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TZOTZIL MAYA ETHNOECOLOGY: LANDSCAPE PERCEPTION AND MANAGEMENT AS A BASIS FOR COFFEE AGROFOREST DESIGN

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ABSTRACT.—In Los Altos de Chiapas and other regions of Mexico, indigenous producers maintain multilayered, rustic coffee agroforests (RCAs). Focused on Polhó (municipality of San Pedro Chenalhó), a Tzotzil Maya community, indigenous ecological knowledge and landscape categorization relevant to the design and establishment of RCAs were identified. The methodology involved: 1) structured interviews with 50 coffee growers encompassing ecological knowledge (soils, microclimate, vegetational units, and succession) and management history of RCAs; 2) collection of vouchers of vascular plants having ethnobotanical importance; and 3) identification of plants within one hectare of an RCA. As a result of their multiple-use strategy of natural resource management, Tzotzil informants perceive several vegetational units, soils, and microclimatic conditions. Tzotzil ecological knowledge is critical to the design and establishment of an RCA, especially regarding ecological succession. Two common routes for RCA establishment were observed: 1) from other cultivated fields (predominant source); 2) from secondary vegetation. Coffee growers' activities such as protection/promotion of native trees, cultivation of crops and nitrogen-fixing trees, and elimination of pioneer species seem analogous to processes of ecological succession.

Key words: Tzotzil, rustic coffee agroforests, ethnoecology, ecological succession, landscape management.

RESUMEN.—En la región Los Altos de Chiapas, y en otras partes de México, los productores indígenas mantienen sistemas agroforestales rusticos multi-estratificados SAR). Centrado en Polhó (municipio de San Pedro Chenalhó), una comunidad Tzotzil Maya, fue estudiado el conocimiento ecológico indígena y la categorización del paisaje que es relevante en el diseño y construcción de los SAR. La metodología incluyó: 1) entrevistas estructuradas con 50 productores de café sobre su conocimiento ecológico (suelo, microclima, unidades de vegetación y sucesión), y la historia de manejo de los SAR; 2) colecta y herborizacion de plantas vasculares y la información etnobotánica; y 3) identificación de las plantas en un hectárea de SCA. Como resultando de las estrategias de uso para el manejo de los recursos naturales, los informantes Tzotziles perciben diversas unidades de vegetación, suelos, y condiciones microclimaticas. El conocimiento ecológico de los Tzotziles es critico para la construcción de los SAR, siendo el conocimiento ecológico de la sucesión lo más importante. Fueron observadas dos rutas para el establecimiento de los SAR: 1) desde otro terreno cultivado (la condición dominante); 2) desde la vegetación secundaria. Las actividades que realiza el productor de café (protección/promoción de árboles nativos, el cultivo de especies domesticadas y fijadoras de N, la eliminación de especies colonizadoras y pioneras) parecen ser análogas al proceso de sucesión ecológica.

RÉSUMÉ.—Dans certaines régions du Mexique comme les hauts plateaux du Chiapas, les producteurs indigènes pratiquent un système d'agroforesterie naturelle et stratifiée de café—agroforêts naturelles de café (ANC). Cet article examine les connaissances écologiques et les méthodes indigènes de classification du cadre naturel utilisées par une communauté maya tzotztil de la région de Polhó (municipalité de San Pedro Chenalhó) pour la conception et la création d'agroforêts naturelles de café. La méthodologie de ce projet était la suivante: 1) interviews structurées de 50 producteurs de café portant sur les connaissances écologiques (sols, microclimats, unités de végétation, et succession) et l'historique de l'établissement des agroforêts naturelles de café; 2) collecte d'exemplaires de plantes vasculaires importantes d'un point de vue ethnobotanique; et 3) identification des plantes recensées dans un hectare d'agroforêt naturelle de café. Parce qu'ils exploitent les ressources naturelles de multiples façons, les producteurs tzotzil interviewés définissent plusieurs catégories de paysage (unités de végétation), sols, et microclimats. Le savoir écologique des Tzotzil est essentiel à la conception et à l'établissement d'une agroforêt naturelle de café, particulièrement en ce qui concerne la succession écologique. On a observé deux démarches courantes pour la création d'une agroforêt naturelle de café: 1) à partir d'autres champs cultivés (source principale); 2) à partir de végétation secondaire. Les activités des producteurs de café, comme la protection/amélioration des arbres indigènes, les culture vivrières, les cultures d'arbres fixateurs d'azote, et l'élimination d'espèces pionnières, semblent correspondre au processus de succession écologique.

INTRODUCTION

In the coffee-growing regions of Latin America, forest exploitation ranges from little disturbed natural forests to agroindustrial, monospecific plantations. Between these two extremes are the rustic coffee agroforests under indigenous management. In Mexico, the coffee crop is dominated by traditional small-scale growers both in terms of the number of cultivators and the total amount of land planted in coffee (Moguel and Toledo 1999). As in other regions of Latin America (Perfecto et al. 1996), these coffee growers maintain multilayered, shaded coffee agroforests that combine relatively high and sustainable economic benefits with a seemingly diversified, productive system. In the rustic coffee system, coffee bushes substitute the plants growing on the floor of mature and/or secondary forests. The result is an exuberant coffee garden with a great variety of arboreal, shrub-like, and herbaceous species, both wild and domesticated.

Because indigenous ecological knowledge is critical for the construction of

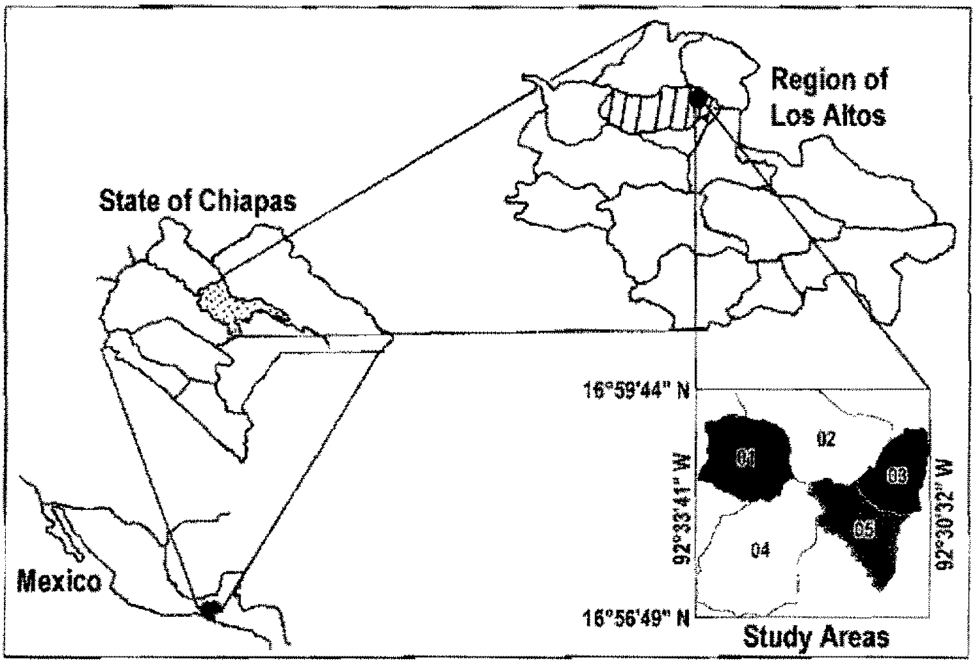

FIGURE 1.—Location map of Polhó, Chiapas.

these rustic coffee agroforests, this paper is devoted to exploring by a case study how indigenous producers employ their perception of soils, climate, vegetation masses, plant species and ecological processes, in order to create and manipulate these coffee gardens.

The Study Site.—The study area is located in the Los Altos de Chiapas region between 19°59′49″ and 19°59′44″ N latitude, and 92°33′41″ and 92°30′32″ W longitude (Figure 1). It lies within the municipality of San Pedro Chenalhó, whose name is partly derived from Tzotzil, ***Chenalhó*** 'water well'. This study area encompasses 1837.6 ha of the total 130 km^2 (about 13%) of the municipality of Chenalhó. Five subareas with contrasting environmental conditions were selected for this study. These include all of the land associated with the studied community, Polhó, as well as a small extension of land belonging to the Tzotzil communities of Tzajalukum, Acteal, Poconichin, Narajantik Bajo, Narajantik Alto, Yabteklum, and Yebeljoj.[1]

In the northern sector of the municipality of Chenalhó, where Polhó is located, the climate is of the type (A)C(m)—sub-warm-humid with abundant summer rains, as defined by the Köppen classification since modified by García for Mexico (SEGOB 1988). The average temperature in this zone where coffee thrives ranges from 18 to 22°C, and the annual rainfall is between 2000 and 2500 mm. Geomorphologically, the study area is defined by steep mountainsides, formed by folded structures of Cretaceous limestone, and similarly sheer high hills. In the structurally controlled valley bottom there are some alluvial plateaus of Quaternary age.

