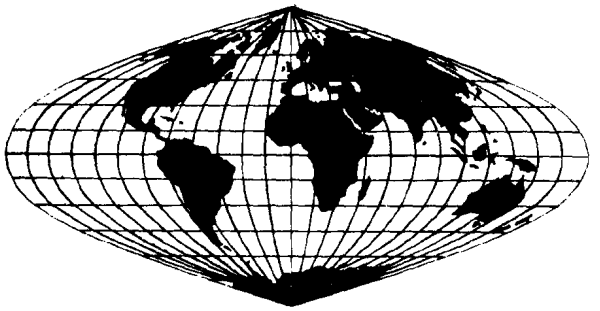
May 1984
Reissued May 1986

A.E. Research 84-4

CORNELL/INTERNATIONAL AGRICULTURAL ECONOMICS STUDY

INTENSIFICATION OF PEASANT AGRICULTURE IN YUCATAN

Peter T. Ewell



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May 1984

It is a pleasure to introduce Peter Ewell's study of agricultural intensification among the Mayan peasants of Yucatan. It is the fifth in a series dealing with the development of Mexico's tropical lowlands carried out by members of Cornell's Department of Agricultural Economics. If the series has had a theme so far it is that development of this potentially productive area has frequently been hampered rather than helped by the government's efforts to stimulate agricultural change.

The history of Mexican agriculture during the past 40 years has been mixed. Mexico was the site of the first "agricultural miracle" of the postwar period, of the green revolution in its first blossom. As of the end of the Second World War, the country was importing 15-20 percent of the staple foods needed to feed a population of 22 million. By the mid-1960s, although the population had doubled, the deficit had been eliminated, and for a few years appreciable quantities of maize were exported. More recently the combination of rising population and stagnating production has brought about a reversal. Since the early 1970s Mexico has once again become an importer and in the last few years has depended on foreign sources for between a quarter and a third of its maize.

The early successes were localized on large holdings in the arid North and Northwest and made possible by massive irrigation works and the application of technology developed in the United States. Most projects in the tropical Southeast have attempted to follow a similar pattern. They have tended to be large and centrally administered, with the peasants afforded minimal scope for individual decision making. Tacitly assumed has been that it is the government functionary, not the peasant, who knows best. Examples abound of the failures that ensued. I documented some of the earliest in my study two decades ago of the Papaloapan Project (1), and Sara Scherr has updated the record (2). The fiasco that resulted from the attempt to organize peasants into centrally-controlled collectives for the production of mechanized rice in the rainforest at Uxpanapa was the subject of an earlier study by Dr. Ewell (3). And Turner Price has chronicled the failings of schemes designed to encourage small farmers in the Selva Lacandona to plant extensive areas to maize (4).

It would be gratifying to record that the government has finally learned that temperate-zone technology and centralized management will simply not work in the tropical Southeast. But this is not so. Even

today much of the remaining forest in Quintana Roo and Yucatan is being cleared through large mechanized projects.

Dr. Ewell's study points to a different approach. It focuses on the Puuc region of southern Yucatan, an area where the peasants have successfully developed more intensive production systems. There, over the past 40 years, some 3,500 families have gradually shifted from subsistence milpa to the cultivation of fruits and vegetables for the market. Small-scale irrigation facilities were constructed by the government, but the farmers retained the freedom to modify their traditional technology as they saw fit. In explaining how this success came about, Dr. Ewell provides rare insights into the economic strategies followed by the peasants, and challenges the government to incorporate these into the planning of future projects.

The study draws on nearly two years of field work, made possible by grants to Cornell by the Scott Paper Company and the U.S. Agency for International Development. Other researchers in Yucatan were generous with information and guidance: the Maya Food Systems project of CIDER/UNDP/UNRISD, directed by Rafael Baraona; the Milpa Project of the Graduate College of Agriculture at Chapingo, directed by Dr. Efraim Hernandez X.; the Puuc Regional History project of the National Institute of Anthropology and History, directed by Lic. Margarita Rosales; the Tropical Forestry and Land-Use project of the National Forestry Research Institute, coordinated by Ing. Bernd Neugebaur; and the "Dr. Hideyo Noguchi" Center for Regional Studies of the University of Yucatan. Ing. Abdo Magdub of the SARH, Ing. Ramon Alvarez of Irrigation District #48, Ing. Fernando Salas and Ing. Jorge Ludlow of BANRURAL, and Ing. Antonio Nava and Dr. Magella Dagduy of the SPP made data available and opened many doors.

At Cornell Professors Daniel G. Sisler and H. David Thurston shared with me the pleasure of guiding Dr. Ewell's work. The maps were drawn by Joseph Baldwin. Mrs. Lillian Thomas prepared the charts and tables and saw the manuscript through the press. Lewis Relyea and Diane Beckley prepared the plates and printed the final copies. Thank you all.

Comments are welcomed and these should be addressed to:

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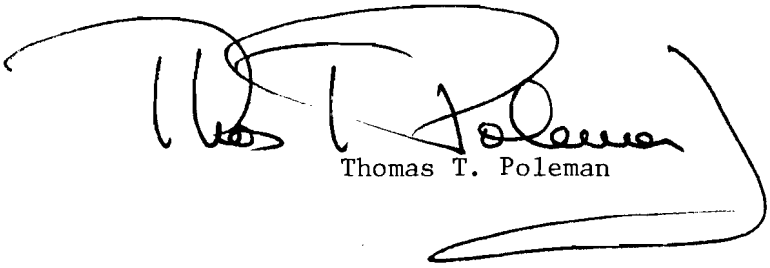

Thomas T. Poleman

1 Thomas T. Poleman, The Papaloapan Project: Agricultural Development in the Mexican Tropics (Stanford University Press, 1964).

2 Sara J. Scherr and Thomas T. Poleman, "Development and Equity in Tropical Mexico: Thirty Years of the Papaloapan Project" (Cornell/International Agricultural Economics Study, A.E. Res. 83-3, July 1983).

3 Peter T. Ewell and Thomas T. Poleman, Uxpanapa: Resettlement and Agricultural Development in the Mexican Tropics (Pergamon Press, New York, 1980).

4 Turner Price and Lana Hall, "Agricultural Development in the Mexican Tropics: Alternatives for the Selva Lacandona Region of Chiapas" (Cornell/International Agricultural Economics Study, A.E. Res. 83-4, January 1983).

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GLOSSARY

Aguada	In Yucatan, a small infiltration basin where water collects. Many were improved as reservoirs by the ancient Maya.
ANAGSA	Aseguradora Nacional Agrícola y Ganadera--The National Crop and Cattle Insurance Company. A Federal agency which insures the recipients of agricultural credit against crop and animal losses beyond their control.
Ak'alche	A Maya term for heavy, hydromorphic soils. See Table 3.
Bajo	Shallow, seasonal lake beds in southern Yucatan where internal drainage has become blocked and heavy soils have accumulated.
Campesino	The Spanish word for a peasant or an agricultural laborer.
Canícula	A short dry period during the rainy season.
Cenote	A natural sink-hole in the limestone bedrock of Yucatan, which provides access to groundwater.
CONAFRUT	La Comisión Nacional de Fruticultura--The National Fruit Commission.
CONASUPO	Comisión Nacional de Subsistencias Popularies--The National Basic Goods Commission. A decentralized Federal agency which buys agricultural products at official prices, handles food imports, and operates retail distribution outlets which sell essential goods at subsidized prices.
Conuco	Small plots in the Puuc hills where vegetable crops, particularly cucurbits, are produced over an extended growing season using modified milpa technology.
COPLAMAR	Comisión de Planeacion para las Areas Marginadas--The Planning Commission for

	Marginalized Areas, a Federal rural development agency.
Crédito de Avio	Short-term production credit, repaid at the end of the growing season.
Crédito Refaccionario	Long-term agricultural investment credit, repaid over a period of years.
Ejido	The institution through which land has been distributed to peasant communities by the land reform program since the Revolution of 1912-1917. Land titles are retained by the Federal government, and the members of the community, or ejidatarios, are granted lifetime usufruct rights. Ejidos are administered by elected representatives, under the supervision of the Agrarian Reform Ministry (SRA).
Ek-lu'um	A Maya term for black soils high in organic matter. See Table 3.
Encomienda	Immediately after the Conquest, Spaniards were granted Royal licenses to collect tribute from designated Indian communities. They had no right over the land, and were not supposed to live in their encomiendas. The institution was gradually supplanted by true landed estates, or haciendas.
Haranch'ak	A Maya term for a superficial weeding with a machete.
Huerta	A parcel planted with fruits and vegetables.
Huipíl	A loose embroidered blouse worn by Maya women.
INI	Instituto Nacional Indigenista--The National Indian Affairs Institute, a Federal agency which provides education and other services, and runs rural development projects for indigenous peoples.
Ka-kab	A Maya term for soils in the vicinity of ancient ruins. See Table 3.
Kanché	A Maya term for a platform raised on poles for the cultivation of delicate seedlings.
Kankab	A Maya term for red soils in valleys and depressions. See Table 3.

Lo'che'	A Maya term for a small curved knife, used for uprooting weeds.
Lo'che'paak	A Maya term for a careful weeding with a Lo'che'.
Mestizo	In most parts of Spanish America, a person of mixed European and Indian blood. In Yucatan, the word refers to the Maya.
Milpa	Throughout Meso-America, a general term for a peasant's plot. In Yucatan, it refers to a specific system of slash-and-burn cultivation and rotation through forest fallow.
Milpa Caña	A milpa in its second year of cultivation.
Milpa Roza	A milpa in its first year of cultivation.
Minifundio	A farm which is too small to provide full-time employment to the operator.
Pach Pa'kaal	A Maya term for an area of fertile soil within a milpa plot which is cultivated with vegetables.
PIDER	Programa de Inversiones para el Desarrollo Rural, later changed to Programa Integrado de Desarrollo Rural--Integrated Rural Development Program. A planning and financial agency for rural development projects.
PRI	El Partido Revolucionario Institucional--The Institutional Revolutionary Party. The official party of the Mexican government, in power continuously since the 1930's. It consists of three mass organizations: La Confederación Nacional Campesina (CNC), the National Peasants Confederation; La Confederación de Trabajadores Mexicanos (CTM), the Confederation of Mexican Labor Unions; and the Confederación Nacional de Obreros Publicos (CNOP), which combines civil servants with organized semi-independent workers such as taxi drivers.
PSS	El Partido Socialista del Sureste--The Socialist Party of the Southeast, a radical regional movement of which Felipe Carrillo Puerto was the prominent leader between 1915 and his death in 1924. The party was

	incorporated as a regional chapter of the PRI in the 1930's.
Puuc Hills	A line of low hills in southern Yucatan which have given their name to the surrounding region.
Rancho	A small, privately operated rural property.
Rural Bank	El Banco Nacional de Crédito Rural (BANRURAL) is a government bank established primarily to serve the needs of the ejidos. It was formed in 1975 through the merger of El Banco Ejidal, El Banco Nacional de Crédito Agricola, and El Banco Nacional Agropecuario. The term "Rural Bank" is used in this study for all of these institutions.
SARH	La Secretaría de Agricultura y Recursos Hidraulicos--The Ministry of Agriculture and Water Resources.
SAM	Sistema Alimentario Mexicano--The Mexican Food System. A planning agency created in the last years of the Lopez Portillo administration to coordinate a set of subsidies to both farmers and consumers.
SPP	Secretaría de Programación y Presupuesto--The Ministry of Planning and the Budget.
SRA	Secretaría de la Reforma Agraria--The Agrarian Reform Ministry.
Solar	A back-yard garden.
Sarteneja	A depression in the rock where rainwater collects; a source of drinking water in isolated areas of Yucatan.
Tsek'el	A Maya term for soils in the rocky hummocks which are prevalent in the limestone terrain of Yucatan. See Table 3.
Trapiche	A small, rustic sugar mill.
Uitz	A Maya term for cone-shaped limestone hills, which are called kegelkarst in the geological literature.

Yaaxhom — A Maya term for relatively well-drained hydromorphic soils. See Table 3.

A Note on Exchange Rates

The Mexican peso has been devalued several times over the past decade. The exchange rate was fixed at 12.50 pesos per U.S. dollar from 1952 until 1976, when it dropped to 26 per dollar. This latter rate is used in this study to maintain a consistent standard, although the peso was significantly over-valued by the time of the next devaluation in January 1982, in the middle of the agricultural cycle about which data was collected. The Banco de Mexico withdrew support in August 1982 in response to a mounting financial crisis, and the rate plummeted to 150 pesos per dollar. It had declined to 180 per dollar by April 1984.

CHAPTER ONE

INTRODUCTION

Most Mexican farmers are peasants: the managers of small operations based on family labor and traditional production practices. They have shared very unequally in the benefits of the development of a country with the second largest economy and the fifth highest per capita income in Latin America (126, pp. 148-149). Although Mexico had one of the highest rates of agricultural growth in the world for many years, development programs and the introduction of modern technology have been heavily biased in favor of a small minority of farmers in privileged regions. The agricultural sector has become polarized between large-scale commercial and peasant farms: they are located in different parts of the country, they operate units of very different sizes, they produce different crops, they employ different technology, they sell in different markets, they have been affected by government policy in different ways, and they organize production according to a different logic. Traditional agricultural systems are by no means limited to indigenous peoples, but they have particularly strong roots among groups which have maintained their languages and cultures. This is a study of one of the most numerous, the Maya peasants of Yucatan. Their economy, which is based on the slash-and-burn milpa system, is under severe pressure, both because of the agro-climatic limitations of the natural environment and because of the deteriorating position of the peasants in the larger economy.

The state of Yucatan is a semi-arid, tropical lowland plain which is marginal for conventional forms of agricultural development. The soils are thin and rocky, the rainfall patterns are highly irregular, and there are no natural sources of surface water. Although it was a site of the ancient Maya civilization and has been continuously inhabited for thousands of years, it has many characteristics of a frontier region. Nearly 70 percent of its area is in forest or in some stage of secondary regrowth. The only two important crops are henequen (sisal fiber), which is grown principally on state-managed plantations, and maize, which is grown almost exclusively in the traditional milpa system. Both are produced using slash-and-burn technology. The henequen industry has been in protracted decline since a boom which peaked during the First World War. Private cattle ranching is expanding, and a few other agricultural products are sold on a small scale. Traditional peasant agriculture in widely dispersed Maya communities has always been, and remains, the principal source of food crops. Average maize yields are among the very lowest in Mexico, rural underemployment is widespread, nearly 40 percent of the population

lives in the principal city, and the state brings in a large proportion of its food requirements from other parts of the country and from abroad.

Away from the city of Merida and the surrounding henequen zone, the population density is low and the Mayas live in small villages. On first observation, a rural community in Yucatan appears to have changed very little for centuries; the cropping methods and the annual cycle of activities are perfectly recognizable from the earliest Spanish chronicles. Virtually autarkic, subsistence-oriented villages could be found in isolated areas of the frontier into this century. The long tradition of empirical knowledge has permitted Maya agriculture to survive in a difficult and patchy environment, but it would be a great mistake to conclude that the peasants live in a static, traditional equilibrium or that pressures for change are only recent.

Since they were forcibly reorganized in the first years of the Spanish colony, the Maya communities have supplied both labor and surplus products to the dominant economy. Both environmental and social conditions have limited the development of large-scale commercial agriculture, except at sporadic intervals. The expansion of government control and of a sugar industry in the first decades after Mexican independence provoked the Caste War, one of the bloodiest peasant uprisings in the history of the country. In the late 19th Century, the great majority of the rural population was absorbed into the rapid growth of henequen plantations, either as debt-peons or as dependent associates. The hacienda economy disintegrated after the Revolution of 1912-1917, and the forest hinterlands were distributed to the Maya in a program of agrarian reform. The traditional peasant economy, based on milpa agriculture, was re-established and experienced a brief resurgence.

In recent decades, the Maya peasants have faced an increasingly serious dilemma. Milpa yields are too low and irregular to guarantee the security of the family food supply. Deterioration in the structure of relative prices has made it increasingly difficult to live from the sale of surplus maize. Individual families have flexibly adapted by diversifying their activities with whatever opportunities become available. Their options are limited, and the concentration of resources and the more profitable enterprises has led to increasing socio-economic stratification within the communities. Many households depend increasingly on intermittent, seasonal, or longer periods of migratory labor. The population has become concentrated in larger, better communicated villages where employment opportunities, schools, and other services are available. Milpa plots are cleared within smaller areas to permit their part-time management, which has meant a reduction in fallow periods, even though large areas of the state are very sparsely populated. Milpa production practices have become simplified, and yields have become more uncertain.

The potential for the intensification of traditional peasant agriculture has long been a controversial issue in Mexico. Throughout the country, most peasant families simultaneously grow a portion of their direct food requirements, produce crops for sale, and supplement their incomes with off-farm labor. They work under very unfavorable conditions in all three areas. If the unpaid family labor employed in self-provisioning food production is valued at the prevailing rural wage rate, they appear to operate consistently at a loss. They continue to sell crops at prices which have driven most private capital out of basic food production, and supply a significant proportion of the national demand for maize and beans. In competition with large-scale commercial agriculture, they are relegated to marginal lands, to relatively unprofitable crops, and to farms of decreasing size. They face low and unstable prices in the markets where they sell, and the terms of exchange for the increasing number of commodities which they must buy are deteriorating. Because they produce a portion of their own needs, they are able to supply their labor as agricultural, unskilled, and service workers on a temporary or seasonal basis for wages which in themselves would be insufficient to support their families. They partially feed themselves at very low cost to the economy, they provide cheap food to the urban markets, and they have helped to keep wage rates low. Through these involuntary sacrifices, they have made a significant contribution to the accumulation of capital and to the industrialization of Mexico.

Support for peasant agriculture has been a central rhetorical commitment of the Mexican government since the Revolution, and the agrarian reform program was one of the earliest and most comprehensive in Latin America. It gave the peasants at least partial tenure security, but government expenditures on irrigation, mechanization, crop research, credit, and other services were highly concentrated in the small modern sector between 1940 and the mid-1960's. Increases in productivity, and the expansion of the area in production in areas where land was redistributed, generated employment in agriculture at a rate of over 3 percent per year and permitted the adequate growth of output. Between 1960 and 1975, the average annual increase in the demand for labor declined to 1.4 percent, while the rate of population growth accelerated to 3.3 percent per year (241). National production became incapable of meeting rising demand, and food and feed imports increased rapidly. Over 75 percent of rural households have incomes below the poverty level, which was estimated in 1975 as the equivalent of 670 U.S. dollars per year (36, p. 20). Migration has provided an escape for many members of peasant families; between 1960 and 1980 the share of the national work force employed in agriculture declined from 55 to 36 percent, and the productivity gap within the sector widened (126, p. 153).

There are many who argue that the marginalization of the peasantry and the extraction of an increasing surplus from it are inevitable results of economic development. According to this view, it is only a question of time before the agricultural sector is reduced to a

relatively small number of large, efficient farms. Others argue that the other sectors of the economy are incapable of absorbing the displaced population, that the social costs of such a process would be too great for the country to bear, and that peasant agriculture consists of flexible and adaptable systems of resource use which could be strengthened through appropriate programs of agricultural and rural development. Faced with a crisis situation, the government has greatly expanded its programs in the peasant sector since the 1960's. The results have been mixed and regionally very uneven.

Government projects designed to introduce more productive agriculture into Yucatan have encountered serious difficulties, and few have provided stable alternatives to the Maya peasant economy. They have attempted to impose irrigation and cropping systems based on untested technical assumptions, financed through rigid credit systems which have not provided sufficient or timely working capital to the participants. Yields and net returns have in many cases been lower than those obtained in traditional systems. They have centralized the locus of decision-making away from the peasant families and communities into the hands of a diffuse and poorly coordinated bureaucracy. The officials are under strong short-term pressures to elaborate schemes which are in conformity with national policies and guidelines, and they often try to fit the peasants into a Procrustean bed. Although the region has benefited from the increased government spending, few projects have provided the flexibility on which the stability of the peasant economy depends. Complex conflicts of interests have developed between the campesinos and the government agencies.

This study will concentrate on a small region in the southern part of the state where peasant families have been able to intensify their traditional production systems in small, irrigated parcels. Oxkutzcab is one of several towns along the margins of a line of low hills which are called the Puuc in Maya. The region has been the source of a variety of agricultural products for urban markets since Colonial times, and has evolved as a center of fruit and vegetable production. It is located 100 kilometers from the city of Merida, and a wholesale assembly market is structured to receive small lots of diverse produce from many small producers. Since the 1940's, the government has drilled wells and constructed over 130 small irrigation projects which have permitted approximately 3,500 Maya families to shift gradually from milpa to the production of crops for the market, and to stabilize the economy of their families. Cases will be drawn from one type of irrigation program, where government intervention in the organization of production has been minimal.

Most of the peasants have financed the development of their plots with long periods of migratory labor. The parcels are managed in a successional sequence of annual, semi-perennial, and perennial crops grown in many different combinations. Diversification spreads the risks of variable yields and prices of the individual crops, and the overlapping sequences permit the gradual accumulation of equity without

the need for capital savings or reliance on credit. The use of hired labor and purchased inputs varies through the development of an individual parcel, as well as between farmers depending on their resources, goals, and fluctuating fortunes. Average yields and net returns are modest. Very few services such as applied research or technical assistance have been provided, and productivity could be increased significantly. Nevertheless, as peasant enterprises, they are designed primarily to maintain the stability of family economy and to accumulate equity in the long-term security of the household, not to maximize the short-term returns to each crop or to each hectare. It will be argued that lessons from the empirical experience of the intensification of peasant agriculture in the Puuc region could be used to improve the design of government development projects in Yucatan.

CHAPTER TWO

THE IMPORTANCE OF TRADITIONAL PEASANT AGRICULTURE IN MEXICO

Mexico is a large country of over 70 million people with rich and diverse resources. Industrialization and economic growth have been rapid; over the past decade it has become a leading petroleum exporter. Its capital will soon become the largest city in the world. The political system is remarkably stable. Nevertheless, the distribution of personal income is among the most unequal in Latin America. The foreign debt crisis of the early 1980's is but a recent and dramatic manifestation of structural disequilibria in the economy, which are particularly severe in the agricultural sector. The country has long been an exporter of a number of crops, and has been the site of dramatic improvements in yields and production practices. Approximately half of the arable lands have been distributed to peasant communities in a comprehensive agrarian reform program. Nevertheless, capital and modern technology have been concentrated on a small fraction of farms located in privileged regions. Mexico's capacity to feed its people is deteriorating, and the overwhelming majority of farmers practice traditional agriculture under unfavorable natural and economic conditions.

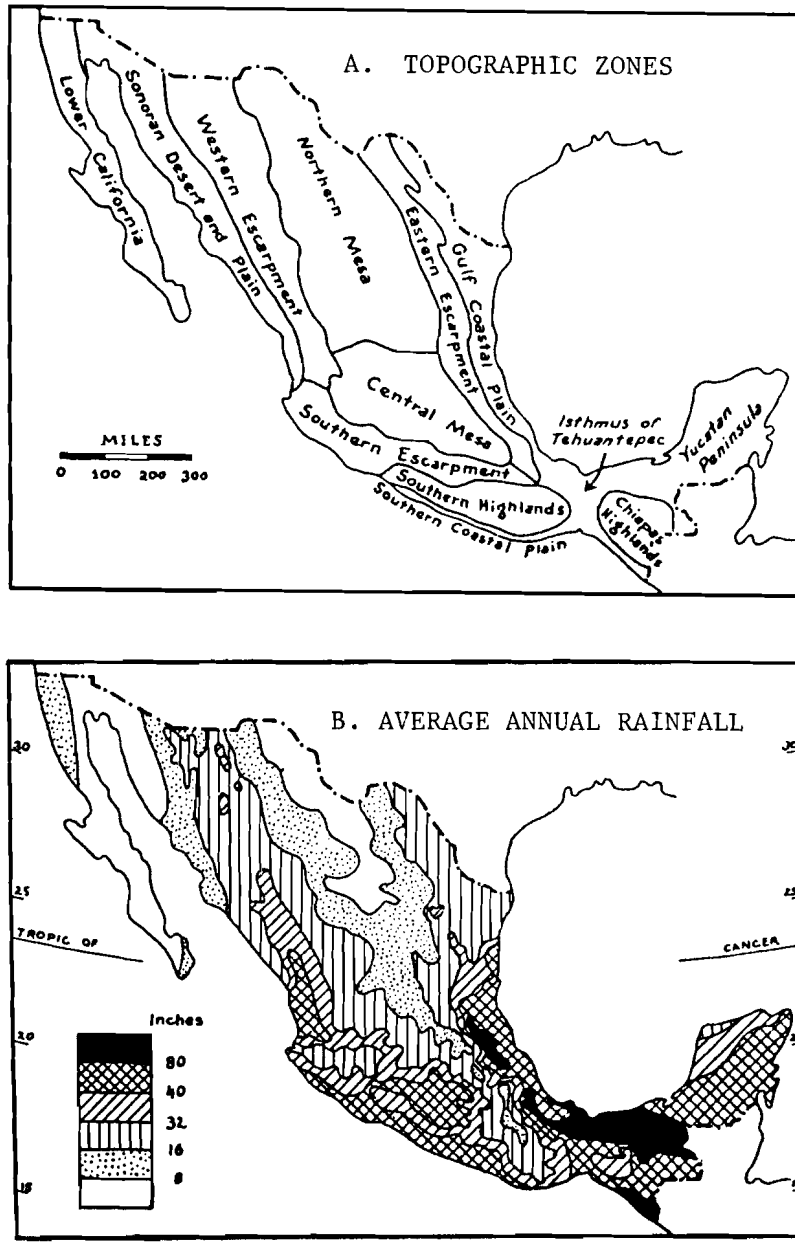
The Dualistic Structure of Mexican Agriculture

There is a marked regional contrast between large-scale, irrigated, commercial agriculture, which is concentrated in the fertile valleys of the arid north, and small-scale, rain-fed, peasant agriculture in the central and southern highlands, and along the tropical coastal plains of the south and southeast. This division has a long history, founded on the cultural response to the geographical characteristics of the landscape (256). It has been reinforced by unbalanced development policies since the Second World War.

Geography: High and Dry

Mexico is dominated by two chains of mountains which divide the country into sharply contrasting life zones: hot, coastal plains, sharply rising escarpments, and interior plateaux (Map 1). The landscape is further subdivided into hundreds of little pockets with highly varied agroclimatic characteristics (144, 301). Two-thirds of the total area is on slopes greater than 10 percent; over one quarter is on

MAP 1. MEXICO: TOPOGRAPHIC ZONES AND AVERAGE ANNUAL RAINFALL



Source: Thomas T. Poleman, The Papaloapan Project: Agricultural Development in the Mexican Tropics (Stanford University Press, 1964), pp. 11 and 13.

agriculturally useless slopes greater than 25 percent. High altitudes produce a temperate climate in much of the country, but over three-quarters of the potentially arable land is arid and the areas where irrigation is economically viable are limited (274, p. 28). Out of a total area about a quarter that of the United States, about 15 percent is potentially arable and about 9 percent is actually cropped. This amounts to 17 million hectares, or a little bit more than that cultivated in the state of Iowa (299, p. 130).

There is no natural breadbasket--no large, fertile area appropriate for the intensive rain-fed cultivation of grain crops analogous to the Midwest of the United States or the plains of Central Europe. Since before the Spanish conquest, the Mexican people have been concentrated in the dry, temperate highland basins in the central and southern parts of the country where the major cities are located. Over half of the population and over half of the cropped land are found in this zone, which receives less then 10 percent of the total rainfall (299, p. 139). Peasant agriculture--and rural poverty--are highly concentrated in these regions (255).

The tropical lowlands were virtually depopulated by disease in the first generation after the Spanish conquest (101, 102). Indigenous peasant cultures survived on a reduced scale, most notably in Yucatan, but until quite recently agriculture on the hot coastal plains was limited to extensive cattle ranches, subsistence-oriented slash-and-burn production, and to sugar cane, henequen, and other types of plantations in a few areas (225). Since the Second World War, a variety of government projects and the expansion of the petroleum industry have led to the rapid development of the Southeast (259, 260).

Emphasis on Large-Scale Irrigation

The arid north was a major economic region during the Colonial period, due to mining and associated support activities (256, pp. 113-117). Many of the military leaders of the Mexican Revolution were from the North, and their influence dominated the development policies of the government for decades thereafter. The Bajio and the short, fertile river valleys along the northwestern coast became the major locus of the development of modern agriculture.

Irrigation has been the key to development of the most productive agricultural systems in Mexico since ancient times (203, 205). Beginning in the early 1940's, the government launched a program of construction of major irrigation projects to bring desert lands into cultivation. Over the next 30 years, between 80 and 95 percent of the agricultural sector's budget was invested in the construction and maintenance of water storage and delivery systems (304, pp. 131-136). Mechanization, credit, and other services were concentrated in these favored regions. An intensive program of research sponsored by the Rockefeller Foundation developed varieties of wheat capable of high

yields when grown using carefully controlled packages of water application, fertilization, and other practices. The yields of other crops have increased significantly.

Capital-intensive, technically sophisticated irrigated agriculture in Federally administered districts generates more than a third of the value of commercial farm output in the country, although it occupies less than 10 percent of the total cropland (90, 299). Although not all of the legal beneficiaries of these projects were large farmers, a privileged group with access to capital, political connections, and a high degree of organization has been able to monopolize most of the benefits. They have been able to enlarge their operations by renting land from small holders and from the members of peasant communities (20; 121, pp. 173-176). Subsidized infrastructure and manipulated factor prices have induced the development of technology and an institutional support structure which have greatly accentuated the polarization of the agricultural sector. 1/

The Agrarian Reform

Peasant agriculture has been based on the community control of land since pre-Hispanic times. The Spanish reorganized the Indian villages to collect tribute from them, and set up a complex system of rights and duties which recognized their access to resources under the semi-feudal tutelage of private and Church estates. In the mid-19th Century, the Liberal reform movement abolished traditional tenure arrangements and social labor obligations to promote the free, individual ownership of agricultural land (64, Chap. 1; 302, Chap. 4). The abrogation of the traditional restrictions, instead of strengthening the position of the poor, removed all protection from the peasant communities which had held their land communally under Royal charter or in informal, unregistered arrangements. The construction of railroads, the improvement of regional communications, and the effects of industrialization on the need for exports created conditions that favored the development of capitalist enterprises in agriculture, and land speculation. The intensive cultivation of sugar cane, henequen, cotton, tobacco, and other commercial crops required a large dependent

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1/ A theory that the relative scarcity of the factors of production--land, labor, and capital in the broadest sense--determines the paths along which technology and institutions develop has been elaborated by various economists (37, 117). It starts from a comparison of the history of agricultural development in the United States, where land and capital are more abundant and cheaper than labor, with that of intensive agriculture in Japan, where land is limiting. In Mexico, technology and institutions have developed in a politically manipulated environment in which factor prices have not reflected their true relative scarcity in the country as a whole.

labor force. A new class of entrepreneurs expanded their haciendas, often to enormous proportions, by declaring undocumented land "idle" and through other mechanisms. It has been estimated that by 1910 over 90 percent of the rural population, in what was still a predominantly agricultural country, owned no land at all (275, p. 33).

The Revolution of 1912-1917 was fought primarily by peasants. Their most basic and universal demand--the restitution of the lands which had been taken away from the villages in an unalienable form of tenure--was met through a complex program of agrarian reform which extended over many decades. Its most active phase was in the 1930's, during the presidency of Lazaro Cardenas. Between 1916 and 1979, 70 million hectares were distributed to 2.9 million beneficiaries in 28,677 ejidos (82, p. 230). The ejido is a complex institution unique to Mexico. The word, which referred to the common lands in medieval Spanish villages, was applied in a general way to communal holdings during the Colonial period. After the Revolution, the ejido was established as a legal institution, with several variants (77; 82; 244, Chap. 6; 264). In the most common type, the land which had been taken away from a village by the haciendas was restored to it as an ejido. If titles could not be found, a large enough area within a radius of seven kilometers was granted to the campesinos as the basis for their livelihood. The land was divided into individual parcels, was managed communally, or some combination of the two.

Ejidatarios are granted certificates which assure them lifetime usufruct rights, which they can pass on to their heirs but cannot sell and should not rent. The Federal government retains title and administers the ejidos through a special bureaucracy in cooperation with the elected representatives of the communities. In theory, a legal minimum size was to be set for each agro-climatic zone to ensure that each family would have access to adequate resources. In fact, there was not enough land to go around, and small plots have been repeatedly subdivided into minifundia too small to meet even subsistence requirements (89). The legal procedures are cumbersome and extremely slow; according to the 1970 census, only one-third of all ejidatarios had received their certificates (64, p. 216). Campesinos who are eligible for a grant, but for whom no land is available, are put on a list of those with recognized, pending rights. The number of landless laborers in these and other ambiguous categories has risen rapidly as the rural population has increased and the process of distribution has slowed to a crawl.

The ejido theoretically provides a democratic framework for the equitable access of the rural population to the land. The haciendas were broken up and redistributed. Restrictions were placed on the size of private holdings, although these have proved easy to evade. Large farms have been reaccumulated through various mechanisms, both legal and illegal, particularly in regions where the returns to large-scale modern agriculture are high (64, pp. 213-231). There were two general schools of thought in the discussions which surrounded the development

of the ejido as an institution. The first, propounded by the revolutionary leaders from the north, held that they should be a transitional phase. Land should be returned to the villages to right previous injustices, but the campesinos should be encouraged to form individual, free enterprises as part of the process of agricultural development. The second, proposed by the southern agrarian leaders including Emiliano Zapata and Felipe Carrillo Puerto, and later adopted by President Cardenas, argued that the ejido should be transformed into the basis for peasant community development. Numerous variants of these two positions have been argued ever since (64, pp. 31-35).

President Lazaro Cardenas (1934-1940) made the development of the peasant sector one of the cornerstones of a policy of active government participation in the economy. He greatly accelerated the agrarian reform process. Between the census years 1930 and 1940, the proportion of the total arable land in ejidos increased from 13 to 48 percent, and the number of landless campesinos dropped from 68 to 36 percent of the rural work force (121, p. 4; 244, p. 501). Collective ejidos were created to preserve economies of scale in industrially organized, vertically integrated plantation craft such as henequen in Yucatan and cotton in the Laguna region in Cohuila (34, 242).

The President created a number of centralized support institutions which tied the ejidatarios to the Federal government in a populist tradition of response to community petitions. Their political organizations were consolidated into the National Peasants Confederation (CNC), one of the three constituent elements of the official ruling political party, the PRI. A special state banking system was set up to provide working capital and technical assistance, as ejidatarios do not own their land and cannot use it as collateral for commercial loans. A variety of other agencies were created to provide a range of services. By the end of the decade, for the first and only time, the reformed sector produced more than half of the total value of agricultural output, and was more productive on a per-hectare basis than were the private farmers (244, p. 501).

The Gap Widens

The orientation of government policies was reversed during the Second World War, which greatly stimulated the development of import-substitution industries. The need to restructure the economy to take advantage of this opportunity coincided with the interests of a new middle class which had benefited from the elimination of the old elite during the Revolution. The compound annual growth rate in manufacturing jumped from 4.6 percent per year in the 1930's to 8 percent in the 1940's (245, p. 166). The agricultural work force contracted by nearly 16 percent, as men migrated to the cities and to the United States as part of the bracero program (121, p. 9). This rapid change disrupted established patterns of food production and distribution, and Mexico

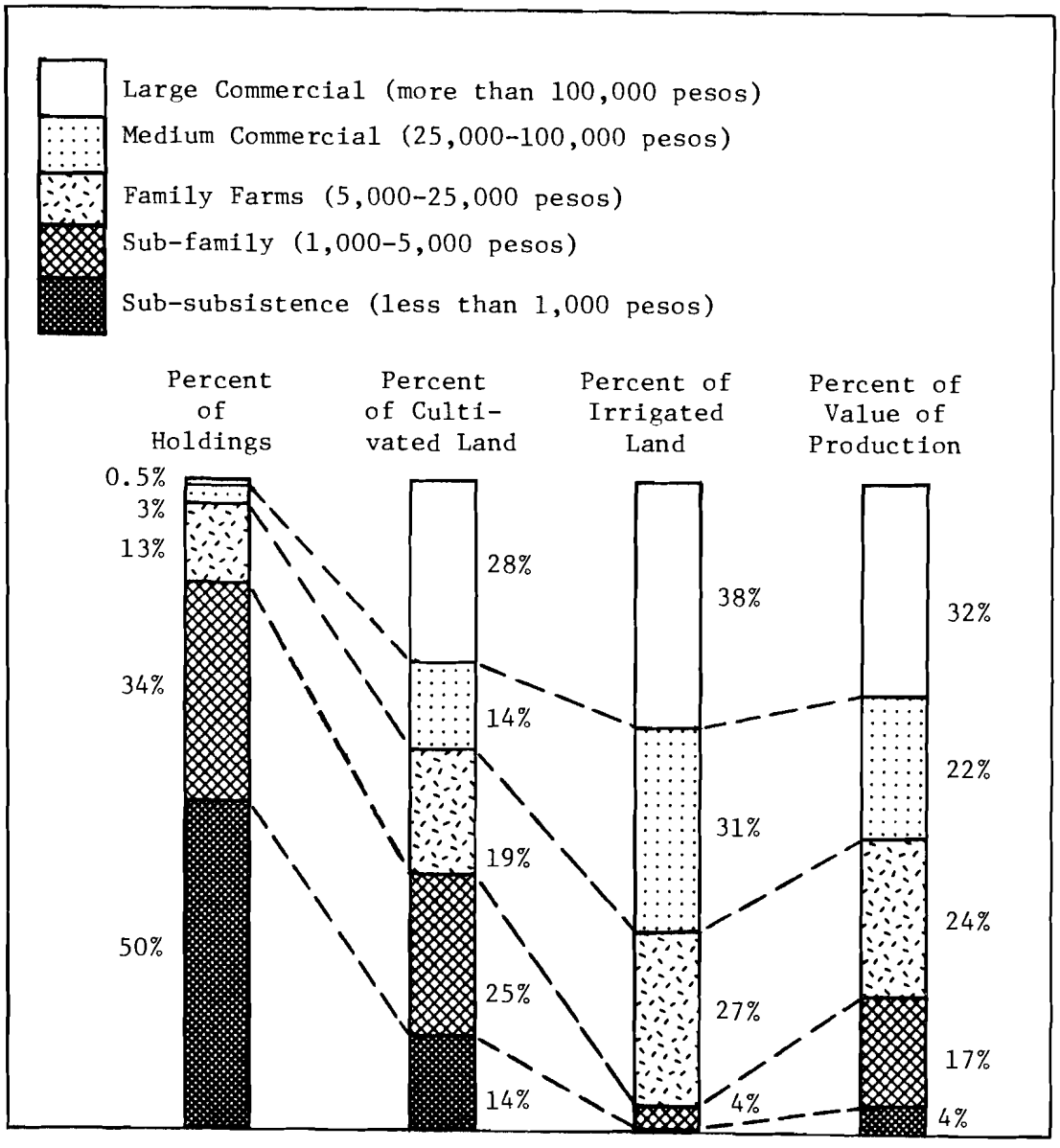
was importing between 15 and 20 percent of its basic food grains by the end of the war (226, p. 8).

Continued industrial expansion depended on the conservation of foreign exchange to import machinery and intermediate goods, and on cheap food in the cities to keep wage rates down. Peasant development programs were curtailed in favor of the concentration of resources in the development of modern agriculture on a tiny minority of private farms in a limited number of irrigated oases. The ejidal sector continued to receive services, but the balance had shifted against them. Land distribution continued, but on a reduced scale in marginal and frontier areas. The peasant communities presented their petitions to the government agencies: an enlargement of their ejidal grant, electrification, a road, a school, an irrigation well, agricultural credit, or whatever. At a rate dependent on the reduced budgets available, political pressures, and the inertia of an increasingly complex bureaucratic structure, the government responded to a portion of these requests. The long procedures tied the elites in each village, and the peasantry as a whole, to the official political party by keeping alive the promise that the social goals of the Revolution were being met (293). This helped to maintain the stability of the government in spite of the increasing inequality of resource and income distribution.

The disparities which had developed within the agricultural sector by 1960 are indicated in Chart 1. Two classes of commercial farmers, who constituted 3.5 percent of all producers, accounted for 42 percent of all cultivated lands, 69 percent of irrigated land, and 54 percent of the value of output. Peasant communities were increasingly integrated with the market through local elites and private middlemen, but the relative economic position of the ejidatarios deteriorated as the infrastructure gradually improved. The private small-holders, or minifundistas, were in an even more precarious position. According to the same census, 67 percent of all private farms in Mexico were smaller than five hectares, controlled less than 2 percent of the non-ejidal land, and produced only 6 percent of the total value of output (69, pp. 127 and 130).

Most peasants simultaneously cultivate a small plot and work off the farm, and many are associated informally with ejidos. This makes it difficult to account for landless laborers accurately from census data. Estimates in 1970 ranged as high as 3 million workers, 65 percent of an agricultural labor force of 5 million--more in absolute numbers than before the Revolution (64, p. 218; 69, p. 131). Migration from rural areas has swollen the urban population; between 1960 and 1980 the share of the national work force employed in agriculture declined from 55 to 36 percent (126, p. 189). The dualistic structure of Mexican agriculture has created problems of crisis proportions over the past twenty years, both for the capacity of the country to feed itself, and for the stability of the peasant economy. The World Bank has set a standard of relative poverty at one-third of the national average household income. Over 75 percent of rural families in Mexico

CHART 1. MEXICO: DISTRIBUTION OF CULTIVATED AND IRRIGATED LAND AND VALUE OF OUTPUT BY TYPE OF HOLDING, 1960



Source: Thomas T. Poleman, "Food, Population, and Employment: Some Implications for Mexico's Development" (Cornell Agricultural Economics Staff Paper No. 78-19), 1978, p. 9; data drawn from Sergio Reyes Osorio, Ed., Estructura Agraria y Desarrollo Agrícola en México (Fondo de Cultura Económica, México, 1974).

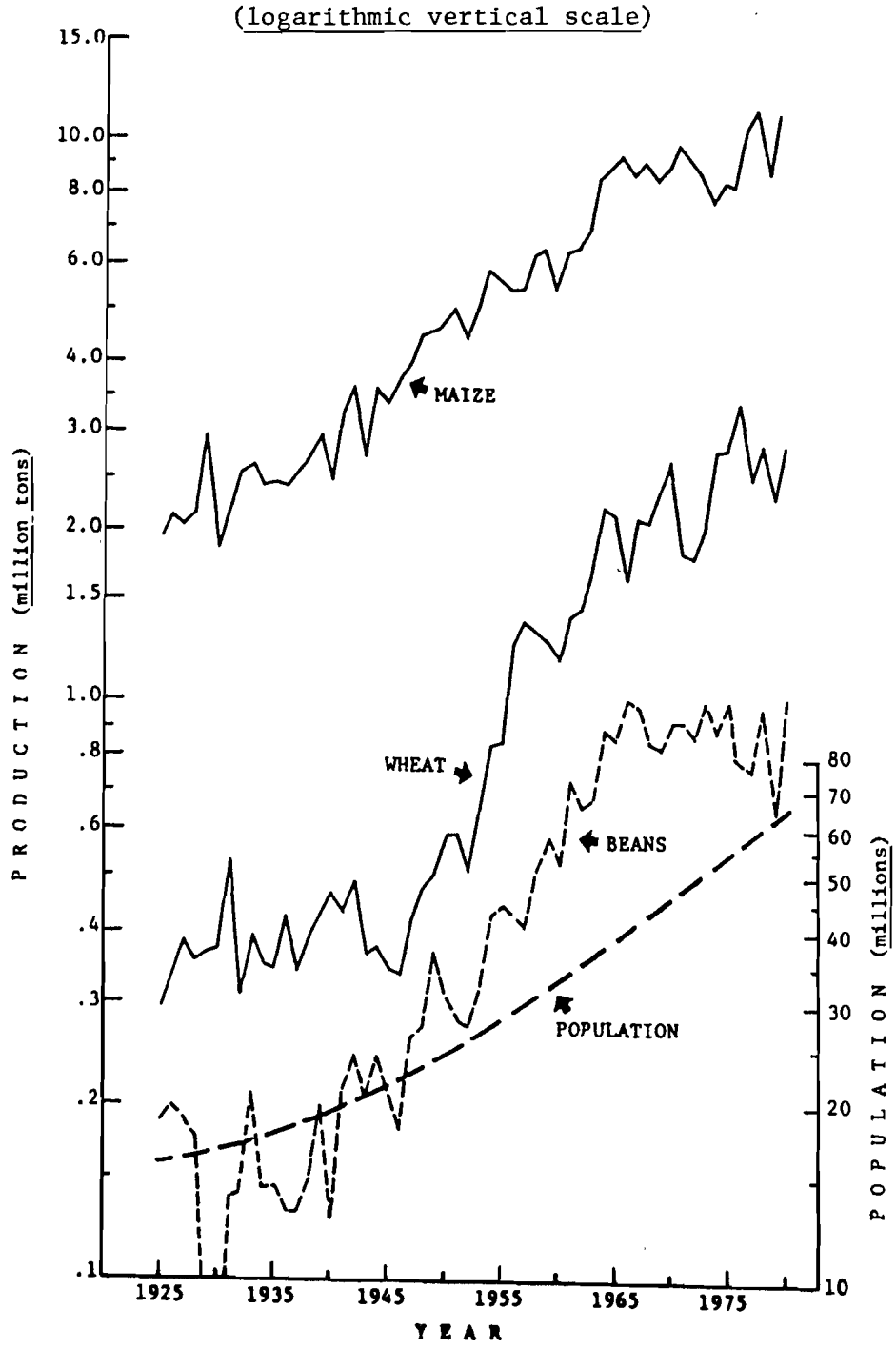
fell below this standard in 1975, which was calculated as the equivalent of 670 U.S. dollars per year (36, p. 20).

The Stagnation of Basic Food Production and the Rapid Growth of High-Value Crops

For the first two decades after World War II, the expansion of the area in production and the adoption of modern technology in a restricted sector allowed basic food production to outstrip the increase in effective demand, which was in any case limited by the unequal distribution of income among consumers. Chart 2, constructed on a logarithmic scale, compares the growth rates in the production of maize, beans, and wheat to the growth rate of the population. Starting in the late 1960's, output began to stagnate and the country has been forced to import increasing volumes of commodities, particularly maize. This grain has been the basic staple in Mexico since it was first domesticated over 5,000 years ago (145, 258). Total apparent consumption per capita is between 150 and 170 kilos per year, much of it as direct human food, and maize provides over 40 percent of both the calories and the protein in the average diet. It is produced on between 50 and 60 percent of the national crop land, almost exclusively in the peasant sector, over 90 percent of it without irrigation. Hundreds of native varieties have been developed over the centuries which are adapted to traditional production systems under a wide range of agro-climatic conditions (300). Yields are low. The national average increased slowly from 700 to 1300 kilos per hectare (11 to 20 bushels per acre) between 1950 and the mid-1970's (170, p. 50). Significant further improvements face serious constraints. Most parcels are too small to mechanize; research, credit, and other services are inadequate, and the variability of agro-climatic conditions prevents the widespread adoption of improved varieties and agricultural technology.

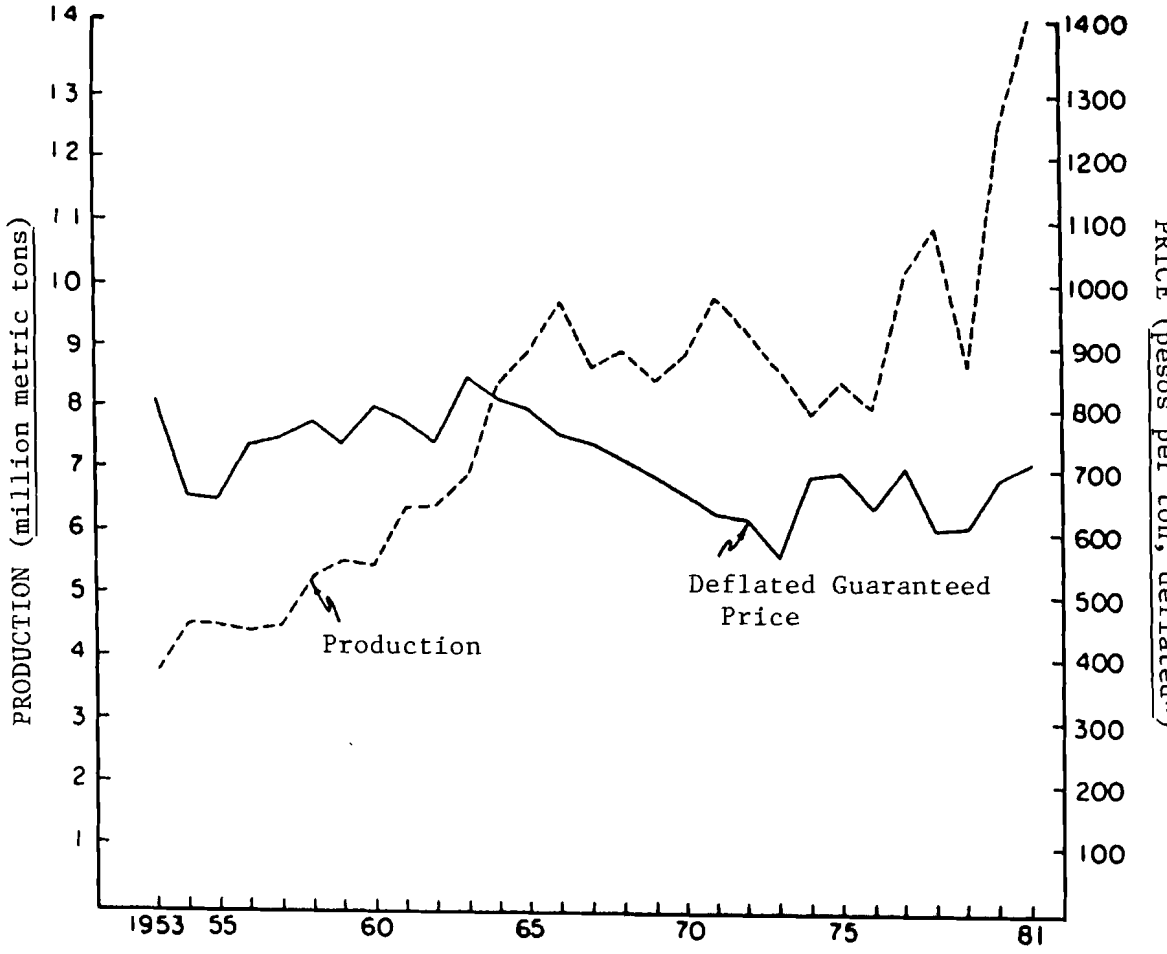
Maize is produced under very unfavorable economic conditions. As is illustrated in Chart 3, the real price of the product was allowed to deteriorate to keep food prices down in the cities. Commercial farmers with more profitable alternatives have abandoned the crop. Peasants with limited resources grow it because it is the basis of their family food supply and because they have few alternatives. In Chart 4, rainfed maize farms are broken down by size class in the principal summer growing season of 1975. The very smallest--with less than a hectare --dedicated nearly 90 percent of their cropped land to maize to meet their subsistence needs. They had no alternative but to cultivate it intensively and achieved the highest yields. As the size of the holdings increases, the farmers are able to diversify, and the proportion of the cropped area dedicated to maize declines. In the same sequence, yields first decline as the peasants find more remunerative uses for their labor, and then increase again as they have more resources to spend on fertilizer, other improved technology, and hired labor.

CHART 2. MEXICO: PRODUCTION OF MAIZE, WHEAT AND BEANS, AND GROWTH OF POPULATION, 1925-1980



Source: Thomas T. Poleman, "Food, Population, and Employment: Some Implications for Mexico's Development" (Cornell Agricultural Economics Staff Paper No. 78-19), 1978, p. 8.

CHART 3. MEXICO: MAIZE PRODUCTION AND THE REAL GUARANTEED PRICE IN CONSTANT 1960 PESOS, 1953-1981



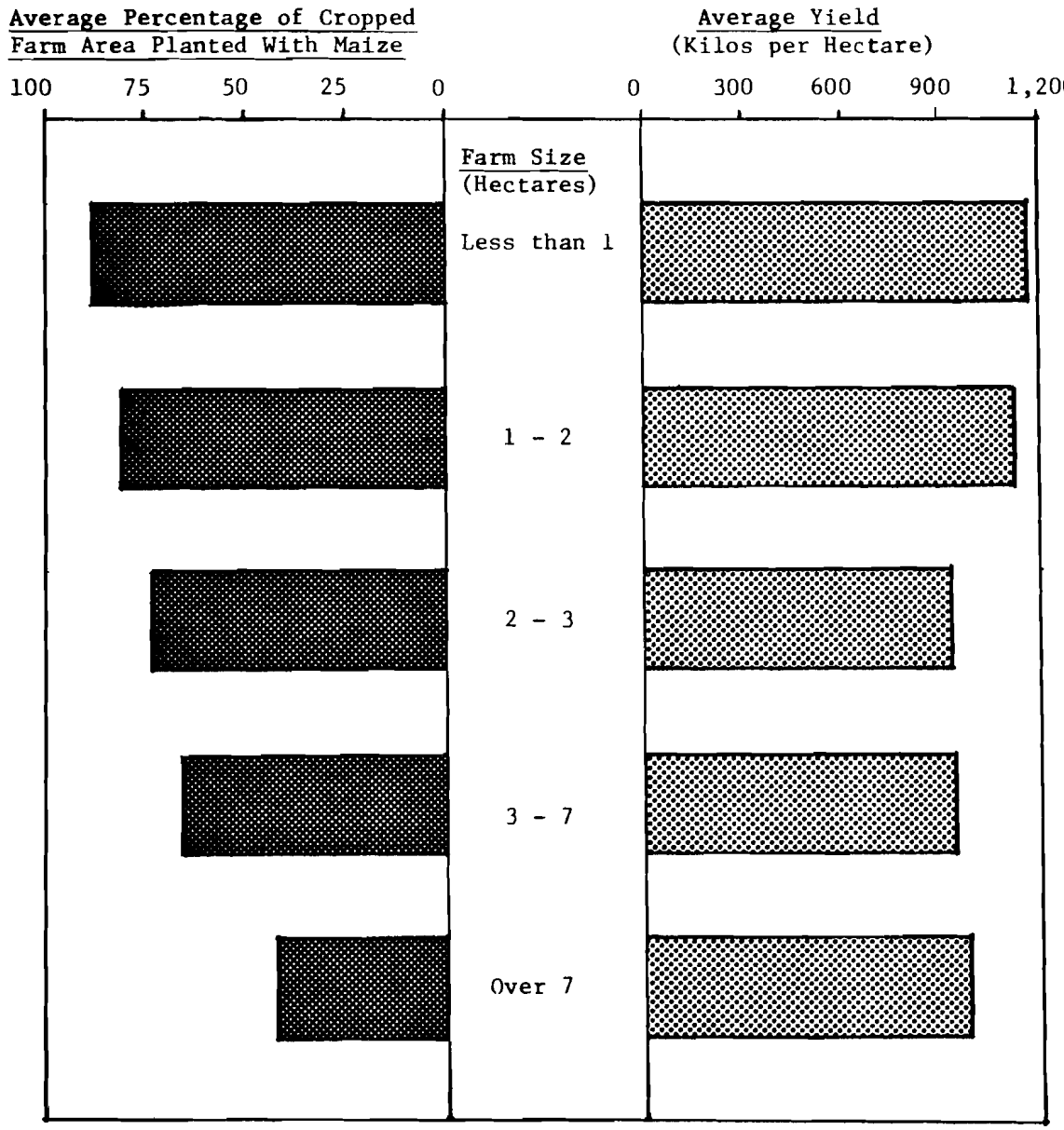
*The guaranteed price has been deflated using the gross domestic product index, with 1960 set at 100.

NOTE: The price of maize is guaranteed by CONASUPO at wholesale assembly warehouses, not at the farm gate. The price which individuals actually receive fluctuates both above and below the official figure, depending on the local supply conditions and on the structure of the local commercial channels.

Source: Lana Hall and Turner Price, "Price Policies and the SAM," Food Policy, Vol. 7, No. 4, 1982, p. 308.

CHART 4. MEXICO: THE RELATIONSHIP BETWEEN AVERAGE FARM SIZE, AVERAGE PROPORTION OF CROPPED FARM AREA PLANTED WITH MAIZE, AND AVERAGE YIELDS, 1975

(rain-fed farms)



Source: Carlos Montanez and Horacio Aburto, Máiz: Política Institucional y Crisis Agrícola (CIDER/Nueva Imagen, Mexico, 1979), Table 10, p. 200.

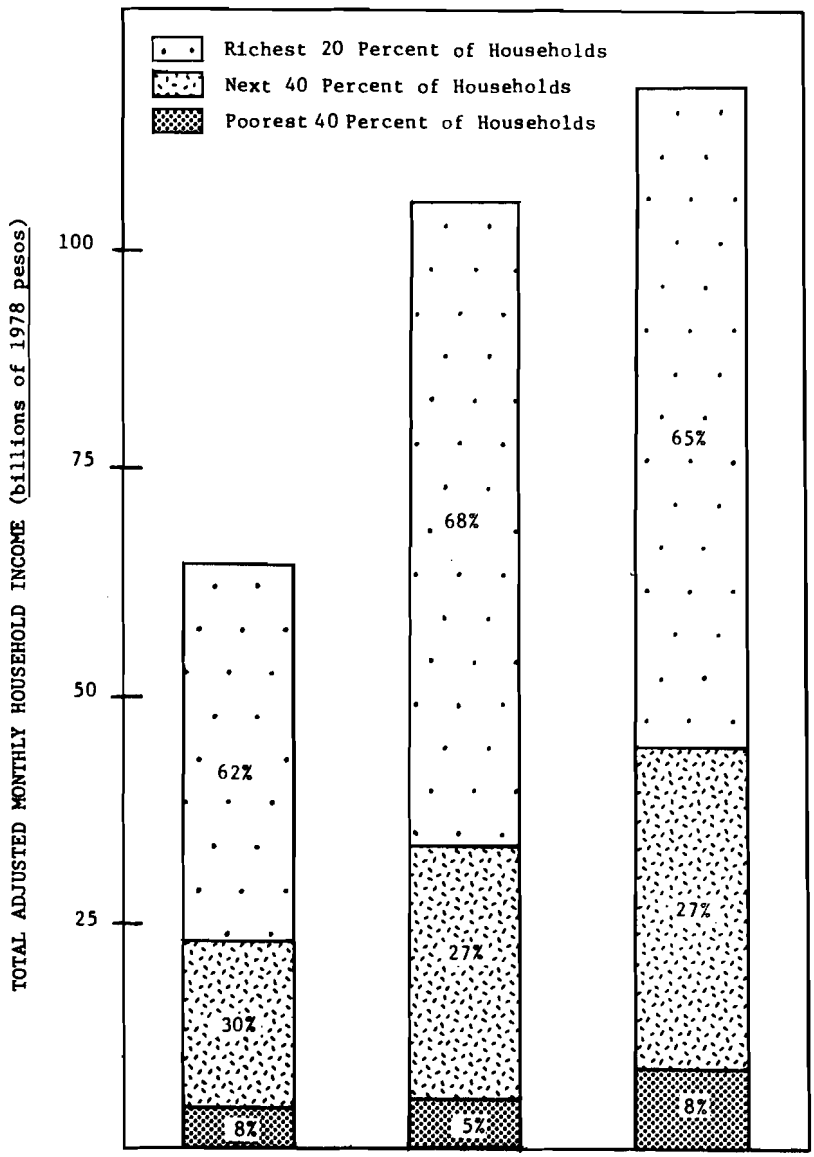
Beans are grown on farms with similar characteristics, and are often intercropped with maize. Wheat shifted to large, irrigated farms in the 1950's and 1960's, and the development of improved varieties adapted to these conditions was one of the first and most dramatic successes of the "green revolution." Wheat has faced the same unfavorable price policies as the other basic grains and is only marginally profitable, in spite of high yields and labor-saving mechanization. Imports of basic food grains increased dramatically in the 1970's. Beans showed a modest trade surplus in most years, but an average of 11 percent of the apparent annual national consumption of maize, and 13 percent of the wheat, were imported between 1970 and 1980 (170, pp. 50 and 64).

At the same time as basic food production has stagnated, certain crops have experienced remarkable growth. This can be explained by the fact that consumer demand is concentrated at the upper end of the income scale. The shape of the income distribution was essentially stable in the 1960's and 1970's, which meant that the upper strata captured the majority of the benefits of economic growth (36). Chart 5 presents data from three national income and expenditure surveys, which demonstrate that the richest 20 percent of all households consistently accounted for over 60 percent of an increasing total income. Studies of this kind are difficult to adjust and interpret, as incomes are chronically underreported, particularly in the peasant sector where families engage simultaneously in a variety of activities, including production for home consumption. Nevertheless, there is no question that high-income consumers, concentrated in urban areas, exerted a rapidly growing demand for meats, processed foods, and other preferred commodities.

This trend has been reflected in the structure of production. Chart 6 illustrates the dramatic gap which has developed between the growth rates in the output of basic and high-value crops. Feed grains have registered spectacular gains, particularly sorghum. In 1960, 209,000 tons were produced, at an average yield of 1.7 tons per hectare. In 1980, 4.8 million tons were grown, at an average yield of three tons per hectare. Even this increase has been unable to completely satisfy the demand of intensive swine, poultry, and cattle operations; imports averaged 11 percent of the total annual national demand for sorghum between 1970 and 1980 (170, pp. 58-59). The crop competes directly with maize over a broad agro-climatic range. Ninety percent of the area sown nationally is mechanized, more than twice the proportion for maize, and for producers with access to the technology, it is the more profitable crop (190, p. 219). 2/

2/ One of the explicit goals of the SAM program (1980-1982) was to regulate the relative prices of maize and sorghum in relation to their relative yields and costs of production to brake this trend (164).

