions, pertaining to air pollution on work sites, are contained in the Labor Code.

4.6.6 Proposed Environmental Protection Legislation

In 1976 the Inter-ministerial Commission prepared a Draft Law on the Conservation and Improvement of the Environment. This law would create a centralized environmental agency (Secretaría) directly responsible to the president. It would have the authority to issue regulations and set national standards and limitations for air, water, and noise pollution, for natural resource exploitation as it effects environmental quality, and for solid waste regulation. The law, which would also regulate wildlife and endangered species and provide for conservation of other natural resources, including the establishment of parks and ecological reserves, would give the general public authority to enforce its provisions.

At the time this document was written, the law was still pending approval at the congressional level of the Government of Guatemala.

4.7 Examples of How Interaction of National Policies, Institutions and Programs Can Deal With Environmental Problems

4.7.1 Reforestation

The Guatemalan government recognizes the problem of deforestation, and how it reduces the productive capacity of the land. Official policy prohibits forest cutting on public lands. However, it is also recognized that forests are a source of income for many groups in Guatemala, and the sale of timber is an important source of capital. Therefore, exemptions to the policy of forbidding forest cutting are sometimes granted.

The government has less control over deforestation on private lands. Although the government discourages clearing, it recognizes that land for agriculture must be made available to feed the growing population.

There are a number of reforestation efforts within Guatemala. INAFOR sponsors several seedling nurseries. Seedling planting is accomplished by crews hired by the Forestry Department, or the seedlings are given to various community groups whose members carry out the plantings. The reforestation effort is far too small in relation to areas already degraded. Less than 10% of land in need of reforestation is actually being planted. Further, land is being cleared faster than it is being replanted.

There are a number of community projects to plant fruit orchards in the lower slopes of mountains and on the more fertile valleys. While this private effort appears to be successful in several communities, it has little impact on the nationwide deforestation problem.

Other analyses of environmental problems of Guatemala have recommended reforestation projects and research into the feasibility of planting "fast growing" species in areas in need of reforestation.

4.7.2 Water Quality Improvement

The problem of water pollution, both in Guatemala City and in provincial towns and villages, is one for which there is no specifically assigned agency. While many government officials realize that there are pollution problems, there has been no effective mechanism for dealing with the problem.

The recently proposed law of conservation and improvement of the environment sets the framework for beginning to attack the problem in that the law specifically states that one objective is the prevention, control, and reduction of pollution. Specifically, a Secretariat for Conservation and Improvement of the Environment must be developed. The function of the Secretariat with regard to water pollution will be to:

- Evaluate the quality of the waters and the possibilities of improving the quality using periodic analysis of physical, chemical, and biological properties.
- Carry out control to assure that use of the water does not cause environmental degradation.
- Establish norms for the quality of the water so that the water is suitable for the uses for which it is intended. Establish requisites for disposal of waters so that water quality remains within established norms.
- Carry out studies of water quality to determine cases where dumping of wastes should be prohibited, permitted, or permitted following treatment.
- Determine what uses should be prohibited for bodies of contaminated waters with specifications regarding when and where the prohibitions apply, so that the contaminated bodies of water can recover.
- Promote and stimulate investigation and analysis of interior lakes and rivers, and the ocean within the economic zone of Guatemala.
- Promote the integrated use and rational management of water basins, springs, and other sources of water.

- Determine and control any cause or source of water pollution, in order to assure the conservation of biological cycles and the normal development of naturally occurring species.
- Initiate the necessary actions through international organizations to protect the climate.
- Conserve the flora in order to maintain the normal water cycling within the country.
- Determine and control any other cause or source of water pollution.

If this law is implemented, the fragmented system of water quality responsibility will be amalgamated and a holistic approach to dealing with the water resource will be adopted. Through this total plan the Republic's waters will have adequate monitoring and attention to alleviate existing problems and to prevent further degradation.

5. CONSTRAINTS TO DEALING WITH ENVIRONMENTAL PROBLEMS

There are numerous constraints affecting any attempt to deal with environmental problems in Guatemala.

5.1 Political and Policy Constraints

There is no effective commitment to environmental protection on the part of the government or leaders of the private sector. In the minds of many leaders environmental degradation is not a problem or if admitted to be one is of secondary importance. The emphasis is on economic development almost at all costs and little recognition is given to environmental degradation that will greatly affect development in the medium- and long-term. The emphasis is on short-term projects and the adverse ecological impact of these projects is usually not apparent in the projects' early stages.

Basically, there is a tendency to disaggregate economic projects and environmental impacts so that the cost of environmental damage is not apparent or is artificially diminished. For example, dumping raw sewage in rivers and streams may be justified if only the cost of water purification downstream is considered. If, however, the multiple impact of stream pollution is considered, then it becomes extremely evident that treatment plants would be cost effective and necessary for sustained economic development.

Too often governmental or private industry environmental projects are more cosmetic than effective. For example, tree planting to aid in reforestation and erosion control is a useful project. However, if the goal is simply planting and there is no effective protection of seedlings and wood is not used in a rational manner, then tree planting is not effective and wastes scarce capital.

Most effort of the government is exerted simply to provide necessary services and functions and to maintain control. Funds and dedication to combat environmental degradation are lacking and the whole question of environmental concern receives scant attention.

5.2 Legal Constraints

The most serious legal constraint on controlling environmental degradation is that there are either no laws that can be used to prosecute companies or individuals who degrade the environment, or that the laws that exist cannot be or are not enforced. Several different governmental officials pointed out that laws dealing with the environment are so vaguely written they cannot be used or are so old they cannot be enforced. Environmental law is a relatively new field and a body of common law has not evolved sufficiently.

Zoning laws do exist in Guatemala City, but are not enforced. Zoning laws are nonexistent in the rest of the country. Incompatible land uses frequently exist side by side. For example, cotton and cattle are found in the same area. Pesticides used on cotton drift onto cattle pastures and the cattle frequently develop high residual pesticide levels. In Guatemala City factories are built without regard to surrounding uses and usually, but not always, it is the urban poor who are exposed to factory air and noise pollution.

5.3 Institutional Constraints

Environmental protection responsibility is divided among several ministries and semi-autonomous agencies. The choice of division of responsibility or the creation of a new agency charged with overall environmental protection is really immaterial. The main institutional constraint is the prevalence of an attitude that environmental protection is not really important. As long as such an attitude exists the question of fragmented or unified responsibility is a moot point.

The institutional focus and organization is not geared to environmental concerns; focus is on maintenance of the status quo. There is a lack of commitment on the part of many governmental officials to environmental quality and thus a lack of enforcement of law designed to prohibit environmental degradation.

In essence, there is no institutional strength for environmental protection. There are, however, a few individuals who are concerned and trying to establish an environmental protection policy.

5.4 Attitudinal and Cultural Constraints

Of all the constraints on environmental protection the attitudinal and cultural are most important. Organizational, legal, institutional, funding, technological, and political constraints are to a large degree a reflection of culture. If attitude is changed then other aspects of culture can be modified.

Many private citizens and governmental officials ignore that there are environmental problems. They believe that if degradation occurs it is a localized and temporary situation--the winds and rains will wash it away. Many Guatemalans believe environmental damage is a necessary facet of economic development and that technology can cure any significant problem. There is an excessive confidence on technological solutions to all problems.