Predominant soils in the area, particularly in subareas 1, 2, 4, and 5, are orthic and chromic luvisols (INEGI 1991). Such soils have a characteristic B horizon of clay, are shallow, and exhibit low fertility. Rendzina soils are the dominant type in subarea 5. The area is devoid of navigable rivers and the vegetation types present are coniferous forests (subarea 3) together with fragments of cloud forests (in subareas 1, 2, 4, and 5), which have been deeply altered by centuries of slash-and-burn agriculture.

The estimated total population of Polhó is 399 people in 78 households (INEGI 1991). Between the 1970s and the 1990s, Chenalhó's population more than doubled, from 13,522 to 30,680 (INEGI 1991). The houses are built with local materials, such as clay and wood, and are hay-thatched, although in recent years the building patterns have changed and concrete houses with metallic or cardboard roofs are being adopted. In the 1990s, the people of Polhó proclaimed themselves a Zapatista Autonomous Municipality as a result of a confrontation between them and Chenalhó municipal authorities, who have a close relationship with local rulers (*caciques*). This close relationship has perpetuated the long history of exploitation of the local people. Moreover, the emergence of paramilitary forces since 1996 and the more active presence of the Mexican army in the region have been additional sources of insecurity and social conflict.

Local Landscapes.—The landscape in Polhó is a patchy mosaic of *milpas* (polycultural fields in which the main crop is maize), home gardens, diversified groves for shaded coffee, a few specialized shaded coffee plantings, *potreros* (grazing grasslands), banana and sugarcane plantings, fallow fields, and forests in various stages of ecological succession. The dominant floristic elements of these forests separate them into two types of secondary vegetation: 1) the *acahuales*, in which tropical elements are dominant and which occur in the northern zones encompassing subareas 1 and 2; and 2) secondary vegetation with conifers, which includes subareas 4 and 5 to the south and subarea 3 to the west. The surface covered by mature coniferous and cloud forests is nowadays very narrow. The coniferous forests in the more temperate areas have an extension of 26 ha of conserved woodland, and 30 ha of altered woodland (F. Bandeira et al. in press). These two fragments of forest, which were located in the more elevated and protected areas, crowned the landscape until 1997, when they were largely cut down by the Mexican army, and to a lesser extent, by 2500 newcomers who had been displaced from their original communities (Unión Majamut, personal communication, 2000) as a result of the 'Zapatista' conflict in the region (Collier et al. 1994). These immigrants settled on these lands after a massacre carried out by paramilitary groups in December 1997 in the community of Acteal, near the study site.

Majomut: an Indigenous Coffee Grower Organization.—The Unión de Ejidos y Comunidades Beneficio Majomut is an organization that is mostly composed of organic and conventional coffee growers from the municipalities of San Pedro Chenalhó and San Juan Cancuc, in the northern part of the Los Altos de Chiapas region. In these municipalities, people live in several dispersed settlements or *parajes*, which are the basic units of the community; each one of these harbors between 20 and 200 households (Majomut 1983). The main modes of land tenure are a Mesoamerican communal property regime (the prevailing mode) and the *ejido* (an institutional land tenure system created by the Mexican state in the beginning of the twentieth century to distribute land to rural communities); privately owned estates are less common (INEGI 1991). By custom, land use rights may change hands in two ways. Privately owned land is simply inherited from father to son. Less commonly, the use of communally owned land is allocated by traditional authorities. The average size of individual properties is 2 ha, with a trend towards extreme reduction and spatial dispersion of agricultural fields.

Even though the land is communal property, each coffee tree has an owner. Production is organized by family: the coffee crop is sold and the products of the milpa are kept for home consumption. These activities are the basis of the economy of the community of Polhó. Rain-fed cultivation for subsistence occupies a central role in this agricultural production system, mostly in the form of milpas; milpas are interplanted with beans, squashes, and chili, and these crops are supplemented by gathering tolerated weedy species considered edible—*quelites*. These milpas—a common feature of Mesoamerican agriculture—are based on slashing and burning mature or secondary vegetation, with cultivation cycles punctuated by relatively long fallow periods for restoring soil fertility and for reducing populations of unusable weedy plants, pests, and plant pathogens. In contrast, coffee growing is much more recent. Coffee was introduced into the region less than 100 years ago and adapted to the Maya *solares*, permanent gardens including useful trees, shrubs, herbs, climbers, epiphytes and annuals, which are owned by a household, and whose produce is either for home consumption (most) or the market. It was the grandparents and parents of the current producers who brought the shrubs from the coffee *fincas*, privately owned large rural estates, in Soconusco, where they were employed as *jornaleros* (day laborers). Only in the twentieth century was coffee cultivation incorporated into the indigenous food production system, and it has played a significant role in the economy of the region during the last four decades.

The coffee growers of Polhó are Tzotzil who have ancient roots in the land. This research builds on earlier studies of Tzotzil culture, including. studies of Tzotzil cosmology (Jacorzynskl and López-Hernández 1998; Vogt 1964), ethnobotany (Breedlove and Laughlin 1993), and various other ethnographic, anthropological, historical, and socioeconomic topics (Collier 1990; Laughlin 1969; Nigh 1989; Parra-Vázquez 1993a; Wasserstrom 1989).

METHODS

General Survey.—During December 1996 (15 days) and March (15 days), an initial general survey of the area was carried out in all of the communities belonging to Majomut, with the purpose of selecting one of these communities for study. We interviewed delegates and leaders of each community visited in order to explain the objectives of the research to be conducted. After this, the community of Polhó was selected for more detailed study, based on geographical criteria (its ecophysiographic heterogeneity), geopolitical status (its relevance of the community at the regional level, and its spatial relations with other communities within Majomut), its diversity of production (productive and landscape managing strategies observed), and the apparent physiognomic diversity of its coffee agroforests.

We conducted an environmental inventory of the Tzotzil territory accompanied by local farmers and reviewed the extant literature. Also, a photographic record was made of the landscape and of the several land uses in the eight local geographical demarcations, or *barrios*, of Polhó: Majomut 1, Majomut 2, X'oyep 1, Xoyep 2, Polhó Centro (Central Polhó) Canolal, Majunpenpetik 1, and Majunpenpetik 2.

Detailed Survey.—The specific methods employed in the detailed survey of the coffee agroforests of Polhó and of the ecological knowledge of its designers and actors were the following:

1) Structured interviews (Alexíades 1997) were carried out between June and July, 1997 (60 days) with 50 of the 173 local organic coffee producers. These structured interviews had the objective of eliciting local knowledge about the ecology (classification of the landscape or management units, of the phases of ecological succession, and of the vegetation types), pedology (classification of soil types), and climatology, following the system of Toledo (1990). Additionally, the surveyed producers were questioned about their practices of management of the coffee agroforests and of soil conservation, as well as about other ethnoecological data, such as the number, surface and location of their management units. These interviews were carried out in the plots of each producer surveyed, either in Spanish or in Tzotzil, with the aid of a bilingual worker from Majomut or an organic coffee promoter.[2]
2) Voucher specimens were made of all trees, shrubs, vines and herbs growing on a one-hectare plot of coffee agroforest in Polhó. Each specimen was accompanied by its corresponding Tzotzil and Spanish names, use, and parts used. The specimens were identified by the staff of the Herbarium of the Faculty of Sciences, UNAM (FCME), where they are housed.
3) For all surveyed plots, data were recorded on their history of management, such as past uses and time used as coffee agroforests; additionally, for some of these plots, elevation and geographical coordinates were recorded.

RESULTS AND DISCUSSION

Tzotzil Ethnoecology.—Ethnoecology was defined by Toledo (2000:1181–2) as a multidisciplinary theoretical and methodological approach "that explores how nature is perceived by human groups through a screen of beliefs and knowledge and how humans, in terms of images and symbols, use and/or manage natural resources" (see also Toledo 1999). This study reveals, describes and analyzes the ethnoecology of Tzotzil coffee producers of Polhó: their systems of management of natural resources that includes their cosmology, and local knowledge of biota, ecology, and pedology. Their ethnoecology incorporates structural, dynamic, relational, and utilitarian components, deriving from a wisdom that has been produced and reproduced through several generations.

This discussion covers some of the aspects considered by other authors to be pertinent in the context of traditional Tzotzil coffee growing systems in the stud-

TABLE 1.—Ethnopedological categories recognized by Tzotzil informants in Polhó, Chiapas.

	Texture	
Color	***cham-Lum*** 'clayey soil'	***chab-Lum*** 'silty soil'
ik' 'black'	***ik'al cham-Lum*** 'clayey black soil'	***ik'al chab-Lum*** 'silty black soil'
k'an 'yellow'	***k'anal cham-Lum*** 'yellow clayey soil'	***k'anal chab-Lum*** 'yellow silty soil'
tzoj 'red'	***tzajal cham-Lum*** 'red clayey soil' (unproductive land)	***tzajal chab-Lum*** 'red silty soil' (unproductive land)

ied area, and centers on the knowledge about the local ecological succession processes, vegetation, soils, climate, and part of the plant diversity that is managed as part of the floristic structure of coffee agroforests.