CHART 5. MEXICO: DISTRIBUTION OF ADJUSTED TOTAL HOUSEHOLD INCOME, 1968, 1975, AND 1977 a/

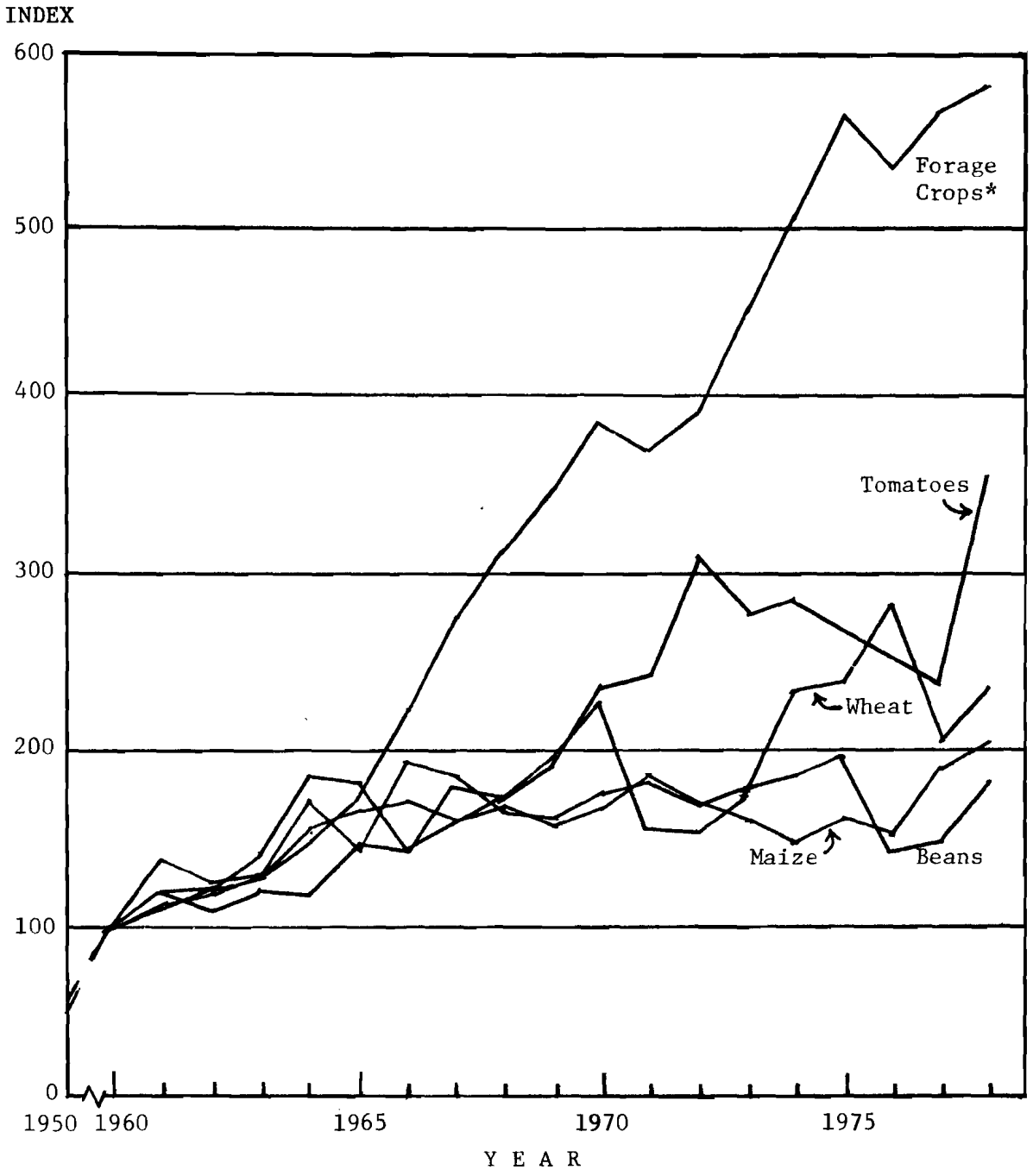


a/ The author of the study adjusted reported incomes for under-reporting, using a log-linear, piece-wise interpolation method. His results have been converted into constant 1978 Pesos, using the Banco de Mexico national consumer price index.

Source: Joel Bergsman, "Income Distribution and Poverty in Mexico" (World Bank Working Paper No. 395, Washington, D.C., 1980), Tables 5 and 6.

CHART 6. MEXICO: INDICES OF PRODUCTION OF SELECTED CROPS AND GROUPS OF PRODUCTS, 1960-1978

(1960 = 100)



* Principally alfalfa and grain sorghum.

Source: Appendix Table B1.

Other industrialized grains, fruits, and vegetables are increasingly channeled through processing and marketing systems with rigid seasonal and quality requirements. Producers who have the resources to organize their operations around this demand are able to out-compete those who depend on fluctuating regional markets and traditional middlemen. Transnational corporations, and national firms organized according to the same centralized model, have found it profitable to expand into the processing and distribution of products directed to this privileged market, which they have helped to develop through advertising (26, 87, 232). These trends have reinforced regional differences between irrigated and rainfed agriculture, and have also expanded the area of competition between peasant and commercial farmers for the best resources throughout the country.

The Shift in Government Priorities

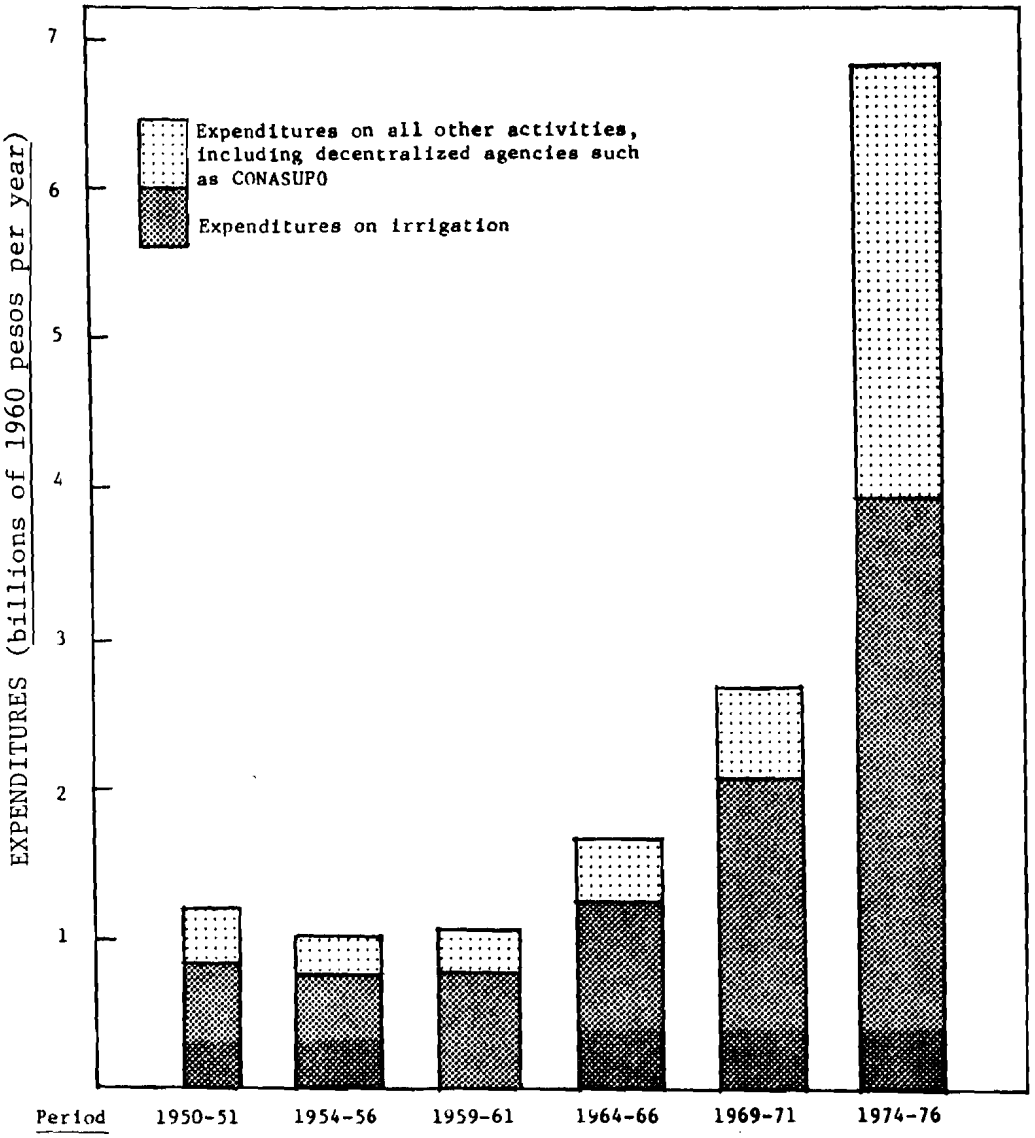
At an accelerating rate over the past twenty years, the government has expanded its role in the agricultural sector, and has developed a wide range of programs designed to reorganize the peasant economy around national priorities. In the first postwar decades, Federal expenditures concentrated on the construction of irrigation and other infrastructure to expand modern agricultural production, and on the maintenance of the bureaucracy which provides services to the ejidos. Major efforts were made to incorporate the tropical lowlands into the national economy. Large hydroelectric and flood control dams were built, the railroad and road system was expanded, and malaria and other diseases were controlled (25, 225). Public lands in the forest frontier were divided into ejidos to promote colonization and relieve population pressure in the highlands (243, Part 1). Several integrated development projects, supported in part by the international banks, were established to introduce modern technology into areas which were believed to have significant potential (23, 84). Nevertheless, as Chart 7 illustrates, overall spending declined in real terms until the mid-1960's, and investments in irrigation continued to predominate.

By that time, the broad outlines of the "agricultural crisis"--regional polarization, increasing food imports, the precarious economic position of the majority of the peasant farmers, and increasing unemployment in both rural and urban areas--were overwhelmingly obvious. The Echeverria (1970-1976) and the Lopez Portillo (1976-1982) administrations greatly increased the agricultural budget, and developed a large variety of new agencies and programs directed to the peasant sector.

Policy has been organized around three major goals: the increase of food production to regain national self-sufficiency, the introduction of improved technology into the ejidal sector, and the improvement of conditions in marginal and depressed areas to slow the massive migration to the cities. The support prices of maize and other basic products were increased, and the state marketing agency (CONASUPO)

CHART 7. MEXICO: REAL TOTAL FEDERAL EXPENDITURES IN THE AGRICULTURAL SECTOR, AND SHARE ALLOCATED TO IRRIGATION, 1950-1976

(billions of 1960 pesos)



Source: Victor J. Elias, "Government Expenditures on Agriculture in Latin America" (Research Report No. 23, International Food Policy Research Institute, Washington, D.C. 1981), Tables 1 and 26.

expanded its buying activities and increased the subsidy on consumer prices. The agricultural credit system was reorganized and expanded to finance the introduction of improved seeds, fertilizer, other inputs, and mechanization. Major programs were undertaken to expand the agricultural frontier through massive land clearing and the development of small-scale irrigation. Agro-industrial enterprises and other forms of infrastructure were built to encourage the participation of the ejidal sector in the market for higher value products. A variety of programs were developed to encourage cooperation among peasant producers, from attempts to fully collectivize ejidal production under government management to the organization of informal groups to receive credit and technical assistance. Rural development projects were set up in marginal areas to stimulate production and to create employment. An attempt was made to reorient research and extension to the specific problems of traditional agriculture in rain-fed areas. A variety of input and product prices were subsidized heavily, particularly during the SAM (Mexican Food System) program in the last years of the Lopez Portillo administration (15, 109).

Much of this increased government expenditure was financed by the petroleum boom, and with international credit. It contributed to inflation and balance of payments problems which put the Mexican economy as a whole under severe stress in the early 1980's. The rapid expansion of a great variety of government agencies has tended to centralize decision-making, and control over productive resources, away from the peasant communities into the hands of an increasingly technocratic, inefficient government structure. The populist tradition of response to peasant demands is still an important rhetorical component of the political system, but its real importance is fading. The agricultural crisis has prompted much research and debate on the nature of the peasant economy, its role in national development, its prospects for survival, and on the potential for the intensification of traditional production systems.

The Peasant Economy

Peasants are farmers with limited resources who depend primarily on family labor to meet the consumption and other economic requirements of their families. They organize the management of resources according to different criteria than large commercial farmers, who allocate capital investments, land, hired labor, and the cash costs of production to obtain a profit. Peasants can and do sell products on the market at rates of return which would ruin an entrepreneur. This is illustrated in Table 1, an accounting exercise drawn from data on the principal maize producing regions of Mexico in 1976. It compares the value of output at the average yield achieved with different combinations of inputs to standard budgets of what the costs of production would be if all labor and other inputs were paid in cash at prevailing market rates. As we can see, only the very highest levels of technology have

TABLE 1. MEXICO: APPARENT NET RETURNS PER HECTARE TO MAIZE PRODUCTION AT DIFFERENT TECHNOLOGICAL LEVELS (1976 Summer Cropping Season)

Level of Technology	Average Yield per Hectare	Official Support Price per Ton	Gross Income per Hectare	Costs of Production per Hectare, Assuming All Labor and Inputs Paid in Cash	Apparent Net Returns per Hectare
	(kilos)	(pesos)	(pesos)	(pesos)	(pesos)
RAIN-FED					
Traction animals and low input use	540	2,340	1,265	3,165	-1,900
Traction animals and medium input use	1,000	2,340	2,490[a/]	4,190	-1,700
Traction animals and high input use	1,350	2,340	3,470[a/]	4,810	-1,340
Mechanized with high input use	1,733	2,340	4,370[a/]	4,100	270
IRRIGATED					
Mechanized with high input use	3,375	2,340	7,900	5,850	2,050

a/ Assumes an average 20 percent indemnification by the crop insurance agency (ANAGSA) for crop losses.

Source: Carlos Montañez and Horacio Aburto, Maíz: Política Institucional y Crísis Agrícola (CIDER/ Nueva Imagen, México, 1979), p. 222.

positive apparent net returns. This shows why maize is grown almost exclusively in the peasant sector, and numerous other examples could be given of crops and animals produced under marginal natural conditions year after year at an apparent loss by the majority of Mexican farmers. This paradox does not imply that peasants have a different set of goals and aspirations than economic theory would predict, but it does require careful explanation of the conditions under which their economy operates. This section will outline the general characteristics of the peasant economy in Mexico as a whole, and will summarize the theoretical debates which it has engendered.

The General Characteristics of Peasant Production

Peasant communities operate under highly variable agro-climatic and economic conditions in different regions of the country, and have developed a wide range of production systems. The evolution of the particular circumstances of the Maya of Yucatan will be discussed in subsequent chapters of this study. There is an extensive literature on the organization of peasant agriculture from several academic fields which is difficult to synthesize into a general set of characteristics. Nevertheless, it will be useful to lay out some basic definitions of the peasant economy as it is generally understood within the Mexican context (64, 185, 204, 212, 263, 268, 295, 296, 308).

The Household Unit of Production and Consumption. Each peasant family organizes its resources to meet the needs of the household throughout its development. The relationship between the number of members who participate economically and the number of persons who must be supported has an important impact on both the mix of economic activities and on the intensity of cultivation. Consumption requirements cannot be defined simply as biological subsistence needs; cultural norms are variable, and the development of the country as a whole has led to a rising demand for consumer goods, education, health care, improved housing, and other goods and services. Most families experience wide fluctuations in both the level and the composition of their income over the course of their lives. This is due to the evolution of the dependency ratio and to a variety of external influences: crop failures, relative price changes, opportunities for off-farm work, catastrophic medical expenses, and many others. Family labor is simultaneously a fixed overhead and the principal resource which they command, but it is not a variable cost. Hired help is used only in periods of peak demand.

Mexican peasants are not autarkic, subsistence farmers; over half of them do not have enough land to meet their own food requirements in any case. Most families engage simultaneously in production for home consumption, production for sale in the market, and off-farm labor on a seasonal and intermittent basis. These different types of activity form an indivisible whole as a flexible economic strategy.

The classic distinction between "use-value" for home consumption and "exchange-value" for sale in the market is useful conceptually, but it is very difficult to apply systematically to particular cases. At the time of the maize harvest, a farmer does not separate out what he is going to sell; he takes small quantities to market little by little to exchange for purchases, or he may sell most of his output to pay off past obligations and re-buy at a higher price later in the year. To assure an adequate flow of income, and to insure against very high risks of crop failure and unpredictable prices, most peasant family operations are diversified with a number of crops of different types. All of the members, including women and small children, invest variable amounts of time in various types of production.

The collection of firewood and natural products, and small-scale household production are often so time-consuming that it would be impossible to justify paying anyone to do them, but they reduce cash outlays. Some activities, such as swine production for example, often represent a predictable economic loss if feed is purchased with off-farm income. Nevertheless, the animals consume residues which would otherwise not be used at all, and they can be sold for a block of cash to meet emergency needs. High-value crops for sale are often grown on a small scale, but most peasants cannot afford to specialize in the most profitable alternatives, because they cannot tolerate the risks. Other practices, such as multiple cropping, may provide a positive return in most years. Nevertheless, the purpose of diversification is to insure the long-term security of the family economy, not to maximize the returns to labor, land, or any other fixed resource. This does not mean that the peasants do not struggle to make as much money as possible, but it does explain why they are willing to supply products at prices at which they could not be produced by commercial farmers.

Within this context, off-farm labor on a part-time, seasonal, or intermittent basis is but another type of household activity which provides a vital portion of the income of peasants with very limited resources. As peasants have diverse sources of livelihood, they are able to tolerate wage rates which in themselves would be insufficient to support their families. In many areas, commercial farms could not operate profitably if they did not have access to cheap labor of this kind. Even peasants who migrate to urban areas maintain rights of access to land in their home villages whenever possible, so that they may return if they lose their jobs. A recent study traced an inverse, fluctuating relationship between the level of peasant production in a region of northern Puebla and economic growth in neighboring metropolitan areas (57). There is some evidence that only in the second generation do rural migrants to the United States begin to regard the move as permanent, and stop sending much of their wages to support the family economy in their home communities (184).

Stratification Within Peasant Communities. The peasant family depends on its relationships in extended family groups, and in its community. Members of communities share a variety of "symmetrical"

relationships which involve access to land, water, and other resources; reciprocal labor exchanges, work projects, and religious and other ceremonial activities. Nevertheless, the social structures are by no means egalitarian. The peasants are involved in a variety of "asymmetrical" relationships with the shopkeeper, the money lender, the crop buyer, government agencies, and other people whose frame of reference is the larger economy and who acts as its agents.

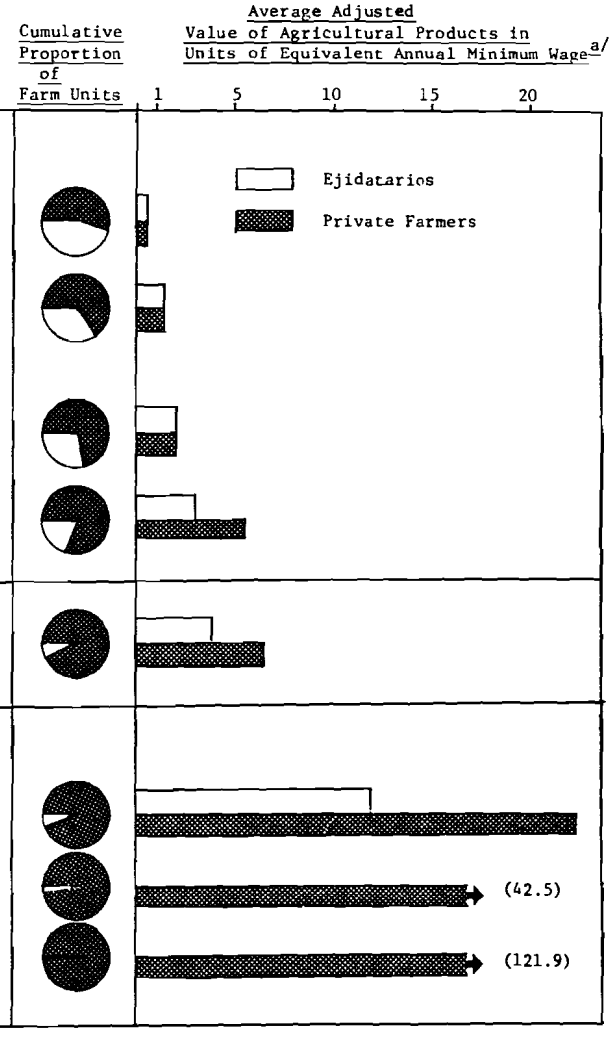
Opportunities to adopt technical innovations are unequally distributed. As regions of peasant production are increasingly integrated with the national market, the pace of change accelerates. New crops and varieties are introduced in response to market requirements, or by government fiat. Fertilizers, herbicides, and other inputs are adopted by many as a defensive reaction to factors such as falling yields, increasing pest pressures, increasing labor costs, and deteriorating price relationships in the market. A minority has the resources to use these innovations profitably, and the communities become increasingly stratified.

The Polarization of the Agricultural Sector. Peasants are semi-independent farmers who historically have always been dominated within the larger socio-economic structure. The agrarian reform and the institution of the ejidos has given many families at least partial tenure security. Roads, electrification, schools, and other services have gradually improved the quality of life in rural areas. Nevertheless, the majority of peasant parcels are too small to support a family, or to permit the introduction of advanced technology. In regions where modern agriculture predominates, many campesinos rent their land to commercial farmers with the capital to use it profitably (20). Within many communities, the concentration of resources into the hands of an elite with political and commercial connections is a common phenomenon (64, pp. 216-218). Peasant farmers who have been able to maintain their autonomy face unfavorable exchange relationships for the inputs and consumption items which they buy, and obtain credit at very high rates. They exploit their own labor at very low apparent returns, and work off the farm in labor markets where their negotiating position is poor. Through mechanisms which have varied greatly from one period and region to another, savings have been transferred from peasant to commercial farmers, and from agriculture to other sectors of the economy.

Chart 8 summarizes a typology of all Mexican farmers based on the 1970 agricultural census. It differs from the breakdown of the 1960 census presented in Chart 1, as the producers are classified according to the internal logic of their farm management, rather than according to the absolute value of output (64, pp. 95-100). The types are created by crossing two variables: the capacity of the farm unit to meet the consumption requirements of the family, and the degree of reliance on hired labor. Subsistence capacity is standardized across highly variable agro-climatic conditions by adjusting absolute farm size by the weighted average maize yields in each region. Peasant

CHART 8. MEXICO: A TYPOLOGY OF PEASANT AND COMMERCIAL FARMERS, 1970

Type	Sub-Type	Definition	Statistical Criterion
Peasant Farmers		Dependent Principally on Family Labor	Hire In Fewer Than 25 Man-Days/Year
	Sub-subsistence	Productive potential inadequate to meet family food requirements	Production unit smaller than four "equivalent hectares" b/
	Subsistence	Productive potential adequate to feed family, but too low to maintain "replacement fund" c/	Between four and eight "equivalent hectares"
	Stable	Productive potential sufficient to maintain "replacement fund"	Between eight and twelve "equivalent hectares"
	Surplus-producing		Over twelve "equivalent hectares"
Transitional Farmers		Significant Reliance on Hired Labor, in Addition to Family Labor	Hire In Between 25 and 500 Man-Days/Year
Commercial Farmers		Predominant or Exclusive Reliance On Hired Labor	Hire in Over 500 Man-Days/Year
	Small	Some use of family labor	Hire in 500-1,250 man-days/year
	Medium	No use of family labor	Hire in 1,250-2,500 man-days/year
	Large	No use of family labor	Hire in over 2,500 man-days/year



1/ The average net value of production, divided by the minimum rural wage for each region, times 250 days.
2/ A synthetic figure, adjusted by indices of the weighted average maize yield in each region, compared to the national average.
3/ The average cost of a market basket of tools and consumption items beyond those required for simple subsistence.

Source: CEPAL, Economía Campesina y Agricultura Empresarial (Siglo XXI, México, 1982), Tables 2, 3, & 34.

farmers, who are defined as those who depend primarily on family labor, are separated from commercial farmers, who hire in over 500 man-days per year. An intermediate category of "transitional farmers" was created to account for relatively small farms which are specialized in labor-intensive, high-value crops such as tobacco and cacao. This type, which most closely resembles the concept of the "family farm" as it is known in the United States and western Europe, represents only 12 percent of the producers. The two lowest categories of peasants, who do not produce enough to maintain the stability of the family economy, are presumably dependent on off-farm sources of income. They account for 72 percent of all Mexican farmers.

The right hand portion of the chart shows the distribution of the value of agricultural output among the typological classes. It has been standardized into units of equivalent annual minimum wage to adjust for differences in the cost of living between different regions. The census figures on which the study is based almost certainly underestimate the value of commodities consumed in the household, but this is a very difficult bias to assess. As the definition predicts, the 56 percent of all farmers in the sub-subsistence category produce less than one could earn working at the rural minimum wage. At the lower end of the spectrum, there is no significant difference between the average farm incomes of small ejidatarios and private minifundistas, but private agriculture has an enormous advantage at the high end--less than 2 percent of all ejidatarios are commercial farmers. The very highest category, which represents .3 percent of the producers, concentrates 8.6 percent of the arable land and 63.1 percent of the value of production (64, p. 211).

Can the Peasantry Survive?

Ever since the Revolution, support for the peasantry has been a central rhetorical component of the Mexican political system. Although industrialization has been rapid, a third of the labor force continues to work in agriculture. The crisis in basic food production, the precarious standard of living and very limited effective demand of the majority of the rural population, and the high rates of migration to the cities threaten the stability on which future development depends. It is not surprising that the peasant economy has become the subject of intense theoretical debate. Are we witnessing the final disintegration of the last remnants of an ancient rural social structure, or is there potential for agricultural development programs which could at least stabilize the economy of the campesinos? This basic issue, which implies very different interpretations of the future of the rural society, has been cast in terms of an analogous debate which went on in Russia in the years surrounding that Revolution.

Chayanov and Lenin. The two best-known spokesmen from that time were Alexander Chayanov, who argued that the peasant economy is a special type of economic organization with very strong internal sources

of stability, and Vladimir Lenin, who argued that the peasantry could not survive in an economy dominated by capitalist accumulation; that it would inevitably become stratified between a small class of rich "kulaks" and an impoverished rural proletariat. 3/ Both economists developed their theories from a vast set of farm management statistics which were collected in the last third of the 19th Century in the rural districts, or Zemstvo, to monitor the reorganization of peasant agriculture after the abolition of serfdom.

Chayanov emphasized the internal logic of the peasant family as a unit of both production and consumption, which balanced its consumption needs against the available labor force. When a newly married couple first sets up their own household, they are easily able to grow enough to meet their needs. As their children are born, the number of consumers--mouths to feed--rises steadily. There is a lag of about fifteen years before the children are able to participate in farm labor. As more and more of them join the work force, the consumer/worker ratio declines and life gets easier. In any particular year, family size is both the principal resource and a fixed overhead, and the farm enterprise is organized around this critical ratio. Chayanov argued that land was readily available in most Russian villages, and that the usual strategy to meet rising consumption requirements was simply to increase the area in production. A statistical analysis of the relationship between the farmed area and the consumer/worker ratio is the empirical basis of his work. Within this dynamic, land, labor, and capital could not be seen as separate factors of production and assigned factor shares. He elaborated a marginal utility theory which related the drudgery--or disutility--of labor to consumption needs, and

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3/ The relationship between the theories of Chayanov and Lenin is far more complex, and less direct, than this simple comparison will indicate. The work of Lenin which I cite, The Development of Capitalism in Russia (139), was written in 1899 as the empirical basis for a polemical attack against the "populists" who idealized peasant life. Chayanov's Peasant Farm Organization (56) was published in 1925 during the years of the New Economic Policy as part of a debate over the best way to organize the peasants to increase production in the Soviet Union. He was the director of the Institute of Agricultural Economics and the leading theoretician of the "Organization and Production School." In addition to the Zemstvo statistics, he and his colleagues collected and analyzed one of the largest sets of farm management statistics in the world at that time. They argued that the peasants should be organized voluntarily into vertical cooperatives by the State, which would also promote the introduction of improved technology. He was accused of being a "neo-populist," idealizing the peasantry and effectively supporting the interests of the rich kulaks. Chayanov was purged from his job by Stalin in 1930. For a summary of the contemporary issues, which are reminiscent of the more recent debate between the "capitalist road" and the "red road" in China, see Kerblay and Lewin (135, 141).

argued that the underlying objective function is entirely different from that of a commercial farm, which attempts to maximize the returns to invested capital. He found that it is "rational" for a family to exploit its own labor at what would seem to be a very high opportunity cost, if conventional methods of economic analysis were used.

While he could include off-farm activities as an alternative source of income in slack periods, his system could not accommodate hired labor on the farm, which he regarded as insignificant in Russia at the time, or differences in productivity between enterprises or farms. He did believe that the same motivational dynamic would apply in more complex economic environments:

> [In countries where land is not freely available] . . . and where, with its high degree of intensity, the capitalist farm and all of its lands form a firmly welded production machine, the pressure of the biological development of the family undoubtedly cannot influence the amount of land for use. It is then expressed predominantly in the relationship between own and hired labor serving the particular production machine, and in the extent to which its own surplus labor goes off to work elsewhere. . . . In this case, if the farm continues to use its own labor, it means merely that the area of land for use has lost its ability to be a measure of the volume of economic activity, and we ought to seek other measures (56, pp. 68-69).

The fundamental point is that the economy of the peasant family is organized around the satisfaction of its own direct consumption needs and the maintenance of its own stability, not around the maximization of profit or the accumulation of a surplus.

Lenin was working within a much wider frame of reference. He looked at the same statistics to find empirical support for the Marxist theory of the transition from feudal to capitalist organization in agriculture. Instead of correlating demographic and production figures for average farms, he stratified the farmers into classes according to size and access to capital resources, of which the number of draft animals was the most convenient indicator in the data. He then looked at the typological classes at different points across a time series, and found what he thought was evidence of a rapid process of accumulation by the privileged classes.

He asserted that the key to this process could be found in the labor relationships. Starting conceptually in a peasant community which has just been freed from its labor obligations to a feudal estate, all of the members are in a roughly equal situation. Through one mechanism or another, a small group of peasants will acquire some small economic advantages. They might have slightly larger or better

farms, more or better draft animals, slightly better access to the market, or whatever. Once a gap is established, there is a tendency for it to widen. The privileged group will hire in increasing amounts of labor, buy more draft animals, and buy or rent increasing amounts of land at "wholesale" prices. The less prosperous majority will find itself in a deteriorating position. They will be forced to earn an increasing proportion of their income from the sale of their labor, rent draft animals, and pay higher rent for the small parcels of available land.

> The rural bourgeois depends on hired labor . . . [they] constitute a small minority of the peasantry, probably not more than 20 percent of the total number of households. But as to their weight in the sum-total of peasant husbandry, and in the total amount of produce raised by the peasantry--the peasant bourgeois are undoubtedly predominant. They are the masters of the contemporary countryside. . . . The old peasantry is not merely "differentiating," it is being completely dissolved, it is ceasing to exist, it is being ousted by absolutely new types of rural inhabitants--the rural bourgeois and the rural proletariat; a class of commodity producers in agriculture and a class of agricultural wage workers. . . . Every crop failure flings masses of the middle peasants into the ranks of the proletariat. In its social relations the group fluctuates between the top group, towards which it gravitates but which only a small minority of lucky ones have success in entering, and the bottom group, into which it is pushed by the whole course of social evolution (139, pp. 177-182).

One key point can be used to illustrate the fundamental difference between the two theories. The Zemstvo statistics unambiguously showed that larger farmers paid lower rents for land than smaller ones. Chayanov used this as evidence that, at the highest point in the consumer/worker ratio, peasant farmers would obtain the extra land which they needed, even if this could not be justified as a capital cost, a concept which lay outside of their frame of reference. Lenin interpreted the same fact to show that the "rural bourgeois" obtained resources on privileged terms. He also argued that the observed relationship between larger families and larger farms simply reflected their greater capacity to absorb labor--few children were forced to seek work elsewhere. Chayanov did not deny the importance of capitalist accumulation in rural areas (56, pp. 256-257):

> The world's agriculture is being drawn more and more into the general circulation of the world economy, and the centers of capitalism are more and more subordinating it to their own leadership . . . which draws masses of scattered peasant farms into its

> sphere of influence and economically subordinates them. . . . Within the Russian peasantry, social differentiation is still in its initial stages. We hope that the labor farm, strengthened by cooperative bodies, will be able to defend its positions against large-scale, capitalist farms as it did in former times.

The two Russians were of course separated by far more than a difference in theoretical opinion; they represented very different political factions in regard to Soviet agricultural policy. If the peasantry was disintegrating, as the Leninists argued, the creation of collectives to protect their interests as workers could be justified. If the family economy was fundamentally stable, as Chayanov maintained, then it would make more sense to organize cooperatives to protect their interests as peasant farmers. Chayanov was purged from his job and position of influence by Stalin in 1930.

Which economist better represented the actual situation in late 19th and early 20th Century Russia is a moot point. We have summarized their positions in this simplified form because they have been picked up by contemporary Mexican scholars. There is broad agreement about the structure of the agricultural sector and the pressures on the peasant economy. There has, however, been a great deal of debate on the implications of this process for future development policy. It is a somewhat artificial but useful exercise to divide a broad range of approaches into two "schools." One group, who are loosely known as the "campesinistas," have expanded Chayanov's concept of the labor farm to explain the persistence of peasant communities and their flexible responses to external pressure. Most of them are anthropologists and sociologists who base their evidence on field experience in rural villages. The Marxist political economists develop their analysis from the historical development of the agricultural sector as a whole, and use case studies as examples of long-term trends. 4/

4/ This summary makes no pretense of covering the extensive recent literature on the peasant question in Mexico comprehensively. It has been reviewed by Alejandro Schejtman in a study published by the U.N. Economic Commission on Latin America (64). The most articulate spokesman for the "campesinista" position is Arturo Warman (293, 295, 296). As director first of CIDER (The Research Center for Rural Development) and then of CISINAH (The Center for Advanced Studies of the National Institute of Anthropology and History), he had directed a number of field studies on peasant agriculture in various parts of Mexico. He works within the tradition of historical anthropology of which Sidney Mintz and Eric Wolf are the best known scholars (185, 186, 308, 309, 310). Rodolfo Stavenhagen participated in a major research project on the structure of Mexican agriculture (244) and has written of the peasant economy as a special type of adaptation (267, 268). The most influential Marxist political economists are Michel Gudelman and Roger

The "Campesinistas." Chayanov's marginal analysis of the allocation of peasant labor time cannot be applied directly to Mexico, as the basic assumptions about free access to land and the absence of hired labor generally do not hold. Nevertheless, the concept that peasant families exploit their own labor beyond the point where it is economically "rational" to do so has been used to explain the flexibility of their response in the face of adverse circumstances. Arturo Warman explains the issue as follows (294, pp. 10-11):

> Maize and its associated crops "don't leave us anything" as the peasants say; there is a negative profit if the factors of production are accounted at their market value. The peasant obtains a harvest to ensure the biological stability of the basic unit of organization--the family. Production is diversified to adjust to the diversified nature of the family work force and to achieve the best possible use of the other available resources. Peasant diversification strategies transform the productive process into a series of complex arrangements and successions, flexibly designed to achieve an equilibrium between the total expenditure and the total income of the family unit. In this context, sources of income and factors of production are not valued individually. The strategic point on which peasant subsistence rests is the intensive use of local resources, to which access is secured through a network of social relationships.

Under conventional accounting measures, the fact that the very smallest farms have the very highest maize yields means that labor output increases with intensification under pressure. The same author argues that within the context of the family economy it represents a decrease in efficiency, because the value of the work required is greater than the value of the additional production:

Bartra (108, 32). Angel Palerm has analyzed the valuation of peasant labor time and its transformation in contact with the capitalist economy (204). Ernst Feder is a polemicist who argues that the inexorable destruction of the peasantry is being accelerated by the expansion of capitalist agro-business and internationally funded development programs and accuses the "campesinistas" of reformism (86, 87, 88). Gustavo Esteva and David Barkin have written on the role of the private capital and state policies within a less rigid ideological perspective (23, 24, 26, 82). Alain de Janvry uses Mexico as one case study in a comprehensive Marxist analysis of the plight of the peasantry in Latin America (69).

> It is their domination, their increasing exploitation for the benefit of other groups, which is the principal motivation for the increase in peasant production. . . . The peasant family's effort, which is constantly greater, barely gives them enough to stay alive, much less to save, or even less to invest. They cannot put aside reserves against a bad year, an illness, a wedding, or a funeral. If one of these things happens, and it always does, they have to borrow money and work even harder in the future (296, pp. 23-25).

The peasantry is interpreted as a group with a specific history and a set of explicit, if not entirely homogeneous interests centered around the maintenance of their own social and economic stability. The individual peasants would of course like to make more money, but profit-maximization is not the overriding principle around which they organize their farms. This view is part of a long historical tradition in Mexico, which sees the peasant communities as semi-autonomous social units in a constant struggle with invaders, landlords, and capitalist exploiters from outside. Arturo Warman is an anthropologist, but he does not restrict his argument to Indian groups with special cultural values to protect.

He did his most comprehensive study of the peasant economy in eastern Morelos, a region of *mestizo* peasant agriculture which has been in very close interaction with the urban economy for centuries (295). It was the center of Emiliano Zapata's revolt, which is conventionally interpreted as a reaction to the massive loss of community lands to the sugar haciendas in the years before the Revolution (311). Zapata led the peasants to regain what they had lost--to reestablish the resource base and the stability of their economy. The agrarian reform and the creation of the ejidos were explicit responses to these demands. Other peasant revolts, including the Caste War of Yucatan, have been interpreted as analogous struggles for peasant self-preservation (30, 31, 238, 277, 309).

The viability of peasant agriculture is increasingly threatened by a complex set of asymmetrical social and economic relationships with people whose frame of reference is the dominant economy and who act as its agents. Commercial farmers make personal arrangements with the peasants to acquire access to their land, irrigation water, and labor. Intermediaries with personal contacts in the urban markets buy surplus commodities in small quantities, assemble, pack, and ship them. Merchants and shopkeepers supply goods and credit for both agricultural inputs and consumption needs at very high rates of effective interest on the basis of personal trust. The government bank and other official agencies make resources available to the peasants to meet national priorities and production goals. The peasants protect themselves through their symmetrical social and economic relationships within the extended family and the community. This is the basis of their economy

and their stability as a group, but they are being pushed to the limits of their flexibility. This anthropological approach is being applied in many studies throughout Mexico and the wide range of strategies which have allowed the peasants to survive are becoming better understood.

The Marxist Political Economists. The large and complex Marxist literature on the dynamics of economic development in the "peripheral capitalist" countries of Latin America has recently been summarized by Alain de Janvry (69, Chap. 1). There is a great deal of theoretical and factional dispute between scholars, but they generally agree that these countries are characterized by lopsided growth in the cities, based on capital-intensive industries organized to meet middle and upper income demand, and on the production of primary products for export. De Janvry calls this kind of development, which does not depend on complementary increases in the buying power and effective demand of the majority of the population, "disarticulated accumulation." The concentration of demand from the upper income strata, which follow the consumption patterns of the developed countries, encourages the penetration of transnational corporations in industry--to produce automobiles, for example--and in the processing and distribution of high-value foods. This leads to the increasing "internationalization" of these sectors, increasing structural stresses in the economy and political system, and to inflation (24).

The national economy depends on low wages for its growth, which leads to "cheap food" policies. The agricultural sector becomes polarized between a privileged minority, which is supported by a variety of direct and indirect subsidies, and the peasantry, which is increasingly squeezed. This polarization is called "functional dualism" because it is a function of the macroeconomic structure of the economy. The peasants are in an unstable, transitional position, and rising food imports are a symptom of the fact that they cannot continue to produce indefinitely under such unfavorable conditions. Increasing numbers of them are forced out into the unskilled labor market--into the proletariat.

On the community level, the Marxists follow Lenin's model, which, as we have seen, posits an irreversible process of accumulation and stratification as large commercial farmers compete with the peasants for the available resources. They believe that the situation is inherently unstable, and that the capitalist development process is locked in a contradiction--it depends on the peasants for cheap food and labor, but at the same time it is rapidly undermining their economy. They see no evidence that the peasants have any special system of organization which protects their stability:

> The only difference between a capitalist producer and a peasant is the capacity to generate and expropriate a surplus via the use of hired labor: the closer this surplus is to the average rate of profit, the closer

> our producer is to capitalist production. It is not that the peasants do not aim for a profit (a surplus); it is that they will remain in production even in the face of their inability to earn a profit (69, p. 152).

Roger Bartra takes the point even further (32, p. 74):

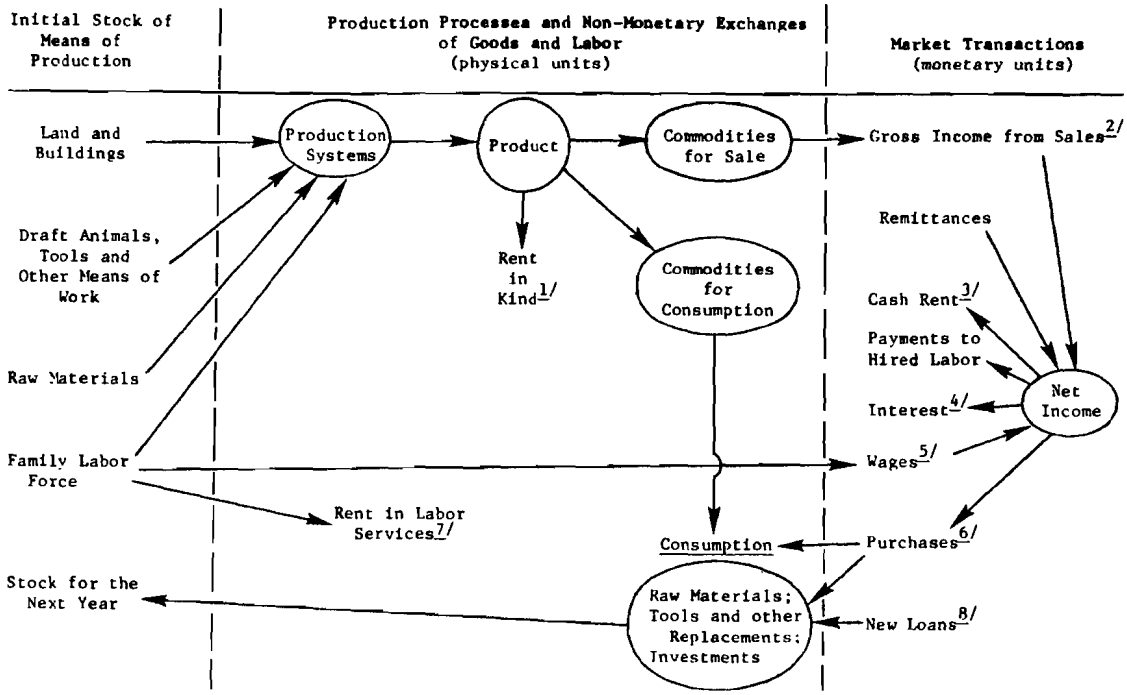
> Only about one-fourth of the product of (the average) peasant family is consumed in the home. Subsistence production is only a complement to monetary income. Nevertheless, it does help to explain the resistance of the peasant economy to adverse market conditions, along with a sentimental attachment to the land.

The Marxists argue that the process of proletarianization is inexorable, if slow and regionally uneven. The rate depends on a large variety of factors, including the local degree of competition for resources, the relative power of special interest groups, and the structure of employment opportunities. Government land distribution and rural development policies are interpreted as strategies to keep surplus population in the countryside, where the peasants partially sustain themselves at a low cost to the system, and to subsidize a social group which plays an important, if subordinate role in economic development (69, Chaps. 6 and 7; 86).

The peasantry is defined as a group in a process of social differentiation. The rate and nature of this process is determined by the mechanisms through which the surplus is extracted. The Marxist economists who work at the micro level analyze how these mechanisms change in form and intensity through time. Chart 9 is adapted from a study of a peasant community in northern Peru. It is a generalized model of a household economy, divided into three parts: the stock of resources available at the beginning of a given year, the production processes and nonmonetary exchanges of goods and labor, and the market. The points where surplus is extracted are indicated in the notes.[5/] It is a useful model, and we will discuss the changing historical relationship between the Maya communities and the larger economy of Yucatan in the next chapter.

[5/] Using the same cross-sectional data from a Peruvian community, Carmen Deere tested both Chayanov's and Lenin's original hypotheses to see which better explained observed differences in farm size. She found some support for both, but concluded that Lenin's model of social stratification based on privileged access to resources was the more powerful. Nevertheless, she concluded that differences in family size and family labor force could be a useful framework within which to investigate the intra-family allocation of work tasks (72).

CHART 9. GENERALIZED MODEL OF A PEASANT HOUSEHOLD ECONOMY



Points of Surplus Extraction:

1/ Rent in kind, in sharecropping arrangements.

2/ Sale prices are subject to manipulation, large marketing margins, and unpredictable fluctuations.

3/ Cash rents for land and equipment are subject to manipulation and imperfect competition.

4/ Interest rates, particularly for short-term consumption loans against the harvest, are extremely high.

5/ Wage rates are low due to imperfections in the labor market, or a "buyers' market."

6/ The prices for goods in small stores or other imperfect markets are high.

7/ Rent in labor services in return for land, in lieu of cash loan repayment, etc.

8/ Loans are often granted under unfavorable terms at very high interest rates.

Source: Carmen Diana Deere and Alain de Janvry, "A Conceptual Model for the Empirical Analysis of Peasants," American Journal of Agricultural Economics, Vol. 61, No. 4, 1979, p. 603.

Nevertheless, the assumption that there are no sources of stability in peasant farm organization is too rigid. It cannot explain the diversity of traditional production systems, or the flexibility with which they make use of the available resources. The peasant economy is very definitely threatened, both by the polarization of the agricultural sector as a whole, and by stratification within individual communities. Nevertheless, there is a range within which peasant agriculture can be strengthened. An analysis of this range requires careful investigation of the specific context within which particular groups operate, and of the traditional production systems themselves.

Approaches to the Study of Traditional Agricultural Systems

The diversified agricultural systems of peasant farmers throughout the world are receiving increasing attention from a number of perspectives. Researchers from different disciplines carry with them a set of interests and assumptions which affect how they conceptualize the issues involved. There is broad agreement that existing technology cannot be applied without adjustment in traditional production systems, particularly in the tropics. Agronomists oriented to agricultural systems as a whole emphasize a detailed understanding of traditional practices as a key to their improvement. More conventional agronomists reproduce simplified cropping systems under controlled conditions to find ways to increase their efficiency. Others take an even more restricted approach, and concentrate exclusively on the environmental limitations within farming systems which must be overcome to increase the yields of target crops. Ecologists and other biologists attempt to reproduce the diversity and stability of traditional systems while introducing new crops and technology, or by recreating ancient practices. Economists study the internal management of farm units, and try to identify factors which would either allow the producers to use existing resources more efficiently, or to adopt more productive technology.

Applied Research to Improve Agronomic Practices

Efraim Hernandez X. has directed groups of students from the Graduate College of Agriculture at Chapingo in long-term research projects on the ethnobotany and agronomy of traditional systems in selected regions of Mexico, including Yucatan. The research is based on the concept that the detailed study of the production practices will reveal the adaptations which the campesinos have made in response to both the natural and the socio-economic environments within which they operate. The selection of crop varieties, the timing of operations such as land preparation, planting, and weeding, the use of different plants, both the "weeds" in the field and the species in the natural environment, are studied in detail as keys to the empirical knowledge which the peasants have accumulated.

The information is systematized and used as the basis for a regionalization of traditional agriculture according to its own internal logic. Scientific research, based directly on the experience of the campesinos is used to develop or adapt technology which helps them to compete in the changing economic environment. As an educational program, it is intended to make problems raised within the set of empirical practices, rather than more general scientific questions, the basis for research hypothesis and design. This approach requires long-term participant-observation with the campesinos by interdisciplinary teams of students. The generation of concrete results is slow, although the projects incorporate demonstration and extension activities directly into the research (47, 119, 120).

Another approach, more rigid and quantitatively sophisticated, has been developed by Antonio Turrent, also at Chapingo. He divides the factors influencing production into those which are regarded as fixed, external constraints and a limited number which are allowed to vary. Traditional cropping systems are replicated under controlled conditions and multi-factorial statistical methods are used to quantify the interactions between variable factors. This analysis is used immediately as the basis for experimental programs designed to improve their productivity (283, 284).

The orientation of research to the specific conditions in complex systems of traditional agriculture is a reflection of the food production crisis and other factors which are affecting government policy as a whole. Its academic content is derived to some extent from the experience of the Puebla Project. This was an internationally funded program to extend high-yielding varieties and other "green revolution" technology to rain-fed maize production, and was the subject of an intensive public relations campaign directed to the world agricultural development establishment. The attempt to introduce new varieties of maize into a region in central Puebla was unsuccessful because the native varieties are better adapted to local conditions. When the project was broadened into a program of extension based on standard agronomic improvements such as fertilizer, increased planting density, etc., it was quickly found that the complex, diversified family economy of the campesinos, the systematic bias against them in the input and product markets, and the lack of effective institutional support, would prevent any dramatic yield increases in the short run (48). Antonio Turrent has commented (285, p. 3)

> It is necessary to recognize that the process of agricultural modernization in Mexico will follow its own rules, which have yet to be discovered. It will require a long period of transition during which the ability of the producers to choose their own objectives and means will need to be respected. We will have to take better advantage of their broad knowledge of their resources and of the production of crops and animals, at the same time as we try to

> introduce the selective use of modern inputs within the logic of their systems.

CIMMYT is working in a similar direction, although their approach is limited to a single crop and the environmental conditions which affect its growth. 6/ On the basis of an evaluation of the adoption of improved maize varieties in various parts of the world, one of their studies came to a very simple conclusion:

> Our impression from these studies is that the most pervasive explanation of why some farmers don't adopt new varieties and fertilizer while others do, is that the expected increase in yields for some farmers is small or nil, while for others it is significant, due to differences (sometimes subtle), in soils, climate, water availability, and other biological factors (222, p. 893, emphasis added).

CIMMYT has developed a methodology for identifying constraints within farming systems, but it is explicitly limited to the factors which affect the design of technology for the target crop under specific environmental conditions (49). For example, the first step in a study in northern Veracruz was to identify "recommendation domains": farms in roughly homogeneous agroclimatic zones which could be expected to respond in a similar way to a particular set of innovations. It excluded farmers who were shifting into other crops from the sample, although maize production is declining precipitously in that region in competition with citrus (113). The analysis does not include regional or socio-economic factors beyond the internal questions of farm management at a particular moment. This mode of farming systems research is designed to provide guidelines for crop and agronomic improvements. Its focus is too restricted to explain the dynamics of peasant agriculture, or its relationships with the larger economy.

6/ CIMMYT is the Spanish acronym for The International Center for Maize and Wheat Improvement, which is located just outside of Mexico City. This organization and its direct predecessor, the Rockefeller Foundation's Office of Special Studies, have been working on the genetic improvement of the two crops since the early 1940's. Their development of dwarf, rust-resistant varieties of wheat, well adapted to controlled conditions in the northern irrigation districts, is usually credited as the first major breakthrough of the "green revolution." The maize varieties which they have developed have not been widely adopted in Mexico, although they have had a significant impact in other parts of the world.

Agro-ecological Research by Analogy with Natural Systems

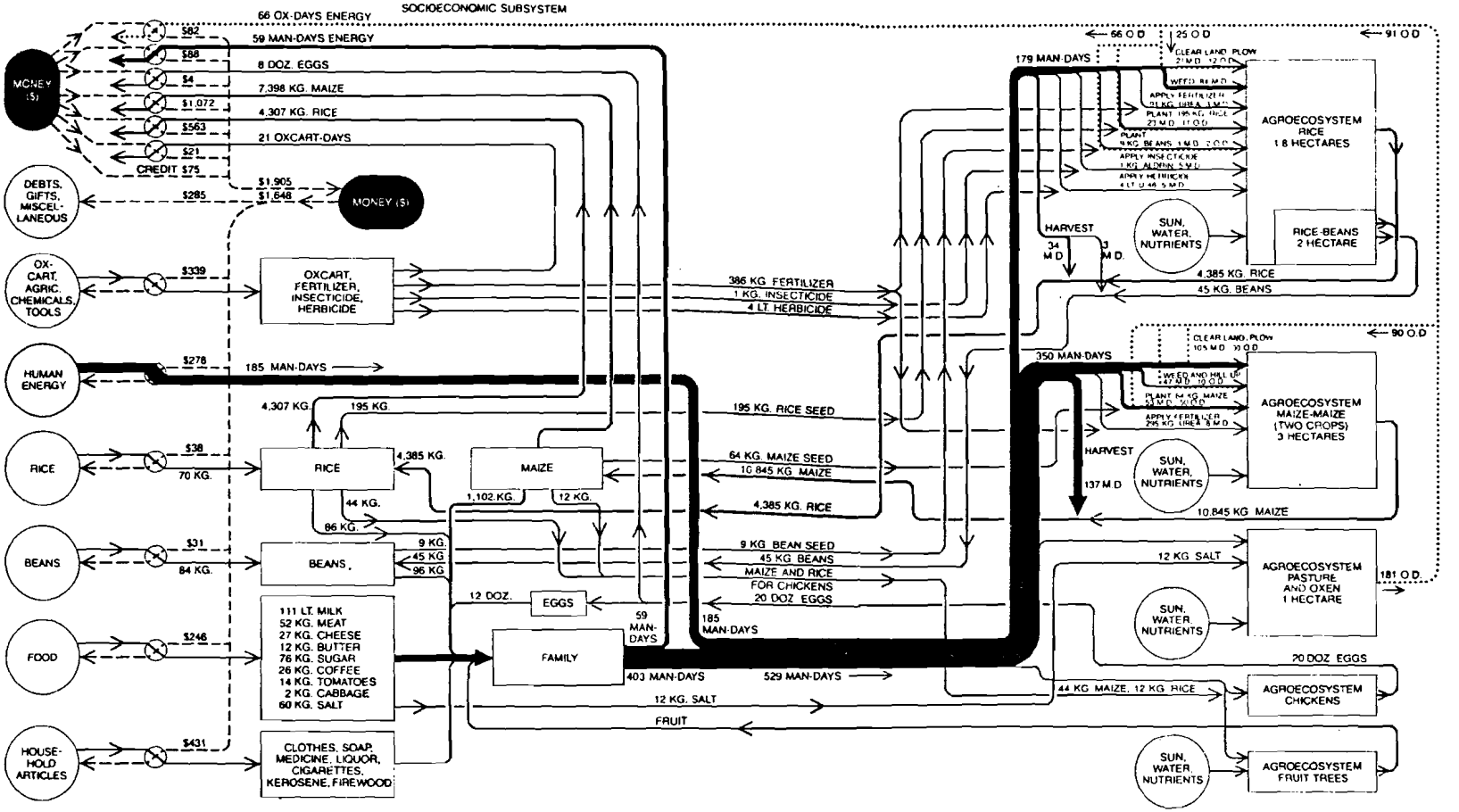
Ecologists and other biologists have done studies of traditional farming practices which place great emphasis on their diversity. By analogy with the natural systems of the tropics, they assume that diverse combinations of crops are more stable than the monocultures which characterize modern agriculture (103). A number of researchers have attempted to find a single set of measures which relate the structural and species diversity of traditional farming systems to both the short- and long-term interests of the peasants.

One way to do so is simply to borrow the concept of energy efficiency from ecology and apply it directly. An elaborate study of a Neolithic people in a pair of isolated valleys in New Guinea balanced the kilocalories of energy expended in slash-and-burn gardening and pig-raising against the food energy value of the commodities consumed (233). The author argued that the culture has evolved mechanisms to regulate this balance, although of course the absolute level of living is very low. Various attempts have been made to apply this concept to more complex and intensive types of agriculture (43).

In a general sense, it can be argued that subsistence agriculture has evolved to meet basic food requirements for a minimum labor investment, but it is difficult to explain every element in highly diversified systems in this way. The problem becomes even more complex when there is any contact with the market at all, because high-value crops like chile require a great deal of labor and yet contain very low amounts of energy. In other words, it becomes progressively more difficult to discover a mechanism through which a farmer would actually allocate his labor in terms of biochemical energy relationships. Studies have been made on a more general level to compare different agricultural systems in terms of their energy efficiency and degree of dependence on fossil fuels, but this is really a separate issue, and leads to the conclusion that the most primitive systems are the most efficient (223). This argument has a certain rhetorical value for demonstrating that the exclusive reliance on economic indicators masks other types of inefficiencies, but it is not a very useful basis for the design of agricultural development programs.

A complex analytical device has been developed by Robert Hart at CATIE in Costa Rica (115). Using the circuit diagrams developed by Odum to analyze natural systems (198), he divides peasant production systems in a hierarchy of sub-systems from the region, to the farm, to the individual crop and animal enterprises, down to the weeds, diseases, insects, and soils. Chart 10 is a diagrammatic model of a farm in Honduras constructed from data of a year's agricultural activities. It traces the flows of labor time, inputs, and products between the various cells in quantitative terms. The inputs of solar energy, water, soil nutrients, and money are indicated, but no attempt is made to measure them in constant terms. There is no way to net out the various elements into a single index of efficiency. This is a very

CHART 10. ENERGY FLOW MODEL OF A PEASANT FARM



Source: Nevin S. Scrimshaw and Lance Taylor, "Food," Scientific American, Vo. 243, No. 3, 1980, pp. 86-87.

static type of analysis. While it is possible to use simulation techniques to trace hypothetical changes in key parameters through the system, it is not constructed as a decision model. The campesino appears as labor input and as consumption demand, but the junctions are not arranged around key moments in the year when he actually has to decide what to do. This makes it difficult to assess the validity of simulated changes in prices, yields, or other parameters as real alternatives, or to evaluate trends in any detail.

Several pilot projects in tropical Mexico have been based on the controversial assumption that there is a direct, functional relationship between species diversity and economic stability. Demonstration plots have been set up with a large number of native and introduced species on the basis of a theoretical appreciation of the value of diversity in traditional systems. The Mexican Forestry Institute has developed a module on an experiment station in Bacalar, Quintana Roo (55). No mechanisms for evaluating its applicability to the needs of the local peasants were included in its design, and an attempt to apply it in a pilot rural development project in northern Yucatan was not successful. A project of the Tropical Agricultural College in Cardenas, Tabasco established diversified modules in several ejidos in cooperation with the PIDER rural development program. They were run initially with salaried labor, and their integration into the economies of the communities has proved difficult (103). In another part of Tabasco, a modern adaptation of an ancient system of raised fields, or chinampas, was built to benefit a group of Chontal Indians living in a swampy area (106). Further research will be required to develop cropping systems appropriate to these conditions. An agro-forestry program in southern Yucatan has drawn upon both ancient and contemporary Maya technology in the design of multiple-use combinations of different micro-environments and sources of water (194, 195).

These are valuable experiments, and much has been learned from studies of traditional production techniques within this conceptual framework (53, 200). Analytical tools for studying the ecological and energy efficiency of resource use in tropical farming systems are being developed (83, 130). Nevertheless, there is little empirical evidence of a universal or automatic relationship between species diversity and economic stability. Peasant management systems are not stable because they are diverse; many of them are diverse because families with very limited resources have developed complex cropping arrangements which are appropriate to their needs, and which minimize their risks in an uncertain economic context. Their systems are based on very detailed knowledge of the local resources accumulated through a long tradition of empirical experience, but they are not static or immutably "adapted" to their environment. The particular combinations of crops which they grow, and the cultural practices which they use, are continuously adjusted to the needs and resources of each family, and to shifting external conditions.

Microeconomic Analysis

In the short run, an individual peasant family has little or no control over the external circumstances within which it operates. In any given year, they allocate the resources which are available to them to meet their needs. These needs can be expressed in terms of subsistence requirements in self-provisioning communities, in terms of cash when commodities are produced primarily for sale or when agriculture is combined with other sources of income, or some assemblage of complex goals. In any case, the economic efficiency of production is the relationship between inputs and outputs, and is a function of available resources, technology, and management. Farm management analysis starts from the assumption that the goal of individual farmers is to maximize returns from a given set of resources and inputs. It is often most convenient to set up the accounting measures in monetary terms, but it is possible to broaden the "objective function" to include the assurance of a minimum food allowance in physical units, a maximum allowable risk of loss, a minimum fluctuation in the annual profile of labor requirements, and many other specific and subjective factors.

In agricultural production, the application of labor and other inputs increases physical output up to a certain point. Then first the rate of increase and then the absolute level of output decline. The principal goal of microeconomic production analysis is to translate this physical relationship--which is called the law of diminishing returns--into uniform terms and identify the optimum point which in a fully commercial context would correspond to maximum profit. The physical relationships between input and output are different for each crop and enterprise, and vary depending on the specific circumstances. In studying modern agriculture, the enterprises are conventionally separated and budgets are developed for each one as the basis for determining the optimum combination. This is not practical in studying most peasant systems, because different crops and enterprises are managed jointly in complex ways.

Certain inputs, particularly land and family labor, are valued not only in terms of their contribution to production, but also in terms of their opportunity cost, or what they could earn if they were used in another enterprise or employed off the farm. This concept is particularly important in peasant family operations which combine both subsistence and commercial production with off-farm work and other economic activities. Once the technical relationships have been identified, the assumption that the farmers will attempt to maximize the input-output ratio in a given cropping cycle must be modified to account for the risks involved, which are very great for peasants operating close to the subsistence level, and for the long-term goals of the family.

Microeconomic analysis abstracts the input-output relationships of farm management by statistically estimating production functions for groups of farms which are assumed to operate under similar constraints.

Once this has been done, their apparent efficiency can be calculated using the principle of marginal analysis. In other words, it is assumed that farmers implicitly attempt to utilize the factors of production so as to equalize their marginal contribution to production. It is difficult to obtain accurate data about diversified farms which allow the aggregation of multiple products in other than value terms, or the separation of the costs associated with each crop. Most studies either confine themselves to the predominant crop, or estimate joint production functions on the assumption that overall profit-maximization is indeed the overriding goal (133).

If it can be shown that the farms from which the function is abstracted have managed to equalize marginal returns, they have achieved what is called "allocative efficiency," which means that none of the resources are "wasted" (202). This implies nothing about the level or the distribution of income. In fact, we would expect farmers with very limited resources to be very efficient, as small margins would be critical to their ability to meet their basic needs. Large farmers with plenty of land and capital could afford to "waste" resources (150, pp. 138-139). As we have seen in Chart 4, highly aggregated data in Mexico suggest that smaller farmers are indeed forced to achieve higher yields, even though they exploit their own labor at very low rates of effective return.

A variety of microeconomic studies of peasant agriculture have explained the absolutely low levels of productivity in terms of what is called the "low-level equilibrium trap" (123, 261). They assume that farmers operate in a stagnant economic environment. The technology has remained constant for a long enough period so that the peasants have learned all of the relationships between inputs and outputs through empirical experience. Ergo, they have an implicit understanding of the production function. Their goals and all resources and prices are absolutely constant. Under these conditions, they would allocate their resources efficiently. They would still be poor, and agricultural development would depend on the introduction of new, more productive technology, a land reform program, or other externally induced changes in the resources available to them.

Peasant agriculture in Mexico, and particularly in Yucatan, is based on a very long tradition and on detailed knowledge of the local resources. Nevertheless, the conditions under which the farmers operate are anything but static. The emergency, short-term needs of the peasant family, weather conditions, and the factors of production which can be obtained, are fluctuating constantly. In addition, there are significant and rapid secular changes in relative prices, access to markets, credit arrangements, off-farm labor opportunities, and many other factors which directly affect the use of productive inputs. There is no reason to believe that most Mexican peasants operate in a stagnant equilibrium of limited resource allocation.