Guatemala is culturally divided. The Ladinos have traditionally been oriented toward short-term economic gain without much regard for the future. This attitude can be traced to the earliest periods of Spanish control. Today, with political instability an everpresent danger, Ladinos strive to obtain maximum possible income while they are able to without regard to the future. The Indian culture group is diverse but traditionally has practiced conservation methods. The problem of environmental degradation with the Indian is not so much a problem of attitude or culture but one of a lack of alternatives. However, many Indian practices have been lost by the gradual breakdown of their society.

5.5 Lack of Information, Data and Statistics

In only a few incidents has the extent of environmental degradation been demonstrated--pesticides on the Pacific Coast for example. Although many aspects of degradation are readily observable they are usually not recognized. Another reason why environmental degradation is not recognized is that most Guatemalans rarely travel more than a short distance.

There is no official information data source on the environment. As with many nations there is an organization/structure to measure demographic and economic factors, but few data are available on, for example, rates and location of deforestation. The Instituto Geografico Nacional presently is measuring some aspects of deforestation and water pollution but the effort is secondary to other work. INAFOR, USPA, and the School of Agriculture of San Carlos University also collect some environmental data. The lack of statistical data on environmental problems is a major reason why many do not perceive a need for remedial action.

5.6 Lack of Trained Personnel

In contrast to many developing countries, there are many trained individuals who could make substantial contributions to measuring, assessing, and solving environmental problems. The problem is that these individuals are assigned tasks not oriented directly to environmental problems and there is too little coordination among these individuals at an official level.

Trained personnel are lacking in certain technical areas. One problem is the lack of properly compensated trained people to enforce extant laws. Also, many foresters and others who direct reforestation projects fail to gain the confidence of the various indigenous groups who live in the area of the projects and upon whom the ultimate success of these projects depend. If the technicians spoke a Mayan dialect and understood Indian culture, the indigenous groups would be more receptive.

5.7 Technological Constraints

Little has been done on alternative practices such as biological solution to pesticide problems.

5.8 Funding Constraints

Funding for environmental projects should be part of any economic or social development program. Environmental concerns should be an integral part of all projects. More funds should be spent on environmental programs, but it is hardly feasible faced with the limited monies available and the seriousness of economic and social problems.

How much money should be spent is beyond the scope of this study and cannot be determined without a complete review of all government projects, funding sources, and potential returns.

5.9 Population Constraints

One of the principal causes of environmental degradation is increasing population pressure. Population pressure has led to deforestation, soil erosion and depletion and water quality degradation. These forms of degradation will continue until alternative practices or opportunities are available. This pressure is increasing and as new areas are colonized, on the one hand, and as urbanization increases on the other, the problems of degradation will intensify and spread and new forms of damage will occur.

The lack of family planning is a major constraint under present circumstances.

5.10 Specific Examples of Constraints

5.10.1 Reforestation

National policy is not a constraint to dealing with reforestation. The recently proposed law on conservation and improvement of the environment is a basis for dealing with problems of forest renewal.

The prohibition against cutting conflicts directly with the peasants' needs for firewood for cooking. However, the prohibition is not effective in stopping forest destruction, because the law prohibits cutting living trees, but does not prohibit using the wood of trees that are dead but are still standing. Peasants secretly girdle trees, and after several months, when the trees are dead and dry, they fell the tree. The felling apparently is not illegal because the tree is already dead. Apparently, stripping branches from living trees also is permitted, despite the fact that this practice ultimately kills the tree. A major institutional constraint is that INAFOR is understaffed and underfinanced. Consequently, it is incapable of dealing with a problem the magnitude of the deforestation problem. Further, INAFOR is unduly influenced by foresters from temperate zones, and by its own foresters and staff who have received training in institutions heavily influenced by policies and procedures developed in temperate regions. Many of the policies and techniques are inappropriate for tropical regions.

While precise figures on deforestation rates and eroded land are not available, some Guatemalan government officials are fully aware that deforestation is a grave problem and that action should be taken. Even if precise statistics were available, this would mean little, since

conditions are changing so rapidly. Lack of information on deforestation should not impede action at this time.

There definitely is a lack of trained personnel for solving forestry problems. However, the root of the problem is deeper than the local situation in Guatemala. There has been and still is a gross misapplication of temperate forest practices to forests throughout the tropics. It is imperative that personnel be trained in tropical forest practices.

One of the most ineffective ideas foisted upon the tropics by foresters trained in, or influenced, in the temperate zone is that reforestation should be accomplished by planting pine trees in approximately 2 x 2 m squares over an entire area that has been degraded. The practice was developed in the temperate zone for production forestry. However, production forestry is not the principal intent of reforestation in Guatemala or in much of the tropics. Prevention of soil erosion and prevention of degradation of the productive capacity of the ecosystems are the principal intents. Dense planting of pines is a very ineffective method of restoring large land areas. A much more efficient system would be fewer trees planted in each area, but many more areas planted. Further, when trees are planted, they should not be planted in 2 x 2 m squares, but rather in occasional bands or belts, perpendicular to the erosional stress, just as shelterbelts were planted in the midwest of the U.S. to counter wind erosion. More extensive, but less dense planting, allows distribution of replanting resources over a much larger area. A further advantage of this dispersal system of planting is that occasional belts of trees over a wide area results in a much more effective use of animal and wind vectors to bring naturally occurring seeds into the center of large disturbed areas.

It is commonly believed that there is a need for new varieties of trees for reforestation projects, especially so-called "fast growing" trees. Actually, most of the so-called "fast growing" species such as pine, Gmelina, balsa and others are fast growing only in the sense that they increase in volume rapidly. They have very light-weight wood. Rate of dry weight biomass accumulation is no faster than by native species. Some species of Eucalyptus do appear to accumulate biomass rapidly, but the reason is that they have temporarily escaped their natural predators and parasites, native to Australia. Once these pests catch up with Eucalyptus, or native pests evolve to parasitize Eucalyptus, production of this species will decline. The danger of typical reforestation projects is that they are monocultures, and thus much more susceptible to infestation. In general, trees that devote more energy to growth, devote less to protection from insect pests, and trees that in the short term seem desirable because they "grow fast," in the long term may be less desirable because of their high susceptibility to pests.

Guatemala has a policy of encouraging tree planting, and in some cases, records are kept of the percentage of planted trees that reach maturity. This type of approach has negative results. We have observed areas where local laborers are paid to hack out naturally occurring shrubs, legumes, and other native species, just so a particular planted pine would survive. A much more effective approach would be to let the naturally occurring species take over, and permit natural secondary

succession to occur in the degraded areas, so that native species prevent erosion and retard soil fertility loss. There is little need for new varieties of trees. The naturally occurring species are best adapted, and the naturally occurring mix of species is the best adaptation for minimizing infestation of pest species.

Pouring more money into monoculture plantations or research into "fast growing" species is unlikely to improve conditions very much. Doubling or tripling the plantation rate will have negligible effect on the country-wide erosion problem. The money that is now available needs to be spent more effectively first.

The most effective program for reforestation in Guatemala would be one similar to the shelterbelt program in the dust bowl of central U.S. in the 1930s. Lines or belts of trees, preferably native species, planted perpendicular to the erosional gradients over large areas would be most effective. The expertise needed for such a program is minimal. What is needed are people to go out and initiate "shelterbelt" programs. Much more effective than visiting experts on fast growing trees would be Peace Corps-type volunteers who could live in the affected areas, develop the shelterbelt approach, and carry out the programs.