Ethnopedology.—Soils are fundamental for agricultural production processes. Thus, the ways in which Tzotzil farmers recognize and classify soil units enable them to establish adequate patterns of management of this resource. This ethnopedological knowledge may be transmitted across generations as well as across space. The first step involves describing and analyzing local ethnopedology, so that the patterns of management of soils may be better understood.

The Tzotzil informants recognized distinctive soil categories based on texture and color, indicating that they observe, manage, and identify the arable surface of the soil. This result confirms previous studies of Tzotzil ethnopedology (Cervantes-Trejo 1995; Pool-Novelo et al. 1992), and it demonstrates that the pedological classification elaborated by the Tzotzil is comparable to other ethnopedological systems worldwide that are based on the same criteria (Barrera-Bassols and Zinck 2000).

The primary lexeme for soil is ***Lum***. The recognized subclasses of soil are named by a secondary productive lexeme, which is formed by a lexeme for color, followed by a lexeme for texture, both of which are placed before the primary lexeme ***Lum***. Thus, Tzotzil ethnopedology has a hierarchical structure with a general rank containing two inferior ranks, essentially generic and specific. The generic rank has different textures, suggesting different degrees of workability and humidity. The specific rank deals with color and fertility. As reported by Pool-Novelo et al. (1990), texture is the most relevant characteristic for Tzotzil ethnopedology, followed by color. In total six soil types were recorded, according to the Tzotzil ethnopedology of Polhó (Table 1).

Two classes of soils are recognized with respect to texture: "clayey" (***cham-Lum***) and "silty" (***chab-Lum***). They correspond to the soil categories used by the Tzotzil of San Juan Chamula (Chamula): "heavy soils" (***cham-Lum***) and "medium soils" (***cuc-Lum***), respectively. These soils are widespread in the Los Altos de Chiapas region (Cervantes-Trejo 1995). This difference in soil nomenclature is due to dialectal differences between the two communities. Cervantes-Trejo (1995) found in Chamula one additional soil texture category named "sandy or light soils" (***yi'al-Lum***), which was not reported in the coffee agroforests that were visited in Polhó. In this community, red, clayey soils are predominant, perhaps corresponding to the orthic luvisols previously reported to exist in the area (INEGI 1991). According to Pool-Novelo et al. (1990), the classifications of soil based on texture have a trend to designate different management conditions presented by these soils. These authors emphasize a relation between texture and humidity of the soil throughout the year, which together seem to define the timing for performing certain agricultural activities, the degree of difficulty of such activities, and the number of harvests that may be obtained during one year. Additionally, the texture of the soil determines the technology that must be employed, such as the specific characteristics of the hoes (Pool-Novelo et al. 1990).

Attending to color, the Tzotzil informants of Polhó recognize three soil classes based on color present in the studied area: ***ik'*** 'black', ***k'an*** 'yellow', and ***tzoj*** 'red'. The black color of the soils in the coffee agroforests is perhaps due to a high content of organic matter, which is derived from the decomposition of the usually thick layer of leaves that are mainly shed by the trees that provide shade, such as "*chalum*" or ***kok*** (*Inga* spp.), which are abundant in the coffee agroforests.

In Chamula, Cervantes-Trejo (1995) found the same color categories registered for Polhó, but she reports two additional types of soil: ***chacxik'*** 'gray' and ***zac*** 'white'. The gray soils develop from local soil management, by the addition of sheep manure to the ***k'anal cuc-Lum*** "yellow silty, or medium, soil" a characteristic of Tzotzil agropastoral systems with grazing sheep within karstic zones; cultivation helps give the soil a gray color (Cervantes-Trejo 1995). In contrast, the farmers in Polhó do not develop this agropastoral system and because of that the "gray" soil is absent in Polhó.

The ethnotaxonomy of soils of the Tzotzil, both in Polhó and in the other Maya communities of the Los Altos de Chiapas region, suggests a relationship between soil color and soil fertility (Pool-Novlo 1992; Cervantes-Trejo 1995). The Tzotzil lexemes used to name the color of soils, ***ik'*** 'black', ***k'an*** 'yellow', and ***tzoj*** 'red', are associated fundamentally with a decreasing level of fertility. Among the Tzotzil taxa of silty texture soils, ***chab-Lum***, the lexemes for color describe the degree of erosion of the black, top horizon of the soil, which when well developed is classified as ***ik'al chab-Lum***. As this top horizon's organic matter is washed away by the rain, however, new color lexemes are assigned by Tzotzil informants in accordance with the ethnopedological system. Through a process of surface erosion due to surface water run-off, these "silty black soils" are susceptible to being converted into ***k'anal cuc-Lum*** "yellow silty, or medium, soil," or further to ***tzajal cuc-Lum*** "red silty, or medium, soil." The perception of these processes associated with the dynamics of soil fertility is mirrored in the Tzotzil system for classification of soils and provides the framework for a connection of traditional techniques of soil management and soil conservation (Cervantes-Trejo 1995).

Techniques for soil conservation practiced in Polhó and in other communities of the coffee growing areas of the region range from the traditional activities of farming families such as tilling, addition of organic fertilizers (crop remains, manure, the hulls and flesh of coffee berries), the introduced techniques of "organic" agriculture, and the past traditional practices that were resuscitated by agricultural assistance workers of Majomut. These practices include: terrace building and installation of living fences or stones. All these techniques have been applied using local materials and germplasm and are part of the knowledge of the local people. Nevertheless, "innovative technology" for soil conservation, biological control of pests and diseases, and cultivation (control of shade) has been diffused both by the technical staff of Majomut and by local organic coffee promoters, and subsequently adopted in coffee agroforests. This process of innovation has taken place through the participation of local people, and the valorization of both the traditional knowledge and the resources available in the region's ecosystems. For example, in the composition of compost or manure several "organically-grown" materials have been used, including hay, banana leaves, herbs, and shrubs growing near the coffee agroforests. Likewise, for living fences use has been made of a varied spectrum of plant species growing in the *acahuales*, milpas, and home gardens of Tzotzil households.

Differences between ethnopedology in Chamula and Polhó may partly reflect dialect variations, such as the different names used for the same soil type (***cham-Lum*** and ***cuc-Lum***), although additional factors also help explain the ethnopedological differences observed. The geographic areas where Polhó and Chamula are located present different climatic, geological and physiographic characteristics that generate different soil types. Additionally, farmers of the two communities use different soil management techniques that change soil fertility, for instance, the "gray" soil produced only in Chamula. These differences are perceived by local farmers who encode them accordingly. Therefore, while the systems for classifying soils are structurally and taxonomically equivalent between the two communities, the soil types recognized and identified do exhibit some differences.

Tzotzil Conceptualization of Their Territory.—The Polhó region presents a considerable heterogeneity in its physiography and vegetation types. Moreover, the distribution of forest fragments and of surface water in the area are not homogeneous. All these factors contribute to a high diversity of environmental conditions and, consequently, a mosaic of suitable areas for agriculture recognized by Tzotzil informants. This knowledge is essential for coffee production, because this crop has ecophysiological constraints that limit the environmental range where it may be successfully grown and become productive (Willson 1999).

The Tzotzil of Polhó conceptualize the environmental complexity of their territory using the same categories as other Maya Tzotzil in the Los Altos de Chiapas region. They recognize and name two different landscapes in their territory: ***kisin osil*** 'warm farmland' and ***sikil osil*** 'cold farmland'. An additional intermediate or temperate physiographic zone is recognized by the Tzotzil but not formally named. Although these categories are used in general to name the areas in the Los Altos de Chiapas region with low and high elevation, respectively (Maffi 1999: 43), they possess ethnoecological significance since they establish a conceptual link between the physical and human geography and social organization (Maffi 1999:46). According to Luiza Maffi, these categories

> "do not simply designate physiographic features of the land such as climate or vegetation .... Rather, within the framework of what is commonly known as the Mesoamerican hot/cold dichotomy, these categories refer more specifically to the differential fertility and productivity of the

TABLE 2.—Distribution of the Tzotzil categories of the conceptualization of their territory in Polhó, Chiapas.