The issue then becomes one which is far more difficult to calculate, "technical inefficiency." This is a measure of how much farmers produce in relation to how well they could do if the best available technology and management techniques were applied. It is a theoretical measure of the potential for technical change. If one can match groups of farmers with similar resources who achieve significantly different levels of output, or construct a "frontier function" from on-farm experiments, the differences can be analyzed. An elegant study of irrigated rice production in the Philippines--a relatively homogeneous system--compared experimental yields under farmers' conditions with detailed on-farm production data. The authors were able to partition the difference--the "yield gap"--between the allocational inefficiency of the farmers along their own implicit production function and the technical inefficiency with which they used the technology which the government was making available to them (68, 146). This kind of study requires extremely detailed data, and would be difficult to construct for heterogeneous farms producing a variety of crops (73, p. 191).

Conservative economists explain both types of inefficiency in dynamic situations in terms of the individual farmer's competence in adapting to changing conditions. They assume that this depends on education and training, or "human capital" (262). Other analysts have argued that most peasants can be shown to be reasonably efficient if the production function is correctly specified to reflect their true circumstances.

For example, a study of the Puebla Project set out to test the observation that farmers with few off-farm employment opportunities--with a lower opportunity cost on their labor--adopted labor-intensive technology and achieved higher yields than farmers with reliable sources of off-farm income (288). The author estimated production functions for each group which confirmed the hypothesis that poorer producers are often the more "efficient." If a function had been estimated for the population as a whole, it would have implied a negative correlation between human capital and productive efficiency, because better-educated people have an easier time finding employment.

This illustrates the fact that static input-output analysis is very sensitive to the basis on which it is specified (289). Where agricultural production is based on relatively standardized practices within given agroclimatic regions, it is possible to trace dynamic changes by comparing farms of different types at different points in time. The combination of cross-sectional and time-series production function analysis of the highly variable and rapidly changing peasant agriculture of Mexico is a daunting statistical problem, and very few appropriate data sets are available. The short-term efficiency of broadly similar production systems can be approximated using simple budgeting techniques. It is very difficult to compare farms in great detail because the variability of the individual parameters is very great, and because the logic of peasant farm management cannot be

reduced to simple, universal assumptions of profit-maximization or the equalization of marginal returns.

A Case Study of Maya Agriculture in Yucatan

This study is based on the concept that peasant management systems are flexible strategies of adaptation to environmental conditions, to shifting household requirements, and to a dynamic external economy. Maya agriculture in Yucatan was chosen as the subject of a descriptive monograph for several reasons. Throughout most of its history, the state has been isolated from the rest of Mexico. The first overland communications link was not opened until the late 1940's. The unusual agroclimatic conditions, which have limited the production of commercial crops on a large scale to a few brief episodes, are relatively uniform. The history of traditional Maya agriculture, and of the milpa system on which it is based, is well documented. This provides an opportunity to trace the relationship between self-provisioning food production and other economic activities of the peasant population over a long period of time. The development of irrigated fruit and vegetable systems in the southern Puuc region is one of the few cases of the intensification of traditional management practices.

There is a common, but misleading tendency to create an artificial dichotomy between peasant agriculture--a static, traditional adaptation to its environmental and social context--and modern agriculture, an entirely different type of organization with very different goals. The temptation is particularly great in Yucatan, where the contemporary Maya are the lineal descendents of one of the great pre-Hispanic civilizations. Many agricultural and rural development projects are based on the implicit assumption that only through the introduction of entirely new production systems, and the transformation of the peasants into commercial farmers, can their economic conditions be changed in any significant way. It is certainly true that the Maya culture has preserved the empirical knowledge which has permitted the people to survive in a difficult environment. Nevertheless, their history demonstrates that they have been capable of adapting to shifting conditions. The majority continue to base their economy on the milpa system because few alternatives have been available. The case study will trace the conditions under which one group has reorganized their management practices, and the logic within which they have intensified production for the market. This empirical experience will be used to develop guidelines along which government development programs might be improved.

CHAPTER THREE

PEASANT AGRICULTURE IN YUCATAN

Even the most casual visitor to Yucatan is impressed by a paradox. It is a semi-arid region, heavily forested with secondary scrub vegetation, where all agriculture is based on shifting patterns of slash-and-burn cultivation. Nevertheless, it was the site of one of the great pre-Hispanic civilizations and it has been continuously inhabited for thousands of years. The landscape is densely dotted with ruins: of the classic Maya, of the late Maya, of colonial and 19th Century haciendas, and, less conspicuously, of repeated cycles of settlement and abandonment by peasant villagers. All of the contemporary towns, and most of even the smallest hamlets can be located on 16th Century maps. Some have grown into prosperous commercial centers; others have faded into little groups of wattle and thatch houses clustered around the massive ruins of churches and agricultural processing factories. The relationship between settlement patterns, peasant food production, commercial crop production, and the fluctuating forest frontier is the key to understanding the history of the agricultural economy of the region.

The Milpa System

Maya peasant agriculture is based on the milpa, a permanent system of continuous rotation through forest fallow. The combination of crops which is grown, the sequence of operations, and the cultural basis on which the system is organized have changed very little since the accounts of the first Spanish chroniclers. 1/ The only significant technical innovation has been the introduction of iron tools centuries ago. This cropping system is practiced primarily in hundreds of small, dispersed villages of between ten and at most a few hundred families, on land which has been granted to them as ejidos. Although it is flexible in response to significant variations in the environment over short distances, the milpa is much the same throughout Yucatan.

1/ The first account of Maya agriculture was written by Bishop Landa, infamous for burning much of the existent pre-Hispanic literature in an auto-da-fe at Mani in 1562 (138, pp. 93-106). The best descriptions of contemporary practices are by Morley, Steggerda, Perez Toro, and Hernandez X. (191, Chap. 8; 270, pp. 89-153; 219; 118).

The Annual Calendar of Activities

A generalized calendar of the principal operations, and the average number of man-days per hectare required for each, are shown in Chart 11. A plot in its first year of production is called the milpa roza. An average of approximately 60 percent of its area is re-cleared and planted a second time, when it is called the milpa caña. The land is then allowed to revert to fallow; third- and fourth-year milpas are very uncommon. In a given year, therefore, a campesino is working two plots with a modal area of approximately four hectares. In a good year, this will provide him with enough food for his family and a surplus for sale, but weather conditions are highly variable. The yields of maize, the principal crop, fluctuate over a wide range and disastrous years are very common. Milpa continues to be virtually the only method of food production in Yucatan, and the average state maize yield of about 900 kilos per hectare is among the lowest in Mexico.

A new site is selected in August or September according to two principal criteria: the age and state of the secondary vegetation, and its distance from the village and the convenience of access. Only a small fraction of the forest in most ejidos is cleared and cultivated in a given year. Aerial photos of the central maize-producing region of the state reveal a nearly continuous checkerboard of secondary vegetation in various stages of regrowth. The patterns are more complex out into the frontier, but the milpa is a system of continuous fallow rotation. Unlike slash-and-burn systems in many parts of the tropics, it is not a brief transitional phase between forest and more intensive land uses. Although the land in most ejidos is for the communal use of the members, there are some restrictions on access. Families tend to work in sections where they have established a customary right, and influential factions are able to exclude others (217, 218). Some areas have been set aside for cattle pastures and for government development projects of various kinds, and the boundaries with neighboring communities or private landowners are often in dispute.

Most of Yucatan is very sparsely populated. Nevertheless, due to a combination of population growth and the concentration of cultivated plots in convenient areas surrounding the villages, fallow periods have been declining. It was estimated in 1979 that approximately 60 percent of the milpas in the state had been fallowed for less than ten years, even though between 15 and 20 are necessary to maintain a stable rotation (95). Nevertheless, as Chart 12 shows, the weather has far more effect on yields in a given year than the length of the previous fallow period.

The sequence of tasks is determined by the seasonal patterns of the weather in a region with a very long dry season. Up to 20 months elapse between the time a new plot is selected for clearing and the last of the crop is harvested. The timing of some operations, such as planting and burning, is extremely critical. Others, such as tree felling and harvesting, are carried out a little at a time, a few days

CHART 11. THE TRADITIONAL MILPA SYSTEM: THE DISTRIBUTION OF THE PRINCIPAL CULTURAL OPERATIONS

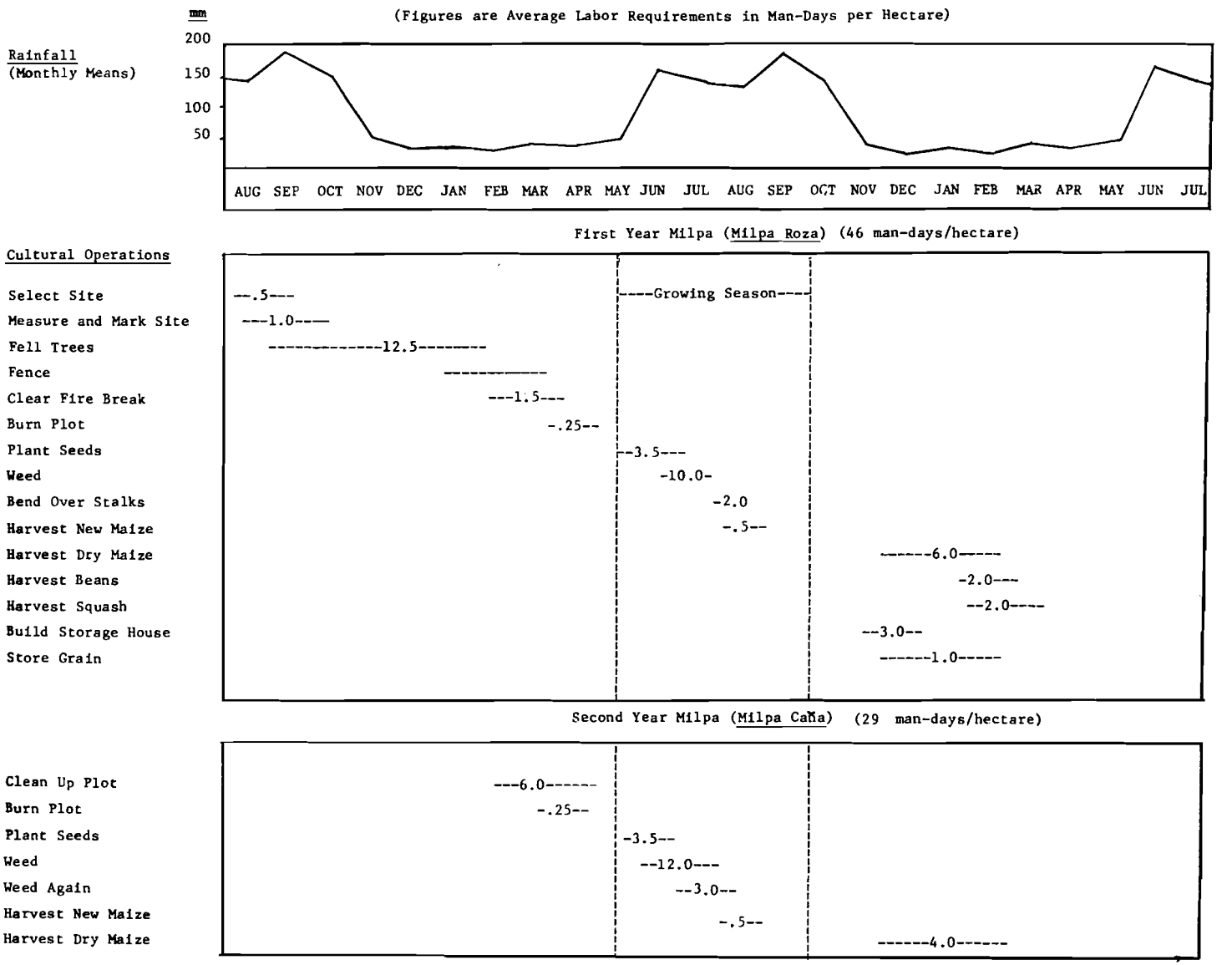
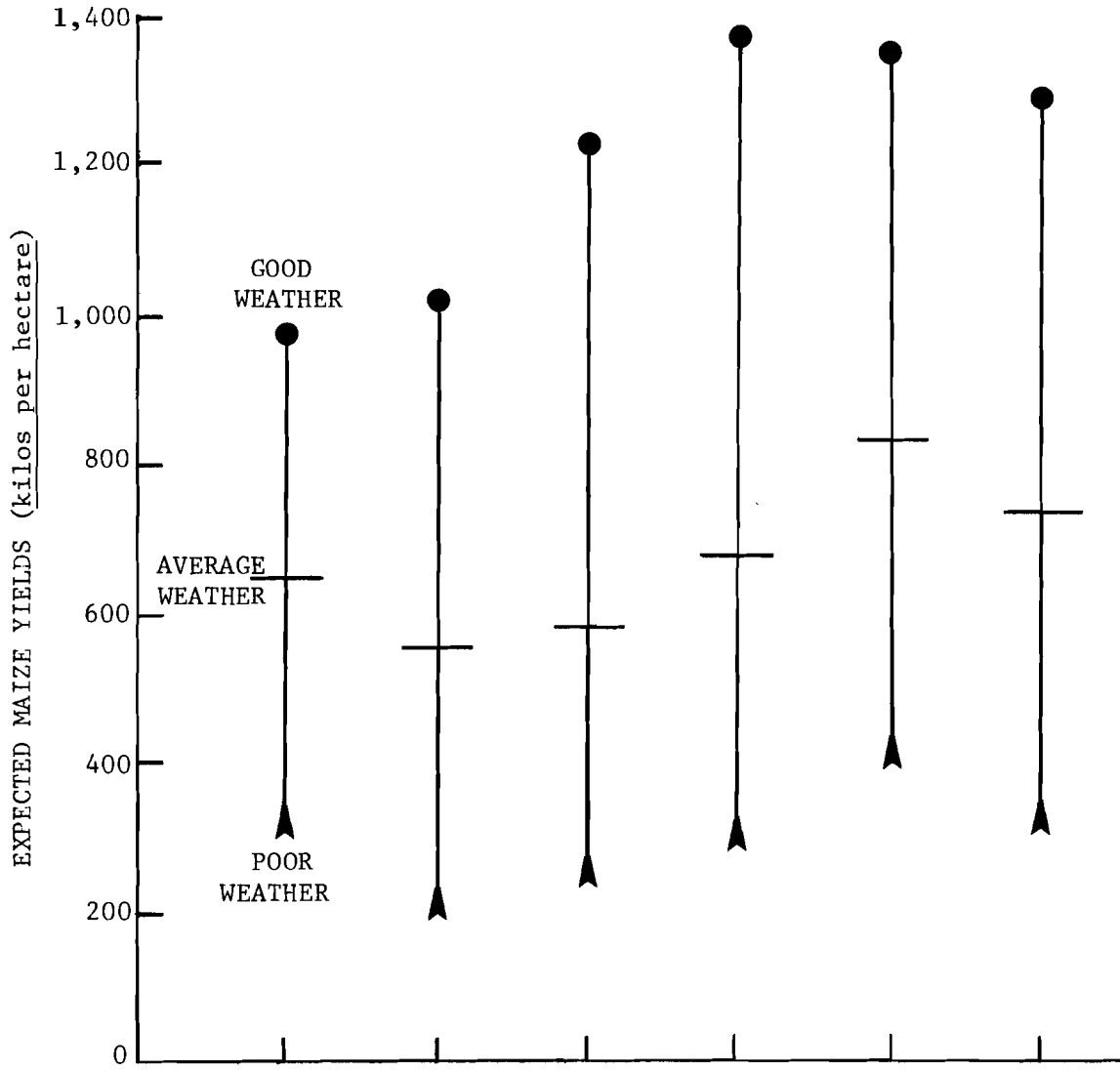


CHART 12. THE PENINSULA OF YUCATAN: EXPECTED MAIZE YIELDS IN THE MILPA SYSTEM, DEPENDING ON THE PREVIOUS FALLOW PERIOD AND WEATHER CONDITIONS



Years of previous fallow	1-3	4-6	7-9	10-12	13-15	Over 16
Percent of Milpas in the Yucatan Peninsula in 1979	7%	35%	16%	21%	17%	38%

Source: Ernesto Gallegos G. de la C., "'La Milpa,' Sistema Tradicional de Producción de Maiz Asociado en la Peninsula de Yucatán" (ms., México, Instituto de Investigaciones Agrícolas (INIA), Mérida, México, 1981).

a week, over periods of several months. Key points in the cycle are celebrated with syncretic religious ceremonies which combine Catholic ritual with traditional Maya practices (234).

The trees are felled between August and January, depending on their age. Large trunks are easier to cut at the end of the rainy season, when the sap is running, and should lie for the entire dry season to ensure a good burn. The timing is less important if the vegetation is small. The management of the milpa system is focused on the single day when the plot is burned. A good burn consumes all the trunks and branches, which have previously been spread evenly over the ground. It kills many weed seeds, and leaves a thick cushion of ash which washes into the soil, providing phosphorus and other nutrients. A poor burn leaves a plot littered with trash, and weed competition with the crops becomes a serious problem. Some organic material is destroyed, and nitrogen is volatalized, but the fire passes quickly and is not so hot that it damages the structure of the soil significantly. Unlike those in many areas of the tropics, slash-and-burn practices in Yucatan do not lead to serious erosion, because the land is flat, and because internal soil drainage is very rapid.

The Maya peasants are very attentive to all of the details of the sun and wind conditions which contribute to a good burn, and are even more concerned four to six weeks later when they must decide when to plant. The beginning of the rains is very uncertain. There are real advantages to planting as early as possible, so that the maize will tassel before a mid-season drought which is common in the region, and be entirely mature before the heavy rains of September. Nevertheless, if they plant too early, a single downpour may stimulate the seeds to germinate. If there is a pause before it rains again, the seedlings will die and it will be necessary to replant at considerable expense in seed and time. If they wait until the rains are well established, competition from weeds in the critical few weeks after germination will be severe.

Maize seed is physically mixed with beans and squash, and they are planted together in holes made with a steel-tipped stick. 2/ The

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2/ The native crop varieties are diverse, and the Maya terminology distinguishes a large number of local variants. A study of the native races of maize in Mexico, carried out by the Rockefeller Foundation in the 1940's, classified the maizes of Yucatan into three families according to their genetic characteristics (300). The peasants distinguish three broad types according to the length of the vegetable cycle and the size of the ears, characteristics which are directly correlated with yield (118, p. 27). The earliest, Nalt'el, which produces tiny ears in as few as 50 days, is now grown only rarely. Xmehenal is an intermediate type with a growing season of approximately three months, which is usually grown in backyard solares and other especially fertile areas. The common milpa maize is called Xnuknal. It matures in

mixture is adjusted to the significant variations in soil type within even small parcels, and the average density of the companion crops is low. Second-year milpas are commonly planted with maize alone. The diversity of the varieties which are used has declined over the past generation, but attempts to introduce hybrids have met with little success. The available "improved" maize types are far more sensitive to irregularities in rainfall patterns and soil conditions than the native varieties, and are more seriously affected by pests, particularly in storage.

A first-year milpa roza is normally weeded once in July; a milpa caña is usually weeded a second time. Except for clearing the plot in the first place, this is the most time-consuming of the operations. The harvest begins in late August or early September, with the new maize, which is the occasion for a festival. After this, the crops are left in the field to dry down, and are harvested and stored gradually in the course of the next dry season. These tasks overlap the beginning of the next year's cycle.

Slash-and-burn cultivation has two principal effects; it concentrates nutrients accumulated in the vegetation into the soil, and it kills various pests, especially weeds and some of their seeds. Plots are abandoned after two years because the yields begin to decline precipitously, and because the labor required to weed becomes too great. Research has shown that declining soil fertility is not the overriding factor. As R. A. Emerson, a maize specialist from Cornell University, observed 50 years ago (81, p. 58):

> Anyone with an agronomic background finds it difficult to believe that milpas, after two crops of maize, have been abandoned because of soil depletion; and equally difficult to conceive that soil fertility, once depleted, would be restored by a few years of tree growth. . . . It seems almost too obvious to require statement that weed competition, rather than soil depletion, is the factor responsible for the lessened yields.

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approximately four months, is resistant to climatic fluctuations, and stores relatively well in the husk. There are white and yellow varieties of both of these latter types. Xk'olibu'ul and Tsama' are black bean types of the species Phaseolus vulgaris. The first is a vigorous pole type which is commonly planted together with the maize in milpas; the latter is sown later in the season. Ib, which are lima or seiva beans (Phaseolus lunatus) as well as cowpeas (Vigna sinensis), are often grown in backyard gardens and are eaten immature as a vegetable. A number of squash (cucurbita spp.) species and varieties are produced, primarily for their dried seeds. A partial list of the cultivated species of Yucatan is provided in Appendix A. The problem of the erosion of genetic diversity has not been studied in detail. The campesinos lament it, and select what seed is locally available.

Morris Steggerda tested this hypothesis by maintaining a small plot entirely free of weeds for five years, and found that soil fertility in fact did not limit crop production (270, pp. 122-123). Nevertheless, the variability of the yields which he obtained without irrigation or fertilizer were not significantly different from those in milpas under traditional management. The labor cost of weeding beyond the second year cannot be justified at the low average levels of production. The traditional agronomy of the system is based on complex interactions between the natural process of forest regeneration in the fallow period, and carefully timed practices in a patchy and unpredictable environment (11, 124). More recent experimental work has shown that there is considerable potential to increase yields by using fertilizer and other innovations but no alternative food production system has ever been developed in Yucatan on a large scale (19, 95, 228).

Insecurity of Food Production and Low Economic Returns

Maya peasant households cannot be assured of either basic food security or an adequate income from their milpas alone. The campesinos constantly lament that "the milpa doesn't leave us anything," that the productivity of their labor is low, and that the risks of production are high. The food requirements of a family vary, depending on its size, age composition, and economic status. A recent study in an isolated village in Quintana Roo found that a family of the average size of seven members and of median economic status used 2,600 kilos of maize in a year--they ate 2,200 in various forms and fed 400 to a small collection of backyard animals (18). Milpas vary in size from small part-time operations to large fields worked with hired labor. An average family can cultivate four hectares without significant amounts of hired help, which will supply its maize requirements if the yield is 650 kilos per hectare. This figure is well within the average range for most parts of Yucatan, but the yields which any one producer obtains fluctuate between 200 and 1,200 kilos per hectares, from one year to another, depending primarily on the vagaries of the weather. In good years, he will buy poultry and swine, and sell a surplus on the market. In bad years, he will sell off his animals, and at least some members of his family will be forced to look for off-farm work, often far from the village. Many households must sell maize at the harvest to pay debts or to meet emergency needs, only to buy it back later at higher prices. In years when the weather is poor, food shortages in the months before the harvest are widespread. Government agencies organize emergency distribution programs, and CONASUPO has set up a string of rural outlets which sell basic commodities at subsidized prices.

The returns to labor from milpa production also depend on the yields. The common range is illustrated in Table 2, a budget exercise based on a model, subsistence-oriented operation of four hectares--2.5 of first-year milpa roza, and 1.5 of milpa cana. Average prices in the 1981 cropping season are used. For simplicity, it is assumed that all

TABLE 2. APPARENT ECONOMIC RETURNS TO MILPA PRODUCTION

Crop	Area[a/]	Yield per Hectare: Low Average	Yield per Hectare: Mean	Yield per Hectare: High Average	Production: Low Average	Production: Mean	Production: High Average	Price per Kilo.	Value: Low Average	Value: Mean	Value: High Average
		(kilograms)			(kilograms)			(pesos)	(p e s o s)		
Maize	4	400	700	1,000	1,600	2,800	4,000	6.50[b/]	10,400	18,000	26,000
Beans	4	10	25	55	40	100	220	25.00[c/]	1,000	2,500	5,500
Squash	4	24	36	45	96	144	180	40.00[d/]	3,840	5,760	7,200
TOTAL	4								15,250	26,260	38,700
Estimated cost of 158 days of family labor, valued at the Federal daily minimum wage of 175 pesos (US$6.75/day)[e/]									27,650	27,650	27,650
Apparent Economic Returns								(US$)	-12,400 (-475)	-1,400 (-50)	11,000 (425)

a/ This accounting exercise is based on an operation with 2.5 hectares of first-year milpa roza and 1.5 hectares of second-year milpa cana. Beans and squash are planted in limited areas within the milpa. The yields of these crops are calculated as total output over the entire area, and are much lower than the actual agronomic yields of the patches where they are planted.

b/ Both the official wholesale guarantee price and the average retail price of maize were approximately 6.50 pesos per kilo in 1981. Both prices fluctuated as much as 25 percent, depending on the location of a particular village and the time of year.

c/ The average retail price of various types of beans was 25 pesos.

d/ Squash seed is grown primarily for sale, and the wholesale price fluctuates through the year depending on supply conditions.

e/ The Federal minimum wage is adjusted periodically to account for inflation in the cost of living, and is used as a very imperfect measure of what it costs to support a family. The actual wages which a milpa producer could earn off the farm vary considerably.

of the work tasks detailed in Chart 11 are done with family labor, which is valued at the Federal minimum wage for the region. In fact, at least some hired help would be required in peak periods, and the true opportunity cost of labor varies depending on the types of employment which are available. The low, mean, and high yields are averages for central Yucatan. Rural retail prices are used for maize and beans, to indicate what it would cost to buy the food if it were not produced. Squash is grown for its dried seed, most of which is sold through middlemen at local wholesale prices. On the basis of these calculations, the apparent economic returns are negative except in unusually good years. Most peasants grow milpa crops to provide a portion of the family food supply, not in the expectation of a profit.

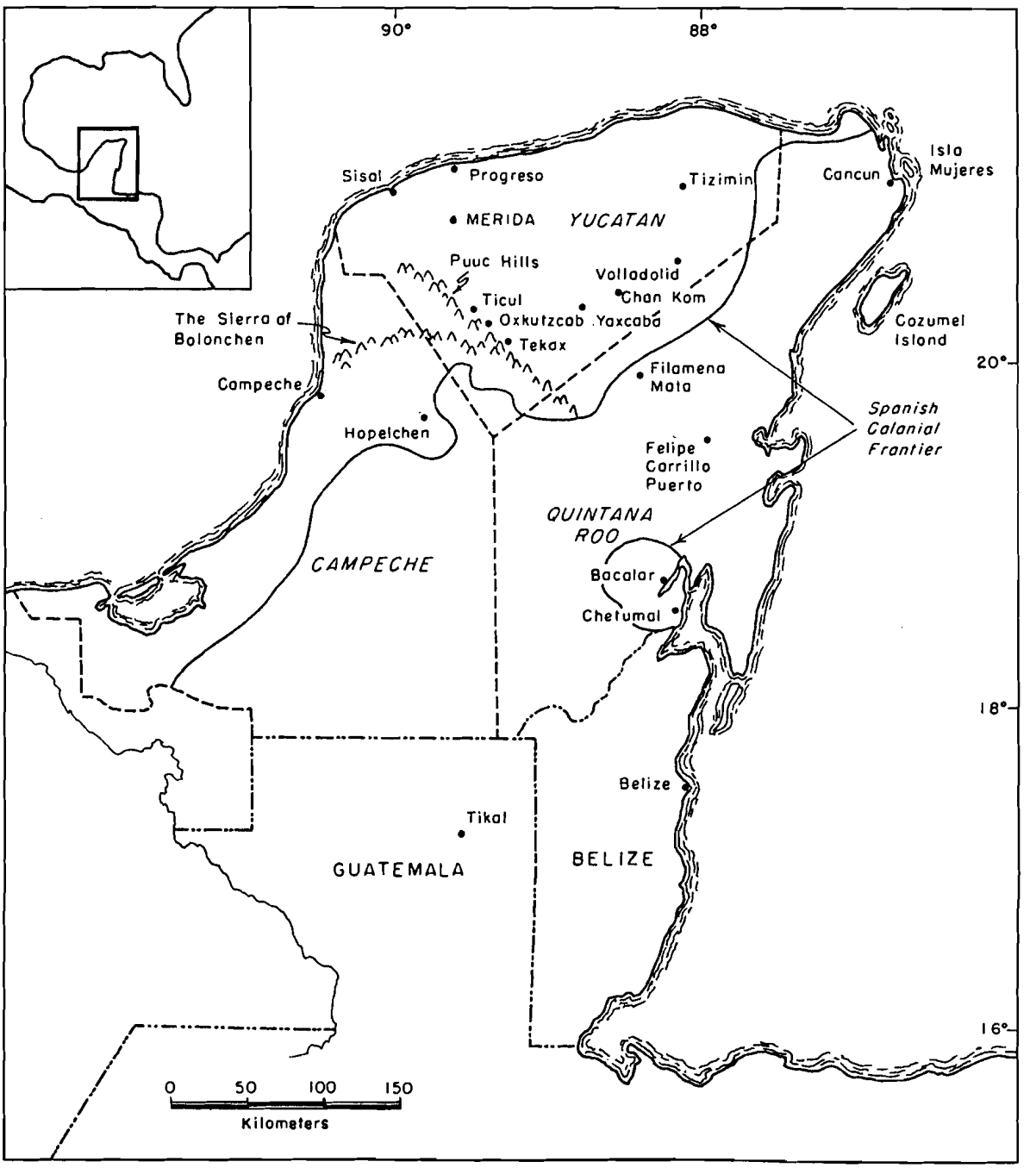
The traditional economy also provides a variety of other products to the household. Small fertile patches within the milpa are intensively cultivated with tomatoes, watermelons, and other vegetables in a system called pach-pa'kaal. Root crops, including cassava and sweet potatoes, are planted in favorable locations. These species, which were apparently introduced into Yucatan from the Caribbean islands before the Conquest, have long been relied upon as an emergency food source (39). The houses in the villages are surrounded with tree-gardens called solares. They are cultivated with short-season maize and a variety of tree crops, and this is where small animals are confined and fed (27, 286). Delicate seedlings are grown on raised platforms, called kanche (287). Deer, paca (tepisquintle), and other animals are hunted. Construction materials and other useful products are gathered in the forest.

The diversified strategies which permit peasant households to take advantage of changing economic opportunities will be discussed in a later section. The rural Maya are not desperately poor; a recent study of 18 villages reported an average total per capita food intake of between 2,300 and 2,500 calories and approximately 70 grams of protein per day (17). Nevertheless, the stability of their economy is never secure. Except in isolated corners of the region, the Maya communities have not been independent or self-sufficient since they were organized in the early years of the Spanish colony. They have been in an uncertain and difficult position between the centers of the dominant society and the fluctuating forest frontier for over 400 years. They have persisted in large measure because the milpa system on which their economy is based is adapted to the variable and patchy agroclimatic conditions of Yucatan.

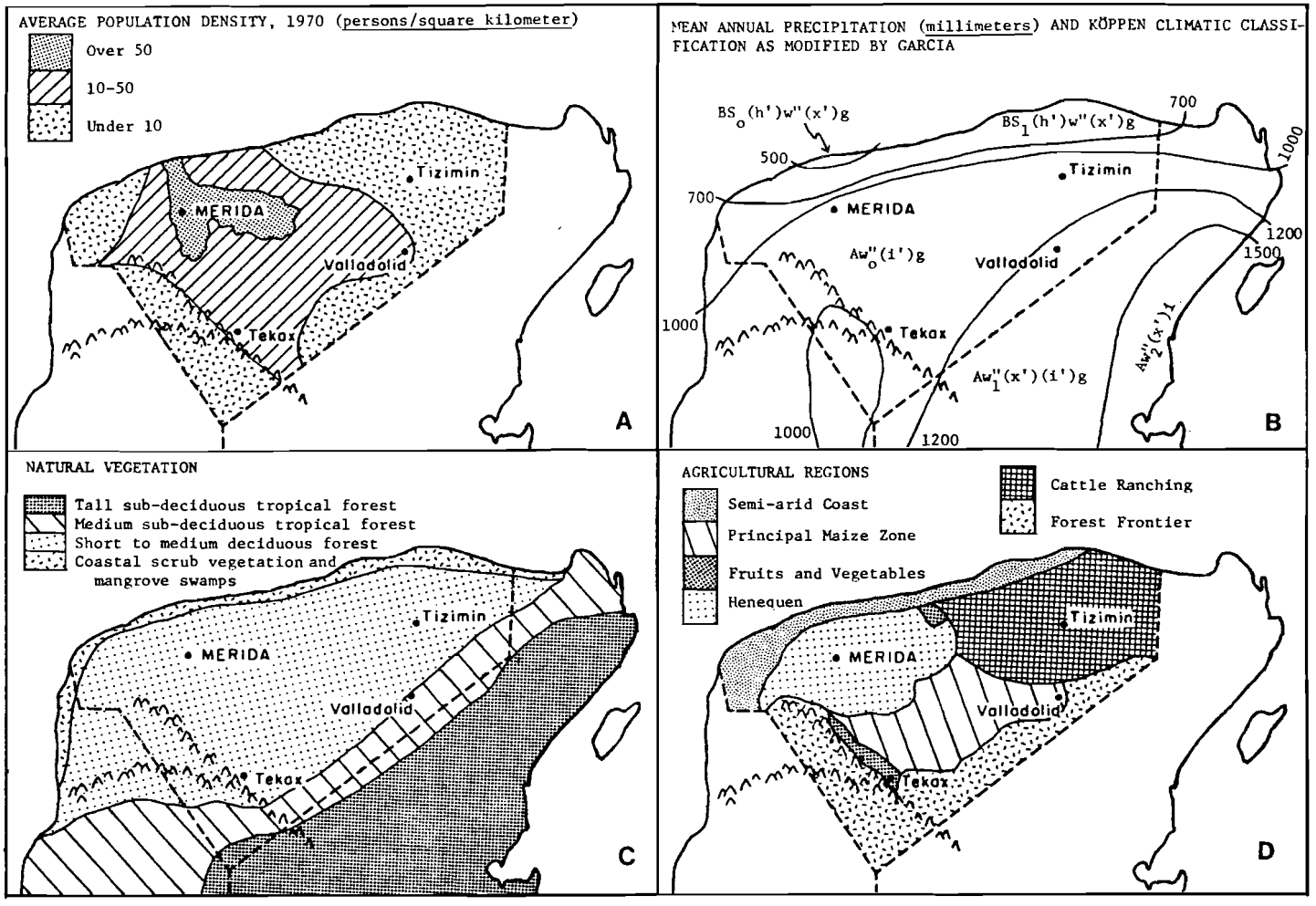
The Geographical Characteristics of Yucatan

The peninsula of Yucatan is a flat, massive limestone shelf which was slightly uplifted from the sea in relatively recent geological time, from the Pleistocene to the Eocene eras (91, 129, 301, 307). As Map 2 shows, it is administratively divided into the states of Yucatan,

MAP 2. THE PENINSULA OF YUCATAN



MAP 3. GEOGRAPHICAL CHARACTERISTICS OF YUCATAN*



*Notes and sources in Appendix Table B2.

Campeche, and Quintana Roo. Except for a strip along the coast of Campeche, and an enclave around the port of Bacalar, the boundaries of Spanish colonial control corresponded roughly to the present state of Yucatan, which is the focus of this study (102). Ever since that time, most of the region has been a sparsely settled forest. The population has been concentrated in the semi-arid northwestern corner, immediately surrounding Merida. The city has been the center, first of the Colonial administration, then of the development of the henequen industry in tightly integrated, labor-intensive plantations, and more recently of rapid urban growth.

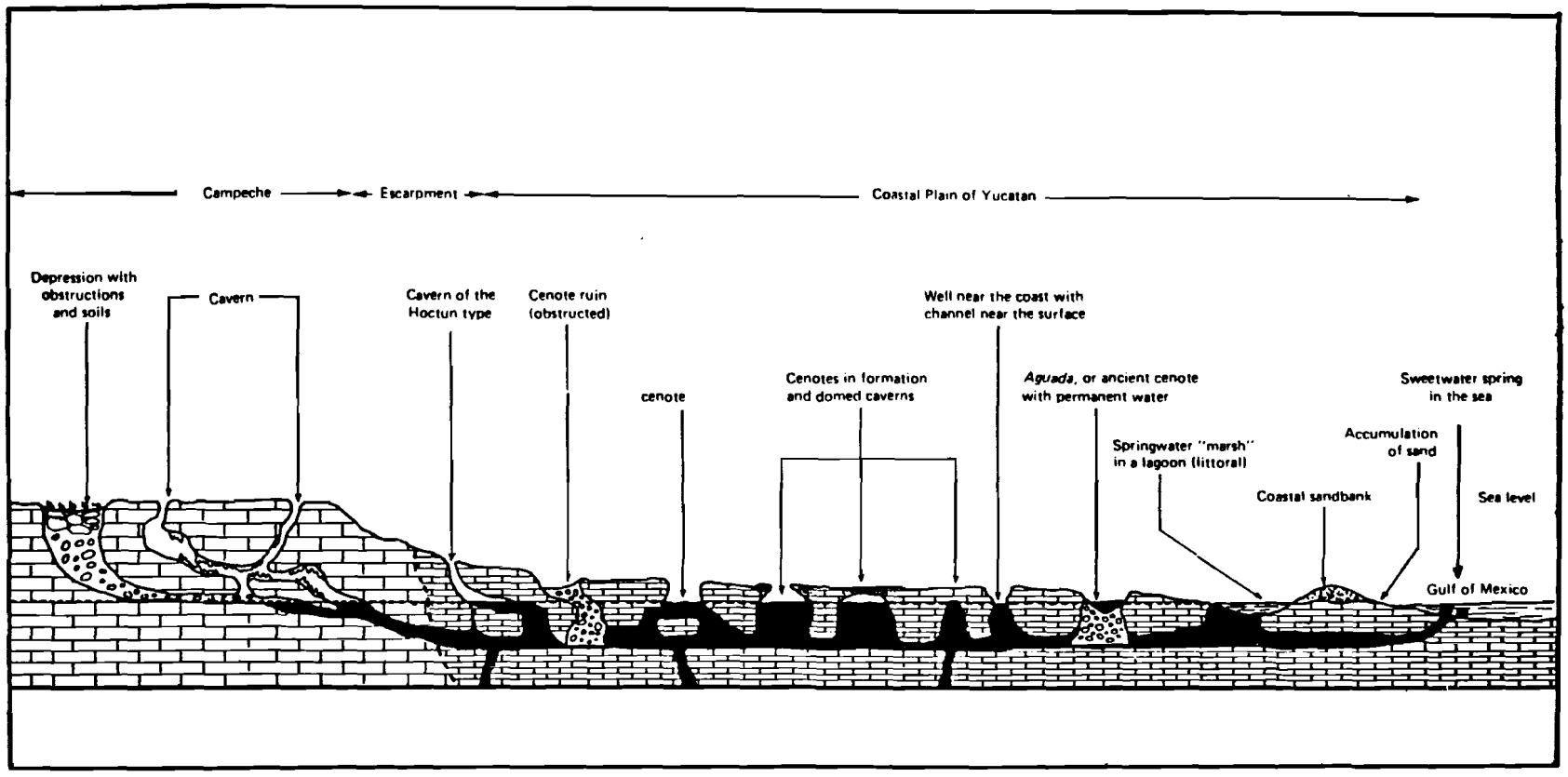
The agricultural economy of the state is marginal and poor, and Yucatan depends on other areas for a large proportion of its food supply. Maps 3A-3D show the distribution of the population, rainfall, natural vegetation, and cropping regions. These patterns, and the position and role of the Maya peasantry, will be discussed first in terms of the geographical characteristics of the peninsula, and then in terms of the history of agricultural production.

Patterns of Access to Groundwater

The distribution of the population, which is indicated in Map 3A, can be explained primarily by the distribution of points of access to groundwater. Rainfall percolates through porous limestone very rapidly. There is no surface water whatever in the state of Yucatan--no rivers, streams, or lakes. The groundwater flows from the south to the sea, as a fresh layer with a mean thickness of 70 meters floating on intruded sea water (74, 140). The precise configurations of this hydrologic system have never been mapped in detail, but Chart 13 is a schematic diagram of the principal features. Within 100 to 150 kilometers of the north coast, the landscape is a nearly level plain with an elevation of less than 30 meters, where karst weathering processes are in very early stages of development. The roofs of scattered underground caverns have collapsed, forming natural sink-holes which are called cenotes. Most of the ancient Maya ruins and contemporary villages are located at these natural water points. Hand-dug wells are practicable as far south as the base of the Puuc hills, which run in a nearly straight line from western Yucatan into Quintana Roo. Over this low range, which rises to 100 meters in an abrupt escarpment, the depth of the groundwater drops from 30 to over 150 meters within a few kilometers. Only in recent years have deep wells been drilled south of the Puuc in any numbers, and the range marks a sharp division in topography, and in the historical patterns of population density and land use.

The inland slope falls off into a chain of narrow structural valleys between the Puuc and another range of hills, the Sierra of Bolonchen. The land then rises more gently into a broken, more developed karst landscape of earlier geological origin which extends to the south for several hundred kilometers. The topography is dotted

CHART 13. THE PENINSULA OF YUCATAN: SCHEMATIC DIAGRAM OF THE DISTRIBUTION PATTERNS OF THE GROUNDWATER



Source: Alfred H. Siemens, "Karst and the Pre-Hispanic Maya in the Southern Lowlands," in Peter D. Harrison and B. L. Turner II, Eds., Pre-Hispanic Maya Agriculture (The University of New Mexico Press, Albuquerque, 1978), p. 118.

with cone-shaped hills which are called kegelkarst in the geological literature and uitz in Maya. They are interspersed with the flat beds of shallow ancient lakes which are called bajos. Although the ancient Maya developed technology to obtain water and grow crops in this region, it has been very sparsely populated since before the Conquest (114, 148, 251).

Although there are no cenotes, a few scattered sources of water can be found. Rain accumulates in surface depressions in the rocks, called sartenejas. In restricted areas, seasonally recharged perched water tables can be tapped with shallow wells, called chenes. Infiltration basins where internal drainage has become blocked, named aguadas, were improved by the ancient Maya as reservoirs which are still used. The landscape is dotted with abandoned ancient cisterns, called chaltunes (195). The relatively rainy lands along the Caribbean coast were almost entirely depopulated after the Conquest, and were never recolonized. The eastern forest frontier of the settled regions of Yucatan has fluctuated through the course of history, and does not correspond to a natural boundary.

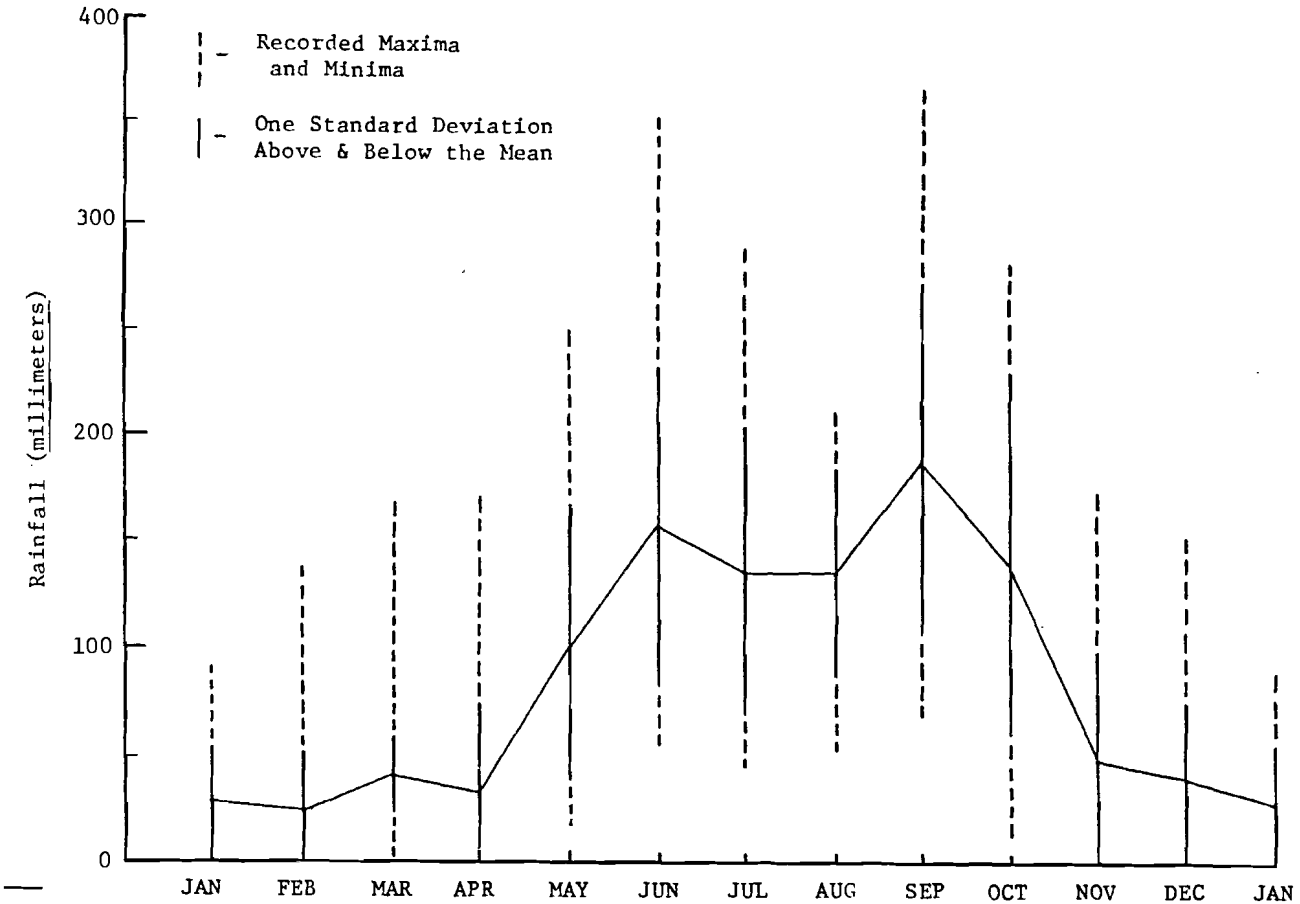
Highly Variable Rainfall Patterns

The peninsula of Yucatan is located in the inter-tropical zone (66). The prevailing trade winds move across it from the southeast to the northwest in the summer months, bringing moist, warm air from the South Atlantic and the Caribbean. The landscape presents virtually no topographical relief, so there are no structurally determined orographic zones of precipitation. Local, convectional phenomena provoke scattered downpours, and Yucatan has what is essentially a marine climate. High temperatures and humidity prevail with little diurnal variation throughout the year, but the rainfall regime is extremely variable, both from one year to another and over short distances. The agricultural cycle is controlled by a marked seasonal pattern, with a rainy season which runs from late May or early June through October, punctuated with a relatively drier period in July or August which is called the canicula in Spanish. In the Fall, cooler air from a different atmospheric system pushes down from the north, and precipitation drops off sharply. This system produces some drizzly rain, and irregular storms, called nortes, buffet the coast and extend inland. Nevertheless, most of the native tree species drop their leaves in the dry season to conserve moisture, and there is too little rainfall to support agriculture except under very special conditions.

The average annual rainfall decreases gradually and irregularly from 1,500 millimeters on the southeastern coast of Quintana Roo to 900 millimeters at the city of Merida. It then declines abruptly in a narrow, semi-arid band immediately bordering the cooler waters of the Gulf of Mexico. The duration of the dry season increases along the same gradient from three to seven months. The peninsula is located in a hurricane corridor which runs in the same direction. Intense, often

CHART 14. TEKAX, YUCATAN: MEAN MONTHLY RAINFALL DISTRIBUTION, 1949-80

(mean annual rainfall--1,087 mm.)



Source: México, Secretaría de Agricultura y Recursos Hidráulicos, Dirección Hidrográfica, (Mérida, 1949-80).

catastrophic tropical storms drop large amounts of rain at unpredictable intervals, particularly in September. The precipitation zones in Yucatan are indicated in Map 3B. It should be emphasized that the least rain falls in the areas where groundwater is the most easily accessible.

The annual weather patterns are so variable that the concept of an "average year" is misleading. Thirty-one years of continuous data from the station at Tekax are summarized in Chart 14. The shape of the mean monthly precipitation profile is typical for most parts of the peninsula. The wet and dry seasons, and the canicula, are clearly evident. The graph also shows the recorded variability in the monthly means. The solid vertical lines mark one standard deviation above and below the means, and the dashed lines extend out to the extreme values within the period of record. The probability of the rainfall achieving the mean in a given month is never as high as .5, and varies from .31 in March to .49 in September (97). These figures illustrate the uncertainty of crop production. The beginning of the rains is variable, and they fall in intense, irregular downpours. Two or three dry weeks at a critical stage of plant development can be devastating. The high precipitation in September is often associated with other micro-climatic factors which promote fungus diseases (276). Each Maya peasant adjusts his calendar of activities according to his calculations of the probability of a favorable sequence of the first rains, the mid-season drought, excess moisture in September, and other subtle factors. Nevertheless, milpa yields are uncertain and highly variable.

Patchy Associations of Shallow Soils

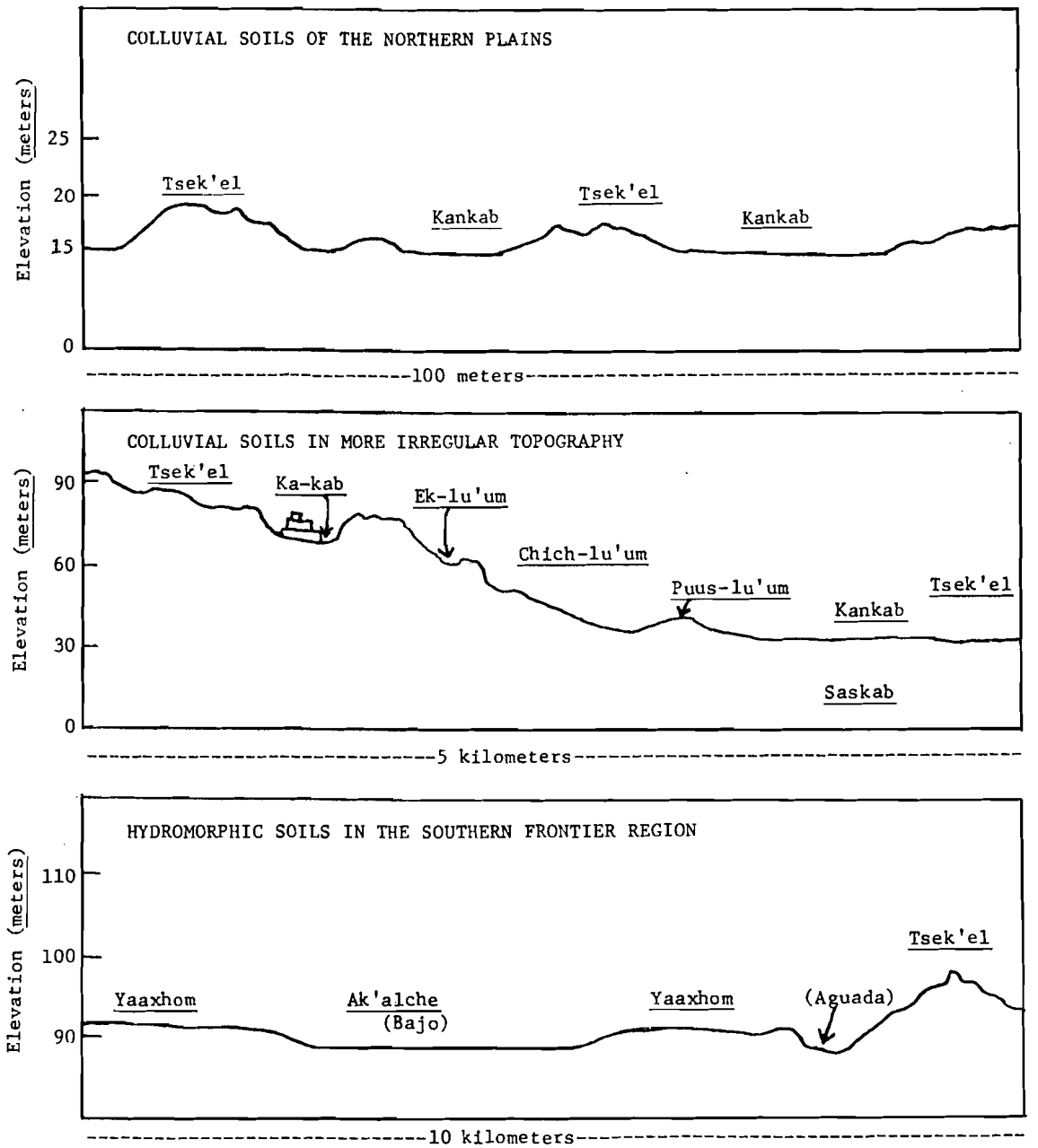
In the generally flat landscape of Yucatan, young, highly alkaline, shallow soils have been formed in complex, patchy associations controlled by the patterns of the micro-relief (1, 118, 219, 270). With the exception of a few areas in the south, they are too rocky and irregular to permit the mechanization of agriculture. They are not easily classified according to standard international taxonomies and everyone who works in Yucatan, including the government research and extension services, uses their Maya names. Summary definitions of the principal types are given in Table 3. Almost any peasant can identify soils in far more detail, using a variety of modifiers and specialized words. The indigenous terms are not absolutely consistent definitions of unvarying chemical or morphological characteristics, but they are precise relative descriptions of how soils with different capacities are distributed in the landscape.

Significant soil variations over very short distances are critical to the milpa system, and the Maya are very sensitive to various indicators of natural fertility, including the composition of the secondary vegetation of a plot which has been left in fallow, and to the presence of indicator plants, particularly the viney species which are their most troublesome weeds. In the northern plain, where milpa

TABLE 3. YUCATAN: MAYA TERMS FOR THE PRINCIPAL SOIL TYPES

Maya Soil Name	Approximate Modern Equivalent	Definition
Parent Material		
Chaltun	Limestone Rock	The surface limestone plate, which has undergone chemical changes and hardened since the Yucatan peninsula was uplifted from the sea. The term also refers to rock outcrops with no soil formation.
Saskab	Calcareous material	A weathering from of soft, unconsolidated calcareous material underneath the Chaltun, which is usually found within a few meters of the surface. It has been used as an aggregate for concrete since ancient times.
Colluvial Soils		
Tsek'el	Lithosols	The term refers both to the rocky hummocks which dot the landscape, and to the soils which are found on them. Soils high in organic matter, intermixed with small limestone fragments, have accumulated in the rocks and fissures.
Kankab	Alfisols or Ultisols	Red, deep, relatively stone-free soils which have accumulated in basins and depressions. Small areas are found in a patchwork associations with Tsek'el in the northern plain; large extensions of several hundred hectares are found south of the Puuc hills. They are high in kaolinite clays and in iron and aluminum oxides, and tend to be deficient in phosphorus.
Ek-lu'um	-	The Maya word means "black soil." They are formed from accumulations of litter and other organic material. They are found in tiny pockets within Tsek'el, or in small basins in more irregular topography.
Ka-kab	-	Soils found surrounding ancient ruins, or in other areas which were cultivated for long periods in the past.
Chich-lu'um	Entisols	Soils found toward the lower end of slopes. The surface is covered with a layer of small stones, which retard evaporation but complicate management. The soils are suitable for the cultivation of tree crops.
Puus-lu'um	-	The term is associated with swelling micro-landforms at the base of slopes. The soils are well-drained, relatively free of stones, and fertile.
Hydromorphic Soils		
Ak'alche	Humic Gley Soils, or Histosols	Soils formed in the beds of shallow lakes which were flooded seasonally over very long periods. A thin, black layer high in organic matter overlies a deep layer of almost completely reduced gley.
Yaaxhom	-	Soils formed of water-carried materials in areas which have not been subject to prolonged flooding. They have a high water-holding capacity and have high agronomic potential.

CHART 15. YUCATAN: GENERALIZED DIAGRAM OF THE LOCATION OF THE PREDOMINANT SOIL TYPES IN THE MICRO-LANDFORMS OF THREE REGIONS



production is the most concentrated, the micro-relief is a patchy association of stoney hummocks and flat depressions. As is indicated schematically in the top panel of Chart 15 the soil in amongst the rocks of the hummocks is Tsek'el; the depressions are filled with an entirely different red soil called Kankab. A single milpa plot of three or four hectares is a patchwork of both types, and the combinations and density of the crops as well as other management factors are adjusted in response to the differences (228). Extensions of Kankab as large as several hundred hectares south of the Puuc hills have been cleared for mechanization in recent years.

The more complex associations which are found in irregular topography, particularly along the margins of the Puuc, are illustrated in the center panel. Small basins are filled with Ek-lu'um, which is rich in organic matter and very fertile. Soils surrounding ancient ruins, or in any area which was intensively cultivated in the distant past, are called Ka-kab. Soil studies in the sites of ruins have demonstrated that ancient agricultural practices accumulated organic matter and increased the concentration of phosphorus, a chronically limiting nutrient in Yucatan (199). The contemporary peasants have great respect for their ancestors, and seek out these soils for their fertility and for the spiritual goodness with which they are permeated (111). Colluvial soils at the lower end of slopes are called Chich-lu'um and Puus-lu'um.

Hydromorphic soils have been formed in and around the bajos and infiltration basins in the southern frontier, as illustrated in the bottom panel of Chart 15. Ak'alche consist of a thin, black A_1 horizon overlying almost completely reduced gley. The ancient Mayas constructed ridged fields in some areas which permitted their cultivation but they are seldom used by the contemporary peasants (280, 281). Recent government projects which have attempted to introduce mechanized rice and maize production into the bajos have encountered serious difficulties (9). Better-drained soils surrounding wet patches are called Yaaxhom. They have good water-holding capacity and are fertile. The word means "green earth," which refers not to the color of the soil itself, which is reddish-brown, but to the fact that the natural vegetation does not lose its leaves in the dry season.

Like indigenous systems elsewhere in Mexico, the Maya terminology classifies soils according to their use-characteristics, including the natural vegetation which they support, as well as their physical properties (305, 306). Various attempts have been made to develop a synthetic system as a basis for mapping relatively large areas according to their agronomic potential, but the results are ambiguous and very general (92, 313). A more promising approach is to use the Maya terms as a first approximation, and then carry out a series of field response trials and soil tests to understand the variations within the types (228).

Fertilizers are only just beginning to be used in Yucatan. Milpas are scattered over too wide an area to make the transport of animal wastes practicable, and the peasants depend on the fallow rotations to maintain fertility. Recent programs designed to help them adjust their practices to declining fallow periods have demonstrated a very definite response to fertilizer, but the results are highly variable over short distances. Very few detailed agronomic experiments have been done, and major investments have been wasted because the soils have not been appropriate for cropping systems and management practices which have been introduced.

Patterns of Primary and Secondary Vegetation

As a fallow rotation system, the milpa depends on the characteristics of the secondary regrowth. With the exceptions of scattered patches of savannah in the south, and a band of xerophytic scrub and mangrove swamps along the coast, the region is forested (Map 3C). As a peninsula with natural conditions distinct from neighboring areas, Yucatan supports a relatively specialized flora. Approximately 17 percent of the recorded species are endemic, and a larger proportion are also found in the West Indies, but not in other parts of Mexico (187, pp. 218-219; 214, p. 15). Primary sub-deciduous associations survive in the southern and eastern frontiers, although they have been significantly modified by centuries of human use. Primary species recolonize scattered milpas left in fallow. The campesinos cut the trees at waist height, which encourages resprouting after the burn, and leave a few individuals standing. The chicle industry, which tapped Zapote trees (Malinikara zapota L.) for the raw material of chewing gum in the first half of this century, affected the forest relatively little (187, pp. 255-256). Only in the past 15 to 20 years has extensive clearing for the expansion of private cattle ranches, and for the establishment of ejidal colonization projects, threatened the survival of the primary forest. It is widely believed that these disturbances have provoked climatic perturbations on a local and regional scale, although the problem has not yet been studied in detail.

The forest in the drier, more populous northwestern regions has been drastically altered. Extensive clearings for henequen plantations, firewood and charcoal production, and repeated cycles of milpa and pasture have all but erased the identity of the original deciduous associations except in isolated patches. They have been succeeded by complex patterns of secondary vegetation, which are carefully observed by the Maya peasants as indicators of areas which may be recleared for planting. There is a detailed Maya terminology for the different stages of secondary succession (270, p. 239). Miranda notes that aggressive, thorny, leguminous tree and shrub species have become prominent. They are well adapted to the colonization of abandoned fields under the special edaphic and climatic conditions of the region, and many are endemic to Yucatan (187, p. 257). Illsley and Hernandez X. report significant micro-variations in the successional sequences,

controlled primarily by the underlying soil associations (124, p. 363). A small commercial timber industry in the northeastern part of the state had virtually exhausted the resource by the 1960's (292, pp. 309-318). Forest products, including precious hardwoods and railroad ties, are important enterprises in areas with higher rainfall in southern Quintana Roo and Campeche (172; 177, pp. 149-159).

Regions of Agricultural Production

The principal agricultural regions of the state are indicated in Map 3D. Over 95 percent of the cropped area is planted with just two crops; henequen and maize (151, p. 27). The henequen industry is concentrated within 80 kilometers of Merida. The crop is one of several Agave species which are native to the peninsula, and which produce the hard fiber which is known as sisal in world trade, after one of the local ports. It is adapted to the semi-arid climate and the thin Tsek'el soils. The plant grows very slowly and requires seven years to come into production. Then the thick, fibrous leaves are cut at regular intervals for 14 to 16 years, after which the stand is allowed to revert to fallow. The cultural practices are very similar to those of the milpa, but the crop is grown in concentrated plantations because the heavy leaves must be transported quickly to decortication plants where the fiber is extracted.

Henequen became a major export crop as the raw material for binder twine after the invention of the mechanical reaper by Cyrus McCormick in 1875, which revolutionized agriculture in the great plains of the United States. At the beginning of the 20th Century, Yucatan was briefly one of the richest states in Mexico, as it was virtually the world's sole supplier. Large numbers of Maya peasants were drawn into the plantations as very poorly paid field workers through a system of debt-peonage. The effects of this process on the peasant economy will be discussed in a later section.

Since the boom peaked during the First World War, the integrated production and processing industry has been in protracted decline. Yucatan's share of the world sisal market fell from 100 percent in 1901 to 53 percent in 1929 to about 18 percent in 1981 (79, p. 49; 65, p. 165). Both the area in production and the average yield have decreased significantly. Well over half of the land in production was

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3/ There are two principal species. Agave sisalana, which is called Ya'axki in Maya, is true sisal. It has been established in East Africa, Brazil, Haiti, and in other parts of the world. Most of the commercial crop in Yucatan is Agave fourcroydes, Sak-ki in Maya, because it is adapted to drier conditions. Its fiber is slightly inferior. Although it is also commonly called "sisal," it is correctly identified as "henequen" in the specialized crop and trade literature (231, pp. 11-29; 65).