It may also be necessary to develop small plantation forest projects in areas where forests are severely threatened by fuel wood use. These plantations could remove some of the pressure from particular forest reserves, refuges, or parks for which protection is important. Native people must have an alternative. Plantation for production forestry is another matter. If it can be calculated that the cost of artificial planting will be paid for by the income wood products in 20-40 years, then the money should be invested. However, government subsidy for production forestry is ultimately a losing economic scheme. Prices for wood products must be high enough for private investors to invest their money in anticipation of a profit. Government subsidy of forest plantation for future profit of forest exploiters should not be encouraged.

Another program to prevent erosion would be to require harvesting, when it is carried out, to be in belts, leaving bands of naturally occurring forest every 50 or so meters down the slope. These remaining bands would serve both as a seed source for natural reforestation, and as a belt to trap the sediment eroding from the cut area. Again this is a very simple technique which could be supervised by minimally trained Peace Corps-type volunteers.

5.10.2 Water Pollution Reduction

The water pollution problem can be broken down into two parts: a) water pollution in Guatemala City, and b) water pollution in provincial towns and villages.

The only alternative for treating waste water from Guatemala City is several modern sewage treatment plants. The constraints in funding and building an adequate sewage treatment system for Guatemala City are beyond the scope of this report. The only recommendation that is within the scope of this report is an economic analysis of the cost-benefit

ratio of a sewage treatment plant. A report that would show that the long-term benefits of a plant would exceed the costs would help convince Guatemalan legislators to approve money for a treatment plant. A further discussion of such a cost-benefit ratio study is provided in the Action or Short Term Recommendations section of this report (Section 6.7).

Water pollution caused by dumping raw sewage directly into streams in the rural towns and villages is a problem which is severe, yet appears to be manageable. There appear to be no policy constraints to prevent developing a water pollution reduction program. Political constraints could be important due to lack of an agency specifically designated to administer the program. There appear to be no legal constraints to such a program.

There is no particular government agency with specific responsibility for dealing with the water pollution problem. This could be one of the greatest obstacles to an effective program.

We recommend that in order to begin to deal with the local sewage pollution problem one or more demonstration or pilot projects are needed. Such a program would demonstrate the treatment effectiveness where sewage is pumped into a settling pond, the waste water used for irrigation, and the organic matter eventually used for fertilizer on adjacent perennial tree crops and pasture, after the harmful bacteria in the organic matter have decomposed. There may be an attitudinal constraint against using human waste for fertilizer. To establish a pilot project, a significant amount of effort may be needed in public relations to convince local people that recycling nutrients, organic matter and water is not only an acceptable way of cleaning up the rivers, but can vastly improve the yield of local tree crops and pastures.

The practice of dumping raw sewage into streams is a common practice in Guatemala. There is a need to identify those areas most impacted by raw sewage and specification of locations where amelioration of the problem is most needed.

Techniques for recycling sewage through settling ponds may require people with direct experience. Pennsylvania State University and the University of Florida have on-going projects of this sort. The University of Georgia has expertise in application of treated effluent to land. In this particular case, a visiting expert from one of these or other universities would be useful to advise the local group of Peace Corps-type people actively developing the project on the best and most appropriate methodology. Existing temperate techniques for sewage treatment can be modified for the special problems of Guatemala.

There are undoubtedly insufficient funds in Guatemala to establish any sort of pilot program on sewage recycling. AID could help finance one or more projects that would convince the government of the merits of the use of this approach.

A pilot project in waste sewage recycling could be a fundable AID project. One or more young Peace Corps-type volunteers with appropriate experience and training who would be willing to work with the local

people would be the key to the success of such a rural project. Occasional visits by experts in sludge recycling to assist and advise the project leader probably would be required.

The main constraint to developing a pilot project could be political. With what agency would a sewage recycling program be carried out? A careful political compromise might be needed to successfully launch the program. This is the reason that we emphasize that the people to carry out and lead the projects recommended here include generalists who can deal with all types of political and social situations. Specialists often lack the overall political and social consciousness to spearhead a project that has as many non-technical ramifications as sewage recycling.

6. ACTION OR SHORT-TERM RECOMMENDATIONS

The recommendations proposed in this section are those feasible strategy options in the public and private sector that can be reasonably developed and executed in the next 10 years. It is our aim to provide suggestions for projects that have a reasonable chance of success, can be developed with existing expertise supported by some outside help, and will yield fairly immediate results. It is these demonstration-type projects that will establish the technology on a small scale that can be transferred to broader geographical areas and to larger projects. We list these projects in relative priority.

6.1. Integrated Watershed-Village Management Program

Recommendation: Establish a demonstration integrated watershed-village management project as a model for other villages in the country.

In many areas of Guatemala, especially in the Central and Western Highlands, natural resources are not well managed; consequently production of crops and firewood is below maximum. The increased population pressure and limitation of available land have reduced the size of individual farms to a point where they are too small to manage effectively. Large expanses of steep hillside have been divided and many small plots of row crops have been planted (Plates 1 and 2). There is a critical need to integrate the fragmented small farms of each watershed into a watershed system and to establish sound agricultural practices on these farms (Plates 3 and 4). If all of the watershed functions of the land within the upper drainage system of a stream were controlled by the governing body of a village located in that watershed, then an effective watershed management plan could be initiated and carried out. The problems of soil loss, reduced soil fertility, firewood depletion, etc., that are individual farm and land owner problems could be integrated into watershed solutions.

An example of a management scheme on a watershed scale might be as follows: part of the basin would be forest, preferably in strips perpendicular to the slope to catch erosion from above; another section would be perennial crops, another annual crops, and another pasture. After several years, when the annual crops reduce soil fertility, that section could be converted to perennial crops and the soil could be fertilized with animal and/or human wastes. The forest could be gradually

Plate 1. Agriculture in the Highlands: extensive forest clearing on steep slopes for farming.

Plate 2. Agriculture in the Highlands: large cornfields on steep slopes without contour planting.

Plate 3. Sound agricultural practices in the Highlands: terraced fields on steep slopes.

Plate 4. Sound agricultural practices in the Highlands: strips of mixed plantings of corn and legumes.

harvested for firewood, and the pasture could be gradually abandoned to forest. Gradual rotation over a large area would minimize soil and fertility losses.

To be more specific, integrated crop rotation and management systems should be developed that will increase a community's economic benefits without detrimental effects to the land. Investigations should be conducted to determine which schemes are appropriate for the climatological and soil conditions, and which are mutually compatible with each other for given environmental conditions including sociological factors. Research should be conducted on crops and cropping systems that require minimum expenditure of fossil fuel subsidies in the form of fertilizer, pesticides, or gasoline, and that will provide the most economic benefit to the farmer.

There could be resistance to an integrated watershed-village management project from the people living in the watershed. Some personal freedoms must necessarily be surrendered in order to realize the long term benefits of the project. In order to minimize objections to the project and to enhance the possibility of its success, we recommend a sociological program to determine where the resistance will be and to define the steps to be taken to resolve the differences. Understanding and acceptance of the sociologists by the local people from the outset of the sociological study will be critical.

6.2 No-till Agriculture

Recommendation: Develop an experimental comparison between till and no-till agriculture.

Because of steep slopes and extensive row crop planting, soil erosion in tilled fields in many regions of Guatemala is a serious problem. No-till agriculture is proving to be an effective method to conserve soil without sacrificing yield. In many situations, weeds are controlled by herbicides sprayed on the soil shortly before seed planting, but this practice is not always required.