Tzotzil term	Sub-area	Average elevation (range) m asl (meters above sea level)	Land use/cover
kisin osil	1	1250 (1017–1500)	coffee fields, secondary vegetation
'warm farmland'	2	1150 (867–1584)	with tropical floristic elements (*acahuales*), corn fields sugarcane and banana planting
sikil osil	3	1600 (1418–1920)	corn fields
'cold farmland'			secondary vegetation with conifers coniferous forests
Unnamed	4	1400 (1339–1680)	corn fields
'temperate farmland'	5	1400 (1320–1540)	secondary vegetation with conifers and some coffee fields

land, by analogy with the concepts of the healthy vs. the diseased human body. The hot country and cold country categories should therefore be understood as ethnoecological concepts that inherently imply human relationship with the land." (Maffi 1999:41)

Within the context of coffee production, the territorial distinction made by the Tzotzil in the region allows them to order their space in terms of ecogeography and productivity. The ecological characteristics of any given area will determine what specialized crops may be grown there, together with maize, beans, squashes, chilies and other basic staples that historically characterize the diet of the Maya. Specialized crops such as coffee, citrus, bananas and other tropical fruits, and sugarcane are only cultivated in the ***kisin osil*** (Maffi 1999:45), although some producers may establish fields within the ***sikil osil,*** either as an experiment or because they do not have available fields in the "hot country." Also, this territorial differentiation allows for the identification of differences in agricultural productivity, which in part is determined by the different climatic and altitudinal characteristics of these two named zones (Maffi 1999).

This ecogeographical and landscape heterogeneity, recognized by the Tzotzil, should differentiate zones with optimal conditions where coffee would be most productive. And indeed, farmers take these factors into account when they decide what use will be assigned to each available plot. The optimal area for coffee production appears to coincide with subareas 1 and 2 (Figure 1, Table 2), which have an average elevation of 1150–1250 masl, and where *acahuales* and coffee agroforests were found to be more densely distributed, together with maize, sugarcane and banana. These subareas were unambiguously classified by local farmers as "hot" country (Table 2).

Subarea 3, with an average elevation of 1600 masl, is perceived to be largely homogeneous and it is utilized for basic crops and coniferous forest maintenance. In contrast, subareas 4 and 5, with an elevation range between 1320 and 1680 masl and an average of 1400 masl, are recognized as more heterogeneous and they harbor portions of "hot," "cold," and "temperate" land (Table 2). Subareas 4 and 5 are used mainly for basic staple crops, with only a few coffee agroforests and a considerable extension of secondary vegetation dominated by conifers (Table 2). In general, the potential coffee growing areas in Polhó exhibit considerable extension and include elevations between 1000 and 1600 masl; the areas with high precipitation (above 2000 mm), evenly distributed along the year and with a well defined dry season; and the zones where the average yearly temperature is 18°C. Only a minor extension of the communal territory of Polhó is unfavorable for coffee cultivation. These lands correspond to subarea 3 and the southern parts of subareas 4 and 5 that are above 1600 masl (Figure 1). These marginal lands are reserved partly for forestry activities (gathering of firewood and medicinal plants) and partly for conservation purposes (communal forest reserves). These forest areas, together with their water sources, are considered sacred by the Tzotzil of Polhó, and special ceremonies take place there.

Tzotzil Categories of Ecological Succession.—Although the Tzotzil informants do not have a specific name for ecological succession, they recognize and identify stages of ecological succession by means of floristic and structural features intrinsic to the vegetation, such as vertical structure, and the diameter and tallness of the trees present in a site. These indicators of ecological succession are related to time elapsed after fields were released from cultivation of annual crops, such as maize, beans, squashes, chili, and peanut (González-Espinosa et al. 1994). In Polhó, they recognize different stages of ecological succession in the patches of vegetation previously used for rain-fed agriculture, that is, when fields are allowed to go into *descanso* 'fallow' (Figure 2).

The lands where grasses and other annual or perennial herbaceous species are abundant are named ***tz` i' leltik***. These are fields that were recently abandoned after a few cycles of planting/harvesting, because the cultivator perceived a decrease in soil fertility. The sites where the remains of previous crops (i.e., *rastrojo,* Spanish for maize stalks) are still noticeable and where shrub species such as ***k'ail*** (*Thitonia rotundiflora*) are abundant, are frequent in the area of Polhó and are named ***k'ajbenaltik*** or ***te'lal kájbe*** by Tzotzil informants. This difference of the nomenclature among informants is derived from dialectal variation in Tzotzil. In these two former cases the vertical structure of the vegetation is simple, lacks a tree stratum, and their cultivation ceased less than five years ago.

Succession stages that are more complex, both floristically and structurally, than those mentioned above are given the following names, in order of succession: ***unenaltik,*** from ***unen*** 'tender', which refers to age and bole diameter of trees; ***toyolaltik,*** from ***toyo*** 'tall', a mid-successional stage with taller structure; and ***abmaltik,*** the mature or primary forests that have nearly vanished, according to local people. It may be safe to assume that the system for the classification of ecological succession of the Totzil in Polhó is equivalent to the classification used in the Los Altos de Chiapas region, based the recognition in the vegetation of a chronological sequence of changes, whose recognized stages are grassland, named ***tz` i' leltik***; shrubland, ***k'ajbenaltik***; early successional forest, ***unenaltik***; mid-successional forest, ***toyoaltik***; and, mature forest, ***abmaltik.***

In the intermediate successional stage, ***toyolaltik,*** local people recognize sev-

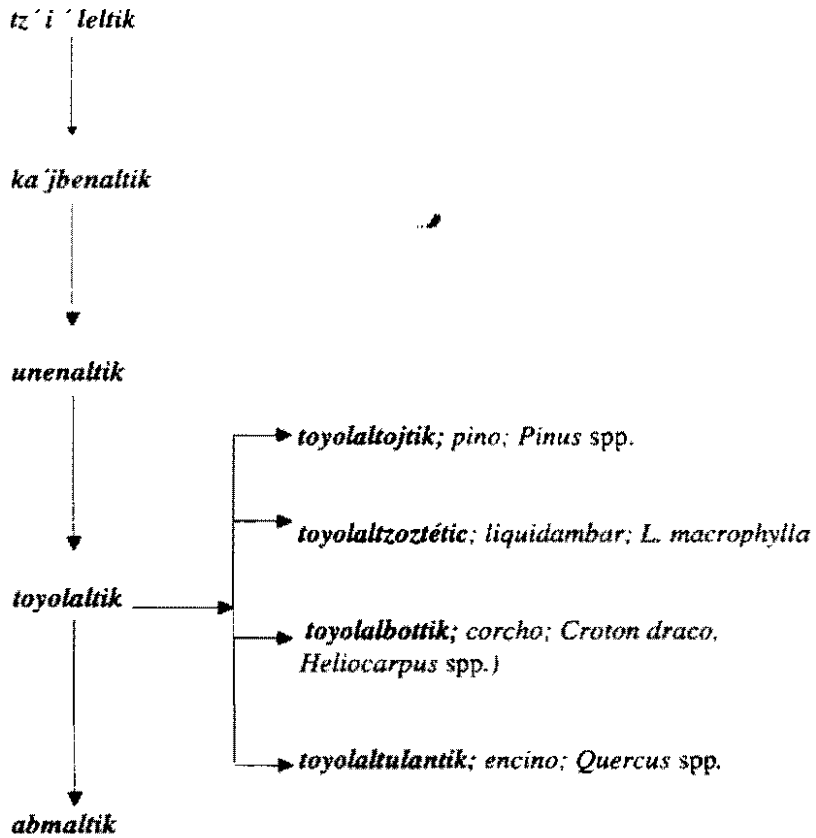

FIGURE 2.—Tzotzil words for the stages of ecological succession in Polhó, Chiapas.

eral plant communities of comparable age, which may be distinguished by the dominance or abundance of a given species of tree, whose name is included in the name for the successional stage. In such manner, mid-successional forests (*toyolaltik*) may be further classified as: ***toyolaltojtik***, dominated by pines (***toj***); ***toyolaltzoztétik***, where sweet-gum (***tzozté***) is abundant; ***toyolalbotik***, dominated by *corcho* (***ch' ichi'bot***); and ***toyolaltulantik***, dominated by oaks (***tulan***) (Figure 2).

Ultimately, indigenous cultivators use ecological succession as a way to restore soil fertility after a number of cycles of cultivation (Alcorn 1993). As one successional stage follows the next, nutrients are added to the soil, enabling the next period of cultivation in a sustainable system (Uhl and Jordan 1984). In addition, successional vegetation provides a variety of products used by local households (Toledo et al. 1995). The successional stages may also influence the energetic efficiency of coffee agroforest establishment, i.e., the balance between the needs of time investment (individual, family and paid labor), of technological resources (transportation and instruments) and of materials (plant germplasm). Such efficiency will be a function of the successional stage at which the coffee agroforest is established together with other factors, such as the distance and accessibility of the field, the size and age structure of the household, the head of household's financial resources, and other environmental components (topography and soil fertility). In theory, the cost of establishing a coffee agroforest will be greater if it is started in an early successional stage (***tz' i' leltik*** and ***k'ajbenaltik***) than if it begins in a more advanced stage (***unenaltik, toyolaltik*** or ***abmaltik***), other factors mentioned being similar and constant.