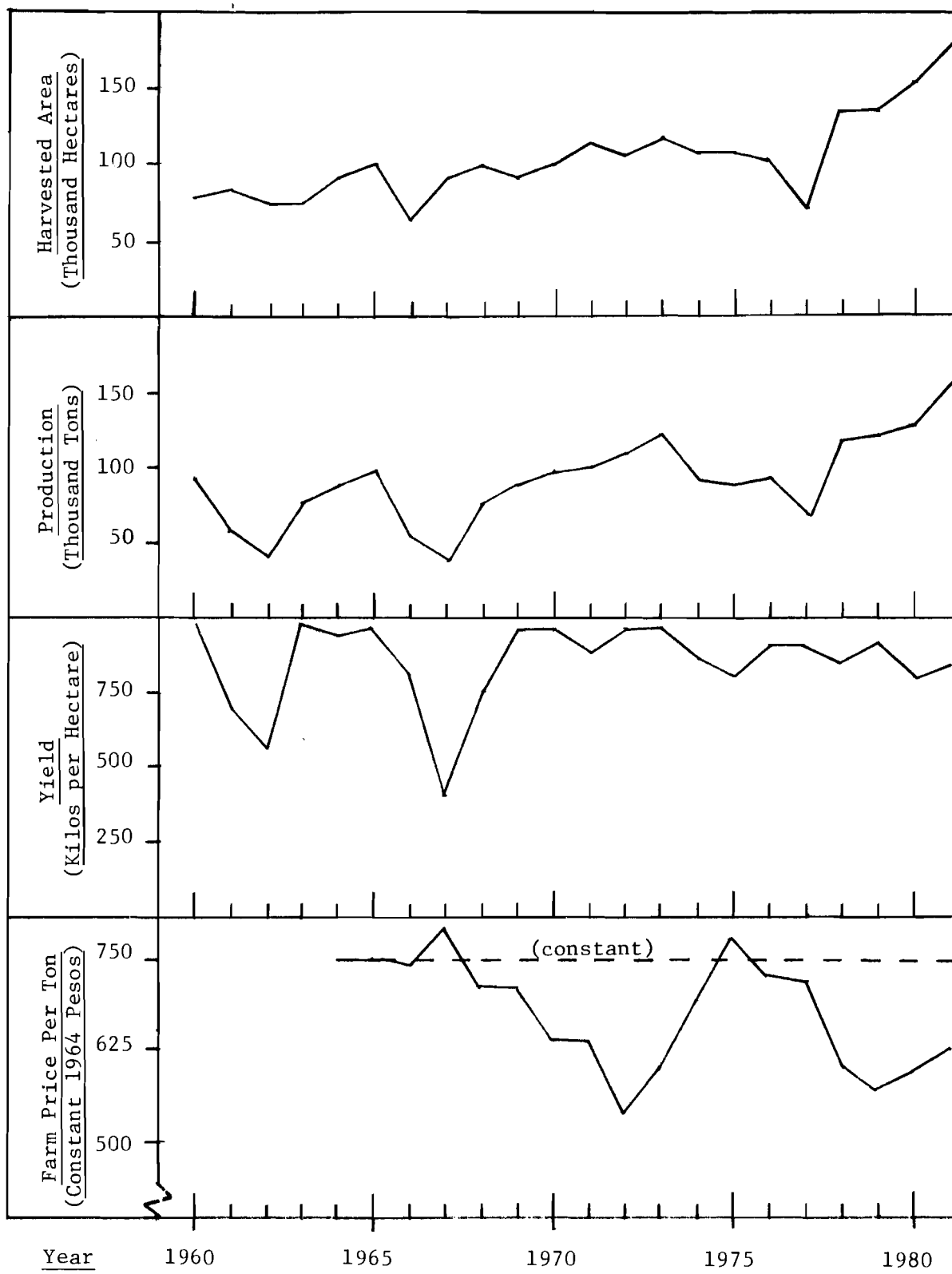
expropriated and reorganized into collective ejidos in 1937 (34, 45). Today, between 60 and 70 thousand ejidatarios are partially supported through a system of institutionalized underemployment. They have a guaranteed right to two or three days of work a week, in return for a credit advance which is substantially less than the Federal minimum wage (22, 100). Private farms and independent ejidal parcels produce approximately 38 percent of the raw material, but most of the output is channeled through CORDEMEX, the nationalized processing and marketing industry (180).

Except in a narrow arid strip along the coast, maize is grown throughout the state. There are a few thousand hectares of mechanized production in the south, but almost all of the output is produced in traditional milpas, where it is intercropped with beans, squash, and other crops on a smaller scale. Honey is also widely produced for export in the peasant sector. It was estimated in 1982 that between 35 and 40 thousand families were engaged in milpa cultivation (207). Assuming an average household of five or six persons, this means that the total population of peasants was something over 200,000. Almost all of them are Maya speakers who are strongly identified with the traditional culture. Their communities are the most heavily concentrated in the central region, to the southeast of the capital. There are not as many water points in the eastern and southern frontiers where the villages, many of which were established as ejidos in the 1920's, are more sparsely distributed.

The history of maize production since 1960 is shown in Chart 16. The accuracy of the statistics on which the graphs are based is questionable, as both the total area of the highly dispersed milpas and the volume of food consumed in rural households are chronically underreported. Except in a few years with disastrous droughts or hurricanes, the state average yield fluctuated between 700 and 1,000 kilos per hectare, among the very lowest in Mexico. Up through the mid-1970's, the area harvested increased unevenly at an average rate of between 1 and 2 percent per year--less than the growth rate of the rural population. The price received by producers in isolated villages was often well below the reported average figure, and its value in real terms relative to the cost of living deteriorated. There was less and less incentive to produce a surplus beyond family food requirements if alternative sources of income could be found. Large-scale commercial milpas worked with hired labor were gradually abandoned as unprofitable. Prices were increased at the end of the decade as part of a national campaign to increase food production. The total area in maize exceeded that in henequen in 1980 for the first time in over a century. In 1981, a record 156,000 tons were produced on 183,000 hectares. In the same year, 140,000 tons of maize and 275,000 tons of other grains were shipped into Yucatan (180).

A private ranching sector has grown rapidly. As the old haciendas in the center of the state lost their land and their labor force to the agrarian reform, the center of cattle production moved into what

CHART 16. YUCATAN: MAIZE PRODUCTION, 1960-1981



Source: Appendix Table B3.

had been a sparsely populated forest and commercial timber region in the northeast (278). Peasant fruit production in small peasant parcels for the regional fresh market is concentrated in a strip along the margins of the Puuc hills, centered on the market town of Oxkutzcab. Vegetables are produced in the same region, as well as in a small area around Dzidzantun, in the eastern henequen zone. The relative importance of the principal products is shown in Chart 17.

A Brief History of Peasant Agriculture

Milpa agriculture is a traditional system with roots which extend back to before the Spanish conquest. It is not true, however, that the Maya communities have lived in primitive isolation until only recently. Their history has been one of constant struggle to maintain subsistence security in a fluctuating position between the dominant economy and the forest frontier. Changes have been relatively slow, and their outlines can be traced over a long period.

Pre-Hispanic Maya Agriculture

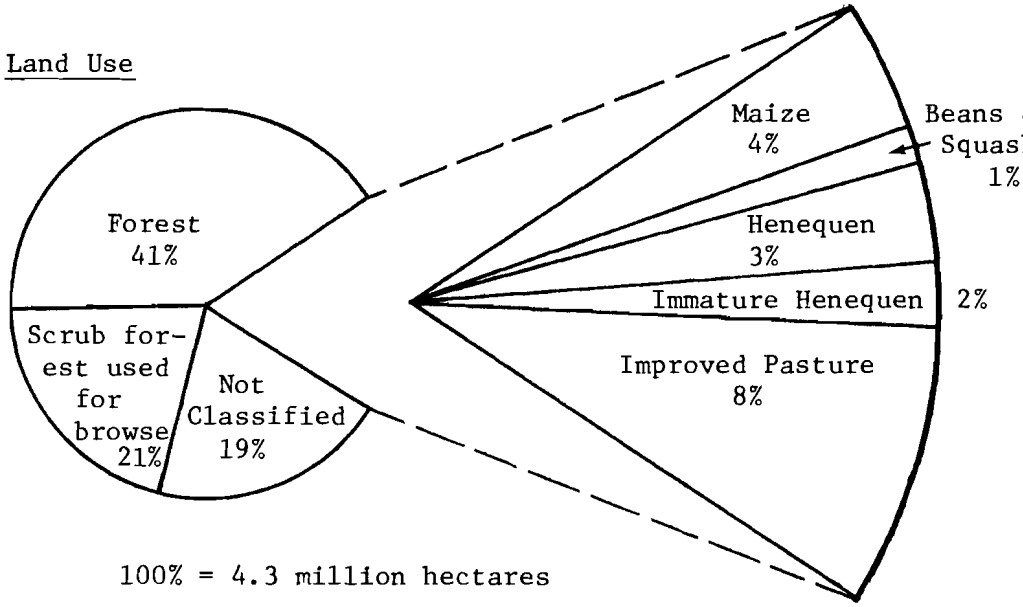
One of the great puzzles of Meso-American archeology is how the classic Maya civilization flourished between the third and the tenth centuries A.D. in what is now a sparsely populated forest frontier, and why it ultimately collapsed. The center of this culture was Tikal, in the rainy lowlands of the Peten in present-day Guatemala, but the northern part of the Yucatan peninsula was also an important area. From the Puuc hills to the south for nearly 100 kilometers there are as many as 2,000 ruined cities, towns, temple complexes, roads, and other structures built in an elaborate architectural style (227). These people developed hieroglyphic writing, a literature, a numerical system which included the concept of zero, and an accurate calendar based on careful astronomical observation (63).

It was long assumed that the population was supported by a dispersed slash-and-burn agriculture very like the contemporary milpa (191). A common hypothesis was that the culture suffered an ecological collapse; that the population exceeded the carrying capacity of the naturally infertile soils, perhaps during a period of extended drought (279). Recent excavations and aerial surveys are discovering increasing evidence of sophisticated hydrological and intensive agricultural systems which allowed the Maya to make use of the diverse resources of the region. These include irrigation, raised fields, reservoirs, cisterns, and other types of infrastructure, as well as sophisticated agro-silviculture and multiple cropping techniques (29, 114, 148, 195).

The factors which contributed to the decline of this culture have not been unravelled in detail, but Uxmal and the other cities south of the Puuc hills were abandoned over 500 years before the arrival of the

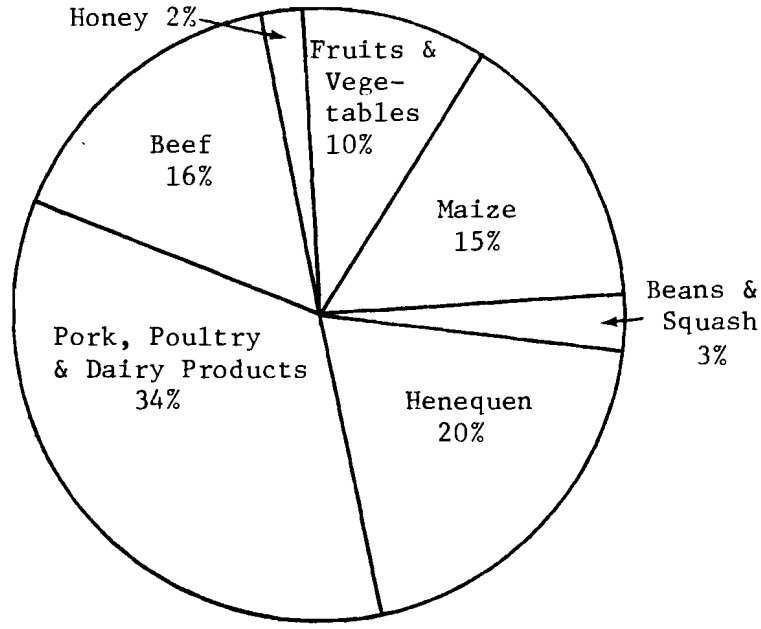
CHART 17. YUCATAN: LAND USE, 1981, AND FARM VALUE OF AGRICULTURAL PRODUCTION, 1981

Land Use



100% = 4.3 million hectares

Value of Agricultural Production



100% = 6.9 million pesos

Source: Appendix Table B4.

first Europeans. The culture of the Late Maya was influenced by Toltec invaders from Central Mexico. They continued to live in large centers, build impressive temple complexes, and evolved a complex network of coastal trade (253). The Spanish conquered Yucatan in 1546, finally crushing a loose confederation of Maya states which had resisted fiercely for 18 years (251). They established direct administrative control over the northwestern part of the peninsula, where groundwater was readily available. The survivors of the war and of catastrophic diseases which drastically reduced the population, were forced into villages dominated by a church (67, p. 23; 102, p. 28). Although the empirical knowledge of the environment and some of the pre-conquest agricultural practices were preserved, the Maya peasant economy was radically reorganized around the needs of the colonial economy. As Chart 18 shows, the population of the Yucatan peninsula did not re-achieve its pre-Conquest level until the 1950's.

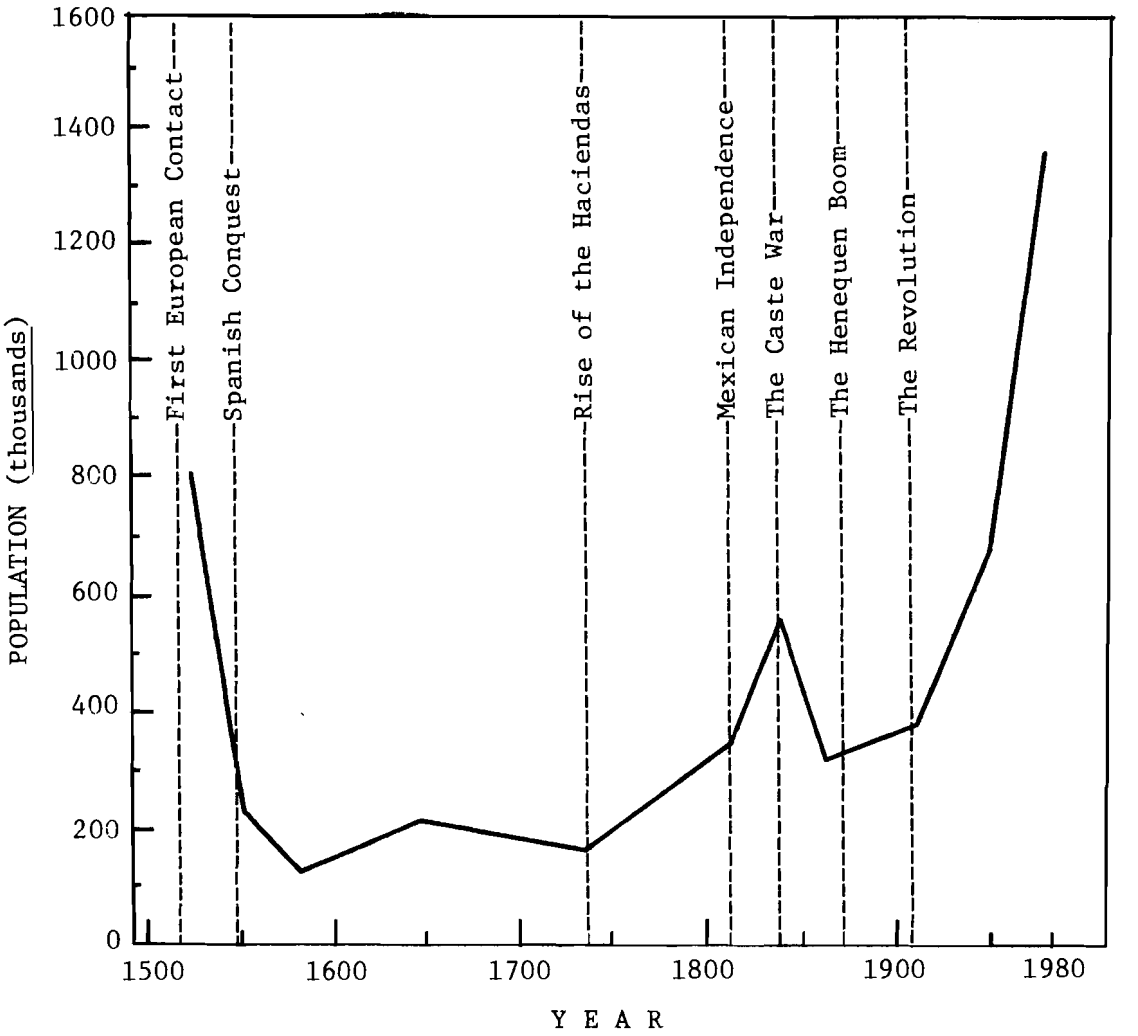
The Colonial Economy

The conquistadores were granted licenses to collect tribute from the Indians in designated areas called encomiendas. The peasant communities were administered by a class of Maya chiefs, who were granted a degree of autonomy in return for the regular delivery of maize, cotton cloth, and other specific commodities as tribute (98; 209, Chap. 2). The common people were allowed to continue to practice their traditional milpa agriculture, and in fact attempts to introduce new crops and production systems were unsuccessful (251). The Maya were legally organized into "The Republic of the Indians" and were governed through a set of laws different from those which applied to the Spanish, the mestizos, or mixed-blood people, the black slaves, the Indian laborers imported from central Mexico, and other explicitly recognized groups in the caste structure of the colonial society.

The Indians were formally protected against slavery and other abuses, but the Crown and the Church hierarchy enforced these laws only erratically, as they conflicted with the interests of the Spanish elite. The institutions which were created in this context have had an important effect on the organization of peasant society ever since. The vast forest lands beyond the pale of Spanish control provided a sanctuary for Indians who could escape, where they lived in small villages. These outlaw settlements were periodically raided by Spanish military expeditions to bring the fugitives back to peasant communities subject to tribute (67, p. 117; 209, p. 153). A fluctuating border zone was administered by the "secular" priests, who did not belong to the dominant Franciscan order which monopolized the most lucrative sources of tribute, particularly in the Puuc region (209, pp. 175-182).

The Spanish population lived in the cities on the proceeds of the tribute and their commercial activities. They were not directly involved in agriculture at all, and the urban food supply was provided by the Maya peasants from their slash-and-burn milpas. Droughts and

CHART 18. THE PENINSULA OF YUCATAN: ESTIMATES OF POPULATION, 1517-1980



Source: Sherburne F. Cook and Woodrow Borah, "The Population of Yucatan, 1517-1960," Essays in Population History: Mexico and the Caribbean (University of California Press, Berkeley, 1974), Vol. 2, p. 122. Figures for 1970 and 1980 are taken from the Mexican national population census for those years.

locust plagues periodically provoked severe famines throughout the province (189). The encomienda was abolished in most parts of Spanish America by the end of the 17th Century, but it survived in Yucatan until 1785 because the local ruling class had no economic alternatives (144, p. 60). Yucatan was a provincial backwater and the hacienda, or landed estate, did not become an important institution until the late 18th Century, when restrictions on direct trade with Cuba and Spain were relaxed (216). At that time, large areas and significant numbers of workers were organized into cattle haciendas to produce hides, tallow, honey, and beeswax for export. Food supplies to the cities were disrupted, and the province was forced to import grain from the United States in critical years (209, p. 207).

The haciendas expanded rapidly and developed a symbiotic, if asymmetrical relationship with the peasant communities, which continued to base their economy on the production of food. The estates secured a core permanent labor force by granting land rent-free to Maya families on which they could supplement their wages by producing maize. Additional labor supplies were obtained in peak periods from associated, but independent villages through a system of part-time corvee labor and a variety of other mechanisms. The villages often depended on the haciendas for access to water points (272, p. 46). They were organized around communal land ownership and subsistence agriculture, but they sold food, firewood, charcoal, and other commercial products to the haciendas and to buyers from the cities. The Puuc region produced an important maize surplus, and roads were built to Merida to facilitate transport (209, p. 310). The members of the free communities were burdened with tithes, taxes and forms of outright extortion, and many chose the relatively secure life on the haciendas after a crop failure or other catastrophe. After 200 years of stagnation, both the level of economic activity and the size of the population grew rapidly (Chart 18). The expansion of the hacienda system was a dramatic change, but it was limited to the historical area of Spanish domination, and to some degree preserved the independence of the peasant communities.

The Expansion of Commercial Agriculture and the Caste War

Independence from Spain in 1821 had two major effects on the organization of the rural economy. The abolition of trade restrictions, both within the ex-colony of Mexico and with other countries, opened up markets which fostered the development of new crops. This trend was reinforced by the industrial revolution, as new production and processing technology made commercial agriculture feasible in what had been marginal areas. The other effect was ideological and institutional. Among other reforms, the Liberals wanted to abolish traditional tenure arrangements and social labor obligations and promote the free, individual ownership of agricultural land. This was one of the major issues of the Independence movement, and was reflected in the short-lived Spanish reform constitution of Cadiz of 1812 (216). Polemical arguments raged back and forth until the Liberal ideology was

formally incorporated into the Mexican constitution of 1857. Vast holdings were taken away from the Church, but the Reform movement also removed all protection from the peasant communities. Liberalism was a major political issue in Yucatan from the late 18th Century (192, pp. 107-111).

After Independence, both the old hacendados and a new class of landowners rapidly expanded their holdings by declaring undocumented land "idle" and through other mechanisms (210). In the period between 1821 and 1847, the production of sugar cane and other crops, including tobacco and cotton, expanded into the frontier in eastern and southern Yucatan, where the agroclimatic conditions were relatively favorable (52, 60, 61, 273). This process provoked a significant change in the relationship between the Maya peasant communities and the dominant economy.

> The colonial economy rested on Maya labor and effort, but it more or less accepted the fact that the Indians be permitted to go their own way, as long as the tribute goods appeared at the designated time. . . . The newer doctrines [regarded] the natives as a human tool, as part of a disciplined labor force necessary for the operation of large-scale commercial enterprises (62, p. 41).

The increasing demand for labor, particularly in the peak season of the sugar production cycle, conflicted with the seasonal labor requirements of the milpa and broke down the symbiotic relationship which had existed between the peasant communities and the extensive, cattle-maize haciendas. The small-scale processing technology and the patchy, irregular agronomic characteristics of the frontier lands did not lend themselves to large, continuous plantations, but the competition for the best lands and particularly for labor destabilized the peasant economy. The southern Puuc region, which had produced major maize surpluses since the Conquest, suffered severe shortages and was forced to bring in food at high cost from other regions (58, p. 62). In an ideological response to this problem, contemporary economists attacked milpa agriculture, which had supported the colonial economy, as an inefficient and primitive means of production (272, p. 50). John Stevens, an American who traveled extensively in Yucatan in 1842 to visit the Maya ruins, gives an interesting narrative account of the changing social conditions in this period (271).

The pressure on labor and land resources, combined with an attempt to control and tax the Maya communities in what had been loosely administered border areas, provoked the bloody rebellion which is known as the Caste War in 1847. The rebels, many of whom had been armed and trained to participate in a series of civil skirmishes between the Mexican central government and various Federalist factions in Yucatan, massacred the white population of entire regions (107, 238). In 1848 they controlled 80 percent of the peninsula, and came to

within 17 miles of the city of Merida before the tide was turned (238, p. 93). The Maya peons on the haciendas in the northwest and the associated villagers generally remained loyal to their masters.

The government reestablished control as far south as the Puuc hills, but the region beyond, which had been the center of the sugar industry, was almost entirely depopulated (239). The eastern frontier also advanced considerably. Cook and Borah estimate that the population of the peninsula had been approximately 580,000 in 1838. Of this number, 120,000 or 20 percent, were killed or emigrated; 100,000, or 17 percent, fled into the interior; and 363,000, or 62 percent, remained under the effective administration of Merida in the early 1860's (67, p. 128). Small rebel bands scattered into the frontier, and their settlements in Quintana Roo were not reconquered until 1901 (238, p. 240; 290, pp. 115-122).

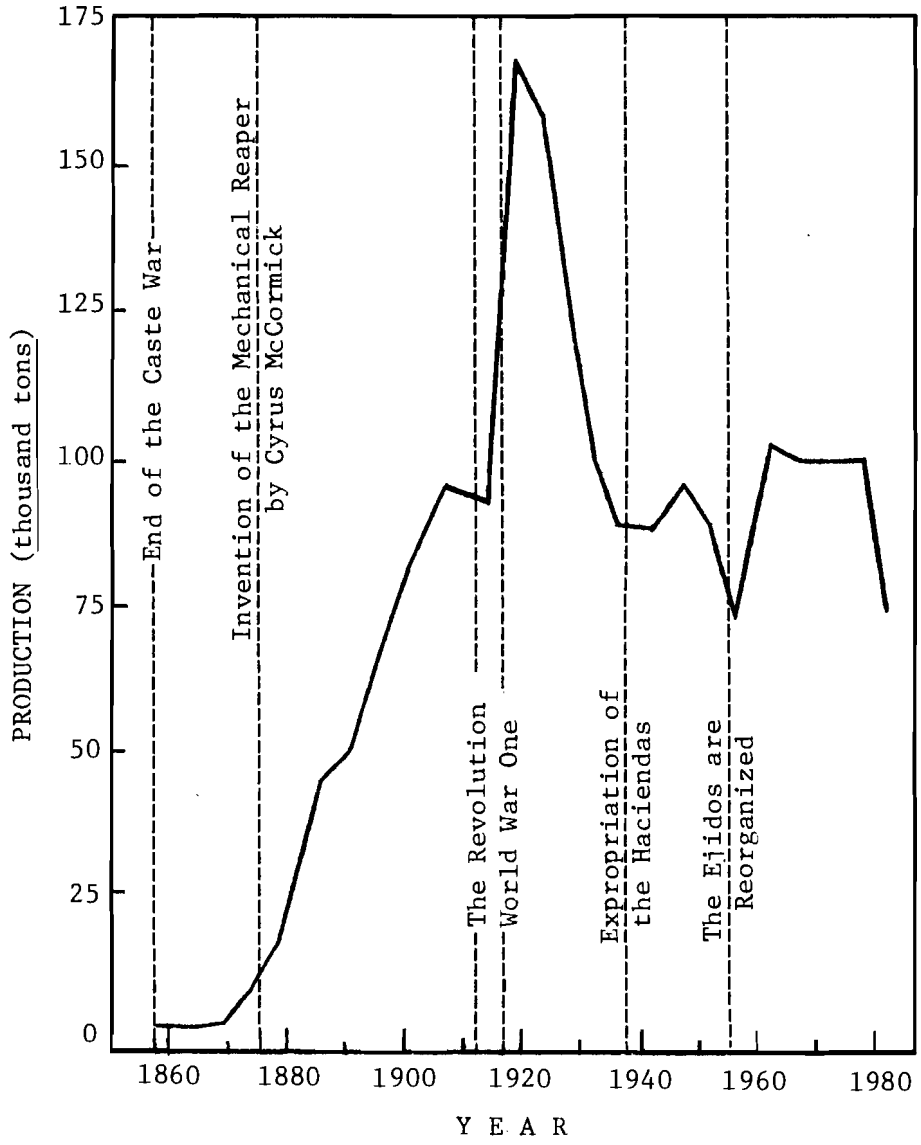
The Henequen Boom

In the last third of the 19th Century, the state's economy was reconsolidated and dramatically expanded in the secure northwestern corner surrounding Merida on the basis of the rapid development of henequen plantations. This crop, and the highly distorted social structure which was the result of its monoculture in plantations, have dominated agriculture in Yucatan ever since. It was produced on a small scale as a cottage industry throughout the colonial period to make ropes, hammocks, and similar items (273, vol. 1, p. 130). A modest export trade developed in the early 1800's; in 1847, just before the Caste War, 1,250 tons were shipped (272, p. 53). The subsequent history of the volume of its production is illustrated in Chart 19.

A few American companies, dominated by the International Harvester Trust, controlled the market and the price. Along with a consortium of American banks, they also supplied the capital to develop the industry, but production remained in the hands of Yucatan's ruling class. It is a great source of regional pride that the mechanical decortication equipment on which the development of large-scale plantations depended was invested by Yucatecos (34, pp. 62-70). The cattle-maize haciendas, which had been well established in the area surrounding the city of Merida since the 18th Century, were rapidly reorganized into plantations (209, Chap. 6). The Maya population was forcibly concentrated into this secure region (127). In a terminology unique to Yucatan, the "pacified" Maya became known as mestizos, a word which is used to designate the aculturated, mixed-blood population elsewhere in Latin America, to differentiate them from the "barbarian Indians" of the frontier. The word "Indian" is now seldom used in Yucatan (132).

Larger and larger factories were linked to the fields with tram lines, and railroads were built to take the fiber to the port of Progreso. A small group of families, who came to be known as "the

CHART 19. YUCATAN: PRODUCTION OF HENEQUEN FIBER, 1860-1980



Source: 1860-1900: Roland E. P. Chardon, "Geographical Aspects of Plantation Agriculture in Yucatan" (Publication #876, National Research Council, National Academy of Sciences, Washington, D.C., 1961), p. 29. 1900-1975: Juan Méndez Góngora, "Analisis Agropecuario y Forestal del Estado de Yucatán," Econotecnia Agricola (Mexico City), Vol. 3, No. 8, 1979, pp. 34-36. 1980: México, Secretaría de Programación y Presupuesto, "Informe Económico 1981: Yucatán" (mimeograph, Mérida, México, 1982).

divine caste" dominated the trade through their exclusive marketing arrangements with the American monopoly, and dedicated themselves to building palaces and civic improvements. Merida, with its paved, electrically lighted streets, tram lines, and elegant homes was known as "the white city," the cleanest and most beautiful in Mexico at the turn of the century.

The rapidly increasing demand for labor, and the expansion of the area in henequen, destroyed the symbiotic balance which had existed between commercial agriculture and peasant food production. Due in part to price-fixing by the American buyers in collaboration with their local agents, the price of fiber was maintained at low levels. The plantation owners, the smaller of whom were in a chronically precarious position, kept their profits up by expanding the area in production and by keeping wage rates at an absolute minimum. They did so through a system of debt-peonage which is universally known as "slavery" in Yucatan. The peasants were brought into peonage with some small debt; the wage rates and the prices which they were forced to pay at the tiendas de raya, or plantation stores, were manipulated so that they could never work their way back to freedom. Peons were openly bought and sold between plantations for prices which fluctuated with the price of fiber and which were unrelated to the ostensible "debt." Escapees were brought back by the rural police, and the whip was used regularly to maintain discipline (282, pp. 12-19). The Maya population was supplemented with Yaqui Indians forcibly deported from their native state of Sonora, and with contract laborers from the Canary Islands, China, Korea, and from other parts of Mexico (273, vol. 2, pp. 310-330). Labor conditions were among the worst in the country at the time, even by the very low standards of the regime of Porfirio Diaz (134).

The agricultural economy of Yucatan became dominated by its export monoculture, and was incapable of meeting the food needs of the population. The early statistics are not very reliable, but it was reported that 240,000 hectares of maize were harvested in 1845, just before the Caste War. In the radically reorganized economy of 1881, less than 15,000 hectares were reported within the much smaller areas under government control (272, p. 58). By 1915, the state was importing most of its grain, principally from the United States but also from Argentina. During the boom years of the First World War, sisal exports were negotiated directly in exchange for grain with Herbert Hoover's Wartime Food Administration (132, pp. 244-246). The transportation

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4/ In 1902, a secret agreement was signed in Havana between Oligario Molina, the largest export agent in Yucatan, and representatives of the International Harvester Company and the Peabody Cordage Company, the principal importers. It specified that Molina's company would "use every effort within their power to depress the price of sisal fiber . . . and pay only those prices which from time to time are dictated by the International Harvester Company" (132, p. 84).

network connected the plantations to the port, and this heavily forested region was importing firewood from New Orleans at the height of the boom (99). Yucatan has never regained food self-sufficiency.

It must be remembered that the henequen industry was located in a small, highly integrated area in the northwestern corner of the state. In the less densely populated regions to the east and south, the haciendas also expanded at the expense of the peasant communities. The sugar industry was reorganized in the second half of the 19th Century after its destruction during the Caste War. The pre-war boom, which had been located in the frontier south of the Puuc hills and in eastern Yucatan, was organized in small units around animal-powered mills, or trapiches (58, 61). The post-war industry was concentrated in large haciendas on the relatively good soils which border immediately on both sides of the Puuc hills.

Their operations were gradually modernized with steam-powered mills and agronomic improvements (14, 70). Unlike the henequen plantations, they continued to operate as diversified, semi-self-sufficient enterprises, producing maize, beans, honey, wax, and other crops as well as sugar and rum. Unlike the colonial haciendas, they depended on debt "slaves" for their work force, and expanded their holdings at the expense of the peasant communities (240). The region became an important commercial center, and was connected with Merida by a railroad in 1901. In the central and eastern areas of the state, the traditional cattle/maize haciendas also drew in increasing numbers of Maya peasants as permanent, resident peons (75). Estimates of the proportion of the rural population of Yucatan which had lost individual access to land by the time of the revolution range from 75 to 96 percent. 5/

The Revolution

In spite of the terrible social conditions, the Mexican Revolution of 1910 was reflected in only a few scattered outbreaks of violence in outlying areas of Yucatan.6/ Not until the state was occupied

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5/ The figure of 75 percent is from a general study of the Mexican Revolution by Frank Tannenbaum (275, p. 33). More recent, detailed studies have suggested that the number may have been higher. Gilbert Joseph states that there were 120,000 peones acasillados on the henequen plantations alone, exactly twice as many as were cited by General Alvarado himself (132, p. 53; 107, p. 337). There are many documentary and archival sources which have never been analyzed in detail, and the current interest in historical research on this issue will undoubtedly lead to more precise estimates.

6/ The city of Valladolid was held for a week by a rebel group in 1910 (107, p. 227). One of the bloodiest uprisings occurred at the

by Federal troops under the command of the constitucionalista General Alvarado in 1915 were structural reforms imposed on the region. The "slaves" on the plantations were immediately freed by decree, and wage rates were regulated by law (3). Felipe Carrillo Puerto fought with Emiliano Zapata in Morelos before returning to his native Yucatan as a rural organizer for General Alvarado. He was instrumental in the establishment of the Socialist Party of the Southeast, one of the most radical regional movements in Mexico at the time. The party organized community Resistance Leagues, developed a system of secular education based on an ambitious literary program, promoted the organization and liberation of women, and encouraged its followers to paint their houses (208). It battled with the Liberal Party of Yucatan, which represented the interests of the plantation owners, in a series of local skirmishes and civil disorders which are known as the "Socialist War" (132, 147). Carrillo Puerto was elected governor in 1921.

The early Revolutionary governments of Mexico were unwilling to antagonize the United States and risk the disruption of export trade which might have resulted from the expropriation of the henequen industry. The ex-peons themselves, after two generations as semi-proletarian wage workers, were more interested in higher wages and job security than in land redistribution. 7/ Carrillo Puerto moved cautiously, and concentrated the agrarian reform program in outlying areas of the state. In 1923, he passed a state law which would have permitted the expropriation of abandoned henequen plantations and their operation as cooperatives. This threat to their interests provoked the local elite into joining the short-lived rebellion of General de la Huerta against the central government. The Federal garrison in Merida revolted, arrested, and shot the governor in 1924. He has since become a revolutionary hero of the official PRI party, which incorporated the

sugar hacienda of Catmis, in the Puuc region near the border with Quintana Roo. In response to notoriously bad working conditions, the peons wrecked the machinery and hacked the owner and his family to pieces in 1911. The same mill was destroyed again in factional violence between the Socialist and Liberal parties in 1923, and was plagued by serious labor conflicts until it was finally closed in 1965. The land was converted into a collective cattle ejido (132, p. 321; 59).

7/ This issue is discussed at length by Askinasy, and the debate is summarized by Joseph (12, pp. 61-74; 132, pp. 352-356). Sidney Mintz has explored the relationship between proletarian labor conditions and political consciousness in Cuba and Puerto Rico (186). He concludes that plantation workers are not peasants, and are not as interested in maintaining the stability of the family and community economy as they are in improving their standard of living through individual or labor union action. The henequen workers in Yucatan were finally offered neither alternative, and their position has stagnated as dependent wards of the Federal government.

Socialist Party as a local chapter a few years later. His martyrdom is used as a symbol of the government's rhetorical commitment to the interests of the Maya peasantry (38, 128, 206).

The henequen industry was riven with acrimonious conflicts, and production deteriorated in a declining market for nearly 20 years. Much of the plantations' land was finally expropriated and reorganized into collective ejidos by President Cardenas in 1937 (45). This is usually considered as one of the most serious failures of his agrarian program. It broke up the tightly integrated production system, and made the ejidatarios entirely dependent on the corrupt and bureaucratic structure of the government Rural Bank and other agencies.8/ The complex history of the industry over the following decades falls outside of the scope of this study. It has continued to decline, with minor, short-term recoveries, in spite of massive subsidies, which were estimated at 800 million pesos in 1980, and a series of programs designed to "solve" the "agrarian problem of Yucatan" (35, p. 88). It continues to be the largest single industry in the region, and systematically under-employs the majority of the state's agricultural labor force at one of the lowest standards of living in rural Mexico (22, 100, 136).

Re-expansion of Peasant Agriculture into the Frontier

The agrarian reform did have a very significant impact on the Maya peasant communities in the rest of the state. The re-establishment of semi-independent villages was the explicit goal of Carrillo Puerto (46, pp. 218-220).

> The Revolution has one fundamental objective: to give the Indian his rightful status as a free man. The sacrifices [of the Revolution] will be justified when the Maya lives in his own community as a free citizen, self-sufficient and secure. . . . Our first goal, therefore, is to redistribute the communal lands, or ejidos, to our people. . . . The Maya are moving out from the estates where they have lived, and are building their homes in small towns. Old men who have never known liberty, who have never planted or harvested their own crops [are now doing so]. . . . But more important than this is the community

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8/ For polemical denunciations of Cardenas' reform by two members of Yucatan's former ruling elite, see Menendez and Molina Font (152, 188). For an account more attuned to the plight of the ejidatarios by an author sympathetic to Cardenas' goals, see Benitez (34). For analyses of the disintegration of the henequen production and processing system, see Chardon and Soberon (54, 266). For a summary of attempts to diversify the economy of the region, see Baklanoff (16).

> life which our people have discovered. They are beginning a new political life, with collective problems and forms of organization, which will lead them to think in a new way which will be totally different from what they have known for 400 years.

The haciendas were not physically destroyed by the Revolution, but the estate economy disintegrated because they lost both much of their land and their captive low-cost labor force in the agrarian reform process, and because the market for henequen and sugar, their principal crops, severely contracted. During Carrillo Puerto's brief administration, 438,000 hectares were redistributed among 23,000 ejidatarios (132, p. 358). By 1930 over 900,000 hectares had been divided into 199 ejidos, a larger area than in any other state except Zapata's Morelos up to that time. The subsequent progress of the land reform is outlined in Table 4. The average ejidal grant in Yucatan is a little over 3,000 hectares of forest, although there is a very wide range of variation. Theoretically, the peasant communities were granted enough land to permit a milpa fallow cycle of 15 to 20 years.

The campesinos redeveloped a self-provisioning economy, drawing upon their cultural traditions of resource use and milpa production. In the decades before the Second World War, they fanned out from the ex-haciendas into the forest hinterlands which had been virtually depopulated since the Caste War in the middle of the previous century. The population of semi-abandoned frontier communities increased, and new villages were formed through a process which Redfield calls "hiving off" (236, p. 28). Perhaps partly as the result of some inter-family feud or other social conflict, and partly to find monte alto, or land which had been fallowed for a long time, small groups of families established settlements in the hinterland. The satellite villages maintained political and ceremonial ties with the parent community during a period of consolidation, after which many became fully independent. Milpa was also produced in temporary forest camps, both large ones financed by merchants to secure a source of commercial maize supply, and small ones occupied by individuals from more densely populated areas. The dispersion of the population in the principal milpa region of Yucatan among 1,099 rural villages and hamlets is illustrated in Chart 20. If we exclude towns with more than 5,000 residents, the average settlement population is 150, or approximately 25 families.

The expansion of Maya peasant communities has continued into Quintana Roo, and to a lesser extent into Campeche, down to the present day. Until very recently, Quintana Roo was continuously forested and extremely sparsely populated by the descendents of scattered bands of refugees from the Caste War (31, 290). There was a boom in the collection of chicle, the raw material for chewing gum, in the 1920's and 1930's, and the industry continued on a smaller scale through the 1960's (13, 137, 292). Peasants from Yucatan who worked there for many seasons became familiar with the region, and have moved permanently with their families into newly established ejidos (94). It is

TABLE 4. YUCATAN: THE STRUCTURE OF LAND TENURE, 1930-1970*

Census Year	Number of Ejidos	Area in Ejidos	Area in Private Sector	Number of Private Farms Smaller Than 5 Hectares	Number of Private Farms Larger Than 5 Hectares
		(1000 hectares)			
1930	199	929	2,164	6,144	4,444
1940	457	1,333	1,390	7,290	5,997
1950	513	1,695	1,591	6,985	7,302
1960	352[a/]	1,707	2,837	4,624	10,250[b/]
1970	589[c/]	1,870	1,075	4,946	7,559

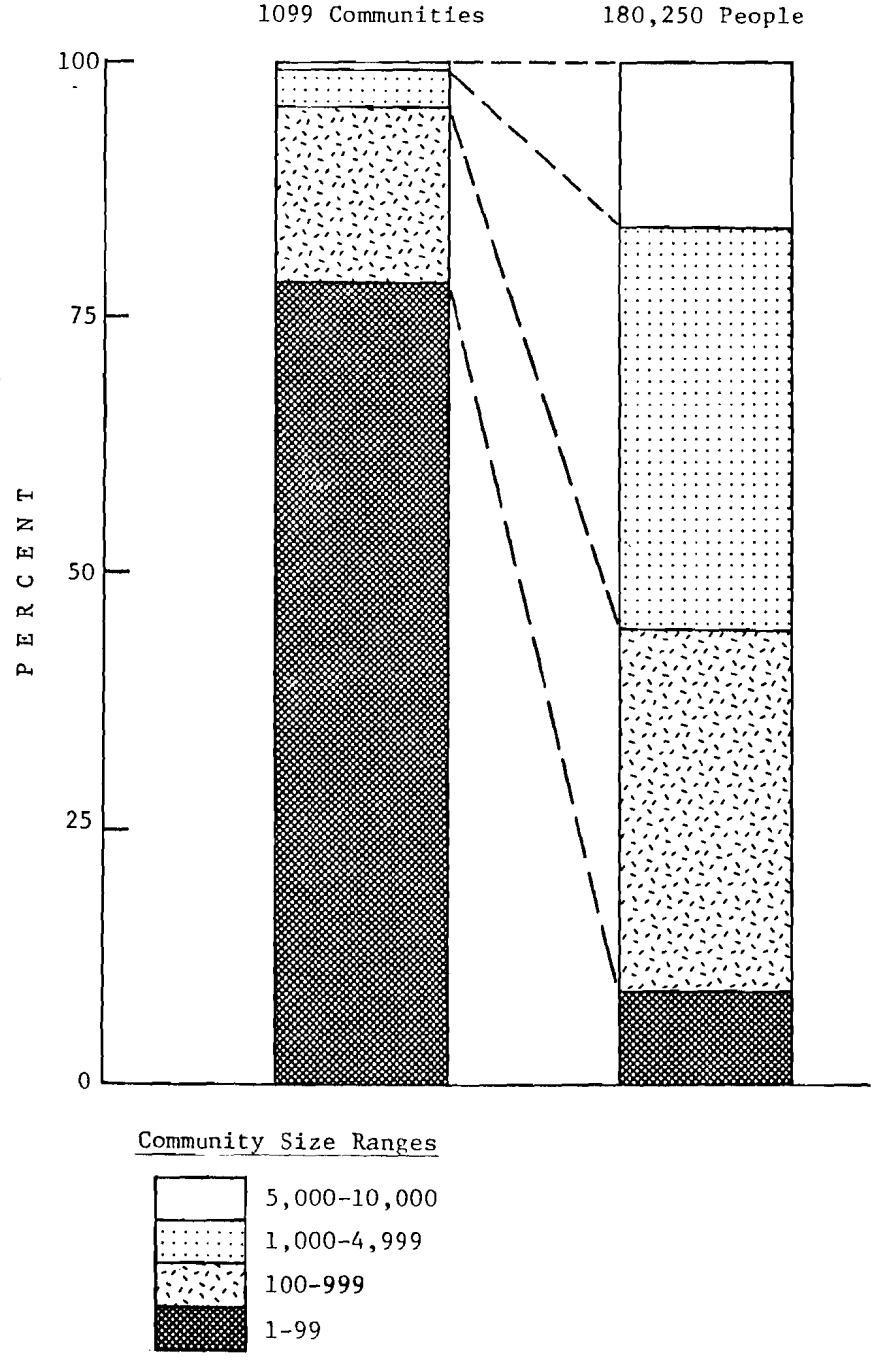
a/ The statistical service has not maintained a consistent method of enumeration from one census to another. Although there have been periodic adjustments and reorganizations of the ejidos in the henequen zone, I have been able to find no explanation for this apparent drop of 161 ejidos between 1950 and 1960. For a discussion of the problems of statistical comparisons of census figures, see "Diagnóstico del Sector Agropecuario del Estado de Yucatán," México, Banco de Crédito Rural Peninsular, Subgerencia de Programación y Presupuesto, mimeograph, Mérida, 1981.

b/ Although this figure may well be inflated, it reflects the expansion of the private cattle industry in the northeastern part of Yucatan in the 1950s.

c/ New Ejidal Population Centers (NCPE) were created in the southern frontier region in the 1960s to encourage and direct colonization.

*Source: México, Dirección General de Estadística, Primero - Quinto Censos Agrícola, Ganadero, y Ejidal, various years.

CHART 20. THE MILPA REGION OF YUCATAN: DISTRIBUTION OF POPULATION ACCORDING TO THE SIZE OF THE RURAL COMMUNITIES, 1970



Source: México, Coordinación General del Plan Nacional de Zonas Deprimidas y Grupos Marginados (COPLAMAR), Programas Integrados; 18--Region Maya de Yucatán (México, 1977), p. 20.

estimated that 80 percent of the migrants into this new state, which is growing at a rate of over 11 percent per year, are campesinos from Yucatan (250).

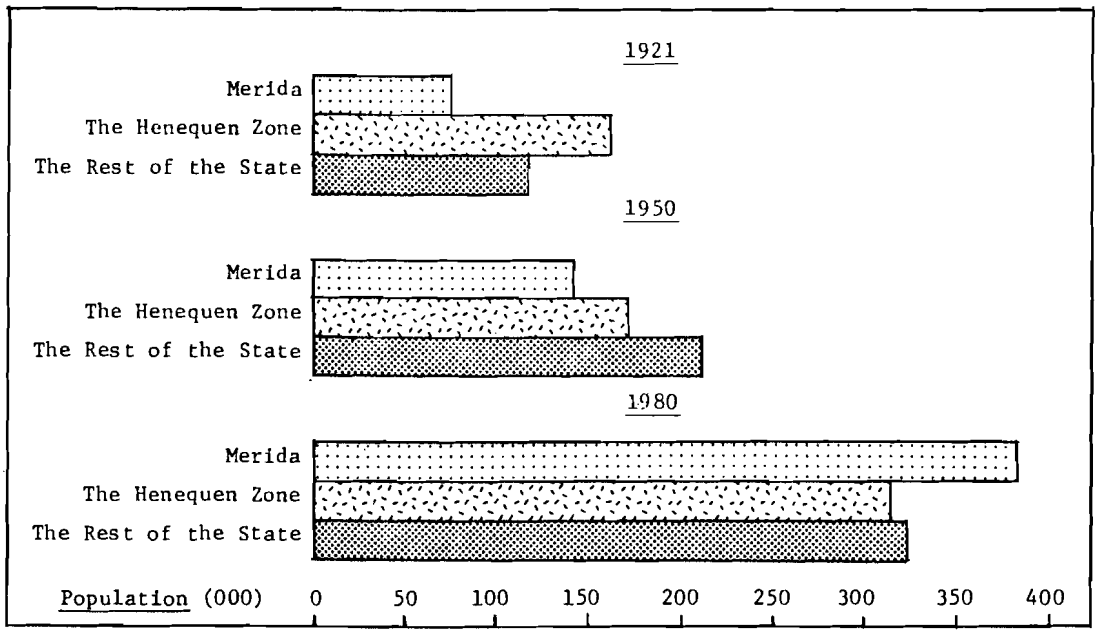
The increase in the number of peasant families engaged in milpa production is reflected in the spotty historical statistics on the area planted with maize. Estimates of the maize hectarage during the henequen boom in the late 19th Century range as low as 15,000 (272, p. 58). By the late 1920's, an average of 38,000 hectares were reported (12, p. 99). A census taken in 1931 reported 48,000 hectares (165). The figure rose to 60,000 by the late 1940's, and to 183,000 by 1981 (79, 180). Nevertheless, as has been shown in Chart 16, the average yield ceiling of the traditional milpa system is less than one ton per hectare, and the year-to-year fluctuations are high.

Improved technology appropriate to the patchy soil conditions and irregular rainfall patterns has never been developed. Except in very small areas in the south, Yucatan is not suitable for mechanization or the introduction of broadly adapted packages of improved varieties and modern cultural practices. Government policy did not support the intensification of the traditional milpa system with resources, credit or extension until the very recent production campaigns of the late 1970's. Farm roads, water points, and other infrastructure which might have encouraged the efficient use of the resources within the entire area belonging to each ejido were not built (118, p. 53). Instead, an expanding road network linked the larger villages with the towns and cities. This has promoted the articulation of the peasant economy with that of the region as a whole, primarily through the market for migratory labor.

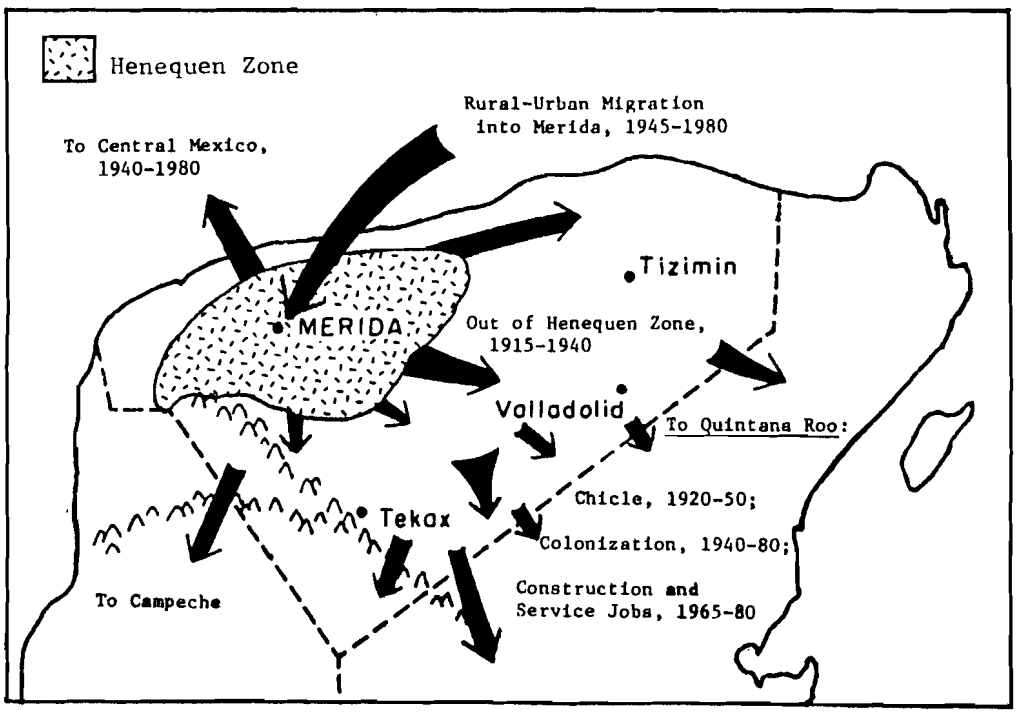
Beginning with a series of droughts and locust plagues in the 1940's, the fission of the peasant village population into frontier lands has been gradually and unevenly reversed (2, p. 295; 243, pp. 67-80; 252). It is not true in any absolute sense that the population has exceeded the carrying capacity of the land; large areas of the state have fewer than 10 inhabitants per square kilometer, and many small hamlets have been abandoned. Instead, the low and unstable milpa yields, the deteriorating real price of maize, and a variety of local factors have tended to reconcentrate the population in relatively stable villages where schools and employment opportunities are available. At the same time, large numbers of rural people have moved into the cities and to other parts of Mexico.

The trends in the movement of population are shown in Chart 21. Between 1921 and 1950, the population of the outlying areas of the state increased by 78 percent, while that of the far more densely settled henequen zone stagnated and increased by only 6 percent in 29 years. Between 1950 and 1980, the growth rate in the zone of peasant agriculture averaged only 2 percent per year, less than the natural rate of increase. In the same period, the population of Merida nearly tripled to 400,000, and urbanization spilled out into the surrounding

CHART 21. YUCATAN: THE REGIONAL DISTRIBUTION OF THE POPULATION, 1921, 1950, AND 1980



Patterns of Peasant Migration into the Forest Frontier, 1915 - 1980



Sources: Emilio Alanis P., "La Población: Problemas Demográficos," in Enrique Beltrán, Ed., Los Recursos Naturales del Sureste y su Aprovechamiento (Instituto Nacional de Recursos Renovables, México, 1959), Vol. 3, pp. 285-334. Jean Revel-Mouroz, Aprovechamiento y Colonización del Trópico Húmedo Mexicano (Fondo de Cultura Económica, México, 1980), pp. 71-77.

henequen zone. In 1980, 110,000 Yucatecans, one-tenth as many as the total resident population of slightly over a million, were living outside of the state (179, p. 6).

Over the past 30 years, the Federal government has made a series of attempts to colonize the frontier systematically (44; 79; 243, pp. 222-226). In the 1960's, over 150,000 hectares of public land in southern Yucatan were administratively divided into "new ejidos" (Nuevos Centros de Poblacion Ejidal) to encourage people to move into them. They were intended to accommodate over 2,000 families, but the development of both productive and social infrastructure has been slow and erratic (183). As part of a national program to extend the agricultural frontier throughout the tropics, over 100,000 hectares in the south were slated for mechanized clearing in the 1970's. The plan was tied to a variety of development projects, including the reestablishment of a sugar industry, the mechanized production of basic food crops, and cattle ranches under ejidal management (167, 176).

The organization of these programs has been poor, and the lack of coordination between the Ministry of Agriculture, the official bank, and other agencies has led to repeated failures in most of them. Ambitious targets have been met by clearing almost any land which is relatively flat at very high cost. Neither the short-term agronomic feasibility of the projects nor the long-term potential of the resources have been realistically assessed in detail. The local population is sparse, and many projects have depended on hired labor brought in from other areas. Maize yields in mechanically cleared and cultivated lands have been lower than the modest standards of the traditional milpa, and the high cost of deep wells and irrigation systems has limited the development of more intensive systems (8). The results of attempts to introduce mechanized rice production into Campeche and Quintana Roo on a large scale in collective ejidos have been disappointing (9). The construction of roads, wells, and other infrastructure will ultimately stimulate the expanded use of the resources in these isolated areas, but their population has grown very slowly and the costs will not be justified for many years.

Maya Peasant Diversification Strategies

In the 1920's and 1930's, when peasant agriculture was expanding into the frontier after the liberation of the "slaves," most families were able to meet their food needs in most years from their milpas, and to obtain other goods by selling surplus maize (273, 270). Their economy was never entirely stable; men have long migrated extensively in search of outside sources of income in times of family emergency. In recent decades, most accessible areas have been settled, and yields have become more uncertain. Although it continues to provide a significant proportion of household food supplies, the milpa cannot assure subsistence security and its relative importance is declining within

the economy of most families. At the same time, the economic expectations and cash requirements of the rural Maya have risen, and their communities have become increasingly articulated with the regional economy. Like peasants throughout Mexico, each family struggles to maintain its stability by constantly adjusting and readjusting a combination of diverse activities.

Each community has its own history and unique social characteristics which only detailed case studies can fully explain. In general terms, the more years since a particular village colonized an area of the frontier, the less land is available for milpa, and the more the people depend on other sources of income. This pattern is illustrated in Table 5, which summarizes data from separate studies of Yaxcaba, Chan Kom, and Filomena Mata. 9/ These villages are ranged along

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9/ This concept of a gradient is intended simply to be descriptive of an historical process of frontier resettlement over the past 60 years. I do not believe that there is any significant difference between the organization of the peasant economy in the three villages. Although I use data from Chan Kom, which was Robert Redfield's principal case study village, I do not mean to reproduce his concept of a gradient along a "folk-urban continuum" (234). The Carnegie Institution of Washington organized a multi-disciplinary team to study the Maya of Yucatan in the 1930's. Redfield, the principal anthropologist, developed a particular theoretical concept of cultural change. He asserted that traditional Indian societies were in a process of being transformed by urban influences and attitudes. He chose four case studies along a gradient of aculturation. The village of Tusik, in what was then a totally isolated region of Quintana Roo was taken as the "purest" available example of the Maya culture. Descendents of refugees from the Caste War practiced a separatist religious cult of the "talking cross" which rejected Mexican influences (290). Chan Kom was chosen as an intermediate case of a peasant "little society." Traditional cultural values co-existed with and adapted to outside influences, and the community was able to "choose progress" without threatening its internal cohesion (235, 237). Dzitas was a railroad town and trade center where the relationship between the cultures was more conflictive. The final case was Merida itself, where "Mayaness" was preserved in the language and in the traditional costumes as an ethnic and as a class, rather than as a truly "cultural" attribute (112). Redfield was a very influential figure in peasant studies, and the detailed field data which he and his colleagues collected is an invaluable resource for students of Maya agriculture and society. Nevertheless, his cultural approach has been criticized by Eric Wolf and many others as an ahistorical distortion of the complex interactions between Maya and Hispano-Mexican society over the past 450 years (310, p. 14). The details of this lengthy debate lie outside of the scope of this study. The community of Chan Kom has been extensively studied in more recent years (104, 105, 110, 153, 154). I am indebted to Deborah Merrill Sands for the use of some of her

TABLE 5. PATTERNS OF ECONOMIC ACTIVITY IN THREE MAYA COMMUNITIES, 1979-1980

	Yaxcaba[a/] (1979)	Chan Kom[b/] (1980)	Filomena Mata[c/] (1980)
I. MILPA PRODUCTION			
Total area of ejido/ family (hectares)	32	48	160
Average milpa size (hectares)	3.0	3.4	5.4
Milpa size distribution (percent)			
Four hectares or less	79	66	57
Four to eight hectares	18	22	28
Over eight hectares	3	1	16
II. RELATIVE IMPORTANCE OF PRINCIPAL ECONOMIC ACTIVITIES			
Percent of families with milpa	80	70	95
Percent of families with cattle	n.a.	25	10
Percent of families with bees	40	45	50
Average number of hives per honey producer	21	44	30
Percent of families with at least one member working outside of ejido	56	62	0

[a/] Luis M. Arias Reyes, "La Producción Actual en Yaxcabá, Yucatán," and Maya Lorena Pérez Ruiz, "Organización del Trabajo y Toma de Decisiones en La Familia Campesina Milpera," both in Seminario Sobre Producción Agrícola en Yucatán, Efraim Hernández X., Ed. (Estado de Yucatán, Mérida), 1980, pp. 259-304 and pp. 425-475.

[b/] Deborah Merrill Sands, personal communication.

[c/] Miguel Baraona and Maria del Carmen Montalvo, "Filomena Mata: Pequeña Sociedad y Alimentación" (México, Secretaría de Programación y Presupuesto, Centro de Investigaciones Sobre el Desarrollo Rural (CIDER), México, 1981). and direct investigation.

a rough gradient in the direction of the expansion of peasant agriculture since the Revolution, and their locations are shown on Map. 2.

Yaxcaba is a town of 305 families in the principal milpa region. It was an important Colonial center, but the population contracted drastically after the Caste War of 1847 (75). The area was divided between several cattle and maize haciendas in the late 19th Century, and the town reemerged as an important peasant community in the 1920's. Chan Kom is located 40 kilometers to the east, in what was an entirely depopulated forested area at the end of the last century. It was first settled as a satellite colony of Ebtun, a suburb of Valladolid, because undisturbed vegetation was available for milpa production (235, p. 2). It was established as an independent village in the 1920's, and had grown to a population of 100 families by 1980 (153). Filomena Mata is a small, isolated frontier village with 54 families in central Quintana Roo. It was used as a military camp during the campaign against the descendents of the rebel refugees from the Caste War in 1901. Over the past generation, it has been settled by families from the area of Valladolid (18).

Milpa Production

Milpa continues to be the basis of the peasant economy in all three villages, and is practiced by between 70 and 95 percent of the households in each. As Table 5 shows, the average population density decreases, and the average size of the plots increases, as one moves into the forest frontier from Yaxcaba to Filomena Mata. Over the 50 years since Chan Kom was a small, isolated settlement, milpa production has become concentrated in a relatively limited area surrounding the village. Between 1932 and 1936, an average of 29 men worked plots with an average size of 4.8 hectares, and harvested an average annual total of 140 hectares (270, p. 112). Between 1980 and 1982, an average of 68 men produced milpas with the smaller average size of 3.8 hectares (155). The total area in production had nearly doubled to 272 hectares, but the average distance of the plots from the village had been reduced from 8.5 to 4.3 kilometers. The average maize yield of between 650 and 750 kilos per hectare did not register any significant change, but the local campesinos are unanimous in their opinion that crop production is far more uncertain than it was a generation or two ago. The continuous time-series data on milpa yields which would be required to

unpublished data. The traditional agricultural systems and the socio-economic organization of the peasants of Yaxacaba were studied in detail between 1979 and 1984 by an interdisciplinary team from the Graduate College of Agriculture at Chapingo (11, 124, 217, 218, 228, 286). Filomena Mata was a case study for a cooperative research project of the Mexican Center for the Study of Rural Development (CIDER), the United Nations Development Program (UNDP) and the United Nations Research Institute for Social Development (UNRISD), in 1980 and 1981 (18, 19, 173). This author participated in the field work.

prove that the variance has increased are not available, but the relative importance of other sources of family income has risen markedly as the community has become increasingly dependent on the cash economy.

Within each village, there is a wide range in the size of the milpa plots which are cultivated. Four hectares is the modal standard of the largest milpa which an average family can cultivate without significant hired help. As we have seen in Table 2, an operation of this size can neither assure the security of the family, nor provide an adequate return to labor except in unusually good years. At one end of the spectrum, many campesinos work for wages and plant small milpas to provide a small part of their family food requirements. Eighty percent of the milpas in both Yaxcaba and Chan Kom are four hectares or smaller. Even in the relatively isolated ejido of Filomena Mata, where land is ample and alternative sources of income are fewer, only a minority of the households are self-sufficient in most years.

A few prosperous families plant large areas with the help of hired labor. Milpas larger than eight hectares--which can be regarded as commercially oriented operations--were planted by 16 percent of the families in Filomena Mata, but by less than 5 percent in the other two communities. Maize and the other traditional products--beans, squash seed, and small quantities of fruits and vegetables--are sold under uncertain and generally unfavorable conditions. Even families with very small plots are often forced to sell maize in the months following the harvest, only to buy at a higher price later in the year. Although the milpa system is the source of virtually all of the state's maize and bean production, it is not in itself a profitable enterprise for most producers in most years.