We recommend an experimental comparison between till and no-till agriculture. Similar crops on similar terrain should be compared, with traditional cultivation versus no-till as the only difference. Differences in production, leaching of nutrients, and erosion should be measured for at least five years, since experience in other regions has shown that differences do not become apparent for several years. The analysis should include total costs, e.g., man-hours of labor, cost of herbicides if needed, and total value of the harvested crop.

This program could be part of the integrated watershed-village management project.

6.3 Agro-Ecology in the Peten

Recommendation: Establish an agricultura/ecological experiment station in the Peten to investigate innovative ways to manage agricultural systems.

The Peten region of Guatemala supported a highly developed civilization for over 1000 years. The population density of the area

during the Mayan colonization was undoubtedly much higher than it is now. It is likely that the Mayans evolved practical methods for maintaining soil fertility, such as mulching crops with leaves from the forest and using crops in a sequence that resembled natural secondary succession (Plate 5). Various universities are carrying out investigations of the Mayan society with hope of finding insight into their agricultural practices and resource utilization. Also, pollen deposits are being analyzed to obtain estimates of vegetation cover during the Mayan period.

One agricultural system, "chinampa," which may have had its origin in an ancient Indian culture, is being investigated in Mexico by the Mexican Instituto Nacional de Recursos Bioticos. In the "chinampa" system, nutrients in water in canals surrounding agricultural fields are incorporated into aquatic vegetation. This vegetation is harvested and is used as mulch in the fields.

We recommend establishing an agro-ecological experiment station in the Peten to investigate innovative ways to establish appropriate agricultural systems. The station should cooperate closely with the Instituto Nacional de Recursos Bioticos in Mexico and with the Colegio Superior de Agricultura Tropical in Tabasco, Mexico, where there is a project dedicated to agro-ecosystems in the lowland tropics.

6.4 Forest Ecology

Recommendation: Establish at least one forest ecology experiment station, preferably in a bark beetle infestation area in the altiplano region.

Guatemala has a variety of forestry related problems that require structuring into an ecological context if solutions are to be found.

Although there is a reforestation program in Guatemala and there are seedling nurseries in various regions of the country, the program is not as cost-effective as it should be. For example, some reforestation is aimed at establishing plant cover on cut-over areas in order to prevent erosion. Pine, cypress, and other species are planted close together over large areas of deforested land. In many cases, the natural secondary succession must be surpressed, usually through cutting by machete, so that the planted seedlings will survive (Plate 6). In many cases, it would be better to let secondary succession proceed, allowing the naturally occurring vegetation to hold the soil. In such cases, there must be recognition of the role of secondary successional vegetation and this vegetation must be protected. In areas where seed sources are distant and plantings are necessary, a few trees planted in a single line perpendicular to the prevailing wind or water erosional force would be as effective as whole block plantings. In certain severely degraded areas, it might be better to initiate recovery with planting of legumes, to be followed later by tree planting.

Another current effort in Guatemala which may not be cost-effective is planting pines in pine areas with severe bark beetle damage (Plate 7). The severe beetle damage may be only a repetition of a naturally recurring cycle. The healthiest or most resistant trees survive and

Plate 5. Secondary forests in the Peten: the remnants of a past civilization once supported by extensive agriculture.

Plate 6. Pine seedlings in an area of rapid natural regeneration. Frequent cutting of naturally regenerating plants is necessary to maintain the pine plantations.

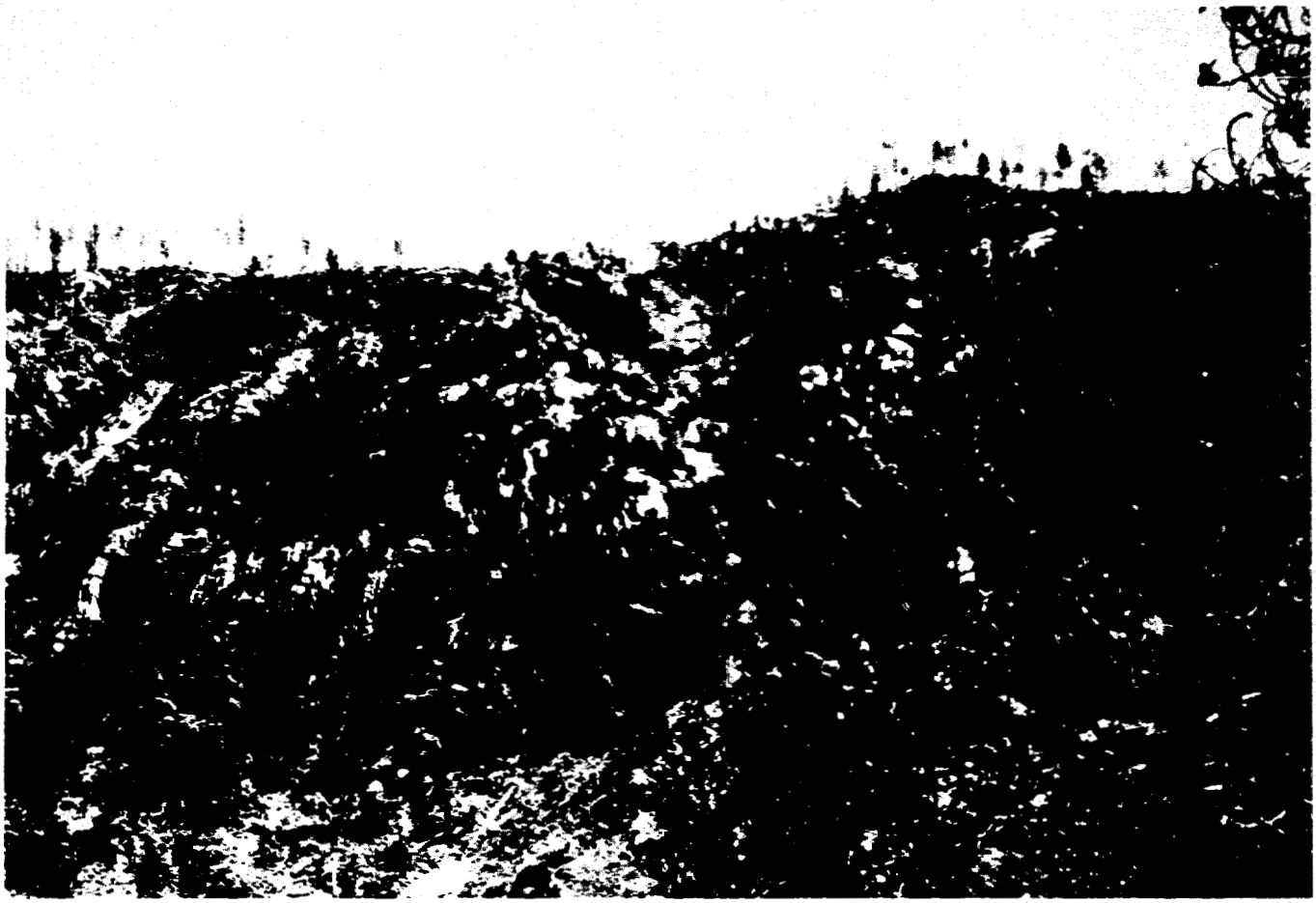


Plate 7. Pine beetle infestation in the Highlands. Note dead trees along the crest of the ridge.

produce more resistant offspring. However, some local people say that the current attack is the worst ever experienced. One suggested explanation for the severity of damage is that pesticides used in nearby lowland areas are blowing up the mountainside and are killing the natural predators of the bark beetle. This problem should be studied in more depth to determine the cause of the outbreak and to ascertain if replanting is worth, in the long-term, both the time and cost.