Because of the increase in population pressure and the land scarcity in the Los Altos de Chiapas region, the time during which fields are left to fallow has been shortened in recent years (Parra-Vázquez 1993a, 1993b). This intensification of land use causes a reduction in the number of fields (close to 5) and in the surface area for cultivation available per household (average of 2 ha). Hence, it has an adverse effect on agricultural productivity. Given this unfavorable scenario, the establishment of coffee agroforest systems and the utilization of ecologically sensitive "organic" techniques for coffee production appear to act as stabilizing factors, both for the economy of households and for the environmental sustainability of the zone.

Multiple-use Management of the Ecosystem and the Landscape by the Tzotzil.—Multiple-use strategies, as theorized by Toledo (1992), are based on the utilization of temporal and spatial diversity of resources and ecological processes. Tzotzil in Polhó maintain several types of land use and land cover (LU/LC) in order to take advantage of the varied natural resources characteristic of the ecosystem (Figure 3). This "multiple-use" strategy appears to be similar to those used for the management of natural resources by other traditional communities in the highlands and lowlands of the intertropical zone (Denevan et al. 1984; Dufour 1990; Marten 1986; Noble and Dirzo 1997; Posey and Baleé 1989; Toledo 1990; Toledo et al. 1994).

In terms of the diversity of strategies employed, 38 (76%) of the 50 producers interviewed maintained three or more types of LU/LC simultaneously (Figure 4). These are: rain-fed fields (for maize and beans); rustic coffee agroforests; fields in fallow; secondary vegetation in different successional stages; and to a lesser extent, grasslands for cattle, banana and sugarcane plantations. Only six (12%) of these producers maintained merely one type of LU/LC, i.e., are specialized; in those cases they produced only coffee in their own fields, and they shared the crop production and harvest, mainly maize, from fields belonging to close family members, especially their parents. Of the producers surveyed, 70% maintain three to five management units; these households, who practice diverse land management strategies, may be most able to balance productive diversity and energetic efficiency. Under the prevailing demographic, ecological and nutritional conditions, diversification is optimal.

Of the 278 fields mentioned by the 50 interviewed producers, 128 (46%) are devoted to the cultivation of coffee, 83 (30%) to rain-fed agriculture (maize and beans), 61 (22%) to ecological succession (fallow and secondary forest), and only 6 (2%) are used for other crops or productive activities including pineapple, banana, sugarcane and grazing land (Figure 5). In terms of total surface area, rain-fed agriculture is dominant, occupying over 50% of the territory (Bandeira et al. in press).

This result reveals two fundamental characteristics of traditional resource management and the microeconomic system studied: 1) the Tzotzil manage their

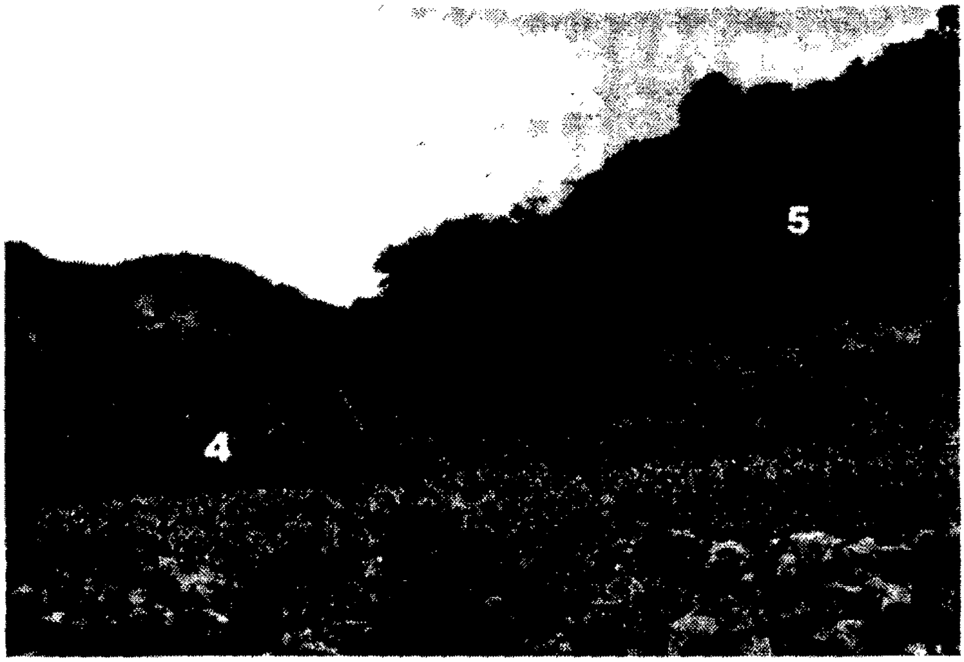

FIGURE 3.—Land use and land cover categories recognized and named by the Tzotzil in Polhó, Chiapas (Photograph by F.P. Bandeira). 1) ***chobtik,*** cornfield; 2) ***tz` i' leltik,*** land dominated by grasses and other annual or perennial herbaceous species; 3) ***k'ajbenaltik*** or ***te'lal kâjbe,*** sites cleared the previous year where the shrub ***k'ail*** (*Thitonia rotundiflora*)—seen in the first plane—is abundant; 5) ***k'ajvetik/unenaltik,*** early successional forest with a canopy of *Inga* spp. where coffee is grown/secondary shrubland.

landscape using a multiple-use strategy (Toledo 1992) and 2) maize plays the central role in the economy of the peasants of Polhó, whereas coffee is exclusively a market product. The dynamics of the maize-coffee cultivation, and of the processes that are associated with it—i.e., deforestation for maize cultivation; management or clearing of the vegetation in order to allow the establishment of coffee; the management of ecological succession through the abandonment of cultivated field and through the establishment of diversified shaded coffee systems (reforestation)—must necessarily be the direct causes of the dynamics of the landscape itself.

Two aspects of the spatial pattern of distribution of the fields per household are important. First, the fields mentioned by the producers are not located within the same barrio and are not contiguous; that is, they are dispersed throughout the community's territory. Second, some of the dispersed fields lie outside the territorial limits of the community, within neighboring communities such as Tzajalukun, Yashgemel, Yabteklum and Yibeljoj, or even further away. Such a dispersed pattern of distribution of productive lands obliges some producers to walk one to five hours in order to reach their fields to do the necessary regular labor and to transport the harvest. It is probable that this considerable dispersion of fields is the result of several factors. The first of these is a sociocultural order related to the patterns of marriage and of inheritance; the second is the growing

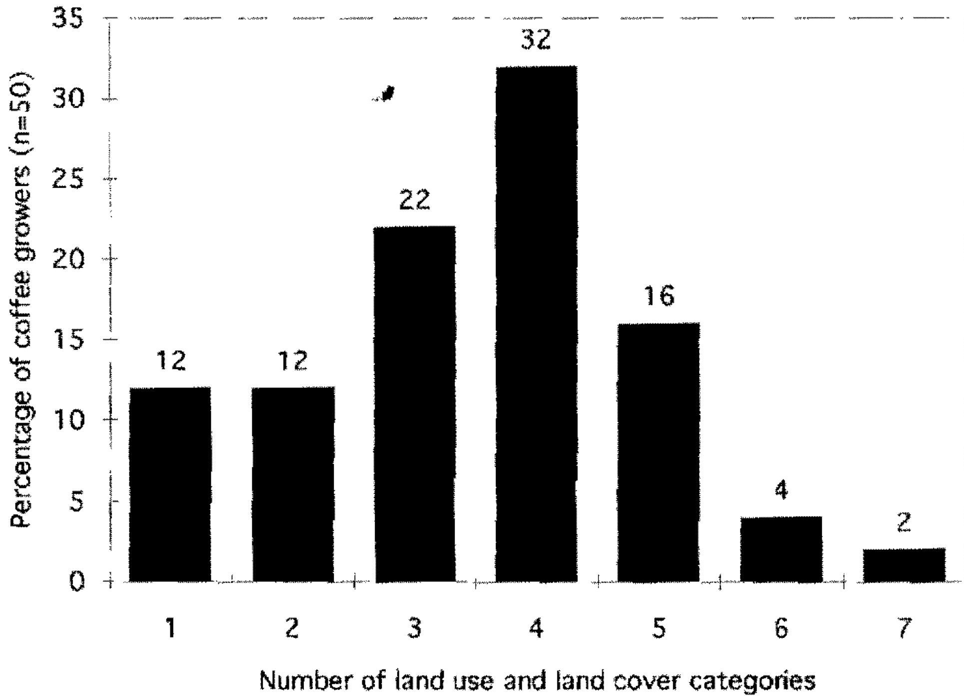

FIGURE 4.—Distribution of the number of land use and land cover maintained by Tzotzil coffee growers in Polhó, Chiapas.