The real price of maize relative to the items which campesinos buy has deteriorated significantly over the past 30 years. Many large-scale milpas operated with hired labor have been abandoned. Families have been moving from small, isolated hamlets into larger villages where they can send their children to school, and where employment is available. Fallow periods have been reduced as the farmers clear plots closer to their homes where they can take care of them conveniently in combination with other activities.

As part of a national campaign to increase food production, credit was provided for milpa in the late 1970's. The Rural Bank organized the ejidatarios into solidarity groups, paid them to clear, plant, and weed, and distributed fertilizers and other inputs. There were many problems organizing distribution channels and technical guidelines and the widely dispersed communities. The peasants tended to regard the program as a secondary source of employment, rather than as a form of support to their own food production. It did increase the harvested area, but as Table 6 shows, it had no significant impact on maize yields. It functioned as a massive subsidy to the peasant sector: the direct credit repayment rates varied between 6 and 20 percent (158).

TABLE 6. YUCATAN: IMPACT OF CREDIT ON MAIZE PRODUCTION, 1976-1981

Year	Total Area Harvested	Area Harvested with Credit		Average State Yield	Average Yield in Areas with Credit
	(1000 hectares)	(1000 hectares)		(kilos/ha.)	(kilos/ha.)
1976	105	42	(39%)	902	900
1977	74	34	(34%)	923	922
1978	136	23	(17%)	859	860
1979	136	37	(27%)	920	913
1980	144	34	(24%)	904	894
1981	183	118	(65%)	855	800

Source: México, Banco de Crédito Rural Peninsular, "Diagnóstico del Sector Agropecuario del Estado de Yucatán" (mimeo, Mérida, México, 1981).

Animal Production

Almost all households raise turkeys, chickens, and pigs in the yards behind their houses. The animals provide eggs and meat to the diet, which are an important feature of feasts at ceremonies and festivals. The numbers which are kept fluctuates with the size of the milpa harvest, the time of year, and the fortunes of the family. Surplus and damaged maize is fed to them, and the animals represent a kind of insurance policy, as they can be sold to meet emergency cash needs. Thirty years ago, pigs were raised on a much larger scale, and provided an important source of cash income. At that time, more people lived out in their isolated milpas, and the animals were much more tightly integrated into the cropping system than they are today (155). The decline in maize production, the development of intensive swine operations close to the centers of urban demand, and the concentration of the rural population have reduced the importance of pig-raising. Squash pulp is often left to rot in the fields, because it is not worth the time to haul it home. Nevertheless, at least a few animals are kept, even if they represent a net cash loss if feed is purchased for them.

Cattle have been raised in Yucatan since the 16th Century, and remain one of the principal agricultural products of the state. They are concentrated on private ranches, which are expanding rapidly into previously forested areas (278). Nevertheless, until the early 1970's, many moderately prosperous peasant families owned small herds. The animals were released at night to browse in the secondary scrub vegetation, and were confined during the day at water points. Rustic thorn and brush fences were built around the milpas to protect the crops, but disputes over damages were very common. A fence law which prohibited free-ranging cattle was passed in 1982 (143, pp. 122-123; 315). Livestock production has become concentrated among the few wealthy members of the communities, who can afford to establish fenced ranches with wells.

Several government agencies have organized collective cattle operations in many ejidos, including Filomena Mata. Most have attempted to establish modern animal production methods based on pastures and supplemental feeding, rather than gradually intensify the traditional browse systems. The agroclimatic conditions are marginal because of the long dry season, and it has proved very difficult to introduce intensive management practices into small units in scattered villages. Few ejidos have been able to compete with the private ranchers in the cattle markets, and there have been charges of corruption against officials of the Rural Bank and other agencies. Credit advances for land clearing, fencing, and the establishment of forage grasses have provided ephemeral sources of employment, but by 1980 very few ejidal cattle units had stabilized as profitable enterprises (175).

Beekeeping

Many peasants who were forced to sell their cattle have shifted into beekeeping. There is a traditional Maya technology for obtaining honey and wax from a native species of stingless bee (Apis melipona), and these products have been exported since the time of the colony (273, vol. 1, pp. 234-237; 297). European honey bees (Apis melifera) were introduced early in the 20th Century as a commercial venture. Over the past 20 years, the imported technology has become widely distributed through the peasant sector. Honey is sold on the world market through two government-sponsored cooperatives. Mexico is the world's second most important exporter after China, and Yucatan is the single most important producing region (154). Between 40 and 50 percent of the households in the three sample communities keep bees.

The hives are distributed through the forest to forage on the flowers of the native trees and shrubs, and water must be hauled to them during the dry season. They are a convenient complementary enterprise to the milpa, as the calendars of labor requirements do not conflict. Some large operations are attended by hired labor, and others are run as a minor sideline. A family with the resources to manage a model colony of between 30 and 40 hives receives a significant proportion of its income from the sale of honey. Nevertheless, beekeeping is not a reliable source of livelihood. Production fluctuates from year to year depending on the rainfall pattern during the dry season, which stimulates the vegetation to flower. Pest and disease attacks are a constant problem, and prices depend on erratic world market conditions and foreign exchange relationships.

Migratory Labor

Temporary migration on a seasonal or intermittent basis is a nearly universal feature of the Maya peasant economy, and individual campesinos have complex work histories. They have been forced to leave their homes for variable periods by family emergencies: disastrous yields, expensive health care needs, and many others. In recent decades, improved communications, rising levels of education, and more widespread fluency in Spanish have provided new opportunities. Increasing numbers of families have come to depend on income from outside of their villages on a regular basis (17).

In most cases, the migrants have been men. They have worked in chicle camps in the frontier. They have worked in groups in large-scale milpas, financed by merchants to secure a source of commercial supply. They have worked on private cattle ranches, clearing land in return for the right to grow milpa crops for a year or two to supplement their wages. They have worked on government projects--railroads, roads, land-clearing programs, and many others. They have moved to ejidal colonies in Quintana Roo and Campeche, and then returned. They have worked in Merida, in the new resort of Cancun, and in the rapidly

growing city of Chetumal. They have gone to cut sugar cane in Belize, and some have gone to the United States, although Yucatan has provided a relatively small proportion of Mexican migrants to that country (131). They have gone to Mexico City, and to the oil fields in Tabasco and Veracruz (196).

Some men commute to their jobs, returning to their families on weekends. Many ejidos in the drier southwestern portions of the state, where the milpa economy has virtually collapsed, are inhabited only by women and children during the week (10). Others leave for a season, a year, or more. Some of course never come back, but many work for extended periods to contribute to the family economy in their home villages. There is also an active labor market within the communities. Most campesinos work for each other at least occasionally for wages, and the richer villagers depend heavily on hired labor.

Approximately 60 percent of the households in both Yaxcaba and Chan Kom had at least one member of the family working outside of the ejido in the year of the study. In the former village, 80 percent of the temporary migrants were heads of households, and most of them worked as laborers (218). In Chan Kom, the situation was quite different; 80 percent of those who left were the sons and daughters of milperos, and most of them worked in the service sector, particularly in the resort of Cancun (153). While this may indicate a greater social mobility out of traditional agriculture from the latter village, short-term trends are very difficult to evaluate in Yucatan. Fluctuation in and out of milpa production has been a constant feature of the peasant economy for many years, and depends on the opportunities which become available through personal networks. Almost all of the campesinos in Filomena Mata have worked for wages at various time in their lives, but nobody migrated in the year of the study. A regional cooperative had been established to market railroad ties, and cutting and hand-hewing trees in the extensive forest of the ejido provided a flexible source of relatively good income (18). If the price drops, or if the resource becomes exhausted, men will almost certainly move out in search of work once again. In ejidos close to sources of employment, such as San Jose Cepeda Peraza near Tekax, virtually the entire village worked for wages in the same year as these studies, even though ample land for milpa was available (173).

It is difficult to generalize about the expenditures which are financed with migratory labor. Much of the money is spent on immediate consumption needs, past debts, and emergency needs such as health care (17). Some families buy cattle or bee hives. Others start a small store or other business. Others finance their migration to Merida. The important point is that in contrast to the fruit and vegetables producers in the south, who will be discussed in the next chapters, the members of milpa communities have few opportunities for the intensification of agricultural production. On the contrary, the greater a family's involvement with activities outside of the ejido, the less time they have available to site their milpas in the best possible

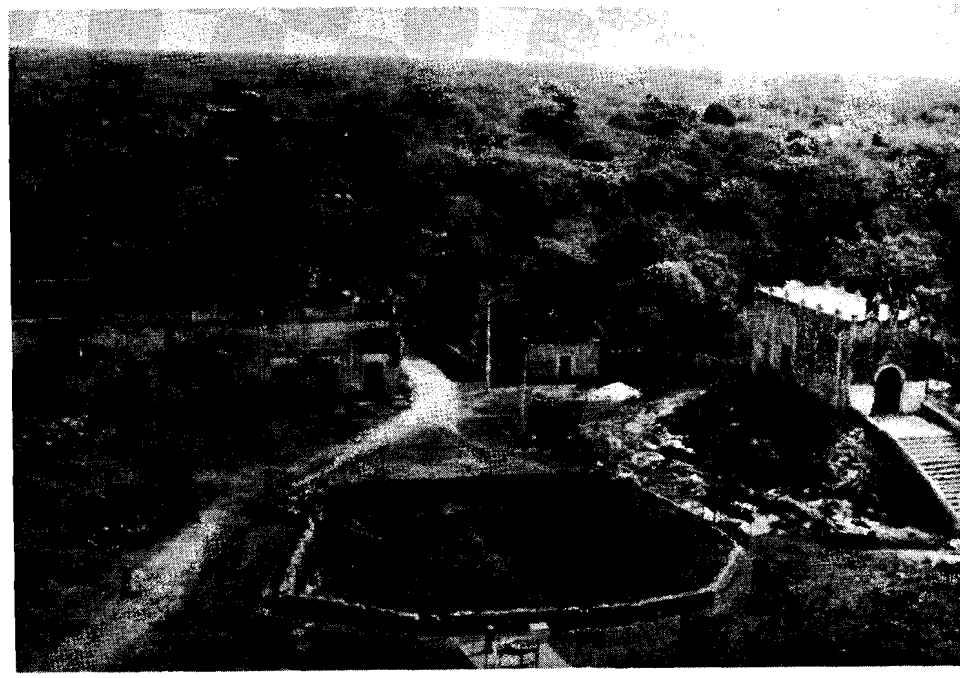
location, or to attend carefully to the detailed sequence of their management. When outside employment opportunities contract, as they have in the past and almost certainly did during the national economic crisis in the early 1980's, the Maya peasants depend on their milpas for a greater proportion of their food supplies.

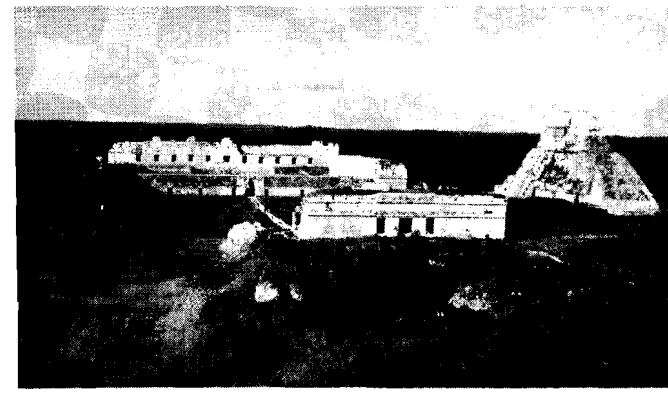
The Dilemma of the Maya Communities

The dilemma of the Maya communities is that the opportunities for the intensification of traditional agriculture are too few, and alternative sources of income are too insecure, to guarantee the stability of the family economy. As the peasants have diversified their activities with off-farm labor, they have planted their milpas within a smaller area and have simplified their management practices. Improved technology has not been available, and yields have stagnated. Except for beekeeping for the export market, the importance of animal production has declined. A variety of government projects has provided little more than ephemeral sources of employment, and very few stable alternative uses for the land and other resources of the ejidos have been developed.

In striking contrast, the peasants of the Puuc region in the south have developed intensive systems of fruit and vegetable production over the past 40 years. The government has built irrigation facilities, and has provided other services, but the individual producers have maintained their autonomy, and have developed diversified parcels gradually at the rate at which they have been able to accumulate resources. The history of this process provides lessons which could be applied to the design and organization of projects throughout Yucatan.

PLATE 1





Yucatan is a semiarid limestone plain in the lowland tropics of southeastern Mexico. There are no permanent sources of surface water. Most villages are located at cenotes, or sinkholes, such as the one shown above in the main square of Yaxcaba.

The region has been continuously inhabited for centuries, and is densely dotted with ruins. Over 70 percent of its area is forested, and it retains many characteristics of a frontier. The ancient city of Uxmal, above right, was abandoned in the 10th century A.D. The sugar hacienda at Tabi, right, was abandoned after the Revolution of 1910-17.

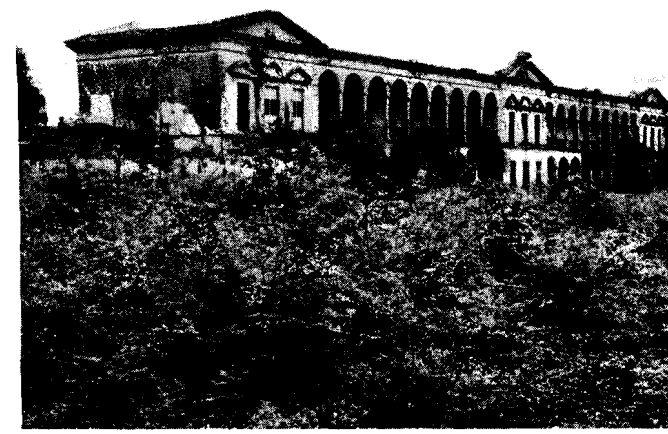
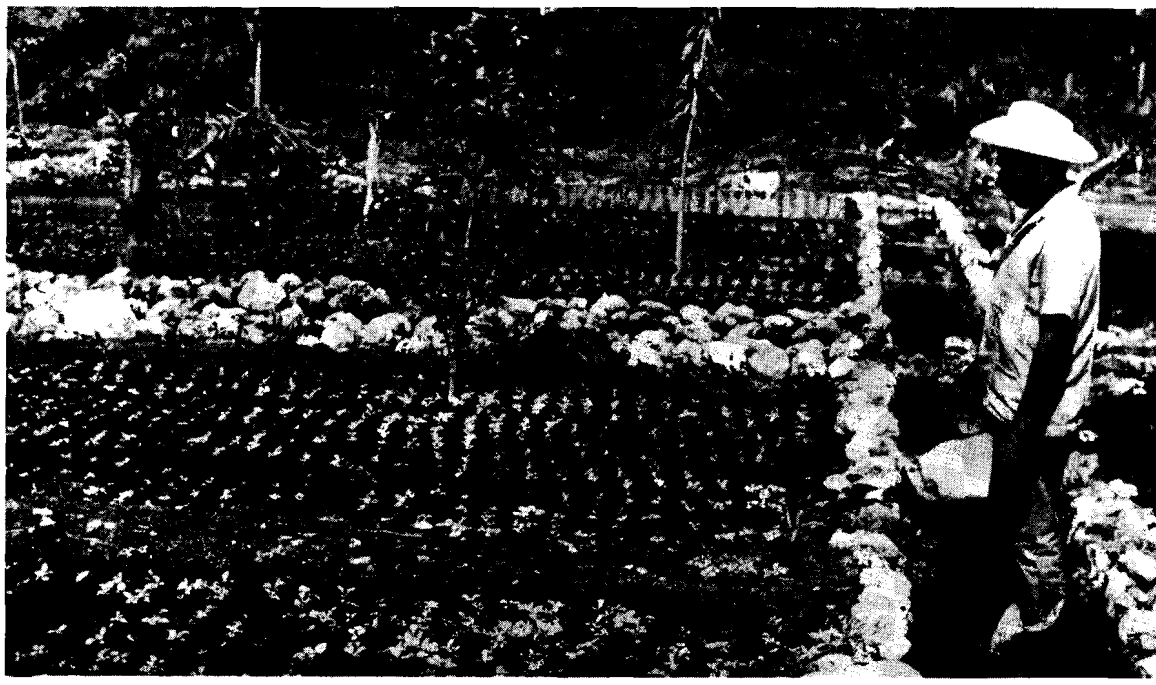


PLATE 2

Food crops are produced almost exclusively in small Maya communities. The milpa system of slash-and-burn cultivation and continuous rotation through forest fallow has changed little since the Spanish conquest. The yields of maize, beans, and squash are low, and the system can assure neither food security nor an adequate income to most families. The peasants have diversified their economic activities with whatever opportunities have been available, but many depend increasingly on migratory labor.

PLATE 3



The region bordering on the Puuc hills has become a center for the production of fruits and vegetables for the regional market. Over the past 40 years, approximately 3,500 Maya families have shifted from milpa to more intensive production systems in irrigated parcels. Wells have been drilled by the Federal government and the peasants have developed their parcels gradually, with small, incremental investments of labor time and cash earned in extended periods of migratory labor. They plant complex combinations of annual, semiperennial, and perennial crops in many different arrangements and sequences. Vegetable production in the early stages of parcel development depends heavily on the use of unpaid family labor.

PLATE 4

The peasants have adapted their traditional production techniques. Above, maize and cowpeas are grown between the rows of young trees. Later, the shade canopy closes over and the intensity with which the parcels are managed declines.

Some of the more prosperous families raise bull-calves, such as the one shown on the right, which are fed grass, weeds, and crop residues.

PLATE 5

Buyers from Merida and other cities come with trucks to the wholesale assembly market in the town of Oxkutzcab. Most of the sellers are women, the wives of the producers. The pair below are displaying avocados of the choice Lagunero variety.

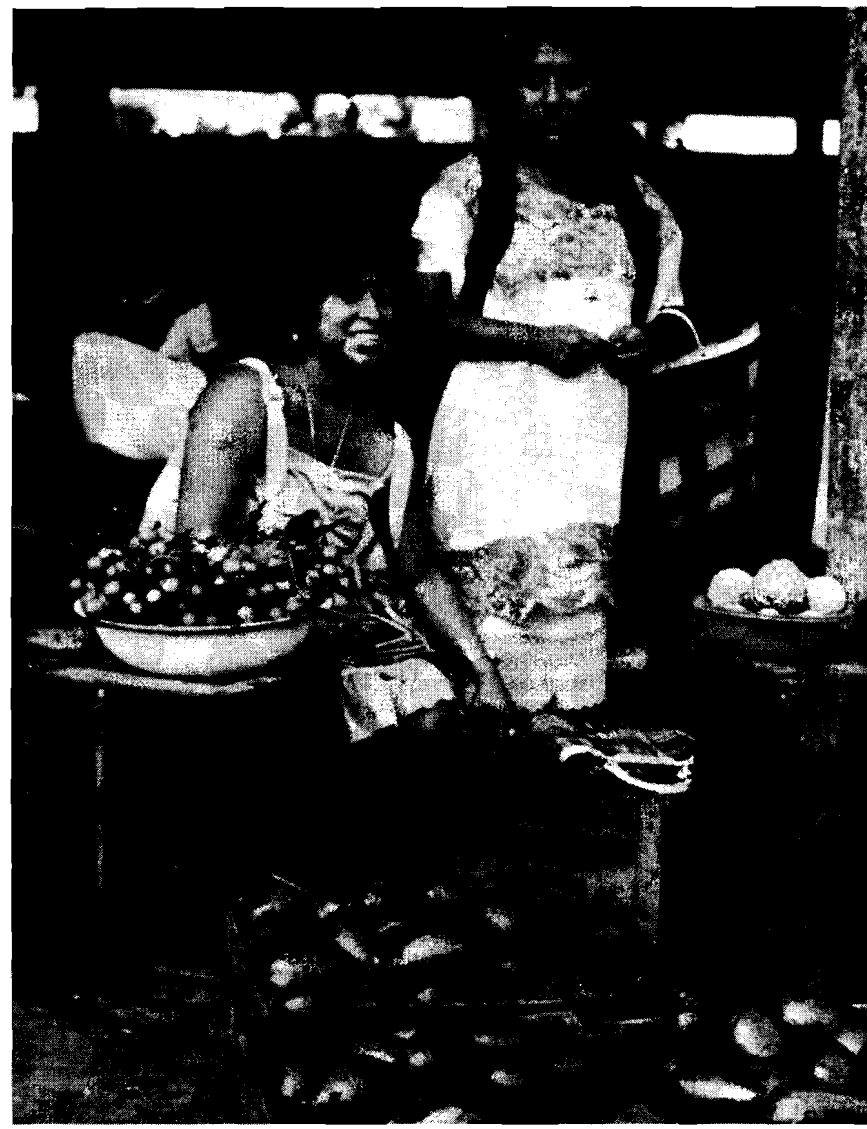
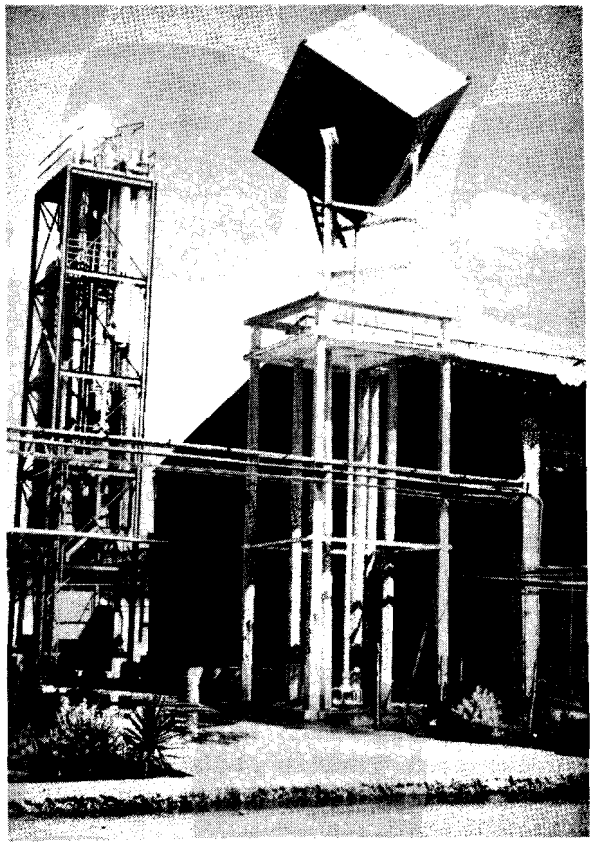


PLATE 6



In recent years, the government has attempted to introduce modern fruit production and processing systems into Yucatan. A frozen orange juice plant, pictured on the left, was built as the centerpiece of an ambitious plan to greatly expand citrus output for the export market. This and other projects have encountered serious technical and organizational problems, and have not provided a stable livelihood to the participants.

The peasants are organized into ejidos and users' associations. In frequent meetings, such as the one below, they negotiate with the government agencies. They attempt to adapt the programs to their needs, and to maintain the flexibility on which the stability of the peasant economy depends.

CHAPTER FOUR

INTENSIVE PEASANT PRODUCTION IN THE PUUC REGION

The Puuc region of southern Yucatan is an irrigated oasis where Maya peasants have intensified their traditional management practices to produce fresh fruits and vegetables for the urban market. Over the past 40 years, approximately four thousand families have gradually accumulated resources in irrigated parcels, which were at first but one of several activities within their diversified household economies. They have gradually abandoned milpa, although many continue to grow at least some maize for home consumption. The majority have financed the development of their parcels with long periods of migratory labor throughout the Yucatan peninsula and further afield. Access to improved land has been secured through membership in ejido communities, and through participation in organized groups which have petitioned to the Federal government for the construction of small-scale irrigation units. Most of their operations are small, between one-half and five hectares, often divided into two or more parcels at different stages of development. The farmers share similar backgrounds and work histories. Almost all of them are Maya speakers with strong ties to the traditional culture, and almost none of them are more than a generation away from the traditional milpa-based economy which was outlined in the previous chapter.

The region is relatively specialized in orange production, but the individual family parcels are managed in a dynamic successional sequence of a variety of annual, semi-perennial, and perennial crops. The development costs of a parcel are concentrated in the first few years. If there were no revenue until the fruit trees came into production five to seven years later, the farmer would be forced to find other sources of income to feed his family at the same time as he irrigated, weeded, and cared for the young seedlings in a period when careful management is critical to future yields. Within a given year, the production of a variety of crops insures that there is a more or less even flow of income both to cover family consumption needs and to pay for water, labor, and other cash costs of production when they are required in the annual cycle. Diversification spreads the risk of fluctuations, both in the yields of individual crops, and in unpredictable market prices.

A common development sequence is as follows. A new parcel is cleared, and the irrigation ditches are built. Maize and other milpa crops are planted for one or two years. Fruit tree seedlings are planted, most commonly citrus and a few other species, in a regular

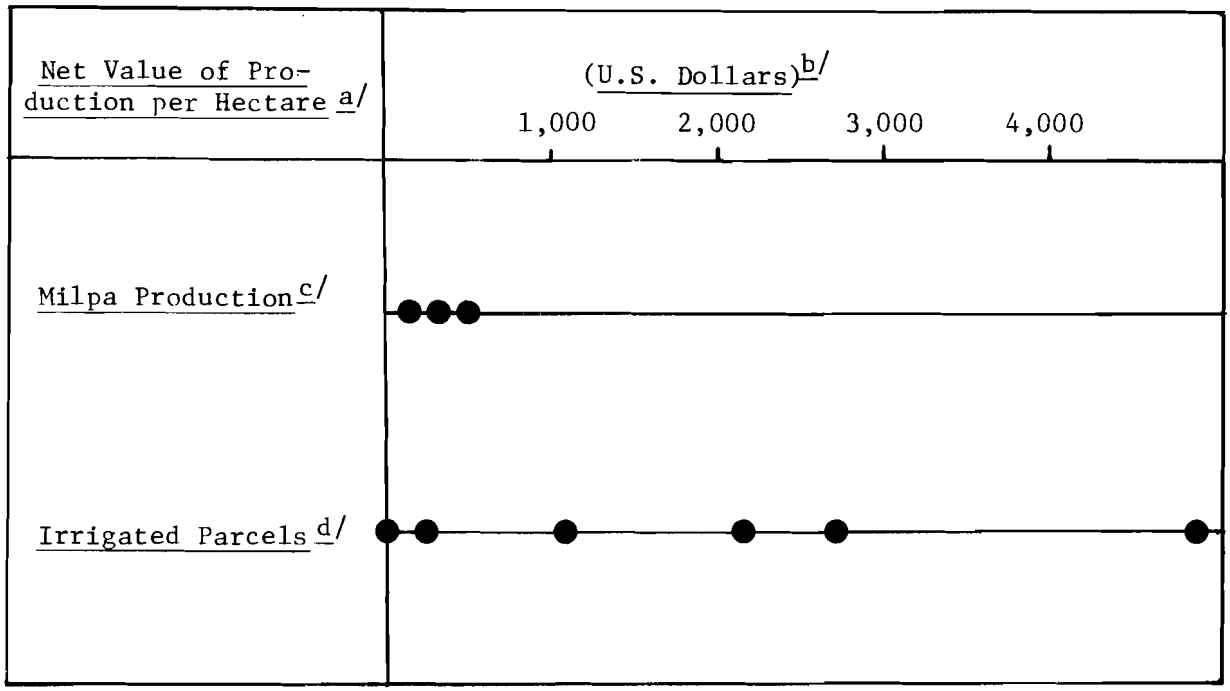
grid along the margins of the ditches, or more randomly. Vegetables and other short-season crops are grown in the open space between the young trees for four or five years. These are gradually overlapped with semi-perennials such as papaya, cassava, and bananas. As the predominant trees mature and the shade canopy begins to close over, other perennials are planted, either in the centers of the grid or less systematically. To make use of the vertical space, they are usually shorter or taller types. Phytophthora spp. causes a fungus disease which persists in the soil, so citrus trees which die or are culled are usually replaced with other species.

As the parcels mature, the complexity of their spatial arrangements increases, and the intensity of their management declines. Vegetables and other short-season crops require frequent irrigation and weeding. Pest and disease problems have become increasingly serious in recent years, and many farmers spray with a combination of insecticides, fungicides, and foliar fertilizer as often as every four or five days. In later stages, the increasing shade cover suppresses weed growth. Mature trees are fertilized only occasionally, and require irrigation less often. Few families can afford the equipment to spray their trees, and they accept yield reductions from insects and diseases as long as the parcel as a whole provides them with a steady income. Gradually, the total output of the parcel decreases. An older peasant farmer is assured of a diversified, relatively secure source of income for progressively less labor and cost. A young family with the means and the work force to do so acquires additional land in which to begin the sequence again.

The producers are peasant farmers at different points in a process of transition from a subsistence to a commercial orientation which has not yet stabilized. The individual parcels are diversified with between four and 20 crops in many different combinations and arrangements, and the yields, costs of production, and net returns are highly variable. Production is organized very differently than in slash-and-burn milpa plots, but Chart 22 illustrates that the average value of production per hectare is much higher than the value of the output of traditional Maya agriculture. Although the economic returns are modest by commercial standards, the intensification of fruit and vegetable production has stabilized the economy of many families, and their incomes are both more secure and considerably higher than the average in most rural communities.

This chapter will address two general issues. First, the history of fruit and vegetable production in the Puuc region will be traced to identify the relative advantages which have permitted the intensification of traditional systems. Second, the characteristics of the management practices, and the wide variation between individual cases, will be explained in terms of the constraints which the farmers have faced. Most have had very limited cash reserves, and almost no credit has been available to them. They have developed their parcels slowly, with the labor of their own families, and with the money which they

CHART 22. NET VALUE OF PRODUCTION PER HECTARE FROM MILPA COMPARED WITH SELECTED IRRIGATED FRUIT PARCELS IN OXKUTZCAB AND AKIL, 1981/82



a/ The estimated value of production, net of direct cash costs. The value of family labor is not counted.

b/ Calculated at the current exchange rate of 26 pesos per dollar.

c/ Calculated as one-quarter of the value of production from a modal four-hectare milpa, consisting of 2.5 hectares of first-year milpa roza and 1.5 hectares of milpa cana, parameterized across the average variation in yields under different weather conditions. See Table 2.

d/ The net value of production from six selected parcels of different types at different stages of development. See Table 9.

have been able to accumulate in migratory labor and other activities common to all Maya peasants. The prices which they have received in the market have been erratic and unpredictable. There has been very little applied agronomic research in the area, and technical recommendations applicable to their operations have not been available. They have flexibly adapted both traditional and new production practices to their needs and scale of operations.

The Fruit Zone of Yucatan

Fruits and vegetables are relatively minor crops in Yucatan. They represented only 10 percent of the total value of agricultural output in 1981 (180). Fruit is widely grown on a small scale for household consumption in traditional backyard tree gardens, or solares, in rural villages (27). Commercial demand is concentrated in urban areas, particularly in Merida, where nearly 40 percent of the state's population lives. Much of the market for fresh produce is supplied from other parts of Mexico, but small-scale farmers in Yucatan are able to compete for a residual share of the demand for certain crops in some periods of the year. Some of them are "truck farmers" with small orchards in and surrounding the principal cities and towns (221). The production of between 60 and 70 percent of the state's orange crop is concentrated in a strip along the margins of the Puuc hills. This fruit zone, where many other types of produce are also grown on a smaller scale, is centered on the market town of Oxkutzcab, 100 kilometers south of Merida. 1/

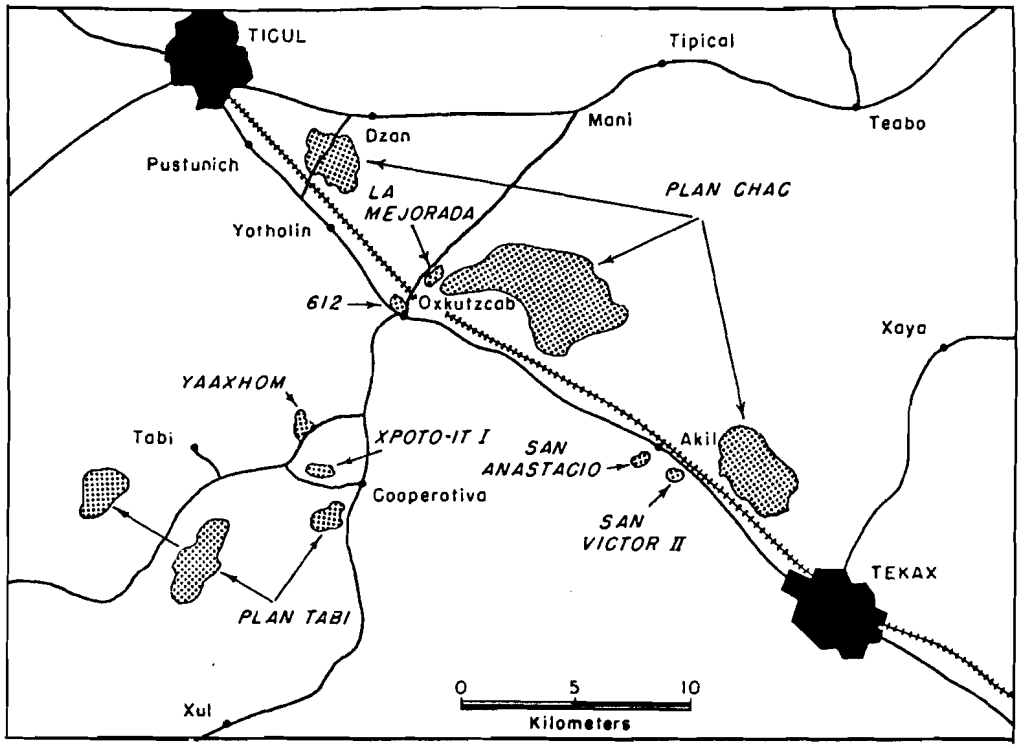
The Oxkutzcab Market

In other regions of Mexico where peasant agriculture predominates, such as Oaxaca, there are many well-developed peasant markets where producers negotiate with wholesale buyers (33). This is not true in Yucatan. The traditional Maya communities are small and widely scattered, and produce essentially the same combinations of subsistence crops. They are supplied with simple household necessities by shopkeepers, who also consolidate the modest surplus of maize, beans, squash, and other minor commodities. The disproportionately large central squares of most villages are nearly always empty. From time to time, a campesino will carry a sack of maize into a store to pay a debt or to buy coffee, kerosene, or whatever.

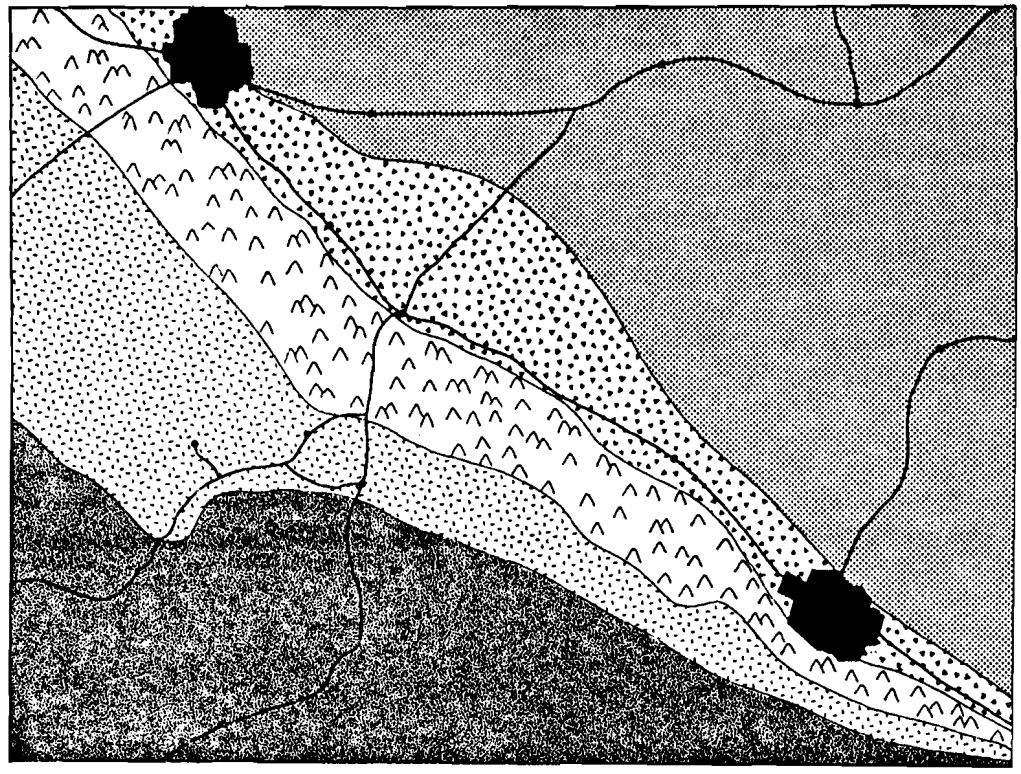
1/ For some of the information contained in this section, I am indebted to Margarita Rosales, Lourdes Rejon, Jose Luis Dominguez, and the other members of the Puuc regional history project of the National Institute of Anthropology and History.

MAP 4. THE FRUIT REGION OF YUCATAN: OXKUTZCAB AREA

A. LOCATION OF IRRIGATION UNITS



B. FIVE AGRO-ECOLOGICAL ZONES



Flat Northern Plain

Band of accumulation of stoney soils

The Puuc Hills

Valley of deep, stone-free soils

The Sierra of Bolonchen; The edge of the forest frontier

By striking contrast, Oxkutzcab is a bustling trade center with a population of 10,000. Every weekday, scores of trucks from Merida, Campeche, Cancun, and other parts of the peninsula converge on the market in front of the 17th Century church in the main square. Hundreds of Maya peasants bring produce in from their parcels. Some come with a box or two strapped to their bicycles, others with five or six loaded into tricycle pedi-cabs. Ten-ton trucks crowded with men, women, and children inch into the plaza; a ladder is lowered, and boxes of fruit are handed down. Soon the covered market and the surrounding streets are overflowing with produce: oranges, mandarins, avocados, mangos, lemons, papayas, sweet potatoes, chiles, and more of many types and varieties. A partial list of the products of the region is provided in Appendix A.

Most of the sellers are solid and vigorous women, the wives of the farmers. They are dressed in elaborately embroidered blouses, or huipiles, with bright necklaces and gold earrings. They negotiate prices in the Maya language. There is a small area set aside for retail sales, but Oxkutzcab is primarily a wholesale assembly point (51).

Some of the buyers are local merchants with established contacts in the Merida market. They have good information on short-term supply fluctuations, and have established complex networks of personal relationships with the women and their families. Many of them are also farmers who operate the larger and more productive parcels in the region, but they are Mayas with strong family and personal ties in the communities. They walk up and down the rows checking quality and prices. They pay for a few boxes at a time of different commodities directly in cash, and hire workers to load them onto trucks. Other buyers come in directly from the urban centers. They are usually looking for a load of a specific product, and are willing to pay slightly higher prices rather than lose time in protracted negotiations. A group of Maya women are permanently installed in the market to speculate against daily price fluctuations, buying and selling in small quantities. The trucks drive back to the central city markets, or to the Casa del Pueblo, a transfer center in Merida.

Geographical Diversity

The escarpment of the Puuc hills rises abruptly on the edge of the town, within six blocks of the market square. A set of worn stone steps leads up to the "Hermitage," a small one-room chapel built in colonial times in the massive block house style of the Franciscan monks. In the view from its terrace, Oxkutzcab virtually disappears under a canopy of trees of many different heights and shapes, and the towers of the church are the only structures visible. On the far edge of town, the lush greenery gives way to the brown scrub vegetation of the limestone plain of northern Yucatan. The sweep of the horizon is as level and unbroken as that of the sea. The fruit zone is truly an oasis, which has been made possible by the development of small-scale

irrigation. Over the past 40 years, the Federal government has drilled more than 135 wells in this and the neighboring towns along both margins of the hills, which supply water to approximately 7,000 hectares organized into several different development programs.

Because they provide an empirical example of the semi-autonomous intensification of Maya peasant agriculture, one type--the Unidades Antiguas de Riego, or "old-type" units--have been chosen as the focus of this case study. Water is pumped from deep wells into systems of masonry canals which feed between 14 and 100 hectares, the units are divided into individual parcels with an average size of less than one hectare. Little direction, financing, or technical assistance has been provided, and the peasant families have gradually intensified their traditional management system at a rate dependent on the resources which they have been able to accumulate through their own efforts.

The central area of the fruit zone is shown in Map 4A. This study will concentrate on the municipios of Oxkutzcab and Akil, where the irrigation programs were first initiated, and which accounts for nearly 70 percent of the region's fruit output. Located on what has always been the forest frontier of Yucatan, these towns have produced surplus agricultural products for sale in the urban market throughout their history. The Puuc region was one of the most important sources of Merida's maize supply during the Spanish colony (209, p. 306). It was the center of the sugar industry in the 19th Century, and was just on the fringes of the henequen zone, which has since contracted. In addition to these major crops, it has also produced a great variety of products on a smaller scale, in part because the peasants of the towns have had access to a diverse hinterland within walking distance.

Five distinct agro-ecological zones are indicated on Map 4B. The first, the edge of the northern plain, is characterized by flat topography and patchy associations of Tsek'el and Kankab soils (see Table 3). This area has been used for continuous milpa rotations of the type described in the previous chapter, and for small cattle ranches. Along the escarpment of the hills, an irregular band of stoney, heterogeneous soils have been formed from colluvial materials. This zone is the site of the principal towns. Henequen was grown here in small plantations before the Revolution, and irrigated fruit production has been developed intensively in recent decades.

The Puuc hills themselves are only 70 to 80 meters high, and the range is between one and eight kilometers wide. The groundwater level is too deep for wells, but the high fertility and good water-holding capacity of the complex soil associations have permitted the development of conucos, a small-scale, intensive adaptation of milpa techniques to the production of horticultural crops through an extended growing season. Until the fence law of 1971, cattle were released into the hills at night to browse, and were confined in corrals in town during the day where water was available. The intensity of land-use in this zone has declined with the development of irrigation.

In the narrow valley south of the hills, large extensions of deep, stone-free Kankab soils have an agricultural capacity higher than most areas of the state. They were used intensively for sugar production in the 19th Century. The hacienda at Tabi, one of the largest in Yucatan, reached a size of 14,000 hectares in 1904 (21). The estate produced cane on the lands suitable for that crop, but also grew maize and other foods, tobacco, honey, and cattle. It had a resident work force of approximately 400 families, and most of the population in the surrounding region was dependent on it (240). After the Revolution, the land reverted to secondary forest and to much less intensive use for milpa and cattle. The first irrigation unit was established in 1941, and the watered area has expanded rapidly since 1970, both for fruit production and for mechanized vegetable operations (249).

The vast area to the south of the Sierra of Bolonchen, where sources of water are infrequent, has been a sparsely settled frontier for centuries. Sugar was produced in small, scattered ranchos before the Caste War, when virtually the entire population was driven out by the rebels (239). Chicle was collected in the early 20th Century. Much of the area has been divided into ejidos since the Revolution, but small cattle ranches and commercial beekeeping operations persist on private and public land. Small hamlets and temporary camps were settled for milpa production by peasants from the towns along the Puuc, but many have been gradually abandoned since the Second World War. Several government colonization projects have been developed slowly and fitfully.

The Evolution of Irrigated Fruit Production

Citrus fruits, primarily oranges, have been produced under rainfed conditions and in traditional solares and in small commercial orchards in the Oxkutzcab region throughout its history (221, p. 32; 247, p. 363). The trees can survive in favorable locations without supplemental irrigation after they have become established, but they suffer stress in the dry season, and produce erratically depending on the rainfall patterns. Soon after the Conquest, the Franciscan monks developed small-scale irrigation systems in their churchyards (7, 58). They introduced citrus and other fruits from the Old World, which were gradually adopted by the Maya. In the 19th Century, the owners of the haciendas vied with each other to develop intensive orchards and vegetable gardens, or huertas. They built elaborate irrigation systems based on mechanical pumps and concrete canals, and imported new species and varieties from other parts of the world. They provided fresh produce to the hacienda community, and also became a significant source of supply to the urban market (221). Many of them brought in Chinese indentured servants, whose intensive production systems had a major effect on the subsequent development of cultural practices in the region.

The Development of Private Orchards

At the time of the Revolution, the peasant population was highly concentrated around the haciendas, which dominated the production and marketing of food crops, as well as of sugar, henequen, and cattle (240). Direct communications with Merida were provided by a narrow-gauge railroad, which was opened in 1901. After the liberation of the "slaves" and the agrarian reform, the ex-peons fanned out and reestablished autonomous family enterprises based on the milpa and other traditional production practices. Trade was taken over by small shopkeepers, who provided credit to the campesinos and concentrated surplus production (248). This kind of business requires close personal contacts with the Maya peasant society, and the local merchants were able to displace the members of the state's elite estate-owning families, including the Barbachanos, who had controlled regional commerce (76).

Some of the shopkeepers were financed by brokers in Merida to outfit chicle collection camps in the southern frontier in the 1920's and 1930's. To feed the workers, and to provide an additional source of maize for the market, they also hired campesinos to work in large milpas. Oxkutzcab became an important trans-shipment point, as carters brought produce to warehouses along the rail line. The peasant production of tobacco, a labor-intensive crop with high production costs, was financed directly by representatives of the urban buyers, several of whom operated out of Ticul (248).

The successful merchants, most of whom were Maya-speaking sons of local peons and milperos, invested part of their profits in agricultural activities based directly in the town. For most of them, the first step was to buy cattle. They dug wells and built corrals where the cows were milked in the morning and confined during the day. The use of these facilities was rented to prosperous ejidatarios with a few head, and to the carters for their horses. The expansion of these enterprises required water pumps. The traditional animal-powered windlasses were replaced with windmills. Small diesel pumps were gradually introduced in the 1920's (215). These provided enough water to establish irrigated fruit and vegetable operations, which moved into the vacuum in the regional market created by the abandonment of the haciendas' huertas. Oxkutzcab began to develop a reputation as "the garden of Yucatan," renowned for its lush vegetation and for the cultivation of many different types of fresh produce (7).

Traditional Production Systems

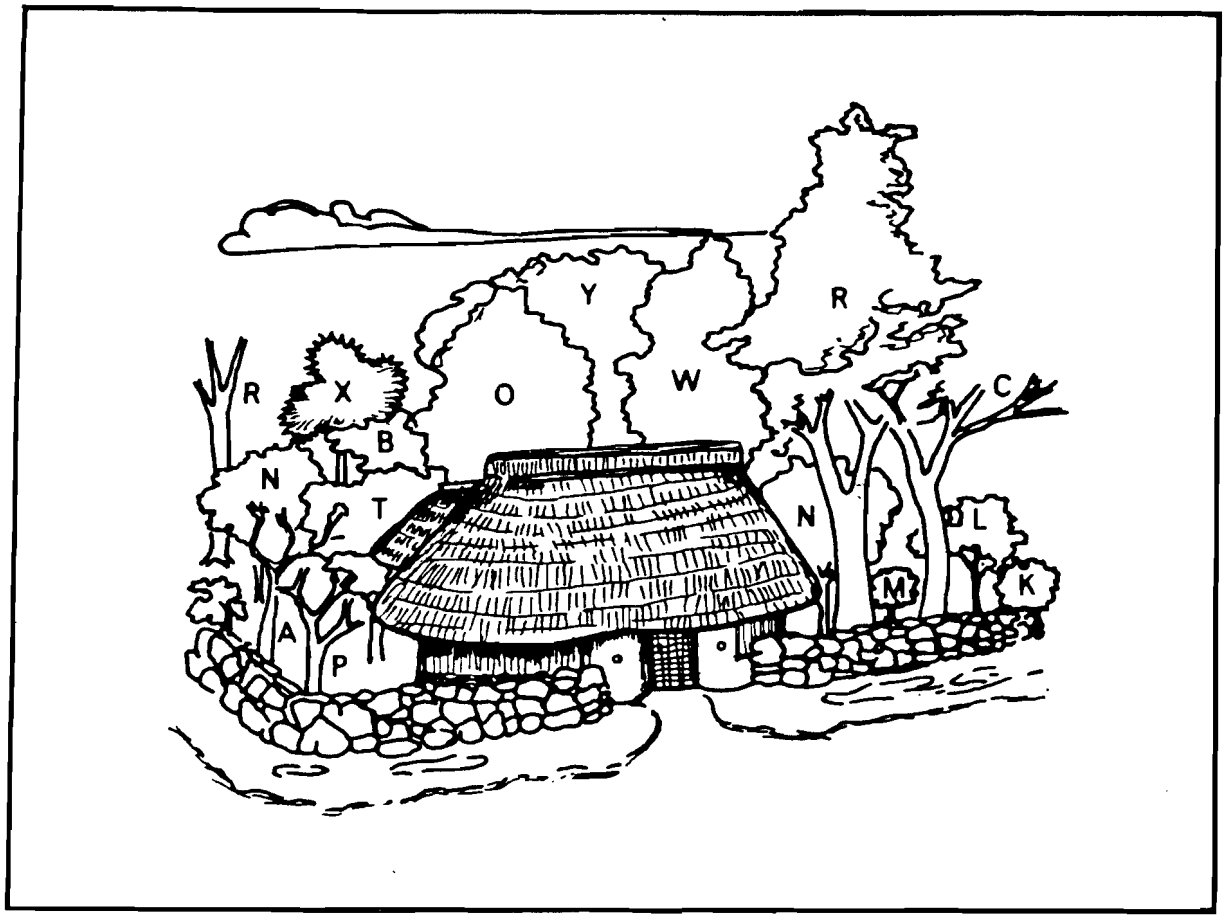
The private orchards have played an important role in the development of intensive production techniques, and the local merchant elite has introduced new crops and varieties. Most of the producers, however, are peasants with parcels in irrigation units constructed by the Federal government. Many of the local practices are derived from traditional systems with a long history in the region.

Solares. In every Maya village, the houses are enclosed within a rough stone wall. The backyard gardens, or solares, are planted with a great variety of fruit and other tree species (27). They are also used to confine pigs and poultry, which limits vegetable production on the ground. Platforms raised on poles, called kanche in Maya, are used for the intensive care of horticultural crops and delicate seedlings (287). The solares are incorporated into the family economy as a relatively minor complement to the milpa and other activities. Most of their products are consumed in the home, although small quantities are sold occasionally. Over the course of a family's development, new trees are laid out a few at a time, and the parcels gradually become larger and more complex. A generalized diagram is shown in Chart 23.

The species composition, vegetative structure, and management practices of the Maya solares have changed relatively little over the centuries, particularly in isolated villages. The predominant species which are found today are listed in early colonial descriptions (138, pp. 101-107). There is a precise and quite uniform Maya terminology for the plants and management practices. Historical references to these names and terms have allowed scholars to trace which species were domesticated in ancient times from the local flora, which were introduced from the Caribbean and central Mexico before the Conquest, and which have been added in modern times (27, 149). It is widely hypothesized that the solar is an essentially unchanged ancient system, and that its stability can be explained by the fact that its diversified structure mimics that of the natural forest (29, 269). One study has attempted to map the spatial distribution of the social classes in a Maya community which was abandoned soon after the Conquest on the basis of the secondary vegetation which grows there today (93).

Although the solares are based on centuries of empirical experience, it is not true that they are static, unchanging systems. A recent study in the town of Yaxcaba has shown that they are managed with a high degree of flexibility, depending on the resources and needs of each particular family (286). There are three conceptual axes along which the variability can be explained. The first is the age of the plot and its stage of development. This is highly correlated with the distance from the center of the village, as the population expands and young families set up new households around the perimeter. The second is the socio-economic status of the family, which determines the size of the solar and the number of animals which are kept. The third is the combined influence of the availability of supplemental irrigation and potential market outlets. A public drinking water system has been installed in some portions of the village. This allows people to water with hoses for a few hours a week during the dry season, which has broadened the range of species which can be grown. Improved communications have encouraged families with this advantage to partially specialize in citrus and other crops for sale, and to confine or get rid of the animals which damage young trees.

CHART 23. IDEALIZED DIAGRAM OF A TRADITIONAL MAYA SOLAR



A. Ciruela (Spondias mombin)
B. Balche' (Lonchocarpus violaceus)
C. Palo Mulato (Bursea simaruba)
K. Achiote (Bixa orellana)
L. Calabash (Crescentia cujete)
M. Chile (Caspicum frutescens)
N. Flor de Mayo (Plumeria rubra)
O. Avocado (Persea americana)
P. Guava (Psidium guajava)
R. Ramon (Brosimum alicastrum)
T. Black Zapote (Dyospiros digyna)
W. Guaya (Talisia olivaeformis)
X. Nance (Byrsonima crassifolia)
Y. Zapote (Manilkara sapota)

NOTE: The English and Maya equivalents of the common Spanish names are provided in Appendix A.

Source: Alfredo Barrera, "Sobre la Unidad de Habitación Tradicional Campesina y El Manejo de Recursos Bióticos en el Area Maya Yucatenense," Biótica, Vol. 5, No. 3, 1981, p. 116.

A similar and very rapid response to improved infrastructure can be observed in many Maya villages, particularly in the north where groundwater is easily accessible. Irrigation and the well-developed marketing system in the Oxkutzcab area have permitted peasant families first to intensify their solares, and then to gradually specialize in the production of fruits and vegetables for the market. The myth that traditional systems are conservative and inflexible persists. Although many villages have requested small-scale irrigation systems with which to intensify their solares, most fruit programs in rural development projects have attempted to introduce entirely new production methods based on modern technology, which have had a very poor record of success (175).

Conucos. The conuco is an intensive adaptation of milpa technology which was developed in the Puuc hills in response to market opportunities (194, p. 61). A variety of horticultural crops, particularly cucurbits, are grown in small plots of fertile soil with good water-holding capacity. The trees are felled in the fall, and the parcels are burned in January or February--much earlier than a normal milpa. The fire draws humidity up to the surface of the soil. Melon, cucumber, watermelon, and squash seed are planted within a day to take advantage of this moisture, and the first crop matures with only minimal, intermittent rainfall. The next major planting is in late May or early June, with the coming of the rains. The principal crops are short-season maize varieties, beans, cowpeas, and tomatoes. A third crop is planted in late August or early September. It usually consists of beans, and of another crop of cowpeas timed to produce in the period of good prices immediately preceding All Saints' Day. A second Fall planting of maize is risky, as the rains are uncertain. The same plot is used a second year for a simplified sequence of crops, and then is left in fallow.

Very similar management practices are employed throughout the peninsula in small, fertile patches within milpas called Pach Pak'aal, but only in the Puuc region do specialized plots produce three harvests a year. The use of the term "conuco" is a mystery. Of Arawak origin, it is used in the Caribbean islands to describe an indigenous production system based on the construction of artificial mounds of earth in which cassava and other root crops were grown (257, pp. 51-55). It is a general term for slash-and-burn parcels in Venezuela. It is not known when or by whom it was first used in Yucatan, but it had its present meaning of a small plot cultivated intensively with cucurbits by the end of the 19th Century (273, Vol. 1, p. 189). Conuco production expanded in the 1920's and 1930's as a source of fresh vegetables for the Oxkutzcab market. It has lost its importance with the development of irrigation, but many of the crop varieties and cultivation techniques have been transferred directly into the management of parcels in their early stages of development, when the fruit trees are still small.

Government Irrigation Projects

By the 1930's, Oxkutzcab was producing a significant proportion of the fresh fruit and vegetables sold in urban markets (165, 247). The Cardenas administration was interested in diversifying the agricultural economy of the state, with preference for the ejidal sector. The president visited the town in 1939, and authorized the first deep-well irrigation system in Yucatan as a personal gesture. That day is still vividly remembered as the first step which gave poor campesinos access to irrigated land. By 1980, 135 small-scale irrigation units were in operation, organized into several different programs.

Small, Shallow-Well Systems. The Second World War disrupted imports of the pumps and other equipment required for deep-well systems. The Federal Irrigation Department set up a program to construct hand-dug wells, cisterns with a capacity of 80 to 150 cubic meters, and distribution systems of small 4" masonry canals to water between two and ten hectares. The idea was that groups of three or four families would operate them cooperatively. A factory was established in Merida to fabricate four and five horsepower one-cylinder pumps. They were not very reliable, and a brigade was organized to keep them in operating condition. Demonstration plots were set up, and Chinese gardeners were hired to work them (78). Extension teams ran courses on irrigation methods, pruning, pest control, and other technical matters. Small loans were made to the producers to help them get started (4, 5, 197).

By 1946, 136 of these small units had been built in the Puuc region, of which 70 were concentrated in the municipios of Oxkutzcab and Akil (78, p. 7). They represented the first serious attempt by the government to encourage Maya ejidatarios to establish permanent agricultural systems, but they were never very successful. The small pumps were unreliable, and the inflexible distribution systems of narrow canals did not deliver enough water (247, p. 366). The Maya family economy went through a period of extreme instability in the early 1940's, as a series of droughts and locust plagues provoked hunger and economic disruption throughout the peninsula. After their milpas had failed for several years in a row, the people did not have the food reserves which would have allowed them to dedicate their time to the development of new parcels through several unproductive years. They fanned out in search of migratory labor, and a considerable number went to the United States as part of the bracero program. Each Maya family traditionally works its own milpa individually, and it was difficult for them to adapt to close cooperation in the management of the units.

Government records of the period are full of complaints about the "irresponsible individualism" of the peasants, and speak of the eviction of as many as four or five families from the same parcel for failure to meet work criteria, in spite of the availability of credit and technical assistance (78). The campesinos recall this as a chaotic and difficult time. They say that the credit program was unreliable

and poorly administered, and that the technical recommendations required spraying and other equipment which they could not afford. The officials actively discouraged the use of the parcels for diversified operations which combined the production of food for home consumption with a modest marketable surplus (220). Even the merchants who participated in the program, who had other sources of livelihood while they set up their parcels, did not feel that these small units were viable systems. They were gradually abandoned, and all of them were out of operation by the mid-1960's. Many of the parcels developed in this program were subsequently supplied with water from larger, deep-well systems.

"Old-Type" Units. Beginning in the 1940's, between two and three thousand families in the Puuc region obtained parcels in 47 deep-well irrigation units with gravity distribution systems. They are known collectively as the Unidades Antiguas de Riego, or "old-type" units to distinguish them from the sprinkler systems which were introduced later. Over half of them are located in the municipios of Oxkutzcab and Akil. They are divided into small parcels with an average size of less than a hectare, although many families combine several into a single operation. A summary table of their characteristics is provided as Appendix Table B5. They were built in response to petitions by organized groups of ejidatarios and small proprietors, within the populist tradition of aid to peasant communities established by Lazaro Cardenas.

The first units were built within the boundaries of the two towns themselves, on land which had been held out of the ejidal grants and assigned as private property for homesites. Others have been constructed on ejidal land, and the parcels have been distributed without charge to the members of the groups which solicited them. The distinction between ejidal and proprietary land is relatively unimportant in the region, as it only reflects the pre-existing status of the area where a particular unit was laid out. Many of the "private" landholders are also ejidatarios, and there is a free market in both types of parcel among registered members of the communities. "Sellers" of ejidal land are compensated for the value of the improvements. Nevertheless, the largest production units, farmed by members of the merchant class, do tend to include large proprietary parcels. There were some protests in the 1950's that the purpose of the reserved areas within the towns for homesites was being subverted by the expansion of commercial orchards, "which in their majority are occupied by merchants who are not ejidatarios and who do not personally cultivate their lands" (85).

In the 1940's and 1950's, the users participated in the construction of the distribution canals, and administered the systems through elected representatives. Since it was established in 1962, Federal Irrigation District #48 has taken over most administrative functions, and has paid the operators. Over the years, several government agencies have organized programs of technical assistance, and have provided

other services at erratic intervals. There has been no continuity in the programs, and the management of the individual parcels has been the autonomous responsibility of the participant farmers.

Centrally Directed Projects. In the early 1960's, when funds for tropical agricultural development became available from the international banks, the government organized a centrally administered program called Plan Chac, after the Maya god of rain. An attempt to introduce modern citrus production into Yucatan, it was based on Israeli sprinkler irrigation technology. The land in 49 separate units was divided into three-hectare family parcels for the benefit of ejidatarios from the region. The establishment of a uniform system of monoculture was financed through a rigid credit system which did not provide the participants with sufficient working capital. The disappointing yields have not provided them with a stable livelihood. The project has been plagued with a great variety of technical and administrative problems.

In the early 1970's, irrigation was expanded in the fertile valley south the Puuc hills for mechanized vegetable production as part of a program called Plan Tabi. The ejidatarios were initially organized into collective units under the technical administration of the Rural Bank and the Irrigation District. The units have since been broken up into individually managed family parcels, and both the irrigation and cropping systems have been extensively modified. Both of these projects will be discussed in more detail in the next chapter. The distribution of all 135 irrigation units in the Puuc region among the three programs is shown in Table 7.

A Sample of Old-Type Irrigation Units

Six of the 29 old-type irrigation units in Oxkutzcab and Akil have been chosen to provide a cross-section of systems of different ages with different histories of organization. Their locations are indicated in Map 4A. A sample was drawn from the Irrigation District's lists of the 396 users, which was stratified according to the size of the parcels. The characteristics of the sample are summarized in Table 8. As the farmers have established their fruit operations, most of them have gradually expanded by acquiring additional land in other irrigation units. Eighty percent of the sampled households operate more than one parcel, and many of them also grow some crops under rain-fed conditions, or are members of groups in the process of soliciting the construction of new wells. The size distribution of both the principal parcels and of the total irrigated holdings varies significantly between sampled units, as is shown graphically in Chart 24.

Unit 612 was the first deep-well system in the Puuc region, constructed in the early 1940's by the personal order of President

TABLE 7. YUCATAN: IRRIGATION PROJECTS IN THE PUUC REGION, 1979

Development Program	Number of Irrigation Units	Area Under Irrigation	Number of Parcels[a/]	Citrus Production
		(hectares)		(tons)
Old-Type Gravity Units	47	2,700	3,475	24,000
Plan Chac Sprinkler Units	48	2,000	1,700	18,000
Mechanized Vegetable Units, including Plan Tabi	40	1,400	750	-
TOTAL	135	6,100	5,925	42,000[b/]

a/ This number does not correspond to the number of producers, as many families operate several parcels in more than one irrigation unit.

b/ This is the official estimate of the Ministry of Agriculture (SARH), and represented 70 percent of the state of Yucatan's total production of 61,000 tons. In the same year, a census carried out by the National Fruit Commission (CONAFRUT) reported a total output of 35,000 tons from a smaller number of active producers.

Source: México, Secretaría de Agricultura y Recursos Hidráulicos (SARH), Irrigation District #48, Ticul, Yucatán.