We are not implying that all the reforestation and plantations efforts are ineffective. We were very impressed with some of the work of local cooperatives in establishing fruit plantations in valleys and timber plantations in uplands. We believe that more plantations such as these for specific economic purposes would be worthwhile. For example, plantations dedicated specifically to saw timber and furniture wood could be managed over a 30-50 year interval. Other plantations for pulp could be managed on a rotation interval of approximately 10 years. Such plantations could represent an important future source of income for Guatemala.

A third area of critical need is to increase firewood production. Over 90% of the wood cut in Guatemala is used for firewood. This use is the major cause of deforestation in Guatemala. Domestic cooking, firing brick-, coffee-, and lime-kilns, driers and bakery ovens are the chief use of this fuel. Firewood plantations could be developed around Guatemala City as a private or government effort and as cooperatives in rural areas in order to reduce deforestation in natural forests that could better be used for other marketable products. Plantations could be managed on 10 year rotational cycles. Naturally regenerating forests also may be used as firewood sources.

In some areas of the altiplano, a vigorous grass, Muhlenbergia macrura (pahón), is covering areas apparently overgrazed by sheep (Plate 8). Sheep do not eat this grass, hence effective utilization of the land is decreasing. A forest ecology experiment station in the altiplano area could also develop research programs to find methods to replace Muhlenbergia with other species more palatable to sheep.

One of the greatest problems with improving land management practices in the altiplano area could be resistance of local people to change and to suggestions from outside. A sociological and educational effort to introduce new techniques and convince the population of their value is critical to the success of a forest ecology program. Such an educational program may take the form of educating key local people in the techniques of forestry and land practices and having these people transfer the information to the local areas.

To investigate these ideas, to experiment with other imaginative techniques, to carry out quantitative measurements and cost analyses of forest establishment, to protect existing forests, plantations, and secondary vegetation, to supervise plantings to ensure greater survival, and to provide extension services, we recommend establishing at least one forest ecology experiment station. An excellent site for the first station is the bark beetle infestation area in the altiplano region.

Plate 8. Sheep grazing in the Highlands. Closeup view of Muhlenbergia macrura (pahón) in the foreground.

6.5 Preservation of Economically Important Species in the Transversal Lowland Rain Forest

Recommendation: Establish a cooperative effort between ecological conservationists and planners to assure conservation of the economic resources of the lowland forest during the development of the Transversal.

The Western Transversal region has one of the few remaining lowland tropical rain forests in Central America. There is a growing world-wide concern about elimination of tropical rain forests because they possess a genetic pool of potentially useful trees, crops, and drugs, and because they represent seed sources for reforesting areas when soils have become depleted after agricultural uses. Although there is planning for the development of the Transversal with the establishment of villages and the planning of Centers for Services, there is a need to incorporate forest and wildlife conservation programs into this planning. The long-term economic and social success of the colonization of the Transversal will depend on sound ecological planning.

The tropical rain forest in the Transversal is being selectively logged for valuable market species such as mahogany. Reserves must be established to preserve seed sources, the genetic pool, of species such as mahogany which are already known to be valuable, and to preserve seed sources of species whose value has not yet been discovered. Plantations often are not feasible for this purpose. Many tropical species, including mahogany, grow poorly when planted close together because of insect predation and disease. Trees must be far enough apart so that predators are less likely to encounter a second tree after finding the first tree. In contrast to temperate or high altitude species, lowland rain forest trees are almost always highly dispersed, with few individuals of any species per square kilometer, but with many species in each square kilometer.

The forest also is being cleared for agriculture. These forest soils will support agriculture only for a short time because fertility will be depleted within a few years (Plate 9 and 10). New areas must then be cleared for agricultural soils. Provisions must be made for re-establishing the abandoned areas with forest. Since plantation forestry is expensive and probably impractical in the Transversal, it is extremely important that native trees be located close to the agricultural fields so that natural regeneration will occur. Native trees could be left in strips or patches close to agricultural land. Natural regeneration is the cheapest, most reliable, and most diversified method of reforestation. If large areas are cleared for agriculture and the natural seed source is not closely adjacent, then these areas may become totally unuseable because of laterization or desertification.

We recommend collaboration of conservationists specializing in ecological reserves with planners for the development of the Transversal, so that programs on the conservation of genetic resources can be carried out. While such programs have potential value to Guatemala, by helping to maintain species such as mahogany, they could have an even greater value to the world by keeping alive species that have medicinal properties, or that could be used as fuel substitutes, or that have other practical properties whose values have not yet been discovered.

Plate 9. Lowland rain forests in the Transversal: Forest clearing.

Plate 10. Lowland rain forests in the Transversal: corn showing signs of nutrient deficiency the second year after forest clearing.

Caution in planning is critical because the Transversal is a politically sensitive area. Problems could arise from interference with either government plans for the area or with the lives of the colonizers and indigenous people.

6.6 Biological/Ecological Reserves

Recommendation: Expand the Guatemalan "biotope" in the Atlantic montane rain forest to assure preservation of the Quetzal and determine other unique ecosystems that would qualify as reserves.

Guatemala has many different ecosystem types, each containing unique flora and fauna. At least a portion of each type should be protected in a park or reserve. Preservation of this uniqueness will provide economic and spiritual benefits to future generations.

To initiate a series of ecological reserves, we recommend an expansion of the Guatemalan "biotope" in the montane rain forest of the Atlantic slopes as the first reserve. This area is one of the last remaining refuges of the Quetzal, the national bird of Guatemala, which is a source of national pride for Guatemalans. This biotope is threatened by exploitation of the surrounding forest. Since ecosystem preservation is essential for species preservation, this ecosystem must be protected. Land surrounding the biotope should be purchased and included in the reserve. Local residents displaced by the purchase could be hired as park guards and rangers and for maintenance and other visitor services.

6.7 Cost of Sewage Dumping in Rivers Surrounding Guatemala City

Recommendation: Develop and carry out an economic analysis of the market and non-market benefits and costs of sewage treatment.

Rivers surrounding Guatemala City are utilized as sewage treatment and conveyance systems. Raw sewage from Guatemala City is dumped without prior treatment into these rivers. Because of the high cost of providing treatment facilities, governments have been reluctant to appropriate scarce money for treatment plants.

An economic analysis of all benefits and costs of sewage treatment would demonstrate the value of treatment. Non-market values, such as cost of drilling for water by downstream villages instead of using river water, cost of increased health care, tourist dollars lost, decreased fish production, and contaminated versus non-contaminated irrigation water, should be examined. This analysis is necessary to demonstrate that long-term costs of resource loss or quality of life are greater than the short-term cost of sewage treatment.

6.8 Sewage Recycling in Rural Areas

Recommendation: Establish a demonstration project to divert sewage into settling ponds rather than dumping it into streams and to utilize the treated sewage and water for agricultural land enhancement.

In many smaller towns near Guatemala City and in many other rural areas, raw sewage is dumped directly into rivers and streams (Plate 11). This sewage can have adverse downstream effects because the

Plate 11. Sewage discharge (left center) into a small rural stream.

waters are used frequently by local people for bathing and washing and for irrigation water. If sewage from rural towns were contained and not dumped into streams, many benefits could accrue from the removal of potential health hazards and the utilization of sewage nutrients for agricultural practices.