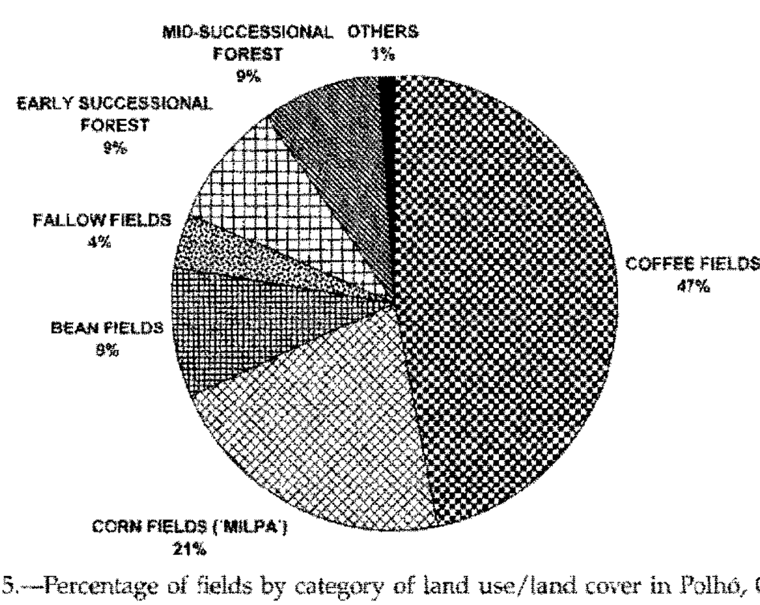

FIGURE 5.—Percentage of fields by category of land use/land cover in Polhó, Chiapas.

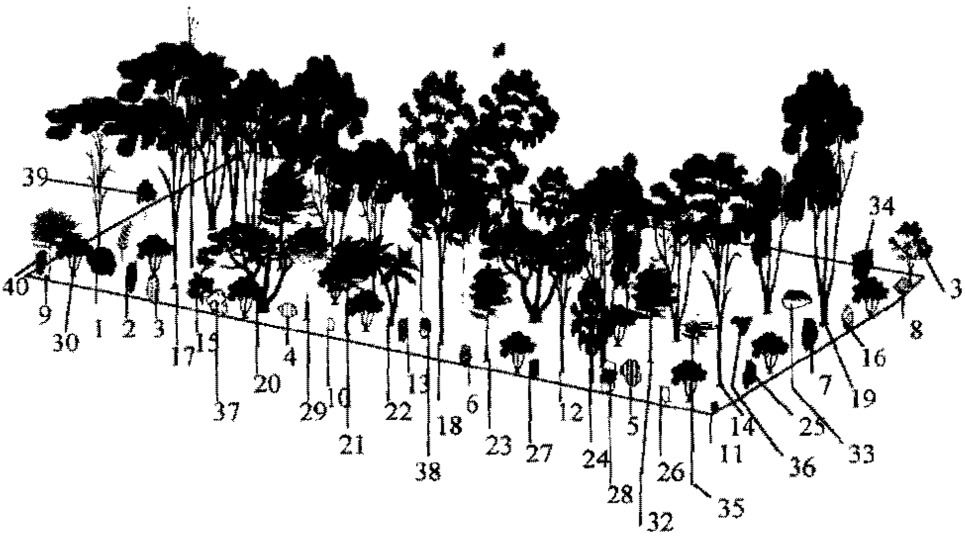

FIGURE 6.—A schematization of the vegetation profile of a one-hectare coffee field in Polhó, Chiapas.

scarcity of land, and to the social and demographic processes historically involved in this scarceness.

Some comments are needed regarding the sociocultural factors. The postmarital residence pattern of the Tzotzil is patrilocal and there is strict endogamy within the barrios of Chenalhó (Laughlin 1993). According to Laughlin (1969), in Chenalhó the elder sons leave the parental house when marrying and only inherit part of the land belonging to the household. The younger son remains in the parental house and receives a minor part of the father's inheritance. When they marry, daughters also inherit part of their father's land, for which the husband is made responsible. Land inheritance is, in other words, eminently partible. Thus, most of the producers interviewed had inherited some land from the father of their wife. But while some of these producers will reside in a different barrio or community, the fields tend to be some significant distance away from their houses. A similar spatial pattern has been describe for other Tzotzil communities, such as Chamula (Cervantes-Trejo 1995). Inevitably, this pattern of partible inheritance eventually results in the observed dispersion of agricultural fields.

The demographic factor mentioned above relates to the pressure on forested lands due to the population increase during the past forty years in the Los Altos de Chiapas region. This demographic surge has generated regional processes such as: migration, the expulsion of some members of the communities, and the colonization by the peasants of new lands (Parra-Vázquez 1993, 1994). Thus, some of the fields lying outside Polhó may have been bought, rented (a common practice in the region due to migration and land abandonment), or barely acquired legally by farmers.

The Tzotzil Rustic Coffee Agroforest.—The floristic survey made in a coffee field measuring one hectare provides a detailed picture of rustic coffee production in Polhó. Figure 6 represents a schematization of the vegetation profile of the surveyed coffee field, depicting some of the species that are present in these productive systems in the region, and in Table 3 are represented by their botanical aspects, their Tzotzil name, their use(s), and the plant part(s) used.

These rustic coffee agroforests are composed of a mixture of arboreal, shrubby, and herbaceous plant species, which are used as source of medicine, food, firewood, ceremonial effects, live fences, ornament, and other goods for the household. Some of these plant species belong to the original secondary vegetation; of these, most are fast growing pioneers species having short to medium life cycles, and a few are slow growing tolerant species having long life cycles. In addition, coffee agroforests acquire many plant species that are introduced by the cultivators, the most frequent origin of such germplasm being exchange among local relatives and neighbors, or it is carried from beyond the region either by occasional migrants or by governmental reforestation programs—as is the case of the *ciprés* (*Cupressus* sp.).

A total of 42 species in 35 genera and 23 families were recorded in the surveyed hectare of coffee agroforest (Table 3). Excluding the epiphytes, which were not collected, 18 of these species were of trees, 7 shrubs, 14 herbs, and 3 vines. According to management status as defined by Caballero (1996) and by Casas et al. (1998), these species are cultivated, tolerated and promoted, and their geographic origins are Mesoamerica, Europe, elsewhere in America and Asia. The similarity of these coffee agroforests in Polhó with the traditional Maya *solares* suggests the former to be an adaptation deriving from the introduction of coffee into the traditionally managed agroforests, a production system that can be traced to pre-Hispanic times.

This floristic survey—although not performed in other similar fields—and the field visits accompanied by the owners to 52 fields of coffee agroforests in Polhó, seem to disagree with Quezada's (1995) statement regarding the impact that was brought about by the transfer by INMECAFE of technological packages inspired in the "green revolution," which during the 1970s and 1980s resulted in the intensification of the rustic polycultural systems over 30% of the shaded coffee production areas of Mexico (Nestel 1995), including other indigenous zones, such as the Sierra Norte de Puebla region (Beaucage 1997), a process that seems to have been absent in Polhó.

Instead, in Polhó only 7 of the 52 visited coffee fields (13%) had a monospecific shade canopy—i.e., fields where a single tree species provides the shade needed for the growth of coffee, mostly those belonging to the genus *Inga*—while the remaining 45 (96%) had a tree stratum composed of two or more woody species.

The discrepancy with the statement of Quezada (1995) may, in part, be explained by the low number of fields visited by this author (n = 15) compared to the those recorded in the present study (n = 52). This difference in sample size, and the fact that the earlier author did not specify the spatial distribution of his study sites, allows us to suggest that his conclusions may not be generally representative of the processes involved in shaping the diversity of the tree canopy used for shading coffee in the area of Polhó.

In order to test these two contrasting hypotheses, it will be necessary to survey a representative number of coffee fields in the area to obtain a better under-

TABLE 3.—The species present in one hectare of rustic coffee plantations in Polhó, Chiapas, and related ethnobotanical information (Tzotzil name, plant part used, and use).