TABLE 8. OXKUTZCAB AND AKIL, YUCATAN: SUMMARY CHARACTERISTICS OF SIX OLD-TYPE IRRIGATION UNITS AND 48 SAMPLED HOLDINGS, 1981/82

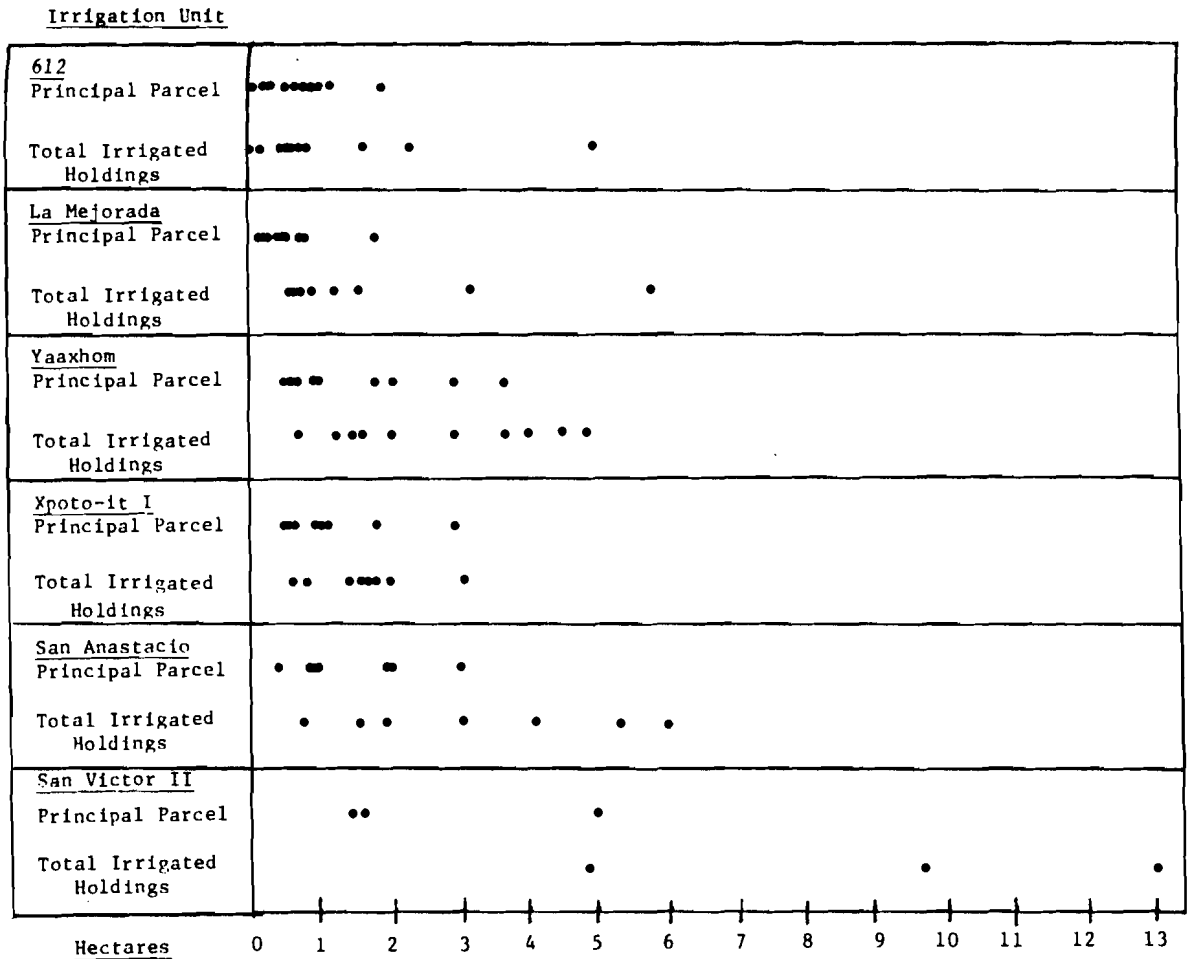
Irrigation Unit	Year Established	Number of Users	Mean Parcel Size	Number in Sample	Median Size of Sampled Parcels	Median Number of Parcels of Sample Farmers	Median Size of Total Irrigated Holdings
			(hectares)		(hectares)		(hectares)
Oxkutzcab							
612	1941	97	.7	11	.6	1.0	.7
La Mejorada	1953	109	.6	9	.2	2.5	1.1
Yaaxhom	1961	59	1.0	10	1.0	2.0	2.5
Xpoto-it I	1964[a/]	54	1.0	8	1.0	2.0	1.7
Akil							
San Anastacio	1951[b/]	51	1.0	7	1.0	2.0	3.0
San Victor II	1977	26	1.3	3	5.0	2.0	9.7
TOTAL		396	.8	48	.9	2.0	1.6

a/ This unit was divided into parcels in 1964, but irrigation water was not supplied until 1977.

b/ The area of this unit was originally included in Akil I, which could not supply enough water. San Anastacio was reorganized and a separate well was drilled in 1975.

Source: Appendix Table B5 and sample survey.

CHART 24. OXKUTZCAB AND AKIL, YUCATAN: SIZE DISTRIBUTION OF THE PRINCIPAL PARCEL AND THE TOTAL IRRIGATED HOLDINGS OF 48 FRUIT PRODUCERS IN SIX IRRIGATION UNITS



Source: Sample Survey.

Lazaro Cardenas. It is located within the town of Oxkutzcab itself, in an area where small orchards had already been established by members of the local merchant class. The new irrigation system allowed these people to enlarge and improve their parcels, and also provided water to a large number of small back-yard solares. The land is held as private property, and the ownership structure is polarized between the two groups. At the time of the study, the median age of the producers was 63, most of them were in semi-retirement, most of their trees were well past their prime, and only a quarter of them operated additional parcels.

Le Mejorada was built in the early 1950's on the other side of the town, in a period when fruit production was expanding rapidly in the region. Most of the parcels are small, privately held, irrigated solares, but 90 percent of the producers have additional holdings. Many of them were in the process of replacing old trees with new plantings in the early 1980's.

Yaaxhom and Xpoto-it I are located on ejidal land in the fertile valley ten kilometers south of Oxkutzcab. Fruit production first expanded into this area in the early 1930's, when a satellite community was established called Cooperativa. A privately organized group cleaned out and deepened an existing hand-dug well, and in 1940 petitioned to the Federal government to build an irrigation system and to assign eight-hectare parcels to the twenty families (183). Very strong opposition developed to the idea that private individuals should try to appropriate communal land and water resources. There were night-time attacks on the fence, and squatters moved in to prevent further expansion. In 1951, when the government deepened the well to the area under irrigation, a faction sued on the grounds that the beneficiaries were not bona fide members of the ejido (215). The case was adjudicated in their favor several years later by the state Supreme Court, and the principle of the free distribution of irrigated land to ejidatarios was established.

The well in the adjoining area of Yaaxhom was drilled to satisfy the demands of people displaced from Cooperativa in the mid-1950's, but the unit was not actually brought into operation because of continuing disputes. In 1961, a new group of ejidatarios acquired control of the facility, and obtained credit from the official Bank for peanut and potato production. That operation collapsed three years later due to problems with marketing and the organization of the credit program, and repossession of the tractor by the Bank. The members of the group subsequently divided the area into parcels and planted fruit trees.

Additional units have been established through long and frustrating processes of petition. The users of Xpoto-it I first laid claim to their parcels in 1964, but irrigation was not supplied until 1977. At the time of this study, some of them were redeveloping orchards which had been planted under rain-fed conditions, and others had land in the very early stages of development, with seedling fruit trees and

horticultural crops. By 1981, there were eight fruit units and twelve Plan Tabi mechanized vegetable units operating in the valley.

The development of irrigation in Akil has followed a similar pattern. The ten old-type units are located in a large, flat plain of colluvial soils between the highway and the escarpment of the hills. San Anastacio has had a complex history. Its land was originally included in Akil I, the oldest unit in the town, but the original pump could not supply enough water. A second well and a sprinkler irrigation system were installed in 1975, and the producers reorganized their operations. The land for San Victor II was purchased privately in 1977 by a prosperous group of families, many of whom already operated large holdings scattered among a number of units.

Types of Management

All of the parcels in the old-type irrigation units are cultivated using simple hand tools, and production techniques derived directly from those used in traditional systems. The development of irrigation and the evolution of a wholesale assembly market have provided the opportunity for Maya ejidatarios with modest resources to intensify production. Nevertheless, there is a wide range of variation between cases. Parcels in different units have been established for different lengths of time, from a few months to 30 or 40 years. Different farmers manage operations of different sizes, they grow different combinations of crops in different arrangements, they have invested different amounts of labor and cash in fixed improvements, they use different combinations of family and hired labor, they apply different levels of inputs, and they achieve highly variable yields and net returns.

Six case studies were drawn out of the sample to illustrate three broad types of management, and the operations were followed in some detail through an agricultural cycle. The categories are flexible, as many individuals have shifted from one to another in the course of their lives, but they provide a useful framework within which to conceptualize the cross-sectional variation between farms.

There are a great many part-time farmers, who operate small parcels in combination with other sources of income with which they pay a portion of the costs of production. Some of their plots, particularly in the older irrigation units in the centers of the towns, are backyard gardens with a function similar to that of the traditional solares. Others are operations in their early stages of development, which will later provide a greater proportion of household income. The majority of the producers in the region are family-labor farmers, some of whom hire supplemental workers. Most of them have worked outside of the region for extended periods, and have gradually accumulated the resources with which they have developed their parcels. A small but

influential minority are hired-labor farmers, who do not work their parcels themselves. They are merchants, or have other sources of capital from outside of fruit production. As we have seen, operations of this type were the first to be developed in the region, and they often include a number of parcels in different irrigation units.

As a basis for comparing very different farm operations, partial budgets were constructed. A summary of the results, standardized on a per-hectare basis, is provided in Table 9. A more detailed breakdown of each case is provided in Appendix Tables B6-B11. The names of the farmers have been changed. As the principal harvest season bridges the new year, the accounting period runs from June 1 through May 31.

The receipts from the sale of all crops were calculated, using a weighted average price through the season after the harvest and transport costs were deducted. The value of products consumed in the household were not included, although the importance of this factor will be discussed in the narratives. The total cash costs of production are difficult to estimate, as they consist of a great many small purchases, so the costs were limited to a uniform set of factors: irrigation water, fertilizer, spray chemicals, and hired labor. The estimated value of family labor was calculated by multiplying the estimated number of days employed in agricultural tasks by the average daily wage in the region at the time of the study. The time of the women in the market was valued at the same rate, and the labor of children under 12 was put in at half-price. The total represents approximately what the farmer would have had to pay to hire in the work.

The bottom line, the apparent net income in a single year, is a useful standard for comparison. It does not, however, represent the same thing as the net return to labor, capital, or management. It does not count the returns to accumulated assets, such as the irrigation network or the trees themselves. It is not a consistent estimate of the total disposable income earned from the parcel, and it does not include other sources of family income.

Part-Time Farms

Case 1. Mario Hau produces some fruit in a half-hectare parcel, but his principal occupation is as an independent mason and construction worker. He was born in 1931 in a small hamlet 30 kilometers south of Oxkutzcab. His father produced the family food supply in milpas, and worked seasonally as a guard at one of the many archeological sites in the area. The family had a house in a tiny irrigated solar in the center of town, where they produced some fruit for home consumption. Hau attended school erratically, and finished the third grade. He worked as an agricultural laborer for many years. In 1961, at the age of thirty, he migrated to Chetumal, Quintana Roo to work on

TABLE 9. IRRIGATED FRUIT AND VEGETABLE OPERATIONS IN OXKUTZCAB AND AKIL, YUCATAN: SUMMARY OF RECEIPTS, ESTIMATED CASH COSTS OF PRODUCTION, ESTIMATED VALUE OF FAMILY LABOR, AND ESTIMATED APPARENT NET RETURNS, STANDARDIZED ON A PER-HECTARE BASIS, OF SIX SELECTED FARMS, 1981/82

Farms	Size of Parcel	Number of Crops Sold	Value of Receipts	Estimated Cash Costs	Estimated Value of Family Labor	Apparent Net Returns
	(hectares)		(.....US$/hectare[a/].....)			
Type I - Part-time Farms						
1. Mario Hau	.5	7	925	675	310	-60
2. Manuel Gongora	.5	3	380	475	3,180	-3,275
Type II - Family-Labor Farms						
3. Transito Us	1.2	15	3,130	400	2,375	355
4. Juan Pech	1.9	7	8,075	3,210	1,460	3,405
Type III - Hired-Labor Farms						
5. Alberto Suarez	3.0	8	1,675	625	60	990
6. Francisco Castro	2.8	5	3,230	1,110	0	2,120

a/ All monetary figures have been converted at the exchange rate of 26 pesos per dollar.

Source: Appendix Tables B6-B11.

construction projects. He left his young family behind with his parents, and was able to accumulate some cash.

In 1966, he bought his parcel in the La Mejorada unit. It had previously been cleared and planted with some trees, but it had never been connected with the irrigation system. He financed its purchase and the construction of 200 meters of canal with the help of his father-in-law, and continued to work in Quintana Roo for most of the year. He moved home permanently in 1971 as a skilled tradesman.

Most of the trees in the parcel are traditional, low-yielding varieties between ten and twenty years old. Hau has never grown vegetables or other short-season crops. One of his children works with him in his business, two are in school, and the other three have children of their own. He works in the plot occasionally, but pays laborers, including his brother-in-law, to irrigate and weed. He sells the fruit on the tree to a merchant with whom he has a long association. At one point, he experimented with spraying fungicides and insecticides, but he did not feel that the costs were justified. He applies a little chicken manure every other year as fertilizer.

The cash income from the sale of fruit is modest, and the apparent net returns are negative. Any significant improvement would require the redevelopment of the parcel with more productive crops, and more intensive management practices. He does not have the time to do the work, and maintains the operation as a source of fresh fruit for his family, and for the long-term security which it provides should his construction business flag.

Case 2. Manuel Gongora operates a parcel of the same size, which is in its early stages of development. He was born in 1943 in a small community in the southern frontier near the border with Campeche. His father had moved down there from Xaya, one of a number of extremely poor villages on the fringes of the maize zone. The settlement was reorganized in the early 1960's as a government-sponsored colonization project, but promised services were never provided, and the family subsisted almost entirely on the basis of their milpas. Gongora moved to Oxkutzcab at the age of 33. Through family connections, he was admitted as an ejidatario in 1979, and acquired a one-half hectare parcel in the Xpoto-it I unit.

In the first years, he worked as a day-laborer in the surrounding parcels to support his family. He cleared the land, built a simple stick and thatch house, and grew milpa crops as he built the irrigation ditches. The eldest of his four children was 12, old enough to help regularly with routine production tasks, but otherwise he worked entirely alone. In 1981, he began to plant a successional sequence of crops, following the practices of his neighbors. The first step was to plant papayas and bananas, which produce after a year, in rows spaced two meters apart. Six months later, he bought and transplanted his first seedling orange trees in between these rows. When he has the

money, he plans to get avocado, lemon, and mango seedlings and to gradually fill the parcel. He also grows vegetables--chile, hybrid maize for roasting ears, cowpeas and cassava--in relayed intercropping arrangements.

In the year of the study, Gongora was only just beginning to sell crops in small quantities. Although the value of his receipts did not even cover the direct costs of production, he was able to produce a significant proportion of his family's food requirements. He continued to work for wages three or four days a week, but he was expanding as rapidly as he could. As his trees come into production, he will be able gradually to abandon off-farm work, and hopes to acquire more land. His highly negative apparent net income reflects the fact that he is building up an investment in the future security of his household.

Family-Labor Farms

Case 3. Transito Us manages a complex, diversified operation of 1.2 hectares. He was born in 1934 in Oxkutzcab, the son of a traditional farmer with milpas in the plain north of town and conucos in the Puuc hills. The family also owned a small herd of seven cattle, which they were forced to sell to meet a health crisis. He worked for his father throughout his youth. In the late 1950's, he left for five years to work as a contract laborer in large commercial milpa operations in the forest frontier of Quintana Roo. In 1964, at the age of 30, he was elected representative of a group which petitioned to the Federal government for the construction of the Xpoto-it I irrigation unit. The plan was approved by the ejidal assembly, and one-hectare parcels were distributed without cost.

Us cleared the scrub forest which had grown up in the 50 years since sugar cane production had been abandoned in the valley, and planted orange seedlings. He produced fruit under rain-fed conditions until 1977, when the irrigation system was finally completed. During this long period, he grew maize and other milpa crops in the parcel to feed his family, and worked for wages in the local area. In the past few years, he has intensified the management of the land, and has acquired another small plot where he produces vegetables. He commutes every day in the trucks which circulate through the zone from his modest home in the town, ten kilometers away.

He has eight children, has developed the operation entirely with family labor, and has kept his cash investments to an absolute minimum. He owns no equipment except simple hand tools. His eldest son has moved to Mexico City, and two others are staying with relatives in Merida as they attend school. These two, and the youngest who is still at home, help their father on weekends, vacations, and busy times. His four daughters are married, and his wife sells for him in the market.

His holding is divided into three separate sections. The largest part, approximately .7 hectares, is an orchard of mature fruit trees which he planted under rain-fed conditions. It was laid out as a regular grid of oranges, but mandarin oranges and various other species have been planted in the centers. After the parcel was provided with irrigation, water tended to collect in an area of heavy soils along one edge. He cut down the trees, and replanted with lemons, coconuts, mangos, and bananas. He uses the available space between the seedlings to grow a winter crop of maize for fresh roasting ears, and for squash.

In 1979, he purchased a .2-hectare parcel a few hundred meters from the first. It was already planted with a heterogeneous collection of immature fruit trees, intercropped with Achiote (annato seed). The price of that crop was dropping rapidly due to local overproduction, so he pulled out the bushes and rebuilt the irrigation ditches between a regular system of closely spaced beds. He has been planting them with a relay sequence of four short-season crops. He sows maize and cowpeas in alternate rows in January, another crop of maize in June, another of cowpeas in July, another of maize in September, squash in October, and tomatoes in November.

He irrigates his fruit trees every ten days in the dry season, and his vegetables every five. He fertilized his orchard for the first time in 1981, with the help of a little bit of credit from the Rural Bank. He fertilizes and sprays his vegetables regularly, using a borrowed sprayer. He sold 15 different crops in 1981-1982, about 70 percent of them between September and January. His yields were about average for the region, and his cash costs of production were low. He worked virtually every day in the parcel, weeding three times during the year and taking good care of the details of production. His apparent net income was modest, but he was able to support three children in school and to invest 7,000 pesos in a bull-calf to fatten behind his house, a local measure of relative prosperity.

Case 4. Juan Pech is redeveloping a two-hectare parcel and is expanding his operations with the resources which he accumulated in many years of work overseas. He is specialized in avocados, and has selected a number of choice varieties which bear at different times of the year. His cash costs of production are high, and he uses considerable hired labor, in addition to his own and that of his family.

He was born in 1934 in a hamlet near Oxkutzcab. He spent most of his youth in extremely isolated frontier camps in the south, where his father worked as a contract laborer on large, commercial milpas. He did not speak Spanish until he was nine years old, but he was able to attend school irregularly thereafter. In 1959, at the age of 25, he married the daughter of one of the members of the local merchant elite, and acquired an interest in a parcel in the Yaaxhom unit which was already planted with mature trees. To finance its management, he began a long period of migratory labor. He went to the United States for two years in the early 1960's, where he worked picking cotton in Texas and

sugar beets in Wyoming. In 1964, he joined the Norwegian merchant marine, where he worked for 14 years. He sent money home to his wife, who paid workers for routine production tasks. He returned home permanently in 1978, at the age of 44, and began a rapid process of expansion.

He cleared out all of the old trees, and entirely redeveloped the parcel. With the help of hired workers, he reconstructed the water distribution system by leveling basins and lining the ditches with masonry. He planted avocados in a regular grid, and they were first coming into regular production in 1981-1982. In the first two years of the redevelopment process, he grew maize, cowpeas, and beans between the rows, both for home consumption and for sale. Then, in partnership with another farmer, he produced papayas, chile, squash, and tomatoes commercially with the intensive use of chemical inputs. These short-season crops accounted for over 30 percent of his receipts in 1981-1982, but he was very dissatisfied with the results. In spite of the fact that he sprayed them once or twice a week, yields were greatly reduced by a series of pest and disease problems, and the labor costs were very high. Only squash, sold immature as a fresh vegetable, provided a significant net return over the direct costs of its production.

He has six children, all of whom are in school. They help on weekends and on vacations. His wife takes a very active role, both by selling in the market and by participating in the management decisions. His short-term goal is to maintain enough cash-flow to support his family at what is a high standard of living by local measures. They own a substantial masonry house in the center of town. In addition to his own parcel, he helps in his brother's holdings, and is beginning to develop another parcel in an irrigation unit which is still under construction. Within a few years when the avocados are in full production, he plans to abandon the production of vegetables. His apparent net income is the highest of the case studies, but he would not have been able to achieve this if he had not previously accumulated considerable cash savings.

Hired-Labor Farms

Case 5. Alberto Suarez's three-hectare citrus orchard is an example of a relatively specialized, commercially oriented parcel which is not managed to achieve maximum returns. He worked for most of his life as the hired manager of commercial agricultural enterprises. He was born in Oxkutzcab in 1913, the son of a skilled mechanic on one of the haciendas. In his youth, he sometimes planted milpas to feed his family, but he also worked as the field supervisor of large commercial milpas in the southern frontier, and in the supply system for chicle camps. In 1949, he entered into partnership with two merchants to operate a 300-hive commercial beekeeping operation in a private rancho

30 kilometers south of Oxkutzcab, which was his principal source of income until he sold his share in 1974.

In the 1940's, he developed a rain-fed parcel in the community of Cooperativa. He was forced to abandon it in the legal battles of the 1950's, and was one of the organizers of the Yaaxhom unit. He planted orange seedlings in his parcel in 1964, and produced maize, cowpeas, chile, and cabbage between the rows to help pay for the costs of establishment. He also laid out coconuts around the perimeter, and some tall mango and avocado trees in the centers of the orange grid at irregular intervals. By 1980-1981, the trees were past their prime. He estimated that he spent approximately 20 days a year working, pruning and checking. He hired laborers for all of the routine irrigation and weeding. The irrigation system consists of simple earthen ditches, and he waters on a minimal schedule of once every two weeks during the dry season. The parcel is weeded lightly three times a year, and the ground is covered with a thick mat of grass and weeds. He applies chicken manure every other year, but he does not spray or use any other inputs. He sells the fruit on the trees to a long-term associate.

His gross receipts for the season were much lower than the previous case. The difference can be explained partially because he is specialized in lower value crops, partially because the plot is in a later stage of development composed entirely of mature trees, and partially because the logic of his management is quite different. The parcel is not his principal source of income. He invested the proceeds from the sale of his beekeeping operation in a 200-hectare cattle ranch in Quintana Roo, which he manages in cooperation with one of his sons. At 68 years old, he regards the approximately 3,000 U.S. dollars he earns from his parcel as a kind of pension, and tries to keep his costs at an absolute minimum.

Case 6. Francisco Castro is a fruit merchant who owns several trucks and has close family associations in the central market in Merida. He was one of the organizers of the La Mejorada unit. His 2.8-hectare parcel is one of four in three irrigation units which he works entirely with hired labor. He specializes in the production of the choice Lagunero variety of avocados, which he first introduced into the region. He was born in 1920 in Peto, a town on the forest frontier to the east. His father moved to Oxkutzcab as a merchant, first with a small shop serving the needs of the campesinos, and then shipping fruit to Merida on the railroad. The family started raising oranges in one of the small, shallow-well units during the Second World War. Castro took over his father's business in the early 1950's, and actively participated in the expansion of irrigated agriculture. His family is prominent in the town, and one of his sons holds a supervisory post in the Irrigation District.

The parcel was first planted with oranges under rain-fed conditions in the late 1940's. After the irrigation unit was organized, he

paid workers to supply his share of the cooperative labor in the construction of the main canals, and to build a 300-meter stretch to connect his land into the system. The internal distribution system consists of unimproved earthen ditches. In 1966, he cut down the old trees and planted avocados in an irregular pattern following the contours of the terrain. He has never produced vegetables, as he feels that the supervision of the labor involved is too time-consuming. Instead, he raised bananas in the early stages of development until the shade canopy closed over. This is a less profitable crop, but it requires much lower investments in labor and inputs, and the risks are less. One section is planted in an alternating pattern of oranges and mandarins, and he produces some Huano palm, which he allows his workers to cut for thatch. By 1981-1982 the avocado trees were past their prime, and Castro had begun to plant Zapote seedlings to replace them. The price of this fruit has increased rapidly in recent years, and he fears that the market for avocados may be becoming saturated.

He irrigates every ten days during the dry season. He was instrumental in arranging with the poultry operations around Merida to sell manure in the fruit zone and applies it every other year. He uses a mixed weed control system. He has the parcel sprayed with Paraquaat three times a year, and then has workers go through and cut out the resistant weeds by hand. Choice, thin-skinned avocado varieties are particularly sensitive to worms and other pests, and he hires in a team with their own spray equipment to apply insecticide twice a year. He treats fungus diseases with copper sulfate if he detects a problem, and eradicates any ant hills which may appear. He buys all of his inputs in Merida at wholesale prices. He pays for the harvest on a piece-work basis, and transports the fruit to Merida in his own trucks.

Castro is very busy managing his various operations. He drives around in his pick-up truck, delivering laborers to his various parcels, checking on their work, and stopping by the market periodically to follow the prices and check with his agents. Castro is primarily a merchant, but his fruit parcels have played an important role in the accumulation of the modest fortune of a local entrepreneur.

The Production System

These case studies exemplify the range of management systems which are found in the old-type irrigation units. They raise an important question: what constraints have prevented all of the farmers from specializing in the production of high-value crops, and from organizing the most profitable combinations of labor, irrigation water, and improved technology? The majority of the Maya peasant families have not been able to achieve high levels of efficiency, because they have controlled very limited resources beyond their own labor power, because very little credit or technical assistance has been available to them, and because they have faced very uncertain market conditions.

Nevertheless, over a period of 40 years, they have been able to gradually intensify their traditional production systems. Their flexible management strategies have provided a more or less even flow of income to meet their consumption needs, and have permitted them to accumulate equity in the long-term security of their households. This process will be illustrated, using data from the sample of 48 farmers.

Gradual Development of the Family Enterprises

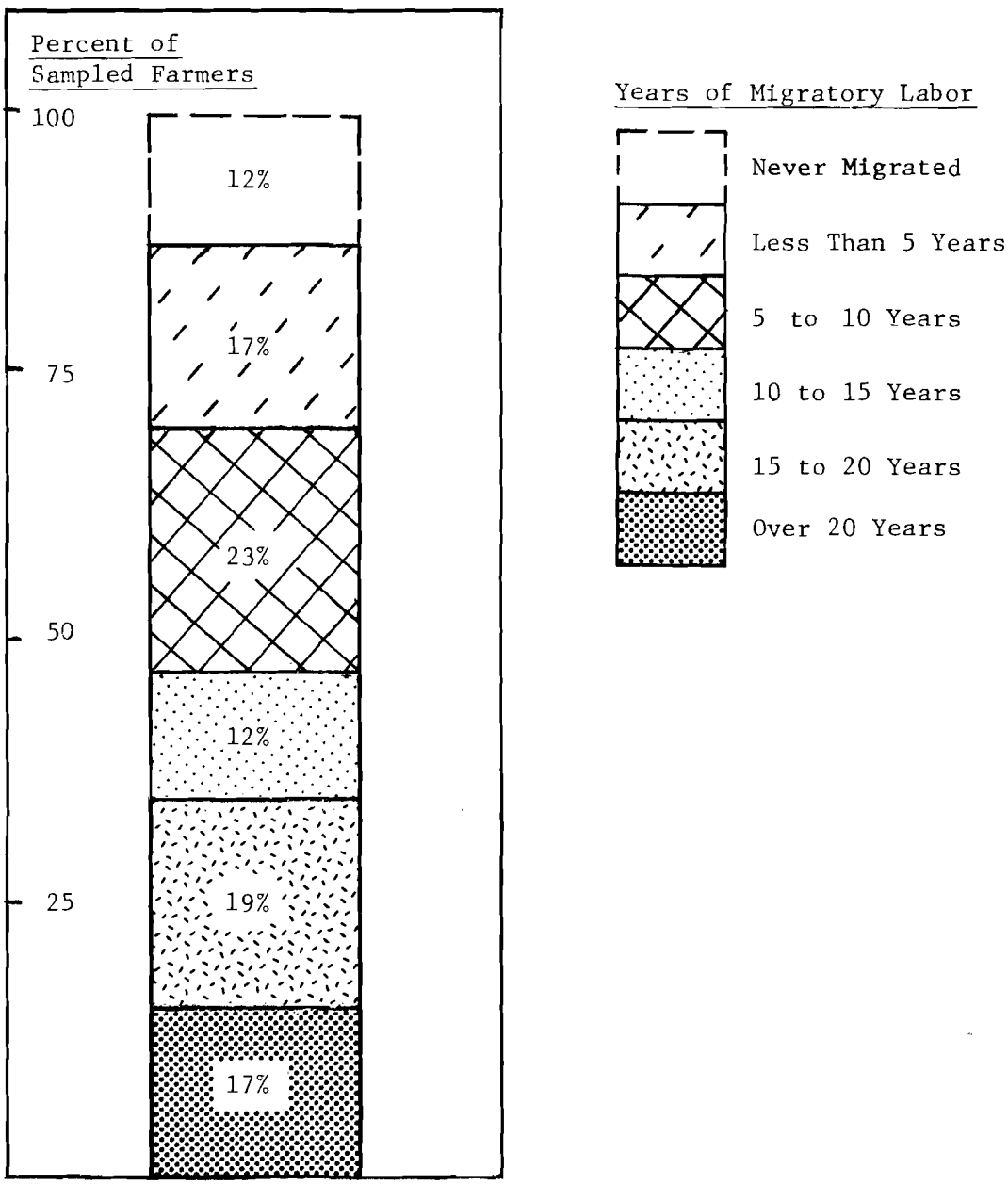
The farmers share similar backgrounds. Almost all of them were born in the immediate region, and almost all of their fathers were independent slash-and-burn agriculturalists in the decades after the Revolution. The costs of acquiring parcels and bringing them into production are very difficult to compare directly. Forty years ago, when the first irrigation units were established, the land was purchased as private property, and the main distribution canals were built with the direct participation of the users, who supplied materials and labor. Parcels in more recent units have been distributed free to ejidatarios who are members of organized groups, and the government has taken over all aspects of their construction. Nevertheless, a combination of inflation and speculative pressure has pushed up costs rapidly in recent decades, and the relative values of land, developed parcels, and expected production have not remained constant over the intervening decades.

At the time of the study, unimproved parcels in an area served by a well were selling for between 5,000 and 12,000 pesos per hectare. Parcels developed for irrigation with trees in production sold for over five times as much--between 30,000 and 70,000 pesos per hectare depending on the tenure status of the land and the quality of the orchard. This difference reflected the value of the accumulated cash and labor time which had been invested in their development.

The majority of the farmers acquired their first parcel when they were in their late twenties and early thirties. Sixty percent participated in the formation of new irrigation units; the others have either inherited their holdings or have purchased parcels already in production. The costs of establishment were too great to finance out of the modest surplus of slash-and-burn agriculture. At the very least, one had to accumulate a food reserve for consumption until the first crops could be marketed.

Except for the local elite, who have transferred capital from their commercial activities, the farmers have paid for the land, the development of irrigation, seedling trees, and other costs with off-farm labor, primarily on a migratory basis. The median number of years which they have worked outside of their home communities is 13; the distribution is shown in Chart 25. Their complicated work histories include seasonal labor in chicle camps and commercial milpas in the frontier, government construction and colonization projects, and

CHART 25. OXKUTZCAB AND AKIL, YUCATAN: DISTRIBUTION OF THE NUMBER OF YEARS WORKED OUTSIDE OF THEIR HOME COMMUNITIES ON A MIGRATORY BASIS BY SAMPLE FARMERS



Source: Sample Survey.

journeys to Merida, Chetumal, other parts of Mexico, and the United States. In some cases, their parcels were semi-abandoned during their absences. In others, family members were able to keep up with at least routine production tasks. Local employment opportunities have improved in recent years, and one third of the sample worked for wages at least part-time in the year of the study.

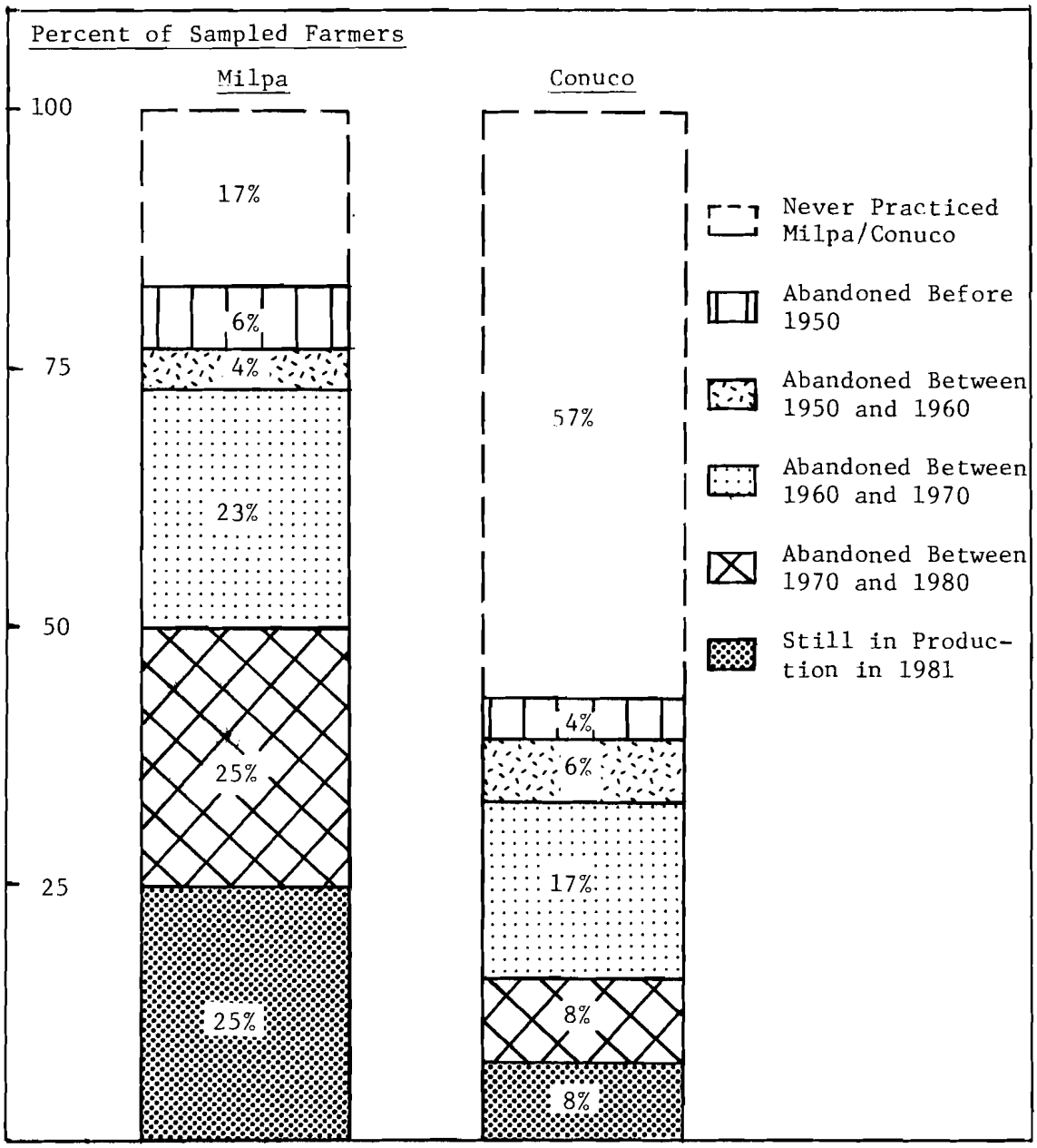
Almost all of them continued to maintain traditional production systems as they brought their parcels into production. Chart 26 shows that over three quarters of them have grown subsistence crops in milpas, and nearly half have produced market vegetables in conucos, at some point in their lives. These activities have gradually been abandoned, although half of the farmers continue to grow at least some maize, and produce enough to meet their household consumption needs for an average of five months of the year.

Small animals are kept by two-thirds of the households in small, backyard operations similar to those found in any Maya village. Chickens, turkeys, and pigs are raised for food, and represent a kind of savings which can be sold to meet emergency cash needs. Twenty years ago, when surplus maize was more abundant in the region, modest commercial operations of 10 to 15 pigs or 40 to 50 chickens were a common sideline in association with irrigated parcels. A few survive to meet local demand, but the decline in maize production, the increasing cost of feed, and the expansion of intensive commercial enterprises around Merida have driven most of them out of business. Approximately a quarter of the families used to own small herds of cattle which they released to browse in the Puuc hills at night. Most were forced to sell when the fence law was passed in 1972, although a handful of relatively rich campesinos have established fenced ranches in the surrounding area.

The profits from a particularly good year are often invested in bull-calves. They are tethered in the backyard, where crop residues, grass, maize, and some feed are brought to them. Although the net profit at the time of their sale is low or even negative, they are a source of prestige, and bring in a considerable block of cash.

As the parcels become established, the labor requirements for routine tasks declines. Although the average household consists of 7.3 persons, in only half of the cases do sons work directly with their fathers on a regular basis. The farmers regard the broadened opportunities for their children as one of the most important benefits of the relative prosperity which they have achieved. Over half of them are supporting children in school, who work on weekends and at busy periods of the year. Many students work throughout the region during the orange harvest on a piece-work basis. The children of the richer members of the community have used education as a path into teaching, government posts, and other middle-class occupations. Members of more modest households are reproducing the work histories of their fathers by migrating outside of the area to accumulate resources.

CHART 26. OXKUTZCAB AND AKIL, YUCATAN: GRADUAL ABANDONMENT OF MILPA AND CONUCO SYSTEMS BY SAMPLE FARMERS THROUGH 1981



Source: Sample Survey.

The Choice of Crops

Sweet oranges have been the predominant fruit crop in the Puuc region since well before the irrigation systems were established, and they are grown in virtually every parcel. A census of the old-type units in 1979 reported that 60 percent of all of the fruit trees in Oxkutzcab and Akil were oranges (162). As Chart 27 shows, this figure is in agreement with their relative abundance in the sample. The eight most common fruit crops account for over 90 percent of all the trees. Nevertheless, orchards in monoculture are virtually unknown.

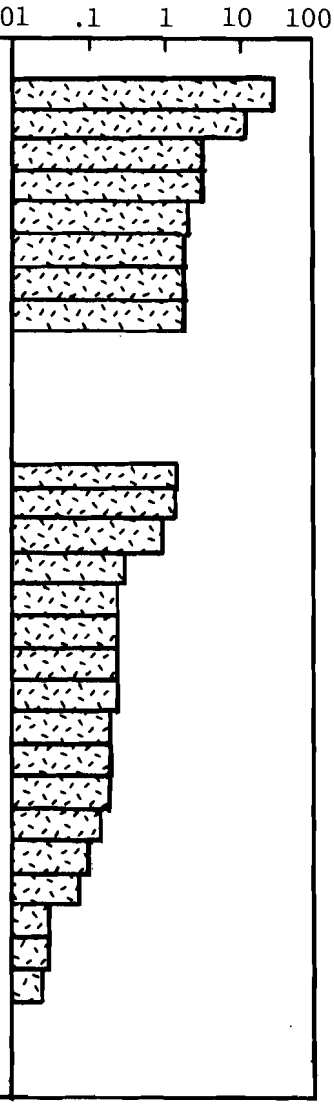
In a pattern which closely resembles traditional citrus groves in the major producing regions of the Mediterranean (41) the parcels are diversified with between four and twenty species of fruit, as well as with annual and semi-perennial crops when the trees are small. They form complex, multi-storeyed arrangements, crowded into both the horizontal and the vertical space. The most frequent companions are avocados and mangos, large trees with delicate, high-value fruit, and mandarin oranges, a small species with growth characteristics which can be combined conveniently with oranges in the architecture of the parcels. The absolute abundance of the other fruit species in the sample as a whole falls off rapidly, but a few trees of each are frequently found in the parcels, and they provide an important, if relatively small fraction of the income of the families.

Gradual Evolution of Traditional Cropping Arrangements. The practice of growing a number of tree crops in combination is derived directly from the rain-fed solares, which have a long history in Yucatan. The transformation of traditional into commercial systems has involved the gradual reorganization of the cropping arrangements and the patterns of diversity. This process, which has taken place at an uneven rate depending on the resources available to each family, can be divided conceptually into three stages: solares, diversified irrigated parcels, and specialized irrigated parcels.

In traditional solares, the frequency with which particular species are grown is ranked roughly in terms of their direct use-value for home consumption. A few individuals of many kinds of trees are planted at irregular intervals through the course of a family's development, and spontaneous seedlings are tolerated. The plots mature into highly diverse, multi-storeyed plant communities. The development of irrigation has permitted the peasants in the Puuc region to specialize in oranges and a few other crops with established and relatively secure markets. Table 10 compares the relative frequency of the predominant fruit species in a sample of solares in the village of Yaxcaba with that in the sample of irrigated parcels. Many of the same crops are found on both lists, but the rank order has changed as the choice criteria have shifted from their use-value to their exchange-value. In addition to three or four principal crops, most of the peasants continue to plant a few individuals or many other trees, both for home consumption and because they provide a source of income outside of the

CHART 27. OXKUTZCAB AND AKIL, YUCATAN: ABUNDANCE OF PERENNIAL SPECIES IN ALL SAMPLE PARCELS IN OLD-TYPE IRRIGATION UNITS

Species[a/]	Number of Trees	%
Sweet Orange	6,750	55
Avocado	1,363	11
Mandarin Orange	763	6
Lemon (Mexican Lime)	760	6
Coconut	511	4
Zapote	401	3
Mango	400	3
Saramuyo	374	3
Subtotal	11,327	91
Huano[b/]	-	-
Naranja Agria	229	1.9
Nance	225	1.8
Toronja[c/]	132	1
Ramon	67	.5
Tamarindo	55	.4
Caimito	52	.4
Mamey	51	.4
Ciruela	44	.4
Guanabana	41	.3
Guayaba	40	.3
Limon Dulce	34	.3
Lima	30	.2
Jicara	14	.1
Cajera	12	.09
Guaya	7	.05
Pepino de Arbol (Kat)	6	.05
Mamoncillo	5	.04
China Lima	1	.01
Total	12,371	100



a/ English and scientific equivalents of the Spanish names are provided in Appendix A.

b/ Huano (Sabal yapa) is a roofing palm which is commonly grown, but the number of individual plants is not quantified.

c/ Toronja is the common Spanish name for grapefruit (Citrus paradisi). In Yucatan, large, high-quality fruit are called "grey," a contraction of the English name, and no distinction is made between less choice varieties and pomelo (Citrus grandis).

Source: Sample Survey.

TABLE 10. RANK ORDER OF FREQUENCY OF TREE SPECIES IN TRADITIONAL SOLARES IN THE VILLAGE OF YAXCABA, COMPARED TO THAT IN IRRIGATED PARCELS IN OXKUTZCAB AND AKIL, YUCATAN

42 Solares in Yaxcaba [a]			48 Parcels in Oxkutzcab and Akil [b]		
Rank	Species [c]	Percent of Parcels Where Present	Rank	Species	Percent of Parcels Where Present
1	Ciruela	83	1	Sweet Orange	98
2	Sweet Orange	74	2	Avocado	79
3	Guaya	71	3	Mango	79
4	Sour Orange	67	4	Mandarin Orange	77
5	Avocado	55	5	Lemon (Mexican Lime)	60
6	Saramuyo	54	6	Saramuyo	51
7	Lemon (Mexican Lime)	48	7	Coconut	43
8	Mandarin Orange	40	8	Sour Orange	40
9	Guava	38	9	Grapefruit	38
10	Anona	38	10	Zapote	36
11	Guanabana	36	11	Huano	32
12	Limon Dulce	31	12	Mamey	32
13	Mango	31	13	Nance	30
14	China Lima	29	14	Caimito	30
15	Grenada	29	15	Guaya	26
16	Zapote	26	16	Ramon	23
17	Tamarind	26	17	Guanabana	23
18	Cajera	24	18	Ciruela	21
19	Nance	24	19	Lime	19
20	Caimito	21	20	Limon Dulce	19
21	Grapefruit	19	21	Guava	17
22	Coconut	14	22	Cajera	11
23	Lima Agria	10	23	Tamarind	11
24	Mamey	7	24	Mamoncillo	6
25	Lime	7	25	China Lima	2

a/ Adelaido Vara Moran, "La Dinamica de la Milpa en Yucatán: El Solar," in Efraim Hernández X., Ed., Seminario Sobre Producción Agrícola en Yucatán (Gobierno del Estado de Yucatán, Mérida, 1980), p. 319.

b/ This data is based on interviews, which tend to underestimate the presence of minor species.

c/ The English, Maya, and scientific equivalents of the Spanish names are provided in Appendix A.

major harvest seasons. The production calendar of the most common species is shown in Chart 28. These plots resemble solares in their complex, multi-storeyed cropping arrangements, but the underlying pattern of their diversity is quite different. A small minority of the farmers have accumulated resources which have allowed them to develop greatly simplified orchards, restricted to crops with complementary management requirements and harvest periods.

Examples of the three types were compared systematically, using a quantitative analysis of data from a sub-sample of 12 plots. 2/ The principal results are outlined in Chart 29. The mean number of tree crops which are grown declines from nearly 20 in the traditional solares, to 13 in the diversified irrigated parcels, to seven in the relatively specialized orchards. When this parameter is transformed to "species richness" to standardize for the differences in the area of the sample plots, the difference between the first two types disappears, although the solares are far more densely planted.

The most significant contrast between the three modes of diversity is not the total number of species, but rather the proportion of all of the trees which are the dominant crop. The simplest measure of this concept is an arbitrary convention--the relative frequency of the most prevalent three species. Traditional solares are planted with a few individuals of many different fruits, to meet the diversified consumption requirements of the households. In the examples, approximately 40 percent of all of them are in the top three. By contrast, an average of 65 percent of the individuals in the diversified, and 85 percent of those in the specialized irrigated parcels are oranges, avocados, mangos, or whatever the most prevalent three happen to be. The patterns are much the same if the relative shares of the value of production are calculated using standardized estimates of yields and prices. Chart 30 is a graphical representation of exactly the same concept. Importance-value curves, which plot the relative importance of the species against their rank, are constructed so that their slopes are a measure of the degree of concentration.

As the trees grow into vertical space and more species are planted, the structure of the parcels becomes more complex. The increasing shade of the canopy, particularly that cast by the larger

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2/ Measurements commonly used in the study of forests and other natural communities were taken of the trunk diameter, height, shade cover, and location on a coordinate grid of 1,318 trees in 15 sample plots. The author is indebted to Dr. Bernd Neugebaur for his help with field methods, and to Don Victor Us for his assistance identifying the species. The data on two traditional solares in the village of Yaxcaba was provided through the generosity of Ing. Adelaido Vara of the Graduate Agricultural College at Chapingo. The measures of diversity are drawn from Whittaker (303) and Peet (213). More detailed analysis of the sample plots is available from the author upon request.

CHART 28. OXKUTZCAB AND AKIL, YUCATAN: GENERALIZED CALENDAR OF PRODUCTION TASKS AND PRINCIPAL HARVEST PERIODS IN IRRIGATED PARCELS

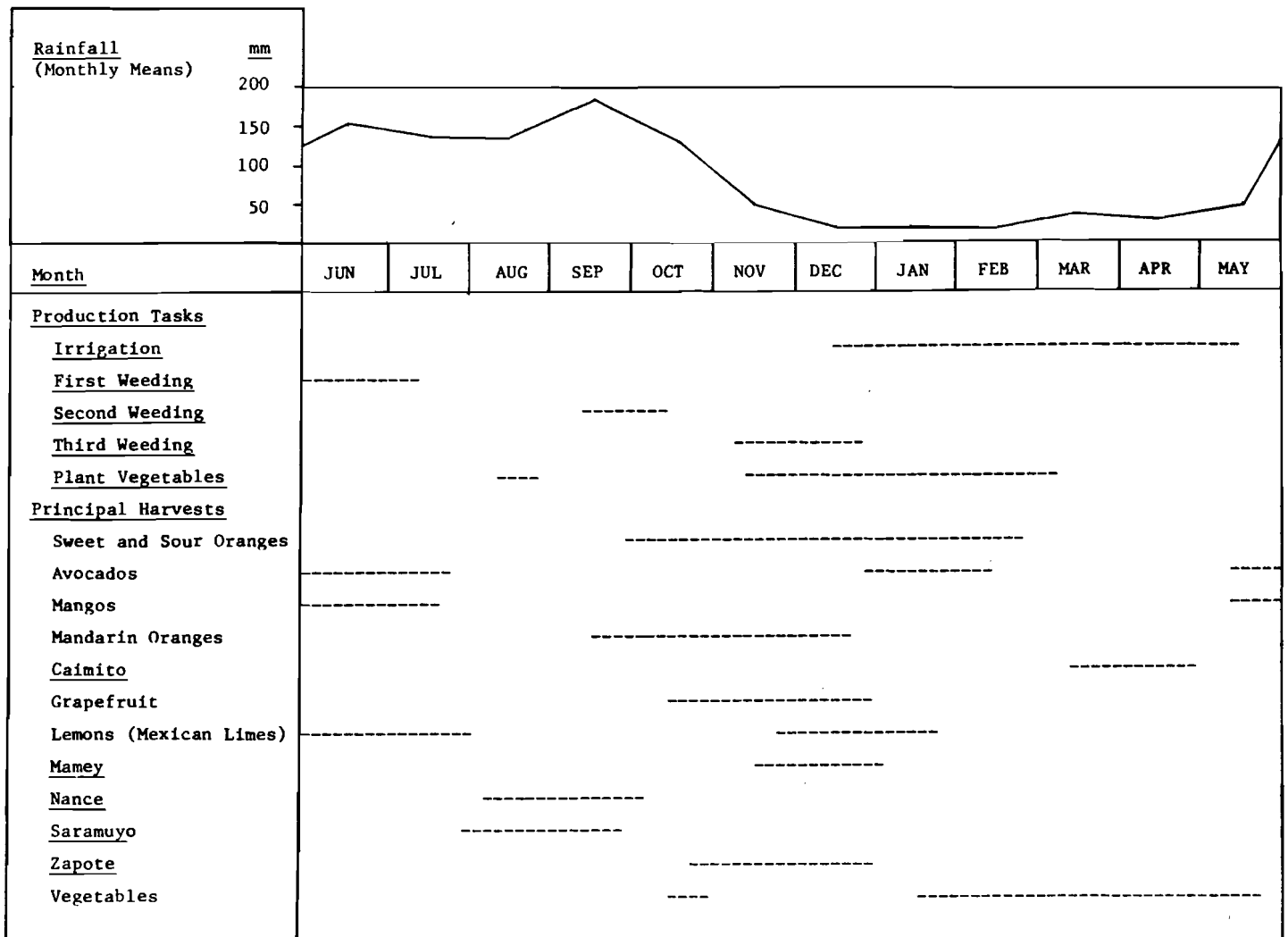


CHART 29. YUCATAN: COMPARATIVE MEASURES OF DIVERSITY OF THREE TYPES OF PARCEL

Number of Species	5	10	15	20	25	Mean
Traditional Solares			X		X	19.5
Diversified Parcels		X X X		X X		13.4
Specialized Parcels	X X	X X X				7.4

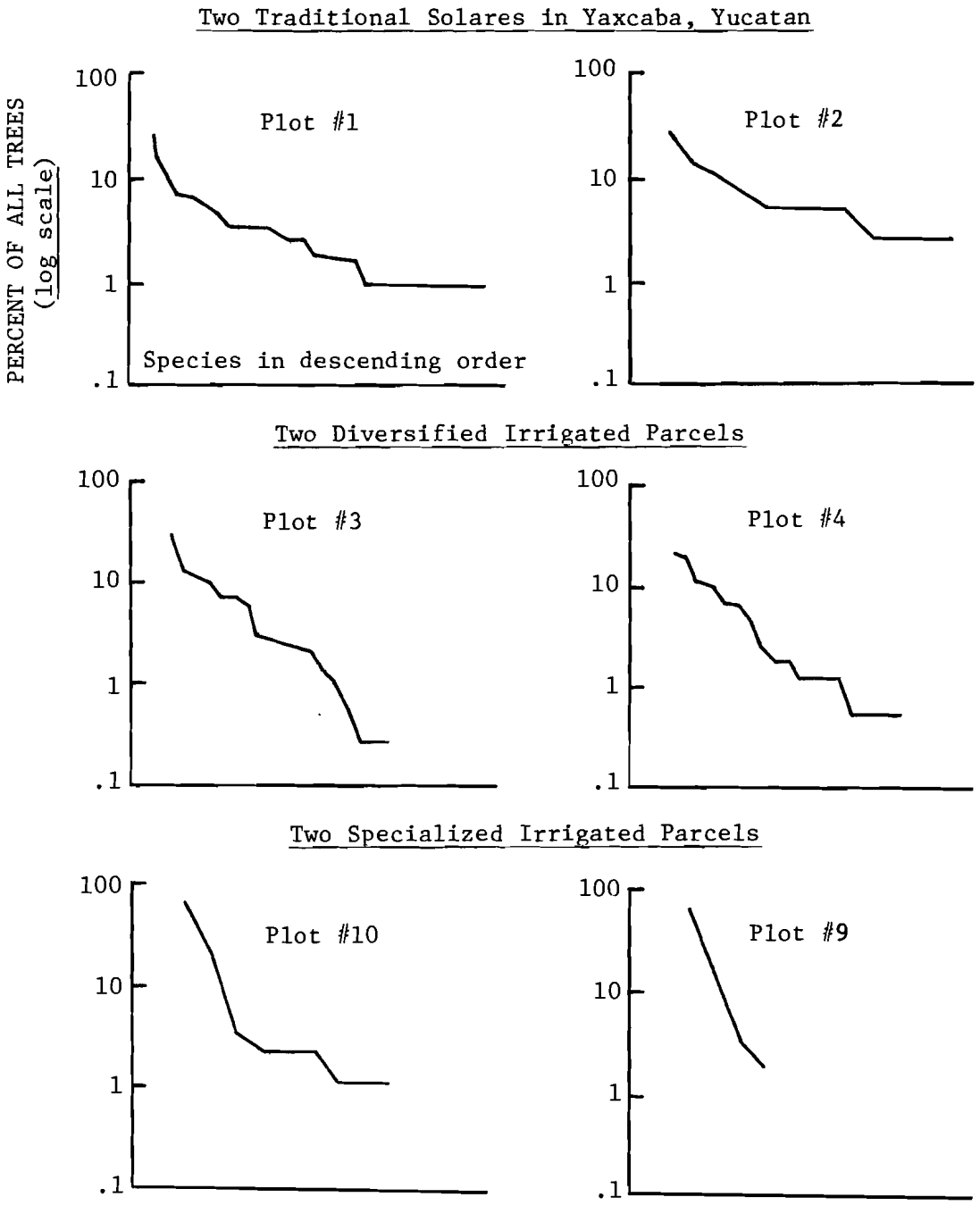
Species Richness/ Log of the Area	1	2	3	4	5	Mean
Traditional Solares				X	X	3.9
Diversified Parcels			X	XX	X X	3.9
Specialized Parcels	X X	X X		X		2.2

Density of Mature Trees Per Hectare	100	200	300	400	500	600	Mean
Traditional Solares					X	X	500
Diversified Parcels			X X	XXX			380
Specialized Parcels	X X X X	X					210

Relative Frequency of Most Prevalent Three Species (Percent)	20	40	60	80	100	Mean
Traditional Solares		X X				38
Diversified Parcels			XX X	X X		65
Specialized Parcels			X	X X	XX	84

Relative Annual Income From the Most Prevalent Three Species (Percent)	20	40	60	80	100	Mean
Traditional Solares						0
Diversified Parcels			XX	XX X		76
Specialized Parcels				X X	XXX	92

CHART 30. IMPORTANCE VALUE CURVES OF SELECTED EXAMPLES OF THREE TYPES OF PARCEL



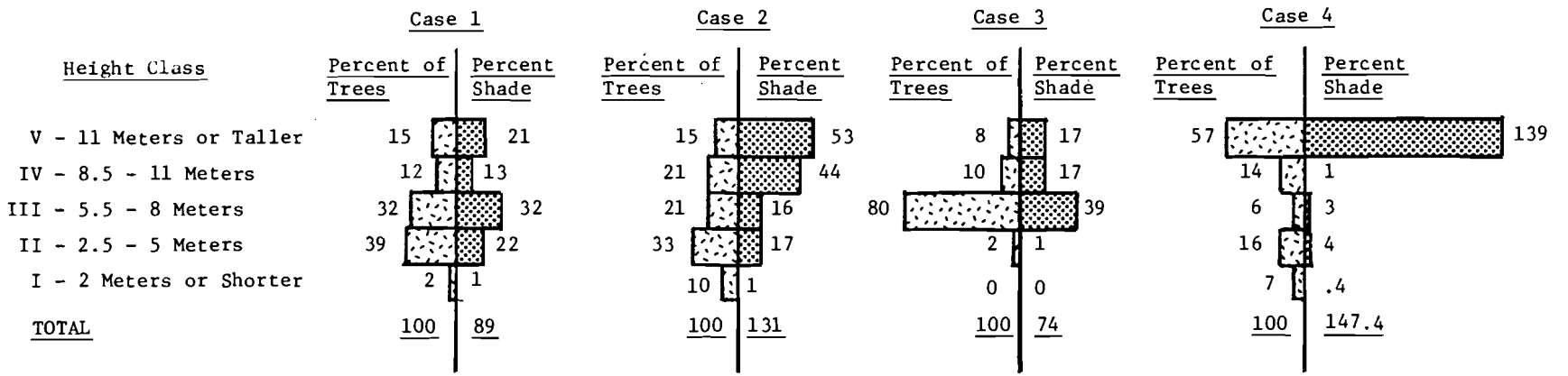
trees, reduces the space available for short-season crops and is the most significant factor affecting management in a successional sequence. Chart 31 shows the distribution of the shade cover between five height classes in selected examples to compare the degree to which the canopy becomes divided into different strata. In the traditional solar, there is relatively little difference between the proportion of the trees in each height class and the proportion of the shade which they cast. In the diversified irrigated parcel, a few tall individuals shade the others. The structure of the specialized parcels depends on the size of the dominant species. In the third example, three quarters of the trees are oranges, which are concentrated in height class III. They are intercropped with taller mangos, which collectively cast nearly as much shade. The fourth example is specialized in avocados, a large species which dominates the parcel.

Throughout the world, there is increasing interest in production systems which combine perennial and shorter season crops in a successional sequence. Several important plantation crops, particularly coffee and cacao, are grown under the shade of taller trees (122, 130). Agro-forestry systems have been designed which accommodate annual species into the development cycles of rubber, coconuts, and other tree crops (40, 116, 193, 194, 298). The agronomy of the many different combinations grown in Oxkutzcab and Akil is very complex, and it would require detailed studies to specify the competitive relationships within the diverse types of parcel for light, water, nutrients, etc.

The local farmers have built up a body of empirical experience about how well different crops produce in different combinations, at different spacings, and under shade. An interesting local enterprise has developed because bananas grown in the under-storey of mature parcels produce soft, succulent leaves which make good wrappers for tomales and other regional dishes. Several merchants hire teams to cut them, toast them rapidly over a small fire, and tie them into bundles for sale to restaurants in Merida. There are other markets for minor crops grown under special conditions. Nevertheless, the heterogeneous mixtures have several disadvantages. Each crop should be irrigated on a separate schedule, to stimulate fruit set and to prevent excessive drop. Pest control measures are greatly complicated by the variable flowering periods. It is more efficient to restrict plantings to a limited number of crops, arranged systematically to facilitate their joint management. As the case studies demonstrate, farmers with parcels of this type realize significantly higher apparent net returns than the more diverse, less systematic combinations. The process of rationalization and relative specialization has been slow and uneven, because the resources of the majority of the peasants are limited, and because yields are variable and prices are uncertain.

Variable Yields. The average yield per tree of each crop varies enormously from one parcel to another, as is illustrated for the most prevalent species in Chart 32. This can be explained in part by the many different types and varieties which are found at different stages

CHART 31. DISTRIBUTION OF TREES BY HEIGHT CLASS IN FOUR SELECTED CASES



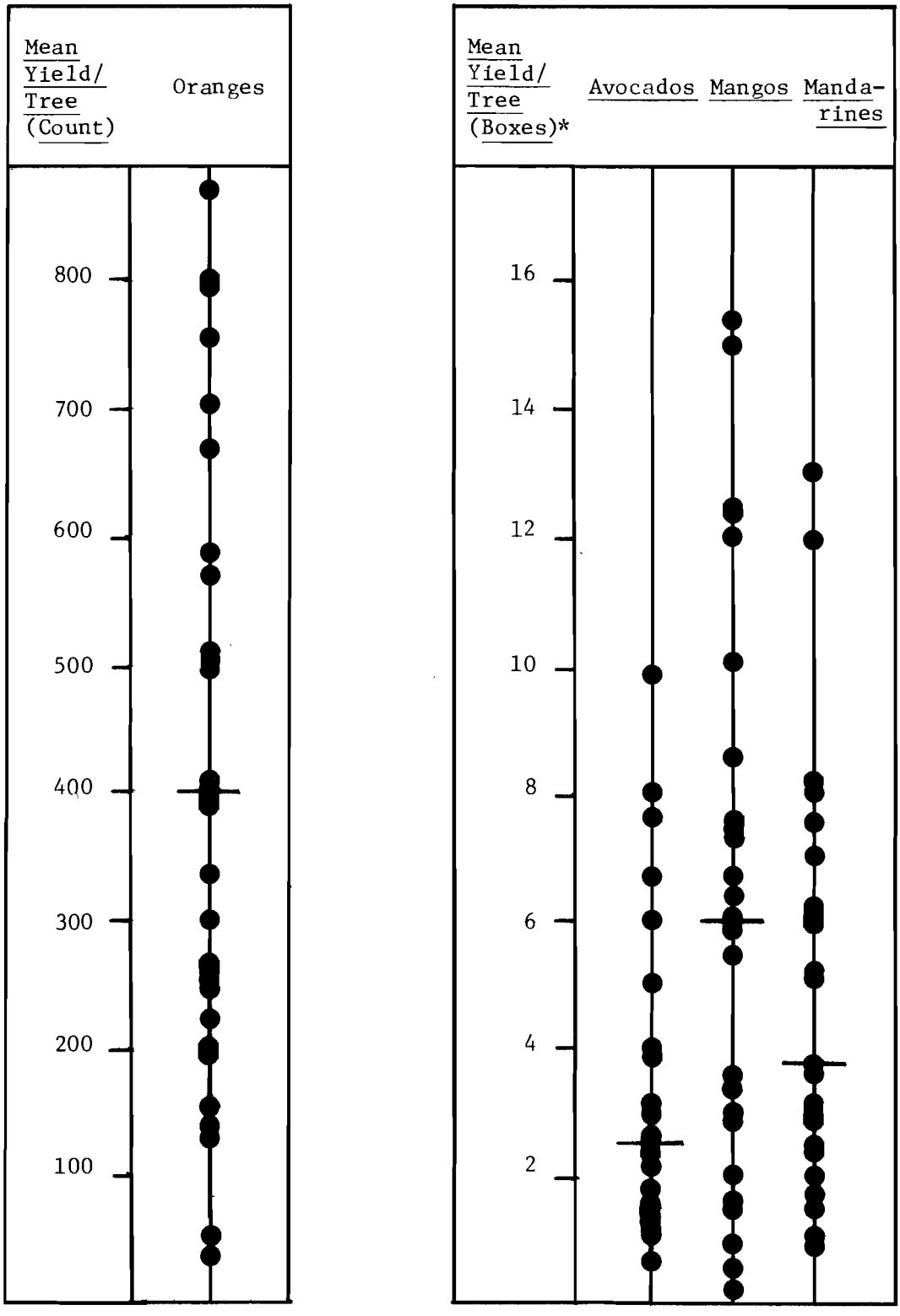
Case 1 - A traditional solar in Yaxcaba

Case 2 - A mature, diversified parcel in Oxkutzcab with irrigation.