We recommend a demonstration project to show the value of diverting sewage into settling (oxidation) ponds rather than dumping it into streams and rivers. The water in the settling ponds could be siphoned off and placed into a trickle-delivery system to irrigate and provide nutrients to crops such as plantains and cattle fodder in nearby fields. Water hyacinths could be grown in the ponds and harvested for fodder and mulch. After it has dried long enough to kill harmful microorganisms, the solid waste material that collects at the bottom of the pond could be used to fertilize nearby fields. Several U.S. universities have considerable experience in sewage recycling; this experience could be utilized to help initiate a demonstration project quickly.

In some rural areas of Guatemala, industrial and hospital wastes are poured directly into rivers. Resolving this problem would be more difficult and require cooperation with the appropriate institution within the Guatemalan government. It may be possible to require sewage treatment ponds as a requisite for licensing by the government or as a condition of a loan.

6.9 Air Pollution

Recommendation: Undertake an economic analysis of the non-market costs of deteriorating air quality in Guatemala City.

Air pollution in Guatemala City does not appear to be as bad as some major cities, but it will get worse if effluent limitations for industries and transportation are not improved. Although the government has the authority to regulate air pollution from industrial sources, it appears that ambient air standards have not been set. As with water pollution, the probable reason that standards have not been set is that all the real costs of pollution are not known.

Non-market costs of pollution, such as effects on health, reduction in tourism, increase in government services, etc., are seldom considered in deciding if the costs of pollution control are affordable. Health costs are the most obvious non-market cost attributable to air pollution. Tourism also should be included in the analysis. The clear air of Guatemala is a prime tourist attraction and should not be allowed to deteriorate. We recommend an economic analysis of the non-market costs of deteriorating air quality in Guatemala City, especially with regard to health and tourism.

6.10. Implementation of Action Recommendations

The infrastructure exists and enough adequately trained people are available in Guatemala to initiate the action recommendations described above. These projects do not require a high degree of technical expertise, but they do require a commitment to initiate them and to follow through with their development. The programs do not require carrying out by "visiting experts" who do not have time to develop and cultivate

local political alliances and mold the social connections that will be necessary for the success of any of these ideas.

The concept of an expert to direct and maintain these small projects is unsound. Frequently, this methodology is used to help develop environmental programs in developing countries and too frequently the project fails when the expert's 2 or 3 year contract expires. The expert leaves and the project declines because the appropriate infrastructure has not been developed. It is also frequently the case that the experts are trained in temperate techniques and philosophy and are not able to adapt this knowledge and technology to viable tropical projects.

We recommend that a cadre of Guatemalan Peace Corps-type people be trained to help develop these projects and to take the lead in implementing the action recommendations. These people would live in the villages and work with the people. They would have regular contact with the appropriate agencies in Guatemala City in order to develop the necessary political support for the projects. Training in forestry and agriculture would be useful but not absolutely necessary. Good ability in Spanish, good understanding of people, willingness to work hard, ability to work with local and national agencies and an understanding that political compromises are made in order to achieve goals are the attributes that will be most useful.

In order to develop the forestry and agricultural experiment stations, an attitude that is free of temperate zone bias is needed. The problems in the countryside of Guatemala are not production agriculture or production forestry problems, areas in which many northern hemisphere agriculturalists and foresters are trained, but in agro-ecosystem and agro-forestry problems. It is essential that those helping establish these projects have a strong ecosystem ecology background and that they are willing to experiment in agro-ecosystems and agro-forestry. Recently trained graduates of the Universities of Georgia, Florida, Michigan, Berkeley, Tennessee, Yale, Colorado State and Cornell will be good candidates for work on these projects. Also, graduate students who are being trained at these universities could be used to help develop aspects of these projects as part of their graduate research. It will be necessary to have some experts involved in these projects, but, again, it should be those that have an ecosystem ecological approach to agriculture and forestry and who understand and can use ecological principles associated with nutrient cycling and productivity in developing the projects.

Our major point in this section is that recently trained, committed people who are beginning their careers and who have the most to gain in terms of reputation are the type of people who will best develop these projects.

7. LONG-TERM RECOMMENDATIONS

7.1 Development of an Environmental Institute

The above action recommendations, if implemented, will begin to alleviate some of Guatemala's environmental problems. These actions are

only a small effort of what could and should be done if the country is to utilize its resources in a sound economical way for the long-term benefit of the majority of its citizens. The resolution of the nation-wide, long-term problems requires establishing an Institute, i.e., a body designated by the Guatemalan government to carry out executive actions and directed by a governing board towards solving environmental problems. Such an Institute would be composed of an interdisciplinary team of ecologists, foresters, agronomists, soil scientists, entomologists, resource economists, geographers, sociologists, etc., that would interact to develop solutions to environmental problems and execute programs to solve the problems.

Actions to be carried out by the Institute should include at least:

1. Policy
   a. Setting environmental standards, such as permissible levels of air pollution and water pollution.
   b. Establishing regulations regarding land use and management, and cooperating with the economic planning council on regional planning.

2. Research
   a. Research upon which the environmental standards should be based.
   b. Research dedicated to improving methods of land management and to establishing parks and reserves.
   c. Economic analysis to determine non-market costs of environmental degradation.
   d. Coordination of the activities of the various pilot programs and demonstration programs being carried out throughout the country.

3. Management
   a. Implementing management schemes on government controlled lands.
   b. Assisting local populations with programs such as sewage recycling.

4. Education/Extension
   a. Training technicians who then train, educate and recommend programs to the local populations outside the capital city.
   b. Educating school children and the general public and possibly establishing advanced level courses in environmental sciences and applied ecology on the university level.
   c. Preparing newspaper stories and commercials for television, and sponsoring of activities such as observance of "Earth Day" in the schools.

5. Enforcement
   a. Determining if pollution standards are being met.
   b. Enforcing essential land use regulations.

To adequately carry out these functions or actions, the Institute should have a building which could house the laboratories for analysis of environmental samples, greenhouses and animal houses for experimental work, classrooms and auditoriums for teaching and extension functions, a library, offices for personnel belonging to the Institute, a workshop for fabricating equipment needed to carry out research and management, storehouses for equipment and sample storage, preparation rooms where samples can be ground for analysis, and motor vehicle pool.

Establishing an Institute, building its staff, and advancing its programs would constitute a truly major long-term contribution toward the betterment of the Guatemalan environment. This effort would help provide a sounder economic base of sustained resource use without the continued reduction in forest products and protection, soil fertility, and water and air quality.

7.2 Alternative Economic Strategies

Many of the environmental degradation problems can be attributed to economic underdevelopment. Lessening the pressure on forests and soils requires development of economic alternatives.

One way to lessen these pressures is to develop alternative livelihood occupations in the region. Limited-skill and labor intensive industries that require small power needs may be one tactic. Manufacturing concerns that might be suitable include: a) light assembly plants such as telephones or radios; b) use of local handicraft skills in more modern systems of production for such items as shoes, soap, bricks, furniture, textiles, and clothing; c) processing of local or nearby agricultural products such as maize and wheat milling, fruit and vegetable canning; d) lumbering and paper-making; and e) manufacturing a variety of household items from plastics or similar natural raw materials.

Pressure can also be relieved by encouraging migration to less densely settled areas of the country. This option has been used to a limited degree and is of questionable value because of the great expense involved. Nevertheless, some colonization in other areas such as the north may be advisable.

Improving traditional techniques in certain favorable areas also will lessen the adverse effects of pressure. More intensive horticulture is feasible in some areas without significant degradation. Careful husbandry in raising various vegetables in such favored localities could relieve the necessity of using more marginal lands and could provide a surplus for further processing.