No.	Taxon	Life form	Common name	Tzotzil name	Used part[a]	Use(s)[b]
	Amaranthaceae					
1	*Iresine celosia* L.	herb	—	***tzajal kam vomol***	1	2
	Apiaceae					
2	*Eryngium* sp.	herb	*cilantro*	***kulantu***	1	1
	Araceae					
3	*Xanthosoma* sp.*	herb	*malanga*	***is-ak' max***	1, 2	1, 1
	Asteraceae					
4	*Bidens pilosa* L.	herb	—	***matas/tz'ekuntul***	5	1
5	*Sonchus oleraceus* L.	herb	—	***uskun-te`***	5	1
6	*Tagetes erecta* L.	shrub	*flor-de-muerto*	***nichim anima'***	5	2, 7
7	*Tithonia rotundifolia* (Miller) Blake.	shrub	—	***k'ail***	1	2, 8
8	*Tridax* sp.	herb	—	***tzepenté***	5	1
9	*Vernonia deppeana* Less.	tree	—	***sitit***	3	3
	Commelinaceae					
10	*Commelina* sp.	vine	*comelina*	***tz`emeni`***	5	6, 7
	Cucurbitaceae					
11	*Sechium edule* (Jacq.) Swartz*	vine	*chayote*	***ch'um-te`***	6, 2	1
	Cupressaceae					
12	*Cupressus* sp.*	tree	*ciprés*	***nukul pat***	—	—
	Chenopodiaceae					
13	*Chenopodium ambrosioides* L.	herb	*epazote*	***koko' on***	1	1, 2
	Euphorbiaceae					
14	*Croton draco* Schlecht	tree	*palo-de-sangre*	***ch'ich'bot***	1, 6	2, 3, 4
15	*Euphorbia pulcherrima* Willd. Ex Klotzch*	shrub	*nochebuena*	***sera nichim***	5	5
	Fabaceae					
16	*Phaseolus vulgaris* L.*	vine	*frijol*	***chenek'***	6	1
	Icacinaceae					
17	*Oecopetalum mexicanum* Greenm. & Thomps.*	tree	—	***kakav te`***	6	1,7
	Lauraceae					
18	*Persea americana* Mill.*	tree	*aguacata*	***on***	6	1, 4
19	*Persea schiedeana* Nees*	tree	*chinino*	***ib***	6	1, 4

TABLE 3.—(continued)

No.	Taxon	Life form	Common name	Tzotzil name	Used part[a]	Use (s)[b]
	Mimosaceae					
20	*Inga* cf. *leptoloba* Schlecht.	tree	*caspirol*	***tz'erel***	6, 7	1, 3, 4
21	*Inga vera* Willd.	tree	*paterna*	***chalon***	6, 7	1, 3, 4
22	*Inga xalapensis* Benth.	tree	—	***chalon***	6, 7	1, 3, 4
	Musaceae					
23	*Musa acuminata* × *M. balbisiana**	tall herb	*plátano guineo*	***kokon lo `bol***	4, 6	1, 6
			plátano rojo	***tzajal lo `bol***	4, 6	1, 6
			plátano manzanillo	***mántzana lo `bol***	4, 6	1, 6
	Myrtaceae					
24	*Eucalyptus* sp.*	tree	*dolar*	—	5	5
25	*Psidium guajava* L.*	tree	*guayaba*	***potov***	1, 6	1, 2
	Phytolaccaceae					
26	*Petiveria alliacea* L.	shrub	—	***poite`***	1	2
	Piperaceae					
27	*Piper sanctum* (Miquel) Schlecht.	shrub	*hierba santa*	***mumun***	1, 4	1
	Poaceae					
28	*Cymbopogon citratus* (DC.) Stapf.*	herb	*zacate-limón*	—	1	2
29	*Saccharum officinarum* L.*	herb	*caña-de-azucar*	***vale`***	4	1
	Rosaceae					
30	*Eriobotrya japonica* Lindl.*	tree	*níspero*	***nixpero***	6	1
31	*Prunus persica* (L.) Stokes*	tree	*durazno*	***turasno***	6	1
32	*Prunus serotina* Ehrh.	tree	*ceresa*	***chix te`***	6	1
33	*Pyrus communis* L.*	tree	*pera*	—	6	1
	Rubiaceae					
34	*Coffea arabica* L. var. *arabica**	shrub	*café arabigo*	***kajve***	6	1
	Rutaceae					
35	*Citrus aurantifolia* Osbeck*	tree	*limón*	***eromunix***	6	1
36	*Citrus sinensis* (L.) Osbeck*	tree	*naranja*	***narinxa***	1, 6	1

TABLE 3.—(continued)

No.	Taxon	Life form	Common name	Tzotzil name	Used part[a]	Use(s)[b]
	Solanaceae					
37	*Capsicum* sp.	herb	*chile*	***mukta'ich***	6	1
38	*Nicotiana tabacum* L.*	herb	*tabaco*	***moy***	1	2
39	*Physalis* sp.	herb	—	***murusin itá***	1	1
40	*Solanum americanum* Miller	herb	*hierba mora*	***kokonxo`***	1	1
41	*Solanum* sp.*	tree	*tomate de árbol*	***caranato chichol***	6	1
	Verbenaceae					
42	*Lantana* cf. *camara* L.	shrub	*té chino*	***chi'il vet***	1	2

Numbers in first column refer to species represented in Figure 6.
* Identified *in situ* by the authors.
[a] Used plant part key: 1) leaves; 2) roots; 3) trunk; 4) stem; 5) whole plant; 6) fruits; 7) branches.
[b] Use key: 1) food; 2) medicine; 3) firewood; 4) shade; 5) ornamental; 6) soil protection; 7) ritual; 8) fertilizer.

standing of the floristic composition and structure of the tree canopy used as shade for coffee in Polhó. However, two important remarks may be made at this point: first, in Polhó, there is not a single unshaded coffee planting. This suggests that the programs aimed at the elimination of shade in coffee plantations, carried on by INMECAFE in the state of Chiapas, have been unsuccessful in the area of Polhó. The second observation which supports the rejection of the hypothesis of "modernization" of coffee production systems in Polhó is the preference by local coffee producers for unimproved coffee variants they inherited from their progenitors: the *tipica* or *criolla* (*Coffea arabica* var. *arabica*) and the *bourbon* (*Coffea arabica* var. *bourbon*). This resistance of local coffee producers to the adoption of "technology packages" that promote the elimination of shade for coffee, the utilization of industrial inputs such as fertilizers and agrochemicals, and the adoption of high-yielding varieties—which hampered the production of coffee in Mexico during the 1970s and 1980s—largely shielded the area from its effects. Instead, such modernizing efforts were more successful in zones where private property prevailed and coffee production was in the hands of specialized middlemen or major entrepreneurs with substantial capital (Nolasco 1985).

The Tzotzil Management of Ecological Succession: the Design and Construction of Coffee Agroforests.—As has been reported for other areas (Perfecto et al. 1996; Rice 1997), Polhó rustic coffee agroforests are most commonly established on previously cultivated fields and to a lesser extent on secondary growth vegetation. This is demonstrated by the management history of 52 coffee-growing parcels in Polhó: 33 (63%) were established on fields formerly used for other crops such as ***chobtik*** 'corn fields', ***vale'tik*** 'sugarcane fields', or ***lo'boltik*** 'banana fields'; 18 (35%) were established on secondary growth (*acahuales*), and 1 (2%) was established on mixed use land (crops and *acahual*) (Figure 7). These data provide strong evidence that the evolutionary trend in landscape management in the Polhó area has revolved around substitution of parcels planted with annual crops and other crops (sugarcane and bananas) with diversified shaded coffee-growing systems. Figure 8 shows how local inhabitants perceive the temporal relationships of vegetation types (that is, successional stages).

The main activities that are developed by coffee producers to create the coffee agroforest are: 1) the clearing of the understory of a patch of mature forest and the planting of coffee under the tree canopy and 2) the establishment and maintenance of the tree and shrub strata by means of cultivation, tolerance, promotion, and rejection of individuals and populations of plant species based on their "emically" perceived worth for the productive system.

Our preliminary observations of Tzotzil practices for the establishment of rustic polycultural systems suggest that the design and construction of coffee agroforests—and perhaps in other coffee producing indigenous zones of Mexico as well—is the outcome of a complex process of management of the floristic structure. By exerting some control over species composition, tree density, and number of plant species per unit of area, farmers influence the survival rate of permanent, tolerant, pioneer plant species in two different ecological systems: 1) patches of mature forest; 2) lands where formerly rain-fed agriculture was practiced (in the cycle *milpa-acahual*) or where there were plantations of banana and sugarcane.