Case 3 - An irrigated parcel specialized in citrus.

Case 4 - A parcel specialized in avocados

CHART 32. THE DISTRIBUTION OF THE MEAN YIELD PER TREE OF THE FOUR MOST PREVALENT SPECIES IN THE SAMPLE PARCELS



*Box = 35 kilos.

Source: Sample Survey.

of development, and in part by the variable conditions under which the trees are grown. Although many traditional, low-yielding types continue to be produced, new and improved varieties have been introduced into the region through both formal and informal mechanisms. When the Federal irrigation programs were first established in the 1940's, the government set up nurseries to sell grafted seedlings, and similar programs have functioned at irregular intervals. Nevertheless, there has not been a continuous program of experimentation and testing, and many of the trees which they have produced have proved poorly adapted to local conditions. Several of the most widely grown varieties were first introduced by the merchants with commercial orchards. Those that did well were reproduced and sold, or twigs were stolen by employees and neighbors for grafting onto their own rootstock. Several private nurseries in the region sell grafted seedlings, and the campesinos exchange planting material among themselves.

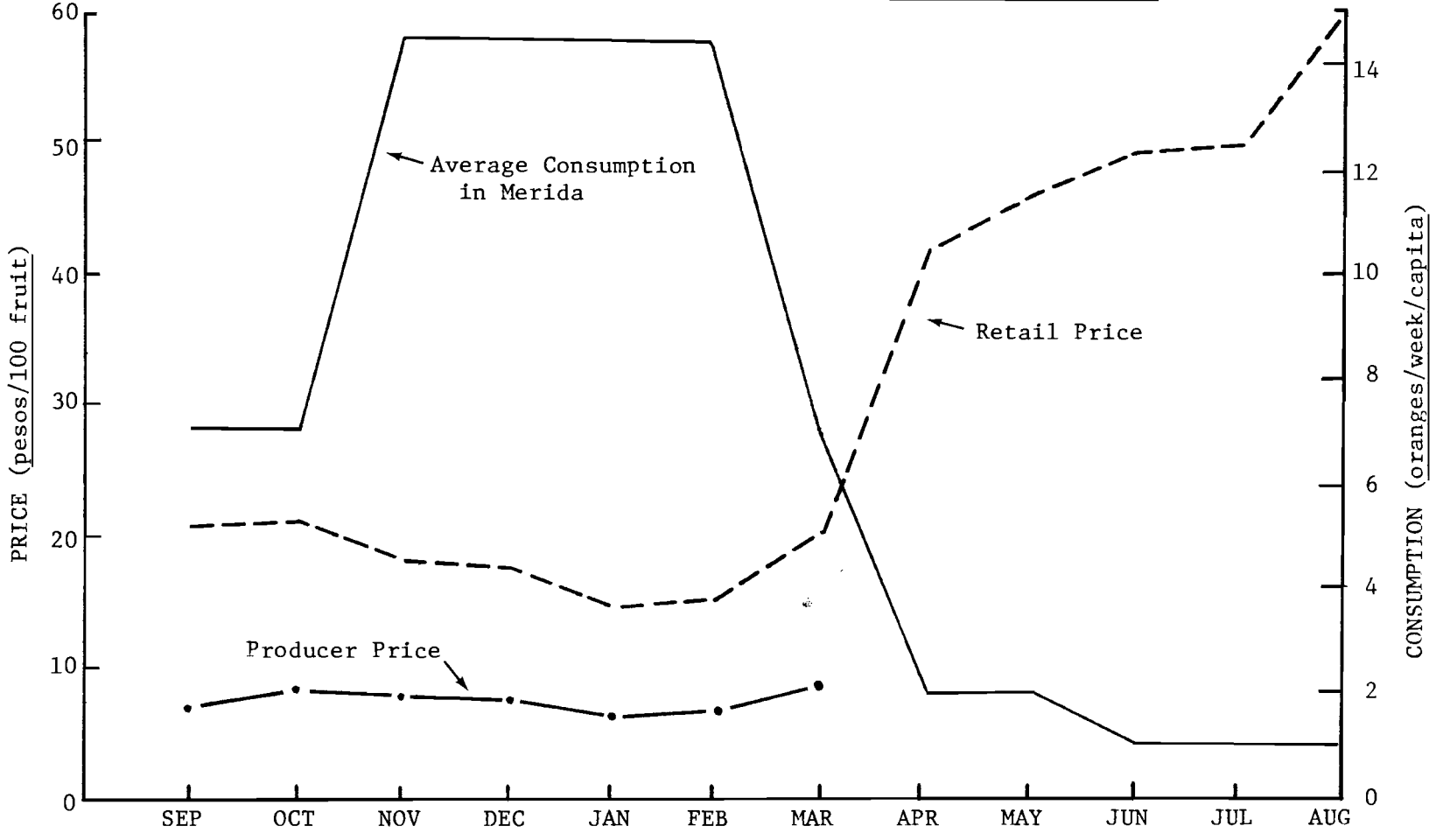
Trees of different ages are grown at different spacings in different combinations with other species, including under heavy shade. This affects their yields in complex ways, but many peasants are unwilling to cull out unproductive individuals, in part because they are primarily concerned with the output of the parcel as a whole, and in part because they do not trust short-term trends. Market tastes and preferences are variable and shift rapidly, and no uniform grade standards are enforced. As prices are impossible to predict, they prefer to hold on every tree which might provide some small income.

Market Conditions and Fluctuating Prices. The instability of the prices in the Oxkutzcab market can be explained by several factors, of which seasonal supply variations are the most important. Although some of the larger producers arrange with merchants to bring trucks directly to their parcels, and others have established long-term associations with regular buyers, most of the peasants receive whatever is paid in the daily market transactions.

Final consumer demand is concentrated in Merida, although trucks also come in from smaller cities in Yucatan, Campeche, and Quintana Roo. Average per capita sweet orange consumption in Merida is estimated at 370 fruit per year, or between 60 and 70 kilos depending on their size (125). This is significantly higher than the national average, which rose from 20 to 27 kilos per year between 1960 and 1979 (201). As Chart 33 shows, both retail prices and levels of consumption are highly seasonal. Almost all of the oranges grown in the state are early varieties, which means that there is a glut almost every year. Average consumption is approximately 15 fruit per week in the middle of the season, and drops off dramatically in March, when fruit is brought in from Veracruz at a much higher price. The price elasticity of demand was calculated as -1.7 in 1975 in response to these seasonal fluctuations, much higher than the income elasticity of demand of .31 (125).

CHART 33. YUCATAN: RETAIL AND PRODUCER PRICES FOR ORANGES, AND AVERAGE WEEKLY CONSUMPTION OF ORANGES IN THE CITY OF MERIDA, 1975

(prices in pesos/100 fruit; consumption in oranges/week/capita)



Source: Instituto Tecnológico Regional de Mérida, "Estudio de Mercado: Naranja" (México, Banco de Crédito Rural Peninsular, Mérida, México, N.D.).

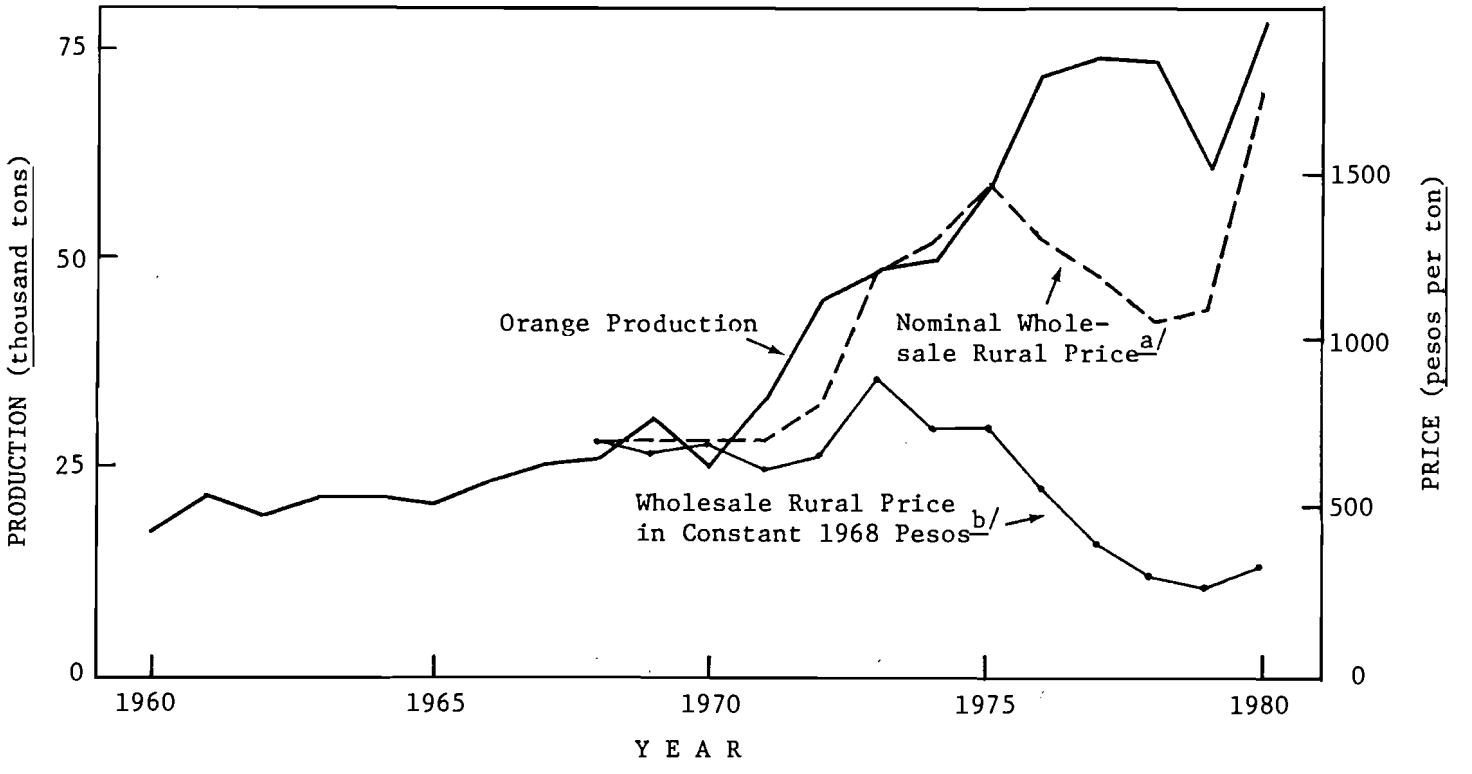
The problem of the seasonal orange glut became increasingly serious in the course of the 1970's, as new parcels in Plan Chac, and in other development projects throughout the state, came into production and saturated the regional market. Chart 34 shows that the average wholesale price declined in both nominal and real terms through much of the decade. This led the producers both to diversify their parcels with other crops, and to put pressure on the government to resolve their marketing problems, which had been caused in large measure by official programs to stimulate production. The sharply higher prices in 1979 and 1980 were the result of the inauguration of a new frozen concentrated orange juice processing plant in Akil, which will be discussed in the next chapter.

The Puuc region does not dominate the regional market for any other crop except oranges, and consistent, reliable statistical series are not available for the great variety which are produced. According to rough estimates of the crop reporting service (DGEA), the municipio of Oxkutzcab accounted for an average of 14 percent of the avocados, 11 percent of the mangos, and 9 percent of the lemons grown commercially in the state in the late 1970's. It was led in all three of these crops by the municipio of Merida, where high-value fruit is grown in small orchards for local sale (178). Minor crops are particularly sensitive to small shifts in market preferences, and many have gone through cycles of brief periods of high prices, expanded production, glut, and precipitous price declines.

A recent example is provided by choice avocados of the Lagunero and Especial varieties. The production of these large, delicate, green-skinned fruit was pioneered by members of the local merchant class, who sell them through their personal network of marketing contacts. It has become one of the few regional products that has ever competed successfully as an exotic in the central Merced market in Mexico City, which is 1,000 miles away. As we have seen in two of the case studies, high-quality avocados have become one of the most profitable crops in the region to produce, and many are planting them. It is widely predicted that the market will soon become saturated. The potential losses from this sensitive, highly perishable crop are very great.

Lemons provide another example, as plantings have expanded rapidly in recent years in response to a structural change in the market. In traditional Yucatecan cooking, sour oranges are used to cut the grease. As the population has become urbanized, demand has shifted in favor of lemons, and prices have risen rapidly. Seedling trees, most of which are less than five years old, have been planted in 60 percent of the sample parcels. The market for each crop, including the vegetables which are grown when the trees are small, has its own seasonal characteristics and demand trends. A great many varieties and types are produced, and the combinations of perennials follow complex patterns of lagged response to price fluctuations.

CHART 34. YUCATAN: ORANGE PRODUCTION, 1960-80, AND AVERAGE NOMINAL AND REAL WHOLESALE RURAL PRICES, 1968-80



a/ Estimated weighted average price over the season as a whole.

b/ The prices have been deflated using the consumer price index for the city of Merida, as reported by the Banco de Mexico. No equivalent index is published for rural consumers, and it is assumed that the trends have been similar.

Sources: México, Secretaría de Agricultura y Recursos Hidráulicos (SARH), Direccíon General de Economía Agrícola (DGEA), "Yucatán en Cifras: 20 Años de Estadísticas Agropecuarios, 1957-1976" (mimeo, Mérida, México, 1978). México, Secretaría de Programación y Presupuesto (SPP), "Informe Económico 1981: Yucatán" (mimeo, Mérida, México, 1982).

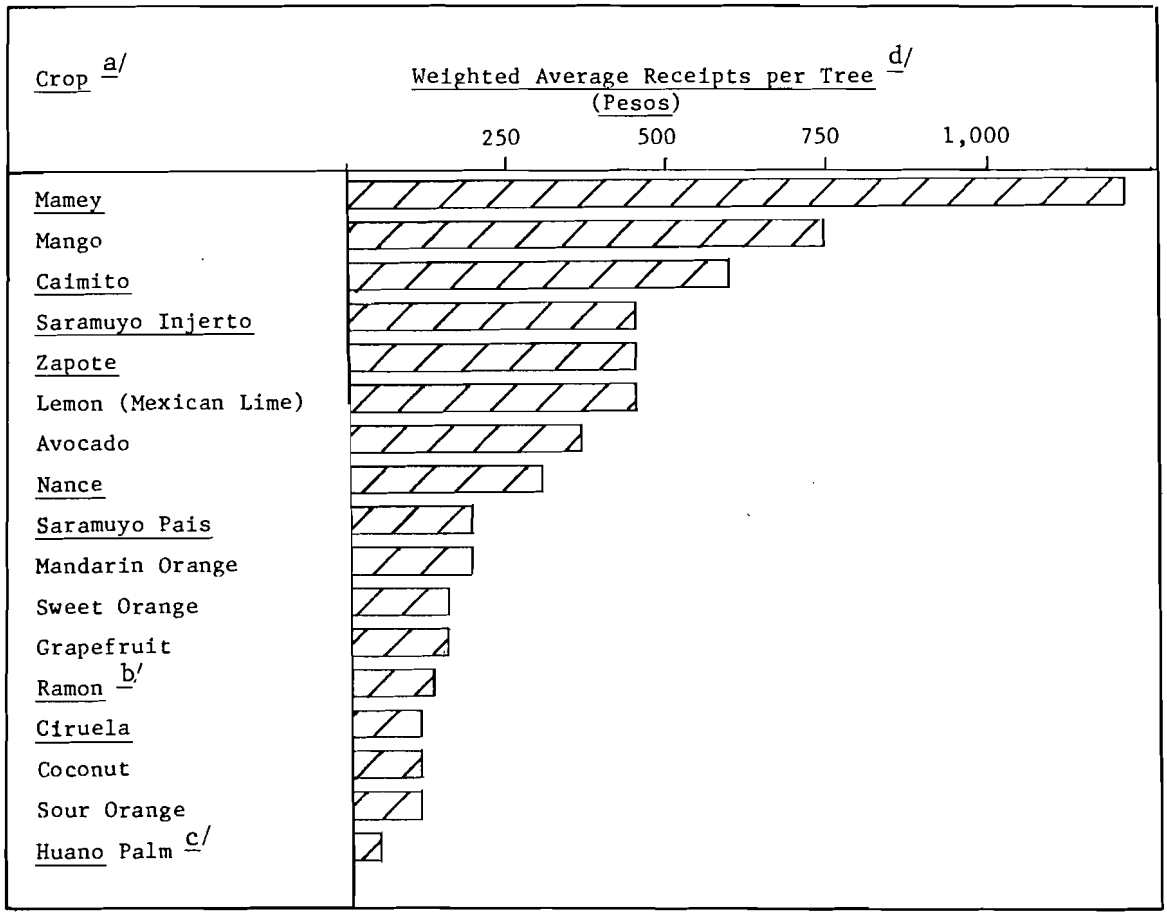
The urban merchants have established considerable power in the market for fresh produce. Those with refrigerated warehouses and contacts with suppliers in other parts of the country are able to manipulate prices and capture the benefits of short-term supply shortages by shipping in and storing fruits and vegetables. The government has made some attempt to protect local producers by restricting shipments during the local production seasons, but the borders are porous and no accurate figures on these inflows are available. The margins captured by the marketing network as a whole are high (166, 314). New types of arrangements with national wholesale suppliers are being developed by supermarkets and resort hotels. Structural changes of this kind, which could seriously squeeze the local campesinos by putting them in direct competition with the major fruit and vegetable producing regions of the country, have been less rapid in the isolated state of Yucatan than in other parts of Mexico (232).

The negotiating position of the peasants' wives in the Oxkutzcab market is weak. The prices which they receive fluctuate from day to day over a wide range, depending on their personal contacts with the intermediaries, on the total quantity of produce presented for sale, and on the number of trucks which arrive. Buyers often hold back until the very end of the day, when they know that the women will be anxious to dispose of their produce and get home. It is to the advantage of the peasants to grow a variety of products. Most prefer citrus, which can be held on the tree for as long as several weeks awaiting a good price, to delicate crops which must be sold immediately when they are ripe.

A detailed study of the supply and demand factors, and of the personal interrelationships which are an important part of the process of price discovery, would require a far more comprehensive market study than was attempted. Chart 35 presents rough estimates of the average gross returns per tree of the principal perennial crops. They were obtained by combining the weighted average yields and prices. The variance of both parameters is very great, and only a few farmers with large holdings and significant resources can afford the risks of specialization.

Chart 36 illustrates the variability of the returns from the four crops most frequently grown in the region. Each horizontal line represents the average receipts per tree. The left-hand bars indicate the range if the yield is held constant and the price is varied by one standard deviation. The right-hand bars show the reverse; the range if the price is held constant and the yield is varied by one standard deviation. Although their average returns are relatively low, oranges continue to be grown as the principal crop in most peasant plots, because the risks are tolerable. Many farmers diversify their parcels with a number of fruits and vegetables, in the expectation that at least some of them will provide additional income, distributed throughout the year.

CHART 35. WEIGHTED AVERAGE RECEIPTS PER TREE OF THE PRINCIPAL FRUIT CROPS GROWN IN IRRIGATED PARCELS IN OXKUTZCAB AND AKIL, YUCATAN, 1981/82



a/ The English, Maya, and scientific equivalents of the Spanish names are provided in Appendix A.

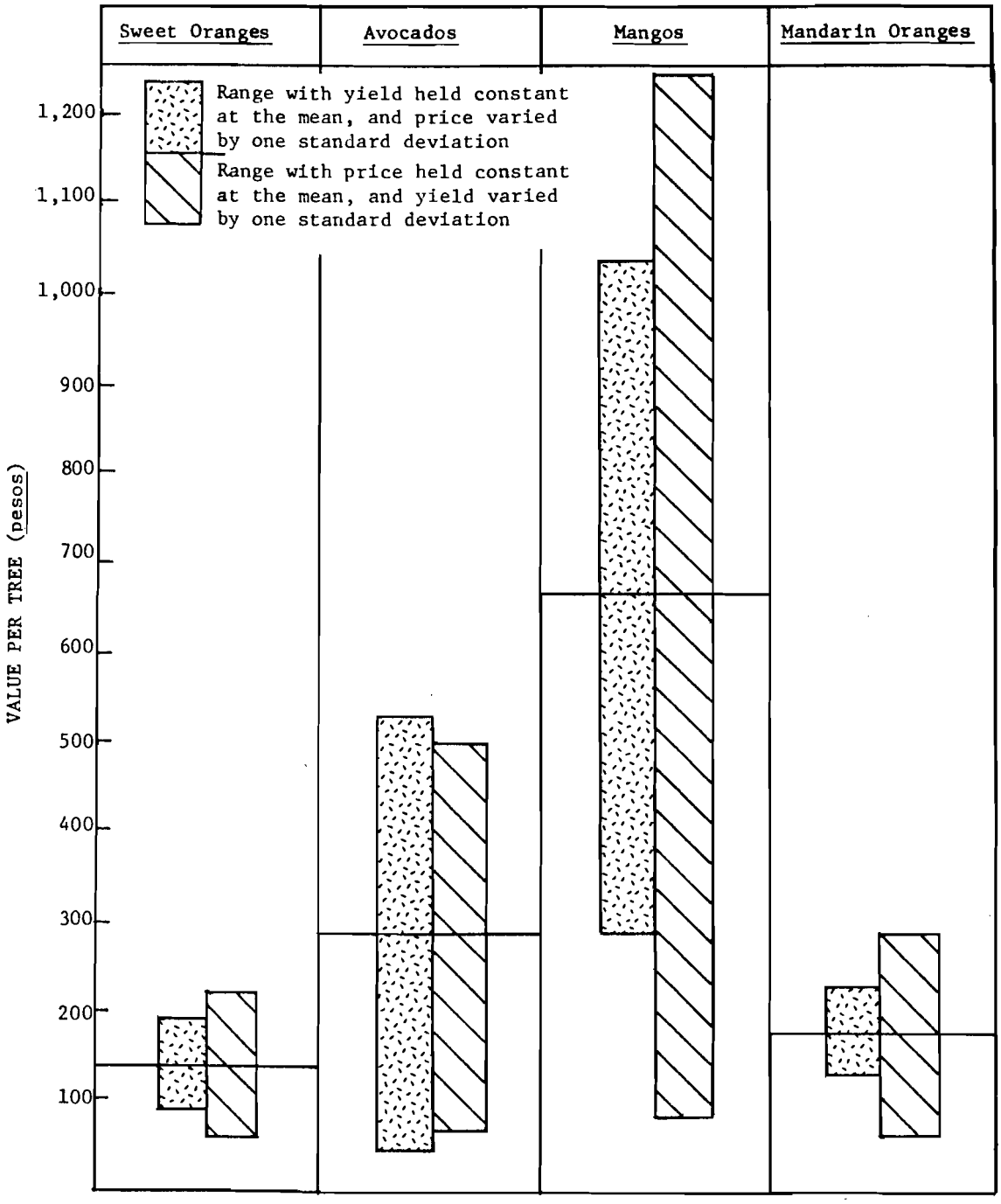
b/ Ramon (Brosimum alicastrum) is a forage tree, the leaves of which are cut and sold as animal feed in the dry season.

c/ Huano palm (Sabal yapa) is sold for thatch.

d/ These figures are rough estimates for comparative purposes. Heterogeneous varieties of different yields and grade qualities are produced, and prices vary seasonally over a wide range. Data for the four most commonly grown crops--Sweet Oranges, Avocados, Mangos, and Mandarin Oranges--were weighted using standard probability calculations for expected value. The others were weighted according to the judgment of the author.

Source: Sample Survey.

CHART 36. THE MEAN GROSS ANNUAL INCOME PER TREE OF THE FOUR MOST PREVALENT SPECIES, PARAMETERIZED BY THE VARIABILITY IN YIELD AND PRICE, 1981/82*



*The horizontal line in each case is the mean gross annual income per tree, calculated by multiplying the mean yield by the mean price from the sample.

Production Techniques

Only minor changes in the technology of production have accompanied the gradual intensification of the management of the irrigated parcels. The simple hand tools, and the techniques of land clearing, weeding, and other routine cultural practices are identical with those employed in traditional milpas, solares, and conucos. Tractors are used only in the government-directed vegetable units of Plan Tabi. Virtually all of the crops, and many of the particular combinations and sequences, have a long history in the region. New inputs, particularly fertilizers, herbicides, and pest control chemicals, have been adopted slowly and unevenly. They are commonly used only in the early stages of the development cycle of a parcel.

The operations are not organized to make use of integrated packages of modern technology, and there is no established model of how they might do so. The regional experiment stations of the National Agricultural Research Institute (INIA) and the National Fruit Commission (CONAFRUT) have concentrated on the testing of new varieties for use in large-scale government projects (171). They have not experimented with fertilization levels or with weed, pest, or disease control measures under local conditions. Their technical recommendations assume that crops are planted in monoculture, and require equipment and levels of expenditure which the campesinos cannot afford. The farmers have adopted selected elements of new technology into their systems as a defensive reaction to increasing weed and pest pressure, and to rising labor costs.

The annual sequence of activities depends on the combination of crops and their stage of development; production tasks and harvests are distributed irregularly through the year. The full-time producers work every day from five in the morning through the early afternoon, dividing their time between different kinds of work, and often between different parcels. Chores which are not seasonal, such as pruning dead wood off the trees and collecting crop residues for their animals, are fitted into whatever spare time is available. The part-time farmers schedule their work around their other activities. Extra help is hired primarily in busy seasons, especially for weeding and harvesting.

Irrigation. The parcels are irrigated in the dry season, from December or January through late May or early June. The Irrigation District sells water in advance, by the hour of access to the main canals. Water charges are fixed according to the age of the unit and the capacity of the pump, and are subsidized at low levels. The schedule is organized to irrigate parcels with vegetables in production two or three times a week, and mature fruit trees every 10 to 14 days. An operator comes around and opens the gates, and the farmer distributes the water within his parcel through a system of ditches and basins. Most flood the entire area, and grow vegetables on raised beds or along the edges of the ditches. The practices have been developed empirically, water is a relatively minor cost of production, and there

has been very little incentive to develop sophisticated systems. Most of the farmers have built concrete stanchions with movable wooden gates to direct the flow into different sections, but only a third of the sample have lined their ditches with masonry to restrict infiltration losses. Few make any effort to keep the water away from the trunks of the trees, although this would help to control fungus diseases. Average irrigation efficiency is low, both in the parcels and in the main distribution systems, which are in poor repair. The systems are simple and flexible, and they can easily be adapted to provide different amounts of water to different crops as the parcels mature. They could have been greatly improved if capital, credit, and technical assistance had been more freely available.

Weed Control. Hand weeding is the most time-consuming routine production task. There are two traditional methods. Lo'che'paak, which is practiced on at least part of their land by three-quarters of the sample farmers, is done with a small, curved knife called a Lo'che. The worker kneels and pulls the tool under the weeds, uprooting them and exposing the bare soil. This method of close weeding is used in vegetable production, and is preferred in any parcel for effective control and to promote the efficient infiltration of water. The time required depends on the density of the vegetation, but in a day an average worker can clean a mecate, a regional unit of 400 square meters, or one twenty-fifth of a hectare. Haranch'ak is done from a stooping position with a conventional machete, and the weeds are cut above ground level. A man can cover twice as much area in a day, but the roots are not disturbed and regeneration is much more rapid.

Parcels in their early, most intensive phases of development are weeded almost constantly. The frequency declines as the fruit trees mature and extend their shade. The beginning of the rainy season dramatically stimulates weed growth, and 70 percent of the producers clean their parcels thoroughly within the next month or six weeks. Depending on its age, a parcel will be weeded one or two more times, most commonly at the beginning of the orange harvest in late September, and again at the end of the year, before the irrigation season begins.

Over half of the sample producers pay at least some help to weed, and wage rates rose rapidly in the 1970's in response to the general pressures of inflation. To reduce this cost, one-third of the sample began to use herbicides, primarily the contact formula Paraquaat, in addition to hand labor. The chemical is convenient to apply with a "Hudson" type backpack sprayer, as it only kills what it touches and does not persist. It can be used among intercrops if the applicator is careful. It is known as "liquid Haranch'ak," an economical but poor substitute for hand labor, because the weeds regenerate rapidly and the tougher ones still must be rooted out. Systemic herbicides are more expensive, and the campesinos are suspicious of them, as they fear that they damage the trees and the soil. The longer a parcel is in production, the more the most resistant types of weeds with underground rhizomes and tubers proliferate. The Maya are very familiar with them,

and have names for each one. Their control in the traditional milpa and conuco technology is based on fallow rotations, and this is at least part of the reason why the farmers prefer to have several parcels in different stages of development, rather than intensify their management practices on a permanent, continuous basis.

Fertilization. Various types of chemical fertilizers, including foliar applications, are used almost universally in vegetable production. Until very recently, the fruit trees depended entirely on natural soil fertility, even in the larger commercial orchards. Then a few of the merchants began to buy chicken manure from the large, intensive poultry operations which ring Merida, through arrangement with the same truck drivers who transport the fruit. It is sold in bags, and is spread under the canopy of the trees at the very end of the dry season, usually in alternate years. The rains wash it into the soil, and the nutrients are released slowly during the summer months, when the next orange crop is filling. Its use has diffused rapidly, and half of the sample farmers had started to apply it within a few years of the time of the study. Very few producers used chemical fertilizers on their trees.

Pest Control. Pest pressures on vegetables have become more and more serious as the area in intensive production has increased. A "cocktail" mixture of insecticides, fungicides, and foliar fertilizer is sprayed by almost all of the producers as often as every four or five days. The materials are obtained from merchants in Oxkutzcab and Merida, and are applied according to empirical rules of thumb. Locally tested technical recommendations are not available, and safe handling procedures are not clearly understood. The use of these chemicals declines as the parcels mature, and many of the farmers have sold their sprayers when there was no longer space to grow vegetables. Only the small local elite can afford motorized sprayers, which has allowed them to become relatively specialized in delicate, high-value fruit with a premium on cosmetic quality. The size and appearance of the citrus which is produced in the region are highly variable, which has limited marketing opportunities outside of Yucatan. Although a third of the sample apply fungicides and insecticides by hand at least occasionally, pest problems, particularly Gummosis (*Phytophthora* spp.), Mexican Fruit Fly (*Anastepha ludens*), mites, ants, and a variety of others cause widespread damage and yield reductions. The cultivation of several species and varieties in combination means that the total loss of the harvest is unlikely.

Pruning. Unlike many temperate fruits, citrus does not require systematic pruning to stimulate fruit set. On the contrary, the trees bear at the tips of the branches and pruning reduces production in proportion to the amount of foliage removed (224, p. 70). Modern orchards are pruned to facilitate the movement of machinery, and to force the trees into a low growth pattern which is convenient for picking. The shape of the trees in the Puuc region depends on the density and arrangement of the plantings, and none of the producers

prune except to remove dead wood and suckers growing up from the rootstock.

The Harvest. The harvest season for oranges, the principal crop, runs from mid-September through late January or a little later. Most producers pick their crop within a month within this period. Harvesters are hired to pick, count, and carry the fruit to the edge of the parcel. In 1981-1982, they were paid between 30 and 50 pesos per thousand, or between 7 and 12 percent of the average wholesale price. Transport costs to the Oxkutzcab market depend on the distance, but averaged another 5 percent of the price they receive. Some farmers avoid these costs by selling the crop on the tree, but many feel that the merchants underestimate the true harvest, and that their workers damage the trees.

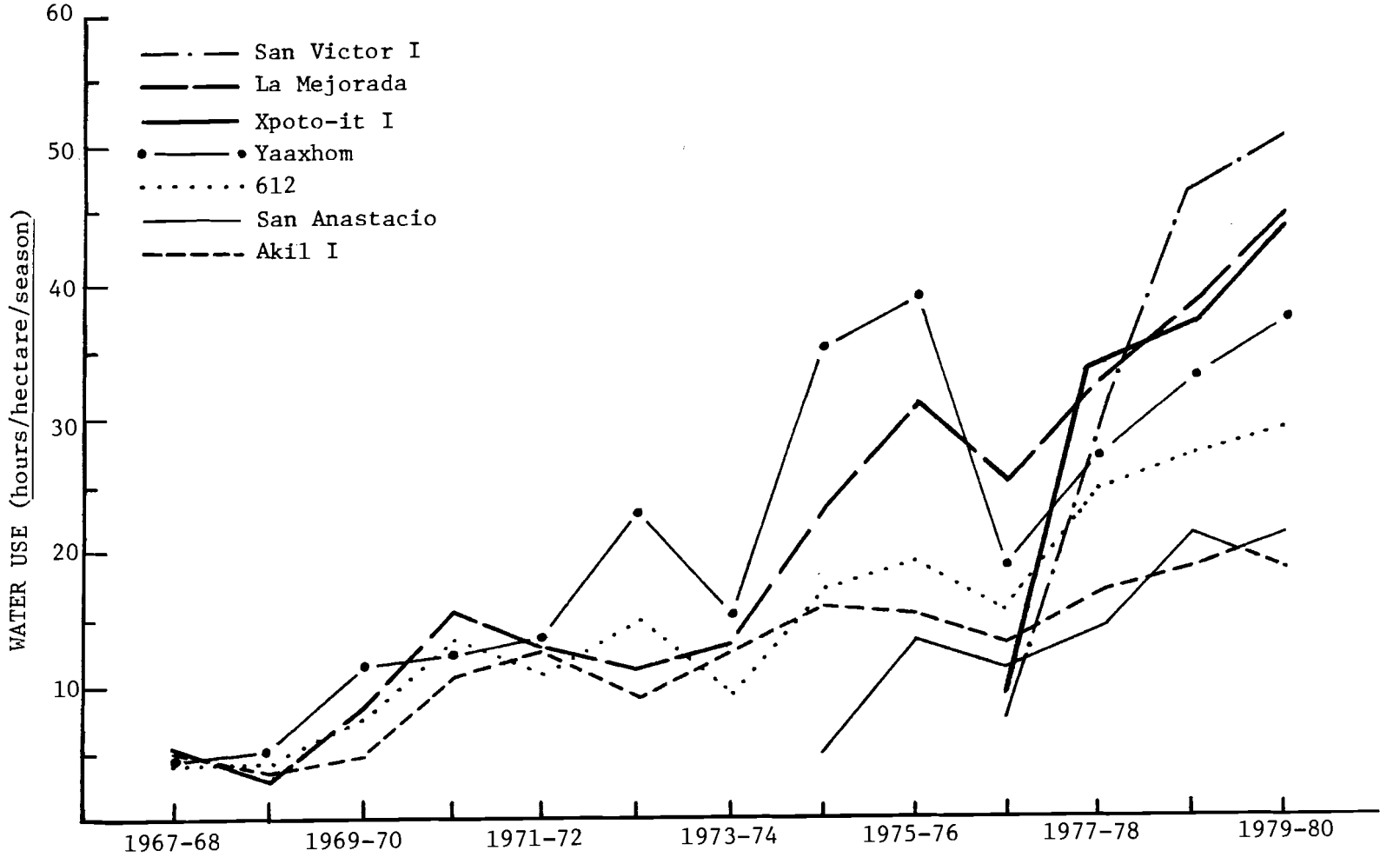
Most of the other fruit are sold in boxes which hold between 30 and 35 kilograms. Most species come into production gradually, and most farmers go out every few days to select and pick the ripe ones themselves. Vegetables are planted starting in November, and the principal harvest season runs from January through late May. A second planting is often timed to harvest in late October, when the popular All Saints' festival provides a good market for traditional foods, including maize roasting ears, cowpeas, cassava, and sweet potatoes.

The Flexibility and Limitations of Peasant Management Strategies

The development of irrigated production systems in the old-type units has been a slow and uneven process, which can be summarized as follows. After a long transitional period when the parcels were but one of several activities within the family economy, many farmers have been able to establish permanent agriculture. The steady increase in both the area in production and the intensity with which the parcels are managed has been reflected in the demand for irrigation water. Chart 37 shows that water use in the sample units, averaged over their entire irrigable area, was only about five hours per hectare in the 1967-1968 season. Since then, more land has been brought into production, and a greater variety of crops has been planted. By the 1979-1980 season, average water use ranged from 18 to over 50 hours per hectare.

Most of the peasants have had very limited resources other than the labor of their own families. They have built up their parcels gradually, with small incremental investments of labor time and of cash earned in migratory employment. They have planted diverse combinations of crops, in a variety of arrangements and sequences, to provide income for consumption and to pay for production costs throughout the year. This strategy has maintained their flexibility, has stabilized the

CHART 37. OXKUTZCAB AND AKIL, YUCATAN: MEAN WATER USE IN HOURS PER HECTARE PER SEASON, IN SEVEN SELECTED OLD-TYPE UNITS, 1968-1980



Source: México, Secretaría de Agricultura y Recursos Hidráulicos, Distrito de Riego #48, Ticul, Yucatan.

economy of their families in an uncertain economic environment, and has permitted the accumulation of equity in a patrimony. With very little assistance from the government beyond the construction of the units themselves, they have adapted their traditional production practices and have adopted selected elements of new technology after they have been introduced and tested by their more prosperous neighbors.

Although their output is well above the low standards of an agroclimatically marginal region, both the yields and net returns of the production systems are well below those in the major fruit-producing regions of Mexico. There are many ways in which they could be improved. The water distribution canals are over-extended and have fallen into serious disrepair. Few farmers have lined their ditches with masonry and average irrigation efficiency is low. A large proportion of the tree crops are traditional, low-yielding varieties. Fertilization and pest control practices are based on empirical rules of thumb and are adopted in response to emergency problems.

Programs to stabilize the market and to provide price information could help the peasants to make better long-term decisions about which crops and varieties to plant. A program of local experimentation and testing could provide the basis for numerous improvements in agronomic practices. Animal production could be better integrated into the systems in various ways. But instead of providing assistance to the Maya farmers to improve their efficiency and economic returns, recent government projects have attempted to introduce entirely different, modern production systems into the region. They have encountered serious technical and organizational problems. More significantly, they have not provided the participants with the flexibility to make decisions which are critical to the stability of the economy of their families.

CHAPTER FIVE

THE IMPACT OF GOVERNMENT DEVELOPMENT PROGRAMS

In Yucatan, as throughout Mexico, the ejidos are simultaneously semi-autonomous peasant communities and the state sector in agriculture. In the first phases of irrigation development in Oxkutzcab and Akil, when the old-type units were organized, assistance was provided within the populist tradition which had been institutionalized during the Cardenas administration. In response to petitions channeled through the political structure, the peasants received a plot of irrigable land, but little else. They retained the autonomy to establish new cropping systems gradually, adapting traditional practices to new opportunities.

Since the early 1960's, funds for tropical development programs have been available through the international banks, and the expansion of agriculture in the under-exploited southeastern lowlands has become a major priority of the Federal government. The natural and social conditions of Yucatan are extremely marginal for conventional projects. Except in very limited areas, the soils are too thin and rocky for mechanization. The peasant population is scattered among many small communities. The productivity of both the henequen plantations and of traditional slash-and-burn milpa agriculture is very low. Fruit is one of the few alternative commercial enterprises which had been established, albeit on a small scale. The region is naturally forested, and fruit trees can be grown if rooting holes are blasted out with dynamite and if supplemental seasonal irrigation is provided.

The resources which became available were channeled into the development of modern fruit and vegetable production systems on a relatively large scale in centrally planned and administered projects. Plan Chac and Plan Tabi were located in the Puuc region, where the population was relatively concentrated, and where transportation and marketing networks were already established. A frozen orange juice concentrate plant was built in the late 1970's, and plans were elaborated to greatly expand citrus production in Yucatan for the export market. Modest fruit projects have been established in Maya villages throughout the state as part of a national rural development program called PIDER. In spite of the considerable investments which have been made, none of these projects has achieved its goals.

The government agencies are interested in increasing yields and marketable surplus to meet ambitious production targets, and must conform to the specific policies and guidelines which filter down

through the bureaucracy. They have been under heavy pressure to make rapid and dramatic progress, and they have imposed technology and cropping systems which had never been tested in the region. They have attempted to establish a comprehensive set of services: sophisticated irrigation facilities, improved planting materials, modern inputs, credit, technical assistance, and a processing and marketing system. The programs have been plagued with serious technical and administrative problems, and have placed the ejidatarios in an ambiguous and difficult position.

The Maya peasants are simultaneously the beneficiaries and a client labor force of the government projects. Although their influence over decision-making is very limited, they depend on a number of poorly coordinated institutions for the construction and repair of the infrastructure, for credit, and for many other services. Their principal interest is to maintain as much control as possible over the resources on which the stability of their family economies depends. They have attempted to adapt the rigid irrigation and cropping system imposed by the government to meet their needs; to grow diverse combinations of crops, and to build up equity in the future security of their households. These conflicts of interest between the campesinos and the government agencies often come to a head in heated disputes, as is illustrated in the following vignettes.

A Meeting of the Union of Citrus-Producing Ejidos

The meeting of the Union of Citrus-Producing Ejidos had been called for nine A.M. on Sunday. The representatives drifted slowly into the meeting room of the newly opened orange juice processing plant, on the highway between Oxkutzcab and Akil. Some came on their bicycles, others in the taxis and slat-sided trucks which circulate through the region. Some were dressed all in white, with fancy white hats and sandals, the traditional Maya dress since Colonial times. Others wore flashy polyester shirts and cheap black dress shoes. They gathered in small groups, and chatted in Maya about the weather, about the price of fruit, and the other concerns of their communities. Officials of the Rural Bank, the Irrigation District, and the Agrarian Reform office came singly, in pick-up trucks with official seals on the doors, and walked around shaking hands. It was nearly ten before the director of the plant arrived from Merida in a large, chauffeured American car. He gathered his colleagues together and they went up to his office to discuss the agenda. A few minutes later they came down and took their places at a table at the front of the room. The campesino leaders moved in and sat in folding chairs.

The Director, a tall, florid engineer from Mexico City, called the meeting to order. He welcomed the newly elected delegates of the nine ejidos in the region who, after years of struggle and low economic returns, would have the opportunity to sell their products on the world market. On their behalf, the Federal government had invested 76 million pesos (three million U.S. dollars) in the construction of this plant and the importation of the very latest equipment. It marked a new beginning for Yucatan, which had for so long been in a marginal economic position, dependent on two unprofitable crops, maize and henequen. Within a few years, up to 40,000 hectares of new citrus plantings would be established in the Peninsula, which would more than triple current output. Over a million seedlings were growing in nurseries, which would soon be distributed as part of a comprehensive credit program.

The ejidatarios of the Puuc region were especially privileged, as they had got in on the ground floor of this new program. They were selling oranges to the plant for more than twice as much as they had received in the Oxkutzcab market the year before. But with this benefit came a heavy responsibility. They were the owners of the plant--its cost had been extended to them as credit. They must organize themselves to make it productive, to pay back the loan, to make it achieve its promise. They must overcome the errors and problems of past programs; they must modernize their production methods. The government institutions were doing everything they could to help; they had brought in a corps of technicians, they were running training programs, they had arranged to buy herbicides and other inputs at wholesale prices for distribution to the members. But the ultimate responsibility lay with the people themselves. The plant would never be successful if it only operated four or five months of the year. They must grow later varieties of oranges to extend the season at least through May. To provide throughout during the summer, it might be possible to process pineapples and tomatoes--he had organized experiments to see what products would be feasible. After giving a formal financial report, he introduced the outgoing President of the Union as "one of your people, the man who, more than anyone else, is responsible for what has been achieved here."

A small, compact Maya, dressed in a fancy pleated Guayabera shirt, stood up. He spoke in the vigorous rhetorical style of Mexican politics. He reminded the people of their struggles to establish fruit production, which had made the southern region one of the most prosperous in the state. The Citrus Producers' Association

had been active for over 30 years, looking for ways to break out of their dependence on the committee middlemen, and to expand and stabilize the market for their produce. In 1979, they had succeeded in exporting fruit to processing plants owned by multinational corporations in the neighboring country of Belize. This experience demonstrated that the good, sweet oranges of Yucatan could be sold on the international market. If private companies could afford to transport the raw material for over 400 miles, surely the producers could do much better if they had a plant of their own, right in their own region.

They had taken their arguments to the governor of the state, and to the appropriate Federal agencies. Extensive studies had been made of the production possibilities, of the quality of the local fruit, and of the market. Yucatan, too rocky for mechanized agriculture, was declared perfect for irrigated citrus production. A line of credit was put together, and the Union of Ejidos was organized under the terms of Federal law to receive the funds and to direct the management of the new plant, one of the most modern in all Mexico. He was proud of the part he had been able to play, but he was happy to step down now that his term was over. He assured the representatives that he had not been tempted by the opportunities for corruption which so often overcome people in responsible positions. The books were open for inspection; he challenged anyone to show that he had abused the trust which had been placed in him.

The next speaker was the delegate from one of the oldest irrigation units in Oxkutzcab, and an influential figure in local affairs. He condemned as a fraud the recent election as the new President of the Union a representative of Muna, the ejido which produced the least fruit in the entire region. He claimed that the process had been rigged by the team of promoters from the Rural Bank to exclude Oxkutzcab, where fruit production had started, and where the majority of the producers lived. Meetings had been announced only a few hours before they were to be held. By the time he had informed his colleagues and arranged transportation, they found that the slate had already been chosen, that there was no real vote. Was this democracy?

The Union representatives were the puppets of the institutions, which held all of the real power. Everything that the government touches fails, due to mismanagement and corruption. Look at what had happened to the sugar industry, once the source of the region's

wealth--driven out of business. Look at the henequen zone, where millions of pesos are stolen by the bureaucrats every year, and where our Maya brothers live in misery. He hoped that the juice plant would not fall into this familiar pattern. The higher prices were certainly a benefit, and he would help his people arrange to sell to it, but he would not personally participate in the Union. Several other representatives from Oxkutzcab stood up, and said that they were also going to leave.

The Director was very angry, and said that this kind of rumor and insinuation was just the problem that the Union was designed to overcome. He said that the privileged elite of Oxkutzcab would have to learn that all ejidos had an equal vote, independent of their past influence, and that they must work together. He threatened that the government would be leary of investing further funds if there was no unity among the people.

A number of other people then spoke, complaining that they were excluded from any real influence on how the plant was managed. Several accusations were made against the permanent staff: that they accepted bribes to allow a truck to move to the head of the line; that they sold the vouchers which were supposed to be distributed free to schedule fruit deliveries. The recent devaluation of the peso had increased the value of the juice on the world market; they wanted to know why their people had not received extra payment. One old man waved a copy of a popular tabloid newspaper, with a front page story about the collapse of a Union of Ejidos on the west coast of Mexico after bureaucratic mismanagement was exposed. The meeting ended on a note of confusion, and the delegates of Oxkutzcab did not return for the rest of the year.

Conflicts Over Water Charges

A similar scene of conflict was repeated a couple of months later in the meeting room of the Irrigation District, where the representatives of all of the units had been called together. The Director used large, colorful charts to outline the budgetary problems which the District was facing. Salaries, electricity, and other costs were going up rapidly. Water charges had not been adjusted in over ten years, and barely covered 15 percent of the direct costs of operation and maintenance, not counting the repayment of capital or the salaries of the professional staff. He was under orders from his

superiors in the Ministry of Agriculture (SARH) to negotiate an increase, and he had called them together to discuss the issue democratically. The new orange juice plant was paying good prices, and the fresh market for many products, particularly avocados and lemons, had vastly improved. All of the water users would have to make a little sacrifice to help pay for a larger share of the services which they received.

The campesinos reacted with outrage and indignation. One after the other, they stood up and gave detailed examples, with names and dates, of the deterioration of the irrigation systems and the failure of the government to provide adequate maintenance or technical assistance. In the old-type units, the canals leaked, many of the gates were missing, and the pumps often broke down at the very height of the season, prejudicing their crops and disrupting the irrigation schedules. In the sprinkler units of Plan Chac, the spring gaskets which seal the joints between sections of pipe had not been replaced in 15 years, and were unavailable in the market. Many of the laterals had been punctured, the sprinkler heads did not rotate, and there was never enough pressure to provide adequate water to the trees. The credit payments always arrived late, and were insufficient to cover rising costs.

The District had plenty of technicians who drove around and observed life through the windshields of their pick-ups, but what work did they do? The representatives were forced to leave their own parcels and waste half a day traveling to the main office in Ticul, not once but many times, before even the simplest repairs were made. When they invited officials to come to meetings and see the problems for themselves, they never showed up. The costs of transporting their crops to market, and the costs of supporting their families, were rising at least as fast as the prices which they received. Now they were being asked to pay more money so that the officials could sit around in their offices in front of their fans, or drive back and forth to Merida, while the campesinos labored in the hot sun to feed their families.

The Director tried to calm them. He admitted that the process of introducing new irrigation technology into Yucatan had been difficult, and that there had been serious shortcomings. In the early years, the government had provided many incentives to encourage people to change their production systems. As the campesinos had been unwilling at first to give up their traditional ways, a great deal of equipment had been supplied without

charge, and water had been priced very cheaply. This had led the people to adopt lazy and wasteful practices. Now that many of them were firmly established in fruit and vegetable production, and market conditions were improving, they would all have to work together to make the systems more efficient.

He wished that the District could afford to completely rehabilitate the facilities and equipment. The current national administration placed a great deal of emphasis on increasing production in ejidos throughout the country, but there was not enough money for everything. The high-tension grid which had been installed to electrify all of the pumps in the region had been very expensive. The juice plant, from which all of them benefited, was one of the largest single investments that had ever been made in rural Yucatan. He had ordered new gaskets and irrigation laterals, which should arrive within a few months. But new equipment was not the only solution. The users should form committees to organize more efficient distribution within their units, and they all should think seriously about lining their ditches with masonry. He was not asking them to pay the entire cost of operating the systems, but a modest increase in water charges would help him to solve the most urgent problems, and would symbolize a spirit of cooperation.

The delegates were unconvinced. One stood up and said that they had all heard promises of this kind before. He outlined the history of his unit, which he denied had been a "gift" of the government. Many years before, a group of men had organized themselves, and divided the land into parcels. After a long period of petition and delay, a well and a pump had been provided to them, but they had supplied most of the materials and labor for the construction of the distribution canals. They had all worked for many years to develop their parcels without any outside help whatsoever. They had elected a committee which had collected water charges to pay for diesel fuel and modest salaries for the operators. One of them had learned mechanics, and had been able to make most of the necessary repairs. Only after the unit was absorbed into the Irrigation District did it begin to deteriorate, because the salaried technicians did not care about their problems. He proposed that they all get together and send a formal petition to President Lopez Portillo, asking him not to raise their water charges, so that they could better contribute to the national campaign to increase production.

The Director saw that he would not push the issue. Over the next few weeks, he made a series of visits to individual ejidos to present his request for increased water rates, but he was received with universal hostility. The charges remained frozen for the time being.

Plan Chac

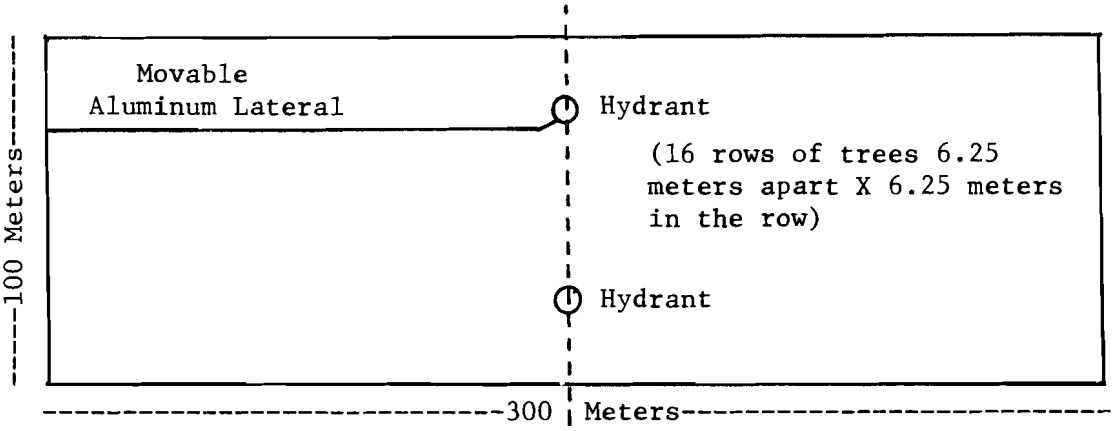
The first major agricultural development program in Yucatan outside of the henequen zone was Plan Chac, which was instituted in 1962. An integrated, centrally planned and administered irrigation project, it consists of 49 separate units in a strip 70 kilometers long, in communities where fruit production had already been developed in old-type units. As Map 4A shows, they are located to the north of the Puuc hills, in thin and rocky soils. They were designed to irrigate a total of 4,000 hectares, divided among 1,600 Maya peasant families in individual three-hectare parcels. The costs of constructing a sophisticated sprinkler irrigation system, which were estimated at 50 million pesos (four million U.S. dollars) in 1973, were born jointly in the Interamerican Development Bank and the Federal government (156, 157).

Eligible ejidatarios received their parcels free of charge. They were extended credit by the Rural Bank to cover the costs of establishing citrus orchards in monoculture, using grafted seedlings distributed from central nurseries. The Irrigation District was established at the same time to coordinate technical operations, and the Ministry of Agriculture set up demonstration plots and an extension system. Further credit was provided by the Ministry of Public Works for the construction of houses in each parcel. The project was designed to diversify the economy of the state, and to bring subsistence Maya peasants into modern agricultural production (6, 181, 182).

Twenty years later, Plan Chac was widely recognized as a failure. Only half of the projected area had been brought into production, at an average capital cost of $2,000 per hectare. The irrigation systems had fallen into serious disrepair, and only a very small proportion of the credit had ever been repaid. The orange and other citrus trees had been poorly cared for, were heavily infested with pests, and yielded an average of less than eight tons per hectare--no better than those in the old-yype units (162). Most of the peasants had developed 1.5 hectares of land or less, and over 90 percent of them have been forced to supplement their incomes with off-farm labor (156, 157).

Problems of the Technical Design

The project was based on sprinkler irrigation, drawing upon what was then the most advanced Israeli technology. This system was chosen to overcome the problems of high infiltration rates in the porous limestone soils of Yucatan. It has never functioned properly according to the original design, and its inflexibility has prevented the ejidatarios from growing diversified combinations of crops. Wells with an average depth of 40 meters and a capacity of between 100 and 150 liters per second feed into open canals. Additional pumping stations pressurize buried asbestos-concrete pipes, which run across the short axis of each 100 by 300 meter parcel. The standard layout is illustrated in the following diagram:



Lines of sprinklers on aluminum laterals, connected to hydrants, were designed to water two rows of trees at a time. They were to be moved every day, and water was to be supplied for 12 hours at a time to organized groups of producers of sufficient size to maintain the correct pressure. If the systems had functioned correctly, they would have delivered 260 liters of water to each tree every eight changes, or every ten days as the pumps were not operated on Sundays.

The construction process was delayed repeatedly, and many seedlings died in the first years both because they were not watered, and because they had been mass produced without adequate testing and were of inferior quality (243, pp. 227-230; 293, pp. 39-40). Faced with budgetary restrictions, the District reduced the number of lateral lines in each parcel from two to one. The users could either cut the planted area in half, or irrigate on a longer schedule, which stressed the trees and stunted their growth. Either way, expected yields were greatly reduced. A chronic shortage of spare parts and a variety of technical problems have plagued the systems, which have never operated smoothly at full pressure.

Within a few years after the forest was cleared, the parcels were invaded by aggressive, fast-growing weeds. Their growth is greatly stimulated by the sprinklers, which spray water from the unshaded centers of the rows, and they compete seriously for moisture with the

shallow-rooted orange trees. A study made in 1975 estimated that the effective delivery to each tree was between 30 and 50 liters per irrigation, less than 20 percent of the original design (211). In rotations which have been stretched out for more than three weeks in many cases, this amounts to a minor supplemental watering to what are essentially rain-fed orchards.

The Vicious Circle of Insufficient Credit

The Rural Bank was created to provide credit to peasant ejidatarios, very few of whom have any substantial cash reserves. Nevertheless, its loans are structured as if they were providing supplemental capital to established commercial farmers. In Plan Chac, both cash advances and actual inputs were provided at irregular intervals through the season, tied to the successful completion of specific production tasks. Particularly in the early stages of parcel development, before the trees came into production, the total did not provide the people with enough income to meet the consumption requirements of their families. They were forced to find other sources of employment, often on a migratory basis. Through a long and chaotic period, which has only begun to stabilize in recent years, many parcels were partially abandoned for long periods. This greatly complicated the operation of the irrigation systems, as their design depended on their simultaneous operation by groups of users.

As the trees suffered the effects of drought stress and intermittent management, the Bank reduced the credit allowances to reflect their lower productive potential. At the same time, the Irrigation District raised its water charges, to recover its costs from a much smaller area in operation than had originally been projected (243, p. 230). This was a strong disincentive for the peasants to irrigate sufficiently, and many of them sold the fertilizers and the other inputs which they received to meet their immediate needs. In an attempt to break the project out of this vicious circle, both the long-term parcel development loans (credito refaccionario) and the housing loans were forgiven in 1974. Short-term production credit (credito de avio) continues to be granted, but only for a small proportion of the total costs, to insure that the loans will be repaid (158). Technical assistance programs have been provided only intermittently, most of the demonstration plots have been abandoned, and most of the parcels produce only a small fraction of their original projected yields.

Attempts by the Users to Adapt the Systems to Their Needs

Unlike those in the old-type units, which can be entirely flooded in a few hours every week or ten days, the parcels in Plan Chac are watered a section at a time. This system requires daily attention, but short-season crops cannot be grown, both because the rows must be kept

clear to lay the pipe, and because irrigation is too infrequent in any one area. Many of the users have attempted to overcome this inflexibility by modifying the systems in ways which allow them to produce more diverse combinations of crops. Some have removed the sprinkler heads, and run plastic tubes from the risers to water vegetables. Some connect large hoses to the ends of the laterals, and direct the entire flow into basins constructed around the base of each tree for a few minutes at a time. This is an awkward method, but it permits them to ignore the rigid planting grid and set out other types of fruit trees wherever space is available. A few have built networks of masonry and earthen ditches.

The Irrigation District has vigorously opposed ad hoc modifications of these kinds. They depressurize the lines, and if they were widely adopted, they would make any future rehabilitation of the systems as a whole impossible. Government studies have recognized that the monoculture of citrus has not provided a stable livelihood to the participant families. Several alternatives have been proposed, including the cultivation of a wider range of fruit species, the introduction of dairy cattle, swine, and other animals in small family operations, and the development of special irrigation systems in compact areas of good soils for vegetable production (143, 181, 182). Ideas of this kind have only been implemented on a very limited scale, because funds have not been available to redesign the project to permit diversified peasant enterprises.

Plan Tabi

In Plan Tabi, the peasants have struggled with considerably more success to achieve independent control over their resources, and to modify a structure imposed by the government. The project consists of 12 mechanized vegetable production units in the fertile valley south of the Puuc hills, with a total of approximately 200 participant families. They are indicated on Map 4A, and are part of a larger program in the south, with over 2,000 hectares under irrigation in 1981.

Program for Collective Management

Plan Tabi was originally planned as an intensive, cooperatively managed dairy operation, a priority type of enterprise of the Inter-american Development Bank, which provided a large proportion of the capital cost (167). When the systems were built in the early 1970's, they were redesigned to produce annual crops with sprinkler irrigation. During the Echeverria administration (1970-1976), national policy promoted the collective organization of ejidal development programs. Most of the land in each unit was laid out in compact blocks of 30 to 80 hectares, which were to be centrally administered to facilitate the use of machinery and modern technology. Each ejidatario would

participate in the labor and the benefits of these collective enterprises, and in addition was granted a "family parcel" of between one-third and one hectare for his individual use. The Rural Bank set up a comprehensive credit program, which included the use of government tractors on a custom basis.

In the first years of the program, the government agencies were under very strong pressure to produce crops which were in deficit nationally, particularly soybeans and sunflowers, but for which marketing and distribution channels did not exist in Yucatan. The Rural Bank provided seed and credit for the costs of production, but they did not have the trained personnel to manage the unfamiliar crops, and in several years they could not find markets for them. The campesinos were paid credit advances for their labor, but they received no more benefit than they would have from any kind of manual work. Their claims through the official crop insurance company (ANAGSA) to cover their mounting debts to the Bank were slowly and incompletely honored.

Fractionalization into Diversified Family Parcels

The history of each of the groups has been slightly different, but they have all gradually broken the collective fields up into individual family plots, and have diversified their operations with a wide range of vegetables, grown in complex relay and intercrop arrangements. Most of the produce is sold through the Oxkutzcab market. By the 1981-1982 season, credit was only available for fresh maize and watermelons, and only these crops continued to be planted in compact blocks, at the insistence of the Bank. The original irrigation systems of movable aluminum laterals were too inflexible to permit the simultaneous cultivation of different crops at different growth stages, with different water requirements. The sprinklers were still used on a small scale, but most of the area had been gradually redeveloped. The pipes were used to feed water into head ditches, through which it was carried into furrows beside each row. This hybrid system is quite flexible, as it permits small fields to be watered individually, and it does not require that large areas of the lumpy terrain be leveled.

The goal of most of the participants is to become totally independent of the government agencies. In the first years of the project, demonstration plots and extension courses were set up to train the ejidatarios in the use of the irrigation equipment and of chemical inputs. The peasants combined this information with a large body of empirical knowledge about vegetable production which they had accumulated in a lifetime of work in their conucos and in the older irrigation units. Their experience with the services provided by the Irrigation District and the Rural Bank has been a long series of frustrations. The machinery often arrives too late to prepare seedbeds or carry out other tasks for which the timing is critical. The delivery of inputs and the payment of credit advances are chronically

delayed, and the process involves constant meetings and visits to a number of offices. The government's tractors are too large to operate effectively in the small plots of less than a hectare into which the project has been divided. The farmers prefer to buy seeds, fertilizers, and spray materials in the market, and several units have succeeded in buying their own tractors.