A fourth method that complements the other methods is to encourage point activities (activities that use little space) such as bee-keeping, small fish ponds, and raising poultry and hogs in confined areas. These activities not only provide high quality protein supplies but manure waste can be used as a fertilizer to partly replace commercial fertilizers. Moreover, the processing of honey, poultry, and hogs can provide other jobs.

A fifth approach is to develop the country's tourist potential. There are few areas in the Western Hemisphere that are as accessible as the Guatemalan Highlands and that still possess a distinctive non-European culture. The magnificent vistas of volcanic mountains, large lakes, and the Indian dress, handicrafts, and culture could easily provide the basis for a thriving tourist industry not only for the foreigner, but also for the Guatemalan national.

A soundly based alternative economic program with environmental safeguards can partially solve some of the socio-economic problems and ease environmental degradation.

8. SUMMARY

The environmental problems of Guatemala are well known and are typical of many highly populated nations. Degradation of forest, soil, water, and air resources are common denominators in all nations, but the intensity of stress on the resource differs depending upon population size, size of resource, alternative socio-economic choices, and the closeness of the coupling of the man-nature system. Given that all these problems are known, the major task is to provide solutions to the environmental problems, so that man will have sustained use of the resource.

We have identified major environmental problems and have proposed solutions to these problems and methodologies to lead to the solutions. We have suggested short-term and medium-term action recommendations to begin solutions to agricultural, forest, soil, and watershed problems. As a long-term recommendation, we suggest establishing an Institute that would focus on the environmental problems of the country and which would attack these problems through research, policy, and education. We also propose some alternative economic strategies to replace subsistence agriculture which, if successful, will reduce people-pressure from the impacted national resources.

The schemes proposed are realistic and do not require new governmental structure. What is required is an integration of human expertise to develop the programs and to convey the technology to the users so that they become the teacher/practitioners.

9. LITERATURE CITED

AID. 1979. Country development strategy statement. FY 1981. Guatemala. Agency for International Development, U.S. Dept. of State, Washington, D.C.

Bovay Engineering, Inc. 1973. Prefeasibility study for a master plan on the renewable natural resources of Guatemala. Vol. 1-7. Bovay Engineering Inc., Houston, Texas.

Goodland, R. and R. Polland. 1974. Chixoy development project: Environmental impact reconnaissance. Cary Arboretum of the New York Botanical Garden, Milbrook, N.Y.

Goodland, R. and G. Tillman. 1975. National energy master plan: Environmental assessment. Instituto Nacional de Electrification (INDE) Guatemala. Cary Arboretum of the New York Botanical Garden, Milbrook, N.Y.

ICAITI. 1976. Primer Seminario Regional sobre Uso y Manejo de Plaguicidas en Centroamerica, Guatemala. Informe final. 344 p.

ICAITI. 1977. An environmental and economic study of the consequences of pesticide use in Central American cotton production. Final Report. Instituto Centroamericano de Investigacion y Tecnologia Industrial. Project No. 1412. Guatemala City.

ICAITI. 1978. Preliminary findings of deforestation in Guatemala. Draft report. Instituto Centroamericano de Investigacion y Technologia Industrial. Guatemala City.

Instituto Geografico Nacional. 1976. Inventario del Recurso Agua en Guatemala. Atlas Hidrologico. Guatemala: Ministerio de Communicaciones et Obras Publicas.

Library of Congress. 1979. Draft environmental report on Guatemala. Science and Technology Division, Library of Congress, Washington, D.C.

ROCAP. 1978. Proposed regional urban environmental baseline study. Project development reports; summaries of trips to Central American capital cities, proposed project description (air and noise), and development of uniform Central American pollution standards. Guatemala City.

UNEP. 1976. Environmental matters of regional importance and suggestions for action. Central America. United Nations Environmental Programs. 37 p.

UNESCO. 1976. Report of the regional preparatory meeting of the countries of Latin America and the Caribbean for the United Nations Water Conference. 30 Aug. - 3 Sept. 1976. Lima, Peru.

U.S. Fish and Wildlife Service. 1980. Republication of lists of endangered and threatened species and correction of technical errors in final rules. Federal Register 45(99):33768-33781.

Wadsworth, F.H. 1971. Forestry potential and its development in Central America. Grupo de trabajo centroamericano sobre dessarrollo y el medio ambiente, Doc. IV-4. 21 p.

Weiss, C.M. 1971a. Water quality investigations Guatemala: Lake Atitlan 1968-1970. ESE Pub. No. 274. Department of Environmental Sciences and Engineering, School of Public Health, University of North Carolina, Chapel Hill, North Carolina.

Weiss, C.M. 1971b. Water quality investigations Guatemala: Lake Amatitlan 1969-1970. ESE Pub. No. 281. Department of Environmental Sciences and Engineering, School of Public Health, University of North Carolina, Chapel Hill, North Carolina.

Weiss, C.M. 1971c. Water quality investigations Guatemala: Guatemalan Rivers 1969-1970. ESE Pub. No. 282. Department of Environmental Sciences and Engineering, School of Public Health, University of North Carolina, Chapel Hill, North Carolina.

Wylie, K.H. 1970. A survey of agriculture in Guatemala. ERS-Foreign-305. Economic Research Service, U.S.D.A., Washington, D.C.

APPENDIX

1. People and institutions visited

Agency for International Development (AID): Eliseo Carrasco, Carlos Crowe, Hank Basforth, Carl Koone, Tom Stukel

Regional Office for Central American Programs (ROCAP): Andy Chacom

Consejo Nacional de Planificació Económica (CNPE): Miguel von Hagen

Instituto Nacional de Transformacion Agraria (INTA): Armando Mijangos

Instituto Nacional Forestal (INAFOR): Jorge Spiegeler

Instituto Nacional de Electrificación (INDE): Rolando Yon

Instituto Geografico Nacional (IGN): Carlos Lemmerhoefer, Francis Gall

Instituto de Fomento Municipal (INFOM): Carlos Prera

Instituto Guatemalteco de Turismo (INGUAT): Alvaro Anzú, Jorge Solis

Division de Saneamiento Ambiental: Julio Garcia

Consejal de la Municipalidad de Guatemala: Marta Pilón de Pacheco

CACIF: Enrique Neutze

USPA: Roberto Prata

Vice-Ministries of Government: Juan de Dios Reyes

Congress: Oscar Vega, Jose Faillace

Museo de Historia Natural: Jorge Ibarra

Universidad de San Carlos de Guatemala: Mario Dary

Universidad de Landiver; Jaime Caceres

Asociación Guatemalteca Pro-Defensa del Medio-Ambiente: Jose Pacheco

2. Bibliography

A.I.D. 1979. Country development strategy statement. FY 1981. Guatemala. Agency for International Development, U.S. Dept. of State, Washington, D.C.

Adams, Richard N. 1957. Cultural surveys of Panama-Nicaragua-Guatemala-El Salvador-Honduras. Pan-American Sanitary Bureau, Scientific Publication No. 33, 669, Washington. 669 pp.

Altschuler, Milton. 1958. On the environmental limitations of Mayan cultural development. Southwest Journal of Anthropology 14:189-198.

Barraclough, Solon (ed.). 1973. Agrarian Structure in Latin America: A Resume of the Cida Land Tenure Studies of: Argentina, Brazil, Chile, Colombia, Ecuador, Guatemala, Peru. Lexington Books, D.C. Heath and Co., Lexington, Mass. 351 pp.