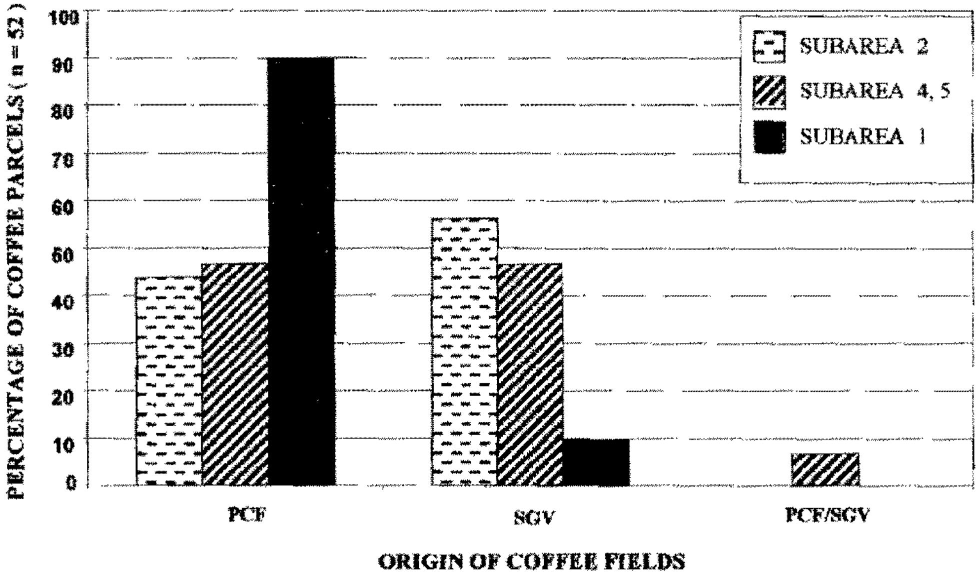

FIGURE 7.—Origin of coffee fields in Polhó, Chiapas. PCF: Previously Cultivated Fields; SCV: Secondary Growth Vegetation

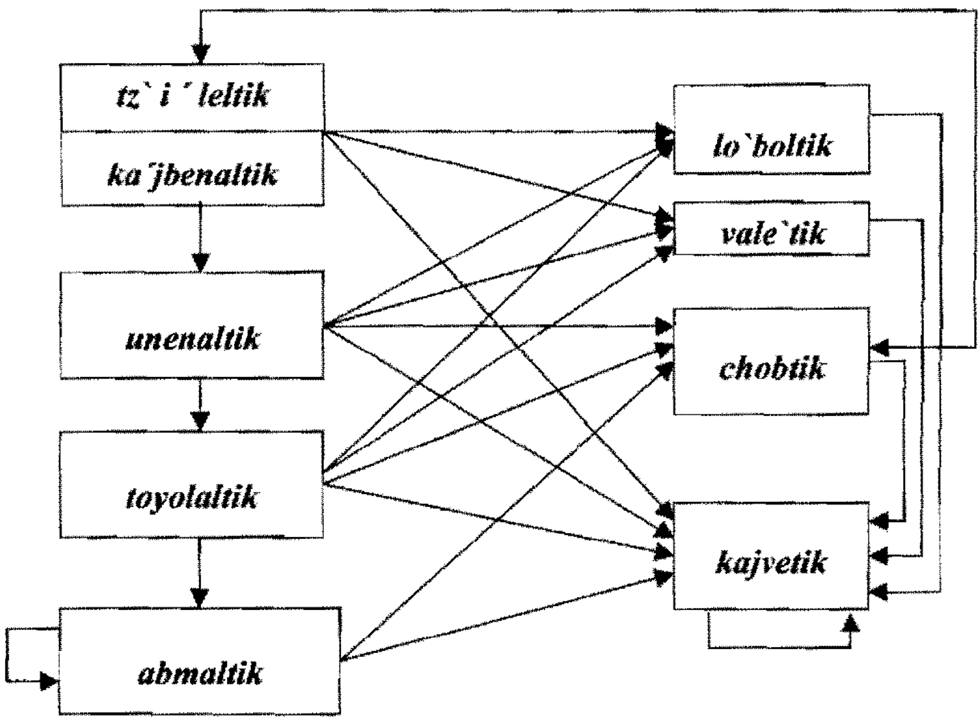

FIGURE 8.—Tzotzil perception of landscape dynamics in Polhó, Chiapas.

When establishing a coffee agroforest, the farmer, although in a not completely directed and controlled way, aims at obtaining a desired floristic composition or, in cases when trees are already growing on a plot, at the use and modification of the existing floristic structure.

In this section we describe a case when a farmer establishes a coffee agroforest on fields previously used for rain-fed milpas or other annual crops, which is the dominant situation in Polhó (Figure 8). In such cases, some of the events that will decide which floristic structure will result in the rustic coffee agroforests seem partially random—colonization and seed immigration—and may either be taken advantage of or remain unperceived by the farmers. Alternatively, the process may be managed directly by the farmer. These latter volitional factors imply the management of individuals, plants, and populations by means of cultivation of domesticated species; promotion of fast-growing, nitrogen-fixing wood and fruit-producing wild species, which is accomplished by the dispersion into the new coffee agroforests of seeds and propagules from other local ecosystems, such as milpas, fields in fallow, secondary and mature vegetation; tolerance and protection of species considered to be useful that were previously present in the new field; and the elimination of some individuals belonging to unwanted tree, shrub, pioneer species.

Through these management activities, the farmer appears to be setting forth a process which is analogous to that of natural ecological succession. These activities will resemble a sequence of events that would occur without human intervention, that is, that would be determined purely by stochastic and historical-ecological processes, such as: facilitation and inhibition, colonization and immigration of seeds ("seed-rain") and other propagules, competition, and others (McCook 1994). The activities carried on by local farmers for establishing and maintaining the tree-shrub canopy of a coffee agroforest suggests these farmers have ample ecological knowledge and are thus able to manage succession to their advantage.

The adoption of coffee by Maya farmers originated in and was adapted to the model of agroforestry systems known and managed by these people before the Spanish Conquest. Present-day Maya farmers also inherited some of the knowledge of plants and ecological processes which is critical for the construction of such agroforestsfrom their forbears. Some species of legume trees, such as *Inga* spp., have been utilized in agroforests since pre-Hispanic times, when they were interplanted with cacao (Gómez-Pompa 1987). This accounts for their widespread utilization in present-day rustic coffee agroforests.

The successful establishment of a coffee production system requires knowledge of the biology of certain key species, such as those of the genus *Inga*. This genus has many species in Mexico. Most are fast-growing small trees, and when cultivated have a dense, widespread canopy, some species being deciduous and shedding large amounts of leaf biomass. Many *Inga* species, moreover, are able to fix nitrogen in the soil. Species of *Inga* grow in the lower canopy of medium and tall evergreen tropical forests and as pioneer species in certain types of secondary vegetation. Such biological and ecological characteristics of species of *Inga* are recognized and utilized by Tzotzil farmers, who are conscious of several fundamental functions of these trees for the process of establishing and maintaining of coffee agroforests: 1) they provide shade to coffee shrubs during the early years of production when other trees in the field have not yet completed their development; 2) they provide organic matter to the soil in form of leaf mold; 3) they are adequate for shading coffee, but at the same time are easy to prune; 4) they protect the soil from the impact of rainfall; 5) the shade and mulch from *Inga* contributes to checking the growth of invasive species that enter into competition with the coffee shrubs and other useful saplings. Because of these characteristics, species of *Inga* seem to be biological models, or "archetypes" of shade trees for coffee agroforests during the initial stage of their establishment, and are amply used by local people, who recognize and protect the saplings of *Inga* spp.—as well as of other trees—cultivating and promoting them by dispersing their seeds within the fields. Acting in such manner, farmers probably accelerate, foment, and direct, in part, the ecological succession of the managed vegetation patches. All this is accomplished by means of the management techniques described above, which induce processes that, at different rates, are also occurring in natural ecological succession, such as: the increase in survival rates of desired species, the decrease of the population numbers of invasive herbaceous species (grasses and sedges), the increase of organic matter content of the soil and the improvement of its physical structure, the favoring of the establishment of plants with strict nutrient requirements, and so on. In addition, by planting *Inga* spp. and of other fast growing trees, farmers, intentionally or not, favor the perching of bats and birds, which act as seed-dispersal agents for potentially useful species.

In conclusion, the perception, naming and identification of stages, and the understanding of the process of ecological succession of the vegetation by Tzotzil farmers in Polhó are all relevant for understanding how this ethnic group manages natural resources, in particular with respect to coffee production systems. The design and establishment by Tzotzil farmers in Polhó of a rustic coffee agroforest, which requires the use of adequate production and natural resource conservation technologies, is a process that has its ultimate foundations in the knowledge owned by the cultivators about the local diversity of plants and of their uses, the ecological processes that are potentially useful (ecological succession), and the natural resources (soils) and environmental factors (climate, topography) that may impose constraints on the production system. A large part of this knowledge is transmitted from fathers to sons and is exchanged among near and allied relatives of large kindred. Additional information is acquired in practice during the process of management itself, or is supplied by the technical staff of Majomut through training and technology transfer programs.

NOTES

[1] Because of the dispersed distribution pattern of fields, the boundaries of each community are almost impossible to define; as a consequence, study subareas were defined following physiographic criteria, such as basin limits, watercourses, and, in a few cases, structural disjunctions (faults).

[2] The "organic coffee promoter" originated from the process of merging with the European organic product market, after Majomut was granted certification by *Naturland*. The organic coffee promoter is a member of the community or barrio who is elected in a cooperative

meeting. His functions are to promote and diffuse technical information concerning the methods of organic cultivation among members of Majomut. The technical staff of Majomut, composed of agronomy technicians and engineers, is in charge of delivering training courses and of supervising the promoters' work.

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