Approximately 25 vegetables are grown, most of which are traditional foods in Yucatan and which supply the demand of the urbanized Maya population. The producers adjust their cropping patterns to maintain a more or less even profile of sales throughout the year, with concentration in periods of good prices. They depend on family labor for many tasks, and cooperate among themselves in the operation of the irrigation systems and to schedule the use of the machinery. They also hire in help on both a permanent and a seasonal basis, and the project has become an important source of local employment. They have been given privileged access to modern technology, and they have adjusted the systems to suit their needs.

Although their incomes are well above the average in the region, their principal concern continues to be the long-term stability of the family economy. After a few years of vegetable production, they begin to look for ways to diversify into perennial crops. Their experience has led them to believe that even the best Kankab soils cannot support intensive management indefinitely. They are mistrustful of production systems which depend on high input levels, and of a marketing system which has always been volatile. Most would like to invest the surplus in the development of orchards--a patrimony to support them when they are older with reduced effort, and as something tangible to pass on to their heirs.

The producers have been relatively successful because they have been able to sell a variety of high-value crops in the regional market, and to organize their operations within the decision-making framework of the peasant economy. The local government agencies have been tolerant of the modifications which have been made to their system, because the project is small and serves the interests of the communities. They have, however, fought the introduction of fruit trees into the mechanized areas as strenuously as they have resisted the cultivation of vegetables in Plan Chac. They want to see the Federal investments which have been made in irrigation pay off in increased production for the market, and want to avoid the declining productivity of mature parcels which is common in the old-type units.

The Orange Juice Processing Plant

A frozen concentrated orange juice plant was constructed in Akil in 1979, at a cost of three million U.S. dollars. It was designed to process 20,000 tons of fresh fruit per year, nearly half of the total

production of the Puuc region, and its capacity could easily be doubled by the addition of a second evaporation tower. It was the centerpiece of an extremely ambitious and quite unrealistic plan to convert Yucatan into a major citrus-producing region for the export market (161). The proposed development of 40,000 hectares of new plantings in the three states of the peninsula would have increased the national area in production by nearly 25 percent (201, p. 19). The costs of irrigation systems, seedling trees, and long-term development credits would have totalled 174 million dollars, more than 60 percent of the gross value of the total output of the agricultural sector in Yucatan in 1981 (180). The estimated 11,000 jobs which it would create would be nearly 10 percent of the economically active population in agriculture. Although the project was justified as a program of assistance to the Maya, and was organized through an ostensibly participatory structure, it has provided only short-term benefits and its future is very uncertain.

The Plan From a National Perspective

Oranges are the single most important fruit crop in Mexico. An average of 1.8 million tons per year were produced between 1975 and 1980, of which 97.5 percent were consumed domestically (201, p. 43). Eighty-seven percent of the national crop is grown in a few highly specialized areas in the northeastern states of Veracruz, Tamaulipas, San Luis Potosi, and Nueva Leon. Yucatan produces less than 3 percent in small, diversified peasant parcels. The small residual which is exported as fresh fruit, primarily to the United States, comes from large, private orchards in the border states. Foreign demand fluctuates dramatically from year to year, depending on frost patterns of other conditions.

The production of frozen juice concentrate has increased rapidly in recent decades, in Mexico as in other parts of the world. Between 1974 and 1980 it rose an average of 15 percent per year to approximately six million gallons (160). Eighteen processing plants supply the highly elastic national demand for canned juices and soft drinks, which is concentrated in urban areas. Approximately two-thirds of their output is exported, much of it to the United States. Due to a combination of rising demand and a declining area in production, U.S. imports of frozen concentrate increased from 31.4 million gallons in 1966 to 151 million in 1978. In spite of its geographical proximity, Mexico supplies only a small, residual share of this market, which is heavily dominated by Brazil. Oranges are produced and processed at relatively low cost in that country. A sophisticated marketing and shipping system, which includes the use of specially modified tankers, has been developed.

In the late 1970's, the National Fruit Commission (CONAFRUT) concluded that it would be feasible to capture a much larger share of the U.S. and other world markets if new production and processing

facilities were constructed. Rather than compete with established suppliers in the major producing regions, they decided to expand in Yucatan, a priority area for Federal investments because of its poverty and high rate of rural underemployment. Test batches of concentrate had a much higher sugar content than Brazilian juice, and it was thought that it would be favored by the American blenders, who combine batches from various sources into a uniform product. On the basis of technical arguments of this kind, the project received the personal support of President Lopez Portillo, and a special agreement was signed with the Rural Credit Bank to provide the funding. Once these decisions had been made in Mexico City, they had to be meshed with a complex set of institutions, local interests, and difficult agro-climatic conditions in Mexico.

The fruit producers in the Puuc region had long been petitioning for some kind of solution to their marketing problems. According to its original plan, Plan Chac was to have produced oranges for sale in central Mexico and abroad, but this had not been possible. Transportation costs were too high to allow Yucatan to compete with the much larger and better organized producers in Veracruz and other states closer to the major metropolitan markets. An attempt to export fresh fruit to Florida was rejected, because of their uneven size and quality. A crisis in the regional market was postponed by the slow development and poor yields of the project, but by the late 1970's Plan Chac accounted for nearly half of the output of the Puuc zone, which exacerbated the problems of seasonal glut and price instability.

Several studies concluded that the state's production was too small, and that access to the world market was too uncertain to justify the construction of a processing plant. They suggested that small-scale warehousing and marketing cooperatives could allow the highly fragmented small producers to compete more effectively with the commercial middlemen. Strict grade and price standards could be set to encourage the peasants to improve the quality of their product, and more effective credit programs could help them to adopt better production methods (211, 314). The national fruit program ignored this advice, and brought in an entirely new staff from Mexico City to side-step the opposition of the local institutions, which irritated the regional pride of the Yucatecans.

Familiar Errors are Repeated

Under intense pressure to spend the budget which they had been allotted, and to expand the area in production as rapidly as possible, the new citrus program repeated many of the same errors which had been made in Plan Chac nearly twenty years before. The realization of even a fraction of its goals required the rapid multiplication of grafted seedlings, the construction of new irrigation systems, and the organization of credit programs and many other details. Rather than build upon the experience of either the local institutions or the

farmers, the technical design and the administrative procedures were imposed from above.

A consulting firm from Riverside, California was hired to set up seedling nurseries. They recommended the use of rootstock resistant to tristeza, a virus disease common in many parts of the world which has never reached Yucatan. Almost all of the trees in the region are grafted onto sour rootstock, which is highly susceptible, so this was sensible advice. Nevertheless, material which had never been tested under local conditions was brought in at high cost, although the local experiment station (INIA) had been working on resistant material for several years. The seedlings were mass produced very rapidly, and their quality and vigor were well below the standards of the local nurseries.

The plan envisioned the development of 40-hectare modular units of ten families each. The organization of the campesinos and the construction of the irrigation systems were slow, and the seedlings were ready to be transplanted long before adequate facilities were available. Over 500,000 little trees--theoretically enough for over 2,000 hectares--were distributed within a few months on an ad hoc basis. One hundred fifty thousand were given out to plant previously undeveloped areas within Plan Chac, although the severe problems of the irrigation systems were well known. Two hundred seventy thousand were taken to the henequen zone to be planted as part of a diversification program. Portable big-gun sprinklers, which are usually used to irrigate pastures, were brought in hastily. Small pumps and hoses were distributed in the north, where shallow wells were available. There were severe technical problems, and the seedling mortality rate was very high. No provision was made for intercropping vegetables or other short-season crops during the development of the trees.

The plantings were financed with a combination of long-term credito refaccionario, to cover the costs of establishment, and short-term credito de avio, which provided payments to the participants to cover their living expenses until the trees came into production. The repayment schedules were set according to projected yields of 18 tons of oranges per hectare, more than twice the average of established orchards in the state, which could only be achieved with intensive, careful management. The credit system is awkward to administer, and does not provide a reliable source of income to the ejidatarios. They were skeptical about the prospects, and could not afford the risks of dedicating themselves to the projects on a full-time basis. The technical personnel were frustrated by what to them seemed like an unreliable work force, and were forced to reduce the labor requirements as much as possible. They experimented with sophisticated drip-and-trickle systems, which cost over four thousand dollars per hectare in tubing and outlets alone. They also tried to move as many seedlings as possible into the private sector, and to establish cooperative agreements between private management and ejidal labor. This was in

direct contradiction with the stated social goals of the project, and antagonized many key political figures (291).

Marketing Problems

The processing plant itself, with the latest equipment imported from the United States, was first brought into full production in the 1981-1982 season. According to the Agrarian Reform and Rural Credit laws, all Federal investments in the ejidal sector must be organized through a participatory structure of elected representatives, and the campesinos became the legal "owners" of the project. While this is in large measure a populist fiction, the ejidatarios take it seriously as a source of leverage over the operation of government projects. The citrus producers in the Puuc region had lobbied heavily to have the plant located in their area, and reorganized themselves into a Union of Ejidos under the terms of the law. As only fruit from parcels already in production would be available for processing for several years, they were responsible for organizing a system of concentration and sales. In spite of a series of difficulties organizing the trucking and delivery arrangements, the season was reasonably successful. The price--3,000 pesos per ton (115 U.S. dollars)--was well above what the producers had received in previous years, and it set a floor under the price of fresh fruit in the Oxkutzcab market. The plant purchased over 13,000 tons of fruit in cash, and paid 38 million pesos (1.5 million U.S. dollars).

As many observers had predicted, the Rural Bank encountered severe problems selling 235,000 gallons of frozen concentrate in the U.S. market. In spite of the efforts of an American consulting firm, they were not able to secure a contract with a single blending and packing company for the entire output. They were forced to sell in small lots through the import brokers along the Texas border who specialize in Mexican produce. Established transportation links did not exist, and they chartered a small ship to send the drums to Brownsville before they had received any firm commitments. The Americans claimed to be suspicious that the product might be adulterated, and insisted on inspecting every drum, one by one. Freight and warehousing charges built up to over 20 percent of the value of the product, and much of it was finally sold on very unfavorable terms.

While it was possible that efficient marketing channels might eventually be established, the project came under heavy criticism from all sides. The ejidatarios, both the members of the Union who sold to the plant and the participants in the new plantings, felt that they were receiving only small benefit from the investments which were being made. The local peasant leaders, many of whom had strong political ties in the state, felt excluded from effective participation in decision-making. Other government institutions were frustrated that their budgets were being reduced at the same time as a project with the

privileged support of the President and other influential people in Mexico City was expanding. Soon after the end of the Lopez Portillo administration, the Director of the project came under suspicion of corruption and committed suicide. One of the most enduring traditions of Mexican politics is that the programs of one presidential term do not survive into the next. The future of the plan to expand citrus production was very uncertain at the time of this study.

PIDER Rural Development Projects

All three of the above cases were overly ambitious attempts to introduce modern production systems hastily in centrally administered development projects. The types of problems which they have encountered are very common throughout Mexico, which has led to the promotion of small-scale rural development programs as an alternative strategy. Within this more modest framework, approximately 60 irrigated fruit units were established in traditional Maya communities throughout Yucatan in the 1970's. They were located in compact blocks of between 12 and 60 hectares, usually several kilometers from the villages, on land which the ejidal assemblies had withdrawn from common use. They were divided into individual parcels of between one and two hectares, and the irrigation equipment and the costs of establishment were provided by the government (175). Their principal goals were to create local sources of rural employment, to reduce the need for seasonal or temporary migration, and to provide a more intensive alternative to milpa agriculture. Their record of success has been poor, and their history demonstrates that the centralization of decision-making into the hands of government agencies creates problems which are not limited to large-scale, technically sophisticated plans.

The National PIDER Program

With substantial support from the World Bank and the Interamerican Development Bank, the Mexican government initiated an ambitious program of rural development in 1973. Called PIDER (The National Investment Program for Rural Development), it was designed to overcome the worst features of the polarization of the rural sector between modern enclaves and the large marginal regions of low productivity and chronic underemployment. The poorest areas of the country have been divided into over 150 micro-regions, and communities with between 300 and 3,000 inhabitants have been targeted for investment programs. Rural roads, small-scale irrigation and cattle projects, and social infrastructure such as drinking water systems, health clinics, and schools have been the principal focus. Over one billion dollars were spent in the first five years, and the annual level of expenditure rose rapidly as projects were developed in increasing numbers of villages (50, p. 3).

Most of rural Yucatan was included in five micro-regions, and expenditures through 1981 totaled 1.2 billion pesos (45 million U.S. dollars) (175; 180). Small-scale fruit development projects were the second most important type of productive enterprise, after cattle production. They were organized in cooperation with the National Indian Institute (INI) and the state delegation of the National Fruit Commission (CONAFRUT), which was entirely separate from the national program created to establish the juice plant. They absorbed 20 percent of PIDER's budget in Yucatan in 1981 (180).

Centralized Planning and Improvised Implementation

The administration and funding of scores of investment programs in small, isolated villages on bad roads was a major challenge. PIDER developed an elaborate planning and evaluation system which was concentrated in the central offices in Merida. The operational agencies were much less successful in coordinating the day-to-day procedures involved in getting the projects implemented in the field.

Feasibility studies for 15- or 20-hectare irrigation projects were two or three hundred pages long. To avoid the concentration of the harvest in a single period, the plans provided for the cultivation of two different fruit crops, usually oranges, mandarins, lemons, mangos, or zapotes. These crops were chosen on the basis of studies of the elasticity of demand in the urban areas where they were to be consumed, but it was not specified how small volumes from out-of-the-way villages were to be transported and sold. Detailed projections were made of the costs and benefits over the life of the units. As the benefit/cost ratios had to meet fixed standards, there was a strong incentive to include high-value, short-season crops in the plans, because the discounted value of the revenue from their sales was relatively high. Very optimistic yield estimates were used, but the organization of the credit, inputs, and sophisticated management techniques which would be required to achieve them was left to the operational agencies.

In theory, PIDER was to have financed the establishment of each project in three years; two for its construction and one for an intensive program of training and technical assistance. After that time, they were to have been turned over to the communities, and arrangements were to have been made with the Rural Bank to provide production credit. In fact, most of them were constructed in fits and starts over as many as seven or eight years, with frequent changes in membership and in technical design.

The field personnel were spread very thinly, and improvised. There were constant problems getting the equipment delivered and the work tasks accomplished according to the rigid timetables imposed by the central office. If funds were not expended on schedule, they were often transferred, or the next year's budget was reduced. This

pressure led to problems: wells were drilled in inappropriate locations or abandoned before the water table was reached, seedling trees were delivered before the irrigation systems were completed, and many others (175, 176).

In the first years of the program, most of the units were set up with sprinkler irrigation, because supply channels for equipment of that type had already been established for Plan Chac. They did not work well, both because they greatly stimulated weed growth, and because they required coordinated irrigation schedules which proved difficult to organize. Later projects were equipped with simple systems of faucets and hoses, which allow the flexible management of each individual parcel. A few more elaborate drip-and-trickle systems were installed on an experimental basis. Where marketing outlets existed, the participants were permitted to plant short-season crops between the rows, and some credit was made available. The coordination between government agencies was poor. The Rural Bank refused to provide credit to many units, because their inspectors concluded that the productive capacity was too low to pay back the loans.

It is very difficult to reconstruct the true costs of individual projects, as the deviations from the original plans were not recorded systematically, but they averaged between 55 and 80 thousand pesos per hectare (between two and three thousand U.S. dollars). By 1982, only a handful were producing any significant quantity of fruit. It was impossible to estimate potential yields, or to evaluate how transportation and sales would be arranged. The agencies planned to establish collection and marketing centers, and were negotiating with the Rural Bank to provide credit for trucks.

Problems of Organization

In communities where the apparent average rate of underemployment is 40 to 50 percent, one might suppose that the ejidatarios would have plenty of surplus time, and would be eager to participate in new enterprises. Nevertheless, the work schedules of peasant families are very complicated, even in isolated villages. They allocate their labor between tasks in their milpas and apiaries according to the cycle of the seasons, and engage in a variety of other activities to meet the needs of their families. The field supervisors tried to organize the labor schedules around slack periods, but encountered significant difficulties.

PIDER funds are direct Federal investments; they are not loans. They covered the costs of purchased items such as the pumps, irrigation equipment, fencing, and seedling trees, and also paid the participants for their work. The rates established for specific tasks on a piecework basis were well below the prevailing wage rate, because the campesinos were expected to provide a portion of the value of their

labor as their contribution to the establishment of the enterprises. Particularly in cases where progress was repeatedly delayed by technical or supply problems, the people tended to regard the projects as relatively poorly paid sources of employment with uncertain long-term prospects. They did not want to jeopardize the security of their family economy by giving up either key tasks in their milpas, or other jobs if they were available. COPLAMAR, a rival rural development agency, paid considerably higher wages, and the organization of labor was particularly difficult in villages with both alternatives (163).

Many Maya communities are riven with conflicts between family, religious, and other factional groups, which were often accentuated by the projects. The field supervisors retained control over expenditures, but the funds were channeled through the elected ejidal representatives, who had considerable influence over where a unit was located, and over who received labor payments. If this leverage was used to favor one group over another, petty squabbles often erupted into major feuds. The organization of work tasks, the scheduling of irrigation, and other routine matters became very difficult or impossible.

The few successful projects were located in ejidos with a strong leader who was able to negotiate on more or less equal terms with the government agencies, and adapt their programs to the needs and conditions in the communities. In most cases, however, a combination of disorganized technical direction, poor institutional coordination, and local conflicts have prevented the establishment of stable, profitable enterprises.

The Potential for the Intensification of Peasant Agriculture

The Maya farmers in the old-type irrigation units in Oxkutzcab and Akil are one of the most successful examples in Yucatan of the spontaneous intensification of peasant agriculture. The state's isolation from the rest of Mexico has provided a market for fresh produce which has been relatively protected from competition with large-scale commercial farmers in better endowed regions of the country. The peasants have been able to accumulate resources from extended periods of migratory labor. They have been able to adapt the empirical knowledge accumulated in their milpas, conucos, and solares to the cultivation of market crops. They have selected new varieties and elements of improved technology which have been tested under local conditions by their more prosperous neighbors. They have been able to modify flexible irrigation systems to meet changing water requirements as their parcels have developed, and to grow combinations of crops which can withstand intermittent periods when they cannot attend to them on a full-time basis. The Puuc region has become an oasis of relatively prosperous peasant production, but the process has been

slow. Both yields and the technical efficiency of water and other input use have been well below their theoretical potential.

Most of the campesinos have operated under the structural disadvantages which have, in one form or another, kept the peasant sector throughout Mexico in a marginal position within the national economy. The infrastructure and other services which have been provided to them as members of ejido communities have been chronically delayed and poorly organized. Very few experimental programs have been designed to develop improved technology appropriate to the special agronomic conditions of the region, or to the very limited cash resources which they control. Credit and technical assistance programs have been minimal. The evolution of a wholesale assembly market has allowed them to specialize in fresh produce, but they have received erratic and unpredictable prices. The value of oranges and of many other crops have not kept pace with inflation in the costs of living and of production, and adjustments in the combinations of perennials which they grow are slow and expensive. Although stratification within these communities has not been as pronounced as in many parts of the country, the benefits of high-value, choice varieties and of improved technology have been concentrated in the hands of a small elite with surplus capital and established commercial connections.

The government projects which have been designed to overcome these limitations have foundered, both because the technical and organizational systems on which they have been based are severely flawed, and because they have not provided a stable livelihood to the participants. In the worst cases, such as many of the PIDER projects, government investments have provided little more than ephemeral sources of employment during their construction. In the best, such as Plan Tabi, the peasants have been able to adapt the program to their needs, and have developed stable family enterprises. Plan Chac is an intermediate case which has certainly been a financial failure, but it has provided a part-time source of livelihood to 1,500 Maya families, and has produced a significant quantity of fruit. The juice plant and the associated expansion plan were set up in response to national priorities and personal bureaucratic ambitions, and it is too soon to assess what the long-term impact will be.

There is no simple solution to these problems; no formula which would provide the Maya with opportunities to move smoothly from the insecurity of milpa agriculture to more stable, productive types of farming. The agronomic potential of Yucatan is low, and the state has been a marginal area through much of its history. The relative advantages of the Puuc region--its deep and varied soils, its concentrated population, its tradition of commercial production, its established marketing and transportation network, and its experience with irrigation--could not easily be reproduced elsewhere. Nevertheless, some general lessons may be drawn.

The intensification of peasant agriculture requires a transitional period, during which the campesinos cannot be expected to work in new projects on a full-time basis. Experience in Yucatan has demonstrated that the peasant economy is a flexible strategy of adaptation, but that few families have been able to accumulate resources beyond those necessary to meet their immediate needs. They cannot afford to dedicate all of their time to programs which do not assure them of a steady income, or which expose them to any substantial risk. If at all possible, they will produce at least a portion of their own subsistence requirements. Any program designed to introduce new enterprises into the peasant economy must take all of their activities into account, and should dedicate at least some resources to the improvement and stabilization of milpa production.

Credit and other forms of direct cash subsidy could speed the process of transition, which extended over a full generation for many of the farmers in the sample. Payments should be made at regular, predictable intervals, and the terms of repayment should be generous. Attempts to impose strict credit standards in Plan Chac have not improved the recuperation rates, and the bank has not been able to enforce the technical procedures to which they are theoretically tied. It must be expected that some of the money will be used to meet immediate consumptions needs, to pay for family emergencies such as illness, or simply be wasted. Nevertheless, the sacrifices which many of the sample farmers made, including long periods away from their families, demonstrate that peasants do invest in the improvement of resources which contribute to the long-term stability of their households.

Irrigation systems should be designed to be flexible, so that the users may adapt them to meet their own needs and schedules. The theoretical advantages of more sophisticated technology cannot be realized if it is impossible to organize their smooth operation. Diversified combinations of crops have many advantages for peasant producers. They minimize the block of capital required to establish perennial species, and provide income throughout the year. Very little research has been done on the efficient management of combinations, and attempts to introduce standard systems of monoculture have been universally unsuccessful. Any development agency will have to conform to production priorities set by the government, but it should not attempt to impose rigid criteria. Traditional Maya agriculture is based on broad experience with a great variety of crops grown under local conditions. If time is allowed to establish demonstration plots, and if current practices are observed carefully, priorities for applied research can be established. In most projects, the details of organizing a marketing system have been left until the crops are in production, which is too late if good outlets cannot be found.

Peasant farmers with very limited cash resources cannot afford to organize their management systems around coordinated packages of modern technology. Chemical inputs, sold in small quantities by merchants,

are applied according to empirical rules of thumb and the experience of neighbors as a defensive reaction to particular problems. If basic information on application rates and product safety were available, the farmers could avoid the pesticide treadmill of increasing costs and decreasing effectiveness, particularly in the production of delicate vegetable crops.

The problems of organizing an efficient, well-coordinated administrative and service structure are by far the most difficult to resolve. The rapid expansion of development programs over the past decades has led to the proliferation of agencies, each of which has its own established set of interests and procedures. The relatively inexperienced officials must conform to the guidelines laid out by their own superiors, and are given very little latitude to solve problems in the field, or to organize their work with their counterparts from other institutions. This tendency was particularly pronounced in the late 1970's, when the petroleum boom created the illusion of unlimited potential for bureaucratic expansion. Although all programs in the ejidal sector are justified in terms of the populist rhetoric of the official political party (PRI), the effective influence of the peasant leaders has been reduced. They are in an ambiguous and difficult position as the mediators between the development agencies and the peasant communities. They greatly resent the frequent charges that they are mere puppets of the bureaucracy, but they are in a very exposed position should a particular project fail to deliver its promised benefits.

The Maya are organized into functional communities, with a long tradition of communal control over land and other resources. Their economy has withstood periods of severe pressure throughout their long history. They are used to coordinating their activities within organized groups, but their fundamental interest is the long-term stability of their families. Most development programs have concentrated on the establishment of modern enterprises, but have not developed plans for the best use of the resources of the ejidos as a whole. Attempts to impose the collective organization of production according to rigid schedules have provoked numerous conflicts and feuds.

The relative success of the farmers in Oxkutzcab and Akil is due to the fact that although they have been organized into groups, each family has retained the autonomy to intensify the management of its own parcels at a rate determined by its resources and fluctuating fortunes. Yields and net returns could be increased significantly if better technical services were provided, and if the market were stabilized. The challenge which faces agricultural development projects in Yucatan is to promote technological improvements in traditional practices without threatening the diversified strategy on which the stability of the peasant economy depends.

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APPENDIX A

PARTIAL LIST OF CULTIVATED SPECIES IN IRRIGATED PARCELS IN OXKUTZCAB AND AKIL

APPENDIX A. PARTIAL LIST OF CULTIVATED SPECIES IN IRRIGATED PARCELS IN SOUTHERN YUCATAN[1/]

Common Spanish Name	Partial List Of Varieties	English Name [2/]	Scientific Name	Maya Name	Origin [3/]	Notes
I. Perennial Species						
Aguacate	Pais [4/] Lugunero Grande Redondo Noche Buena Puerto Especial Monroe	Avocado	Persea americana (Mill.)	On	NTC	The avocados of the region are large, green, thin-skinned varities of the "Guatemalan" or "West Indian" type.
Anona	Colorada Cabeza de Negro Chirimoya	Bullock's Head Soncoya Chirimoya	Annona reticulta L. Annona purpurea (Moc.& Sesse) Annona cherimola (Mill.)	Oop Polbox Pox	NT NTY NTY	All of these species are relatively uncommon in the region. See Saramuyo and Guanabana.
Bonete	Pais	?	Jacaratia mexicana DC	K'uumche	NTY	Common in solares; little marketed.
Cafe	Pais	Coffee	Coffea arabica L.	-	OW	Rarely grown.
Caimito	Blanco Morado	Star Apple	Chrysophyllum cainito L.	Cayumito	NTC	A common fruit in the sapote family with a good market.
Cajera	Pais	?	Citrus amara Link.	Kahpak'al	OW	A minor citrus, used for juice and medicinal purposes.
Cedro	-	Tropical Cedar	Cedrela odorata L.	K'uche	NTY	A high-value native hardwood, grown for shade and occassional use and sale.
China Lima	Pais	Sweet Lime	Citrus limetta Risso	-	OW	A large, sweet fruit

continued . . .

Common Spanish Name	Partial List of Varieties	English Name	Scientific Name	Maya Name	Origin	Notes
Cidra	Pais	Citron	Citrus medica L.	-	OW	Uncommon.
Ciruela	Amarilla	Yellow Mombin or Hog-plum	Spondias lutea L.	K'an-abal	NTY	These and several other native species are among the most common fruit in traditional solares. A minor commercial fruit.
	Roja	Red Mombin	Spondias purpurea L.	Chi'abal	NTY	
	Tuxpena etc.					
Coco	Pais Enano	Coconut	Cocos nucifera L.	-	P	Commonly planted around the edges of parcels.
Cocoyol	Pais	Palm Fruit	Acrocomia mexicana (Karw.)	Tuk	NTY	A native palm, cultivated on a small scale for fruit.
Datura	-	Date Palm	Phoenix dactylifera (L.)	-	OW	Uncommon.
Galchich	?		?			
Granada	-	Pomegranate	Punica granatum L.	Yanu-ko	OW	
Grosella	-	?	Phylantus acidus L.		NTC	Identification uncertain.
Guanabana	Pais	Soursop	Annona muricata L.	Tak'oop	NTC	A prized fruit, common in eastern Yucatan; bears poorly in the south.
Guanacaste	-	-	Enterolobium cyclocarpus (Jacq.)	Pich	NTY	A large, leguminous shade tree.
Guaya	Pais		Talisia olivaeformis St.	Wayam	NTY	A small fruit with a large stone, similar to Mamoncillo.
Guayaba	Pais Grande	Guava	Psidium guajava L.	Pichi	NTC	Limited market for fresh fruit due to endemic worms; declining regional market for preserves.

continued . . .

Common Spanish Name	Partial List of Varieties	English Name	Scientific Name	Maya Name	Origin	Notes
Higo	-	Fig	Ficus carica L. ?	Kopo	?	Uncommon
Huano	?	Jippi Palm	Sabal yapa Wr. Sabal mexicana (Mill.) ?	Bonxa'an Boom	NTY	Universally used in Yucatan for thatch; the fiber jipi from the leaf stems is used for hats.
Jicara	Luch H'was	Calabash	Crescentia cujete L.	Luch H'was	NTY	Grown for drinking vessels; minimal marketing. Two types.
Juy	?	?	Casimiroa tetrameria Mill.?	Hyuy?	NTY	Identification uncertain.
Kaniste	?	Canistel	Lucuma campechana HBK.	Kaniste	NTY	A small fruit in the sapote family.
Limon	Pais Persa	Mexican Lime Persian Lime Lemon	Citrus aurantifolia Sw. Citrus limon L.	-	OW OW	Although a few true lemons are grown, the common "lemons" in the region are actually large limes. They are displacing sour oranges from the local market.
Limon Dulce	Pais	Sweet Lemon	Perhaps a cross between C. aurantifolia and C. Medica		OW	A large, sweet citrus.
Limonaria			Murraya paniculata L.		OW	A shrub.
Mamey	Pais	Mamey Apple	Pouteria sapota L. Mammea americana L.?	Chakalha'as	NTY	A large, high-value fruit. The increase in the tourist industry is expanding the market.
Mamey de Campeche	Pais	?	Lucuma hypoglauca (Standley)	Chooch	NTY	Uncommon
Mamoncillo	Pais	Mamoncillo	Melicocca bijuga L.		NTC	Popenoe identifies this as as an American relative of the Asian litchi.

Common Spanish Name	Partial List Of Varieties	English Name	Scientific Name	Maya Name	Origin	Notes
Mandarina	Pais Roja Blanca Japonesa	Mandarin Oranges	Citrus reticulata Blanco, or Citrus nobilis	-	OW	A broad range of varieties and local crosses are produced.
Mango	Pais Manila Cordoves Mangloba Pico de Loro Gigante Aniseto Obisbo	Mango	Manglifera indica L.	-	OW	A common fruit; the prices vary enormously depending on the quality of the variety.
Marañon	-	Cashew	Anacardium occidentale L.	-	NT	Uncommon species in Yucatan; produces a fruit as well as a nut. Object of a long series of government development projects.
Nance(n)	Amarillo	?	Byrsonima bucidaefolia Standley	Sakpah	NTY	Nance are a group of small fruit with large stones which are gathered as they fall to the ground. Common in solares.
	Rojo	Barbados Cherry	Malpighia glabra L.	Kani'binche'	NTY	
Naranja Agria	Pais much variation	Sour Orange	Citrus aurantium L.	Suuts-pak'al	OW	Used extensively in regional cooking, although it is being replaced in the market by Mexican limes. The universal rootstock for oranges.
Naranja China	Pais Valencia Temprano Valencia Tardia Granito de Oro and a wide range of introduced varieties	Sweet Orange	Citrus sinensis Osb	Chuhuk-pak'al	OW	The most prevalent fruit in the south. The great majority of the local varieties are early, bearing between September and January. Later varieties are being introduced.

Common Spanish Name	Partial List of Varieties	English Name	Scientific Name	Maya Name	Origin	Notes
Pepino de Arbol	Pais	?	Parmentiera edulis D.C.	Kat	NTY	A tree which produces a fruit which resembles a cucumber, used in cooking.
Pitaya	Roja Blanca Amarilla	Pitaya	Hylocereus undatus (Britt)	Chac wob Sac wob Kan wob	NTY	A fruit produced by a climbing variety of cactus, often grown on Huano trees. Used for fresh fruit and juices.
Ramon	?	Breadnut	Brosimum alicastrum Sw.	Ox	NTY	A large tree grown for its leaves as forage, and for shade. The nuts are edible, and are a traditional famine food.
Roble	?	?	Ehretia tinifolia L.	Beek	NTY	A native forest tree, tolerated in solares for shade.
Roshan	?	?	?			
Saramuyo	Pais Injerto	Sugar Apple	Annona squamosa L.	Ts'almuy	NTY	The most prevalent of the Annona species in the south.
Siracote	Pais	?	Cordia dodecandra DC.	Kopte	NTY	
Tamarindo	?	Tamarind	Tamarindus indicus L.	Pahch'uhuk	OW	Tamarind is not a major product in the south.
Tangerina	Pais	Tangerine	Citrus nobilis		OW	An uncommon fruit, much larger than a mandarin orange.
Toronja	Pais Grey	Pomelo Grapefruit	Citrus grandis Citrus paradisi		OW	The distinction between pomelo and grapefruit is ambiguous across a wide range of variation.

continued . . .

Common Spanish Name	Partial List of Varieties	English Name	Scientific Name	Maya Name	Origin	Notes
Tuna (Nopal)	?	Prickly Pear	Opuntia dillenii (Ker-Gawl.)	Pak'am	NTY	Grown on a small scale.
Waxim	?	Leucaena	Leucaena Glauca	Waxim	NTY	Native to Yucatan, grown as a source of nitrogenous mulch.
Zapote (Chico-Zapote)	Pais Kasta X-bolia Huevos de Chivo	Sapote	Manilkara zapota L.	Ya	NTY	The same tree from which chicle for chewing gum is extracted. A common fruit in the region.
Zapote Negro	?	Black Sapote	Diospyros digna (Jacq.)	Ta'uch	NTY	A fruit related to the Japanese Kaki.
II. Semi-Perennial Species						
Achiote	Ki'wi K'uxub	Annato	Bixa orellana L.	Ki'wi K'uxub	NT	This is, strictly speaking, a perennial crop. It is managed as an intermediate crop in the parcels, and is usually pulled out as the canopy closes. The seeds, which are sold as a dye and food colorant, face very unstable prices.
Cana	Many	Sugar Cane	Saccharum officinarum L.	Newech	OW	Formerly a commercial crop in the region, it is now grown on a very small scale.
Henequen		Henequen Sisal	Agave fourcroydes Agave sisalana Agave ixtli Agave minima Agave silvestris	Sak-ki Yaxki Xixki Chukumki Babki	NTY NTY NTY NTY NTY	Formerly grown as a commercial crop in the region, it is produced on a small scale.

continued . . .

Common Spanish Name	Partial List of Varieties	English Name	Scientific Name	Maya Name	Origin	Notes
Papaya	Pais Mamey	Papaya	Carica papaya L.	Put	NTY	A common intermediate crop. The region produces large, high-quality fruit.
Pina	Blanca	Pineapple	Ananas comosus L.	?	NT	A local variety, with small fruit with white flesh and very red skin and leaves, is grown as an under-storey crop.
Platano	Macho Huatano Barbaro Manzano Tabasco Morado	Plantain Banana	Musa cvs.	Xana'	OW	Grown for fruit as an intermediate crop, and for wrapper leaves for tomales and other foods as an under-storey crop.
Yuca	?	Cassava	Manihot esculenta Crantz	Ts'iim	NTY	This crop, of which a few varieties are native to Yucatan, was the basis of a small starch industry in the 19th Century which has disappeared. It is a very minor food crop, and most of it is produced for special dishes at All Saints' Day.
III. Annual Crops						
Berenjena	?	Eggplant	Solanum melongena L.	-	OW	
Cacahuate	?	Peanut	Arachis hypogaea L.	-	NT	
Calabaza	Xmehen-kum Xnuk-kum X-top Cubana etc.	Squash/Pumpkin	Cucurbita spp.	Kum	NTY	Squash is one of the basic crops of the traditional complex of Maya agriculture. In the milpa, a range of varieties are grown for their seed. In the parcels, most are sold immature as a vegetable.

Common Spanish Name	Partial List of Varieties	English Name	Scientific Name	Maya Name	Origin	Notes
Camote [5/]	Blanco Munaco	Sweet Potato	Ipomoea batatas L.	Is	NT	
Cebolla	?	Onion	Allium cepa L.	Kukut	OW	
Chaya	?	Chaya	Cnidosculus chayamansa Mv.	Xchay	NTY	A perennial bush, the leaves of which are cooked as a highly nutritious vegetable. Not marketed much; a common backyard product in Yucatan.
Chayote	?	Chayote	Sechium edule Sw.	Kiix-pach k'um	NT	A spiney, squash-like vegetable which grows on a vine.
Chile	Habanero Verde Serrano X-katik Sak-ik Max Dulce etc.	Chile pepper	Caspicum spp.	Ik	NTY	A wide range of traditional and introduced varieties are grown.
Cilantro	?	Coriander	Coriandrum sativum L.	?	OW	Grown both as an herb and for seed.
Frijol	Ts'ama Xkolibu'ul Xmehenbu'ul Jamapa	Beans	Phaseolus vulgaris L.	Bu'ul	NT	Several varieties of black beans, of both bush and climbing habit, are grown in milpas, conucos, and parcels
Girasol	?	Sunflower	Helianthus annus L.	?	NT	Small varieties are grown for their flowers. There have been some attempts to develop the crop as a commercial oilseed.

continued . . .

Common Spanish Name	Partial List of Varieties	English Name	Scientific Name	Maya Name	Origin	Notes
Ibes	Xmehen-ib Xnuk-ib	Lima Bean Seiva Bean	Phaseolus lunatus L.	Ib	NT	Broad, large-seeded varieties, recognizable as lima beans, are sold immature as a vegetable. A range of the small-seeded, seiva bean types are a common milpa crop, grown on a small scale in the parcels.
Jicama			Pachyrrhizus erosus L.	Chi'kam		A root crop similar to a large, white radish.
Kolinabo	?	Kohlrabi	Brassica gongyl-odes L.	?	?	
Lechuga	?	Lettuce	Lactuca sativa L.	?		
Lec	?	?	Lagenaria spp	Lek	NTY	A gourd with very thick walls used to keep tortillas hot.
Lenteja	?	Lentils	Lens esculenta L.	?	OW	
Macal [5/]	?	Yam Cocoyam	Dioscorea spp. Xanthosoma sagit-tifolium L.	Xmacal	NTC	
Malanga [5/]	?	Taro	Colocasia escu-lenta L.	Chaksots-macal	NTC	
Maiz	Xnuknal Xmehenal Nal-tel Sak-tuk H-507 H-508 etc.	Maize	Zea mays L.	Nal	NT	Of the traditional varieties the short-season Xmehenal is the most commonly grown in solares. The long-season Xnuknal is the most common in the milpa. Most of the maize produced under irri-gation is sold immature as roasting-ears, and the large-eared hybrids are preferred.

Common Spanish Name	Partial List of Varieties	English Name	Scientific Name	Maya Name	Origin	Notes
Melon	Pais Coco-melon	Melons	Cucumis melo L.	?	OW	A large, yellow melon was traditionally grown in the conucos. Several commercial varieties have been introduced in recent years.
Papas	?	Potatoes	Solanum tuberosum L.	Xlop'ik	NT	Potato production has declined in recent years, after marketing problems in the 1960's.
Pepino	Blanco Verde	Cucumbers	Cucumis sativus L.	?	OW	
Rabina	?	Radish	Raphanus sativus L.	?	OW	
Repollo	?	Cabbage	Brassica capitata L.	?	OW	
Ruta	?	Rue	Ruta graveolens L.			
Sandia	Pais Charleston Grey	Watermelon	Citrullus lunatus			The traditional varieties have been largely replaced by commercial seed imported from the United States.
Tomate	Zocatu Rodondo Napolis Roma	Tomato	Lycopersicon esculentum Mil.	Ahpa'ak	NT	Commerce dominated by Italian plum types, grown from U.S. seed.
Xpelon	Xmehen-pelon Xnuk-pelon	Cowpeas	Vigna sinensis L. (V. unguiculata)	Xpelon	OW	Usually picked green and sold in the pods, in bundles. An important crop in the region.
Tabaco	?	Tobacco	Nicotiana tabacum L.	K'utz	NT	Tobacco has been a small-scale commercial crop in the south for many years, but the market is declining.

1/ This list is far from complete. It is based on various sources, not on the collection of specimens from the region, and undoubtedly contains errors. The sources which have been consulted are listed below.

2/ The nomenclature varies considerably within both Spanish- and English-speaking countries.

3/ NT - New World tropics.

NTY - Wild progenitors and/or closely related wild species are found in the Yucatan peninsula.

NTC - Wild progenitors and/or closely related wild species are found in the Caribbean basin.

OW - Old World

P - South Pacific

4/ The term "Pais" is used in Yucatan to indicate traditional varieties or types. It corresponds roughly to the term "Criollo" which is used elsewhere in Mexico. It does not necessarily mean that the species is actually native to the region.

5/ The nomenclature of the root crops Dioscorea, Ipomoea, Xanthosoma, and Colocasia is confusing. Although they recognize the differences, the Maya call them all "Macal."

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APPENDIX B

TABLES

APPENDIX TABLE B1. MEXICO: INDICES OF PRODUCTION OF SELECTED CROPS AND GROUPS OF PRODUCTS

(1960 = 100)

Year	Maize[a/]	Beans[b/]	Wheat[c/]	Tomatoes[d/]	Forage Crops[e/]	Tree Fruit[f/]
1950	56	47	88	84	n.a.	n.a.
1960	100	100	100	100	100	100
1961	115	137	118	117	109	117
1962	117	124	122	112	122	112
1963	127	128	143	114	125	132
1964	156	169	185	114	147	133
1965	165	143	180	143	169	170
1966	171	192	138	143	222	180
1967	159	186	178	159	275	183
1968	167	162	175	172	313	185
1969	155	158	195	184	350	180
1970	164	175	225	238	338	189
1971	186	181	154	241	372	229
1972	170	165	152	309	394	227
1973	159	181	176	281	450	244
1974	145	184	234	288	503	233
1975	156	195	235	272	563	250
1976	148	140	283	251	534	267
1977	187	146	206	244	569	252
1978	202	180	234	359	584	307
1979	156	121	188	394	n.a.	n.a.
1980	228	184	234	375	n.a.	n.a.

a/ In 1960, 5.4 million tons were produced, at an average yield of 975 kilos/hectare. In 1980, 12.4 million tons were produced, at an average yield of 1.77 tons/hectare.

b/ In 1960, 528,000 tons were produced, at an average yield of 398 kilos/hectare. In 1980, 971,000 tons were produced, at an average yield of 551 kilos/hectare.

c/ In 1960, 1.2 million tons were produced, at an average yield of 1.4 tons/hectare. In 1980, 2.8 million tons were produced, at an average yield of 3.8 tons/hectare.

d/ In 1960, 389,000 tons were produced, at an average yield of 6 tons/hectare. In 1980, 1.5 million tons were produced, at an average yield of 19 tons/hectare.

e/ Principally alfalfa and grain sorghum. In 1960, 209,000 tons of sorghum were produced, at an average yield of 1.7 tons/hectare. In 1980, 4.8 million tons were produced, at an average yield of 3 tons per hectare. The spectacular growth of this crop, which competes directly with maize in

APPENDIX TABLE B1 (continued)

many agroclimatic zones, reflects the increased demand for feed, its relatively high profitability, and the relative ease with which it can be mechanized.

f/ Oranges and other citrus, avocados, cherries, peaches, guavas, figs, mangos, pears, quinces, almonds, dates, and various nuts.

Sources: Indices for individual commodities were calculated from the production figures reported in "Consumos Aparentes de Productos Agrícolas: 1925-1980," Econotécnica Agrícola, Vol. 5, No. 9, 1981. The indices for the commodity groups were recalculated from "Breve Analisis del Comportamiento del Sector Agropecuario Nacional: 1960-1978, y Algunas Consideraciones Sobre el Mercado Internacional," Econotécnica Agrícola, Vol. 3, No. 1, 1979, p. 31.

APPENDIX TABLE B2. NOTES AND SOURCES TO MAP 3

NOTE: Symbols used in Map B to identify climates according to the Köppen System as modified for Mexico by Garcia.

A — A group of hot, rainy climates where the mean annual temperature is above 22° C., and where the mean temperature in the coolest month is above 18° C.

w" — A modifier for a climate with the rainy season in the summer months, and a relatively dry period in the middle of the rainy season, which is called the canicula in Spanish.

Aw''_o — A sub-humid hot climate where the rainy season is in the summer, precipitation in the driest month is less than 60mm, and where 5 to 10 percent of the precipitation falls in the winter. The ratio between the mean annual precipitation and the mean annual temperature is less than 43.2.

Aw''_1 — The same as Aw''_o, except that the precipitation/temperature ratio is between 43.2 and 55.3.

Aw''_2 — The same as Aw''_o, except that the precipitation/temperature ratio is above 55.3

BS_o — A semi-dry climate, with a precipitation/temperature ratio below 22.9.

BS_1 — A semi-dry climate, with a precipitation/temperature ratio above 22.9.

x' — A modifier for a climate where over 10 percent of the precipitation falls in the winter months.

The following modifiers define the temperature regime:

i — Isothermic; annual oscillation of mean monthly temperatures is less than 5° C.

i' — The annual oscillation of mean monthly temperatures is between 5° and 7° C.

e — The annual oscillation of mean monthly temperatures is between 7° and 14° C.

g — The hottest month of the year falls before June.

h' — A modifier for dry and semi-dry climates which are very hot, with the mean annual temperature above 22° C., and the mean temperature of the coolest month above 18° C.

Source: "Modificaciones al Sistema de Koppen," Enriqueta Garcia, Ed., (Universidad Autonoma de Mexico, Mexico) 1973.

Sources: A: Carlos Bustamante, "Poblamiento y Colonizacion en la Peninsula de Yucatán" (mimeo, Cuadernos Preliminares de Investigación, Instituto de Investigaciones Económicos, Universidad Nacional Autónoma de México, México, 1979).

B: México, Secretaría de Programación y Presupuesto (SPP), Dirección General de Geografía del Territorio Nacional, "Carta de Precipitación Total Anual, Hoja Mérida" (México, 1981).

C: Faustino Miranda, "Estudios Acerca de la Vegetación," in Enrique Beltrán, Ed., Los Recursos Naturales del Sureste y su Aprovechamiento (Instituto Mexicano de Recursos Naturales Renovables, México, 1958), Vol. 2, pp. 215-271.

D: Juan Mendez Gongora, "Analisis Agropecurio y Forestal del Estado de Yucatán," Econotécnia Agrícola (Mexico City), Vol. 3, No. 8, 1979, pp. 9-83.

APPENDIX TABLE B3. YUCATAN: MAIZE; HARVESTED AREA, PRODUCTION, AVERAGE YIELD, NOMINAL FARM-GATE PRICE, AND REAL PRICE IN CONSTANT 1964 PESOS

Year	Harvested Area	Production	Average Yield	Nominal Price	Real Price[a/]
	(hectares)	(tons)	(kilos/hectare)	(pesos)	(1964 pesos)
1960	82,925	90,647	1,093	750	-
1961	84,442	58,322	691	830	-
1962	76,626	43,733	571	820	-
1963	78,690	77,378	983	850	-
1964	93,113	87,531	940	750	750
1965	99,833	97,661	978	750	750
1966	64,171	51,218	798	800	746
1967	92,957	37,636	405	850	793
1968	101,144	78,670	777	850	708
1969	90,565	88.207	973	850	708
1970	99,321	95,789	964	850	635
1971	113,875	102,038	896	850	635
1972	111,216	108,303	974	850	541
1973	122,642	120,453	982	1,100	593
1974	106,932	93,912	876	1,400	691
1975	108,407	88,692	818	1,900	770
1976	104,829	94,550	901	2,200	726
1977	74,118	68,460	904	2,900	712
1978	136,746	116,921	855	2,900	597
1979	135,694	126,195	930	3,480	573
1980	159,724	129,829	813	4,444	592
1981	183,437	156,466	853	6,650	620

a/ Farm-gate prices have been deflated using the Banco de Mexico's consumer price index for the city of Merida. No equivalent index for rural consumers has been constructed, and it is assumed that the rate of inflation was similar.

Source: 1960-1976; México, Dirección General de Economía Agrícola, "Yucatán en Cifras: 20 Años de Estadísticas Agropecuarios, 1957-1966" (Mérida, 1978), 1977-1981; México, Secretaría de Programación y Presupuesto, "Informe Económico--Yucatán" (Mérida, 1982).

APPENDIX TABLE B4. YUCATAN: AGRICULTURAL LAND USE AND VALUE OF PRODUCTION BY PRODUCT, 1981

Product or Land Use	Area	Percent of Area	Value of Production	Percent of Value
	(000 Has.)		(millions of Pesos)	
Maize	183.4	4.2	1,041	15
Henequen in Production	135.7	3.1	1,364	20
Immature Henequen	108.0	2.4	-	-
Beans and Squash[a/]	38.0	.8	207	3
Fruit	11.7	.3	498	7
Vegetables	3.0	-	199	3
Beef	-	-	1,162	17
Milk	-	-	72	1
Pork	-	-	603	9
Poultry and Eggs	-	-	1,642	24
Honey	-	-	163	2
Improved Pasture	365.0[b/]	8.4	-	-
Natural Pasture and Scrub Forest Used for Browse	896.0[b/]	20.7	-	-
Forest	1,770.0[b/]	40.8	-	-
Not Classified	826.9	19.0	-	-
Total	4,338.0	100.0	6,951	100

a/ Beans, squash, and a variety of minor crops are grown in association with maize in the milpa, and the reliability of official production statistics is low.

b/ Estimated for 1980.

Source: Agricultural statistics: "Informe Económico: 1981," México, Secretaría de Programación y Presupuesto, Mérida, 1982. Pasture and forest estimates: "Diagnostico del Sector Agropecuario del Estado de Yucatán," Mexico, Banco de Crédito Rural Peninsular, (mimeo) Mérida, 1981.

APPENDIX TABLE B5. OXKUTZCAB AND AKIL, YUCATAN: DESCRIPTIVE DATA ON THE OLD TYPE UNIDADES ANTIGUAS DE RIEGO

Irrigation Unit	Irrigated Area	Tenure Type: Ejidal Parcels	Tenure Type: Private Parcels	Number of Active Users[a/]	Parcels in Each Size Class: 0-.49 Has.	.5-.9 Has.	1-2.9 Has.	≥ 3 Has.	Average Parcel Size	Area in Citrus[b/]	Average Citrus Yield[b/]
	(hectares)	(number)			(.....percent.....)				(has.)	(percent)	(tons/ha.)
OXKUTZCAB											
Units Located North of the Puuc Hills											
*612	72.9	1	302	97	65	10	22	3	.72	33	9.7
*La Mejorada	52.3	67	199	109	60	32	8	0	.56	n.a.	n.a.
Ceres	47.4	2	99	67	61	12	21	6	.72	n.a.	n.a.
El Roble	80.3	73	97	95	40	32	27	2	.80	78	18.8
625bis	32.7	84	0	60	58	34	8	0	.52	43	11.5
644	52.2	94	0	91	59	29	12	0	.56	79	17.4
645	52.8	84	4	70	51	22	24	3	.72	73	15.5
628-San Juan	79.6	6	129	107	40	32	27	1	.68	42	11.5
Noh-Chakan	26.5	36	0	31	19	42	35	3	.92	68	11.7
Located in Fertile Valley South of the Puuc Hills											
Cooperativa	91.7	142	0	127	43	24	31	2	.80	77	14.3
*Yaaxhom	76.5	59	5	59	12	0	78	12	1.68	71	13.3
San Pedro I	48.9	50	0	50	16	30	50	4	1.00	77	14.2
San Pedro II	62.2	60	0	60	15	27	58	0	.88	72	14.0
Crucero I	40.9	26	0	26	4	12	72	12	1.76	61	9.8
Crucero II	33.1	27	0	27	15	11	48	26	2.00	35	6.1
*Xpoto-it I	41.5	66	0	54	9	28	61	2	.96	74	11.1
Xpoto-it II	37.1	61	0	61	8	43	47	2	.88	52	4.7
Subtotal	926.8	944	835	1,181					.78	58	13.3
AKIL											
Akil I	110.0	117	9	121	31	31	36	2	.96	75	13.0
Akil II	97.0	73	48	68	42	22	35	1	.72	n.a.	n.a.
*San Anastacio	45.0	52	0	51	15	38	46	0	1.00	63	15.1
Ox-Ak I	64.0	70	7	70	19	31	43	7	1.16	49	14.1
Ox-Ak II	83.0	98	0	n.a.	n.a.	n.a.	n.a.	n.a.	.96	77	8.4
Ox-Ak III	39.0	63	11	68	61	21	15	3	1.24	62	7.8
Ox-Ak IV	49.0	88	0	n.a.	n.a.	n.a.	n.a.	n.a.	.80	70	9.6
Chun-Tuk	28.0	44	0	n.a.	n.a.	n.a.	n.a.	n.a.	.80	35	8.7
San Victor I	14.0	0	22	13	8	23	61	8	1.32	75	7.8
*San Victor II	29.0	0	27	26	31	4	61	4	1.28	88	11.2
Subtotal	558.0	580	124	647					.86	64	11.1
TOTAL	1,484.8	1,524	954	1,828					.81	60	12.5

*Sampled Units.

a/ Many producers operate parcels in more than one irrigation unit, which is not reflected in this data.

Sources: b/ Mexico, Comision Nacional de Fruticultura, Proyecto Citricola del Banrural Peninsular, "Censo de Citricos en el Sur de Yucatan" (mimeograph, Mexico, 1980). Rest of table: Mexico, Secretaria de Agricultura y Recursos Hidraulicos (SARH), Irrigation District #48, Ticul, Yucatan.

APPENDIX TABLE B6. CASE 1, MARIO HAU: SUMMARY BUDGET OF .5 HECTARE PARCEL IN 1981/1982 PRODUCTION PERIOD

Type I - Part-Time Farm		Harvest Season	Income (Pesos)	Costs (Pesos)
Estimated Sales:				
Perennial Fruits	Number of Trees			
Sweet Oranges	40	November - December	4,500	
Mangos	5	April - June	3,000	
Nance	20	July - August	3,000	
Avocados	5	June - July	800	
Coconuts	10	Year-round	500	
Ramon	2	April	250	
Lemons	20	--not yet in production-		
Total	102 = 204/Hectare		12,000	
Estimated Cash Costs of Production:				
Irrigation water				900
Chicken manure				500
Hired labor				7,400
Total				8,800
Estimated Income net of Cash Costs			3,200	
Estimated Value of Family Labor				
Operator's labor - 20 days x 200/day				4,000
Apparent Annual Net Income from the Parcel			-800	

APPENDIX TABLE B7. CASE 2, MANUEL GONGORA: SUMMARY BUDGET OF .52 HECTARE PARCEL IN 1982/1982 PRODUCTION PERIOD

Type I - Part-Time Farm		Harvest Season	Income (Pesos)	Costs (Pesos)
Estimated Sales:				
Semi-perennial Fruit	Number of Trees			
Papayas	10	May - August	1,800	
Bananas	10	May and December	1,600	
Sub-Total	20		3,400	
Vegetables	Area Harvested			
Chile Verde	.5 Mecate	June - August	1,750	
Total Receipts			5,150	
Estimated Cash Costs of Production:				
Irrigation Water				1,050
Fertilizer				350
Chemical Spray Materials				5,000
Hired Labor				0
Total				6,400
Estimated Income net of Cash Costs			-1,250	
Estimated Value of Family Labor				
Operator's labor - 150 days x 200/day				30,000
Son's labor - 130 days x .5 x 200/day				13,000
Total				43,000
Apparent Annual Net Income from Parcel			-44,250	

APPENDIX TABLE B8. CASE 3, TRANSITO US: SUMMARY BUDGET OF 1.2 HECTARE PARCEL IN 1981/1982 PRODUCTION PERIOD

Type II - Family Labor Farm		Harvest Season	Income (Pesos)	Costs (Pesos)
Estimated Sales:				
Perennial Fruits:	Number of Trees			
Oranges	180	October-December	45,000	
Lemons	20	May and November	9,000	
Mangos	10	April-June	8,500	
Mandarins	15	September-November	2,000	
Avocados	5	May-June	1,750	
Grapefruit	10	September-November	1,500	
Zapote	4	November-January	1,500	
Nance	4	July-August	1,200	
Saramuyo	6	August-September	1,000	
Sour Oranges	10	October-December	900	
Sub-Total	264 = 220/Hectare		72,350	
Semi-Perennial Fruits:				
Bananas	30	May and December	5,500	
Vegetables:	Area Harvested			
Squash	3 Mecates	October-January	8,000	
Chile Serrano	1.5 Mecates	July-February	5,500	
Maize (fresh)	3.5 Mecates	May	3,500	
Tomatoes	.5 Mecates	January-February	3,000	
Sub-Total	.34 Hectares		20,000	
Total Receipts			97,850	
Estimated Cash Costs of Production:				
Irrigation water				3,000
Fertilizer				2,500
Chemical spray materials				5,000
Hired Labor				2,000
Total				12,500
Estimated Income net of Cash Costs			85,350	
Estimated Value of Family Labor				
Operator's labor - 300 days x 200/day				60,000
Wife's time in market - 40 days x 200/day				8,000
Sons' part-time labor - 30 days x 200/day				6,000
Total				74,000
Apparent Annual Net Income from the Parcel			11,350	

APPENDIX TABLE B9. CASE 4, JUAN PECH: SUMMARY BUDGET OF 1.9 HECTARE PARCEL IN 1981/1982 PRODUCTION PERIOD

Type II - Family Labor Farm		Harvest Period	Income (Pesos)	Costs (Pesos)
Estimated Sales:				
Perennial Fruits	Number of Trees			
Avocado varieties:				
Lagunero	75	May - August	173,000	
Noche Buena	23	September - August	10,200	
Especial	161	February - March	43,800	
		May - September	22,800	
Mangos	6	May - June	19,000	
Lemons	10	May and December	4,200	
Sub-total	275 = 144/Hectare		273,000	
Semi-Perennial Fruits				
Papaya	600	July - December	57,600	
Vegetables	Area Harvested			
Squash	14 Mecates	October - May	42,000	
Tomatoes	20 Mecates	September - April	24,000	
Chile Habanero	5 Mecates	July - October	2,800	
Sub-Total	1.6 Hectares		68,000	
Total Estimated Receipts			398,600	
Estimated Cash Costs of Production:				
Irrigation Water				2,500
Chicken Manure				3,000
Chemical Fertilizer				12,000
Chemical Spray Materials				41,000
Hired Labor				93,750
Total				158,750
Estimated Income net of Cash Costs			240,000	
Estimated Value of Family Labor				
Operator's labor - 220 days x 200/day				44,000
Wife's time in market - 60 days x 200/day				12,000
Sons' part-time labor - 80 days x 200/day				16,000
Total				72,000
Apparent Net Income from the Parcel			172,000	

APPENDIX TABLE B10. CASE 5, ALBERTO SUAREZ: SUMMARY BUDGET OF 3 HECTARE PARCEL IN 1981/1982 PRODUCTION PERIOD

Type III - Hired Labor Farm		Harvest Period	Income (Pesos)	Costs (Pesos)
Estimated Sales:				
Perennial Fruits	Number of Trees			
Sweet Oranges	335	October - December	60,300	
Mandarins	200	September - November	33,000	
Mangos	25	April - June	18,750	
Avocados	30	July - August	7,500	
Lemons	10	May and December	4,500	
Coconuts	40	Year-Round	3,600	
Saramuyo	10	August - September	1,850	
Grapefruit	10	October - November	1,400	
Total	660 = 220/Hectare		130,900	
Estimated Cash Costs of Production:				
Irrigation water				1,500
Chicken manure				1,350
Hired Labor				45,000
Total				48,850
Estimated Income Net of Cash Costs			82,050	
Estimated Value of Family Labor				
Operator's labor - 20 days x 200/day				4,000
Apparent Annual Net Income From Parcel			78,050	

APPENDIX TABLE B11. CASE 6, FRANCISCO CASTRO: SUMMARY BUDGET OF 2.8 HECTARE PARCEL in 1981/1982 PRODUCTION PERIOD

Type III - Hired Labor Farm		Harvest Period	Income (Pesos)	Costs (Pesos)
Estimated Sales:				
Perennial Fruits:	Number of Trees			
Avocados	300	June - July	196,000	
Zapotes	30	April	21,000	
Immature zapotes	75	-	-	
Sweet Oranges	75	October - January	11,250	
Mandarins	35	September - November	5,775	
Huano	18	March	400	
Total	458 = 164/Hectare		235,000	
Estimated Cash Costs of Production				
Irrigation water				3,000
Chicken manure				7,500
Herbicides				3,900
Insecticides and Fungicides				8,200
Hired Labor				58,000
Total				80,800
Estimated Income Net of Cash Costs			154,200	
Estimated Value of Family Labor				0
Apparent Annual Net Income from the Parcel			154,200	

APPENDIX TABLE B12. AVERAGE YIELDS, PRICES, AND VALUE PER TREE OF THE PRINCIPAL TREE CROPS IN OXKUTZCAB AND AKIL, 1981/1982

Species	Average Value per Tree[1/]	Yield/Tree[2/]			Price[3/]		
		Mean	Low Average	High Average	Mean	Low Average	High Average
Aguacate	350	3.0	1.0	5.0	125	100	300
Caimito	600	3.0	2.0	6.5	200	150	400
Ciruela	90	2.0	1.5	2.5	125	100	250
Coco	90	60pcs.	30	100	1.50ea.	1.00	2.00
Huano[4/]	30	18pcs.	10	25	1.50ea.	1.00	2.00
Limon	450	3.0	2.0	5.0	150	80	300
Mamey	1,250	5.0	2.0	10.0	250	200	500
Mandarina	185	5.0	2.0	9.0	33	25	40
Mango[5/]	750	6.0	3.0	9.0	150	100	350
Nance	300	2.0	1.5	2.5	150	100	400
Naranja Agria	90	300pcs.	150	500	.30ea.	.25	.40
Naranja Chian	143	400pcs.	200	700	.40ea.	.30	.45
Ramon[6/]	125						
Saramuyo Pais	185	1.5	1.5	2.5	125	100	200
Saramuyo Injerto	450	2.0	1.0	3.0	225	175	300
Toronja	140	350pcs.	200	500	.40ea.	.30	.50
Zapote	450	3.0	2.0	6.0	150	100	400

1/ These figures are very rough estimates for comparative purposes only. A large number of heterogeneous varieties of fruit are produced, and the wide variations in yields and prices are not easily standardized. The data for the more common crops--Sweet Oranges (Naranja China), Avocados (Aguacate), Mangos, and Mandarin Oranges (Mandarina)--are weighted using standard statistical probability calculations for expected value. The others are weighted according to the judgment of the author.

2/ The yields are estimated from the data from 48 sample parcels, The units are 35-kilo boxes, unless otherwise noted.

3/ The price estimates are combinations of data from the sample, and from direct observations in the Oxkutzcab market. They are reported in Mexican pesos.

4/ Huano (Sabal yapa Wr.) is a roofing palm sold by the leaf.

5/ Mangos tend to bear in alternate years.

6/ Ramon (Brosimum alicastrum L.) is a forage tree. The right to cut the leaves is sold by the tree.

7/ Saramuyo Pais is a traditional variety of Sugar Apple; (Annona squamosa L.) Saramuyo Injerto is an improved, grafted variety with much larger fruit.

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