Bovay Engineering Inc. 1973. Prefeasibility study for a master plan on the renewable natural resources of Guatemala. Vol. 1-7. Bovay Engineering Inc., Houston, Texas.

Britnell, G.E. 1951. Problems of economic and social change in Guatemala. Canadian Journal of Economics and Political Science 17:468-481.

Britnell, G.E. 1963. Factors in the economic development of Guatemala. American Economic Review 43:104-114.

Bulmer-Thomas, Victor. 1978. Policy for land reform in Guatemala. Civilisations 28:76-89.

Carter, William E. 1969. New lands and old traditions: Kekchi cultivators in the Guatemalan lowlands. University of Florida, Center for Latin American Studies, Gainesville. 153 pp.

Cats, S.G. Manger. 1970. Socio-economic development in Guatemala through incentives to the subsistence sector. Netherlands Journal of Agricultural Science 18:115-124.

Cowgill, Ursula M. 1962. An agricultural study of the southern Maya lowlands. American Anthropologist 64:273-286.

Daines, Samuel R. 1975. Guatemala Farm Policy Analysis. Agency for International Development, Sector Analysis Division, Washington. 126 pp.

Dombrowski, John et al. 1970. Area Handbook for Guatemala. Government Printing Office, DA PAM, Washington. 361 pp.

Elbow, Gary E. 1976. Fertilizer price increases and subsistence agriculture. Geographical Review 66:230-233.

Espinosa, A.F. (ed.) 1976. The Guatemalan earthquake of February 4, 1976: A preliminary report. Geological Survey Professional Paper 1002, Washington. 90 pp.

Fletcher, Lehman B. et al. 1970. Guatemala's Economic Development The Role of Agriculture. Iowa State University Press, Ames. 212 pp.

Fuentes-Mohr, A. 1955. Land settlement and agrarian reform in Guatemala. International Journal of Agricultural Affairs 2:26-36.

Gollas Quintero, Manuel. 1972. Surplus labor and economic efficiency in the traditional sector of a dual economy: The Guatemalan case. Journal of Development Studies 8:411-423.

Goodland, R. and R. Polland. 1974. Chixoy development project: Environmental impact reconnaissance. Cary Arboretum of the New York Botanical Garden, Milbrook, N.Y.

Goodland, R. and G. Tillman. 1975. National energy master plan: Environmental assessment. Instituto Nacional de Electrification (INDE) Guatemala. Cary Arboretum of the New York Botanical Garden, Milbrook, N.Y.

Gottfried, Yolande McCurdy. 1979. The Environment of Guatemala. Available Information, Current International Projects, and Recommendations. Mimeo. Report for USAID, Guatemala. 90 p.

Hidlebrand, John R. 1962. Latin American economic development, land reform, and U.S. aid with special reference to Guatemala. Journal of Inter-American Studies 4:351-361.

Hidlebrand, John R. 1963. Guatemalan rural development program: An economist's recommendations. Inter-American Economic Affairs 17:59-71.

Hudman, Lloyd E. 1978. Tourist impacts: The need for regional planning. Annals of Tourism Research V:112-125.

ICAITI. 1976. Primer Seminario Regional sobre Uso y Manejo de Plaguicidas en Centroamerica, Guatemala. Informe final. 344 p.

ICAITI. 1977. An environmental and economic study of the consequences of pesticide use in Central American cotton production. Final Report. Instituto Centroamericano de Investigacion y Tecnologia Industrial. Project No. 1412. Guatemala City.

ICAITI. 1978. Preliminary findings of deforestation in Guatemala. Draft report. Instituto Centroamericano de Investigacion y Technologia Industrial. Guatemala City

Instituto de Fomento Municipal. 1977. Memoria de Labores, Guatemala, Guatemala, C.A.

Instituto Geografico Nacional. 1976. Inventario del Recurso Agua en Guatemala. Atlas Hidrologico. Guatemala: Ministerio de Communicaciones et Obras Publicas.

Jones, Chester L. 1966. Guatemala: Past and present, 2nd ed. Russell and Russell, New York.

Library of Congress. 1979. Draft environmental report on Guatemala. Science and Technology Division, Library of Congress, Washington, D.C.

Micklin, Michael. 1969. Urbanization, technology, and traditional values in Guatemala: Some consequences of a changing social structure. Social Forces 47:438-446.

Ministerio de Salud Publica y Asistencia Social, Division de Saneamiento Ambiental. 1979. Decreto No. 45-79 Codigo de Salud, Guatemala, Guatemala, C.A.

Ministerio de Salud Publica y Asistencia Social, Direccion General de Servicios de Salud, Division de Saneamiento Ambiental. 1978. Plan Nacional de Saneamiento Ambiental (Plandesa), Guatemala, Guatemala.

Minkel, Clarence W. 1968. Colonization of the Sebol Region in North Central Guatemala. Pacific Viewpoint 9:69-73.

Nash, Manning. 1958. Machine age Maya: The industrialization of a Guatemalan community. Suppl. to the American Anthropologist 60:118. Mensha, Wisconsin. 118 pp.

Naylor, Robert A. 1967. Guatemala: Indian attitudes toward land tenure. Journal of Inter-American Studies 9:616-639.

ROCAP. 1978. Proposed regional urban environmental baseline study. Project development reports; summaries of trips to Central American capital cities, proposed project description (air and noise), and development of uniform Central American pollution standards. Guatemala City.

Saunders, George B. et al. 1950. A fish and wildlife survey of Guatemala. Department of the Interior, Special Scientific Report-Wildlife, No. 5, Washington. 160 pp.

UNEP. 1976. Environmental matters of regional importance and suggestions for action. Central America. United Nations Environmental Programs. 37 p.

UNESCO. 1976. Report of the regional preparatory meeting of the countries of Latin America and the Caribbean for the United Nations Water Conference. 30 Aug. - 3 Sept. 1976. Lima, Peru.

U.S. Fish and Wildlife Service. 1980. Republication of lists of endangered and threatened species and correction of technical errors in final rules. Federal Register 45(99):33768-33781.

Unidad de Estudios y Proyectos, Instituto Guatemalteco de Turismo. 1978. Ordenacion Turistica, Guatemala, Guatemala, C.A.

Veblen, Thomas T. 1978. Forest preservation in the western highlands of Guatemala. Geographical Review 68:417-434.

Wadsworth, F.H. 1971. Forestry potential and its development in Central America.

Weiss, C.M. 1971a. Water quality investigations Guatemala: Lake Atitlan 1968-1970. ESE Pub. No. 274. Department of Environmental Sciences and Engineering, School of Public Health, University of North Carolina, Chapel Hill, North Carolina.

Weiss, C.M. 1971b. Water quality investigations Guatemala: Lake Amatitlan 1969-1970. ESE Pub. No. 281. Department of Environmental Sciences and Engineering, School of Public Health, University of North Carolina, Chapel Hill, North Carolina.

Weiss, C.M. 1971c. Water quality investigations Guatemala: Guatemalan Rivers 1969-1970. ESE Pub. No. 282. Department of Environmental Sciences and Engineering, School of Public Health, University of North Carolina, Chapel Hill, North Carolina.

Whetten, Nathan L. 1961. Guatemala: The land and the people. Yale University Press, New Haven. 339 pp.

Wylie, K.H. 1970. A survey of agriculture in Guatemala. ERS-Foreign-305. Economic Research Service, U.S.D.A., Washington, D.C.