

# **Changes in Diversity in the Process of Milpa Intensification in the Henequen Zone in Yucatan, Mexico**

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Prepared for delivery at the 1998 meeting of the Latin American Studies Association,  
The Palmer House Hilton Hotel, Chicago Illinois, September 24-26, 1998.

## **Abstract**

Traditional slash-and-burn milpa systems in Yucatan are based on high biodiversity which provides flexibility to adapt to the heterogeneous conditions and fluctuating factors affecting milpa production. Because of the environmental degradation associated to this system in the present, there is the need of more sustainable alternative systems. Facing this situation, PROTROPICO has promoted the intensive milpa in the Henequen Zone. This is a continuous maize cultivation system based on tillage, addition of manure, cultivation of legumes and use of improved maize varieties at higher densities. This paper explores the changes in diversity of species and management practices done by the farmers of Sahcaba during the three year period of adaptation of the intensive milpa, in comparison to the changes in the traditional milpa in the area.

## **Introduction**

Diversity is one of the key elements in campesino agriculture in Yucatán. Mayan indigenous communities had to rely throughout the centuries on shifting milpa agriculture as their mayor way of subsistence. In this process, a vast traditional knowledge developed that included the highly variable environment and an array of strategies for production of food and goods that compound milpa agriculture as part of the of complex *campesino* production systems. In sight of the changing circumstances around rural communities in Yucatan involving scarcity of resources, traditional milpa production systems have needed to change, frequently showing signs of degradation. This effect is more obvious in the so-called “Henequen Zone”, as a result of the fading of henequen (*Agave fourcroydes*) production as the major economic income for rural communities (Sánchez, 1989). For this reason, alternative cropping systems have been promoted, with the intent of offering more sustainable crop-production options to rural communities. However, their impact on biodiversity and cultural factors of the rural societies need to be explored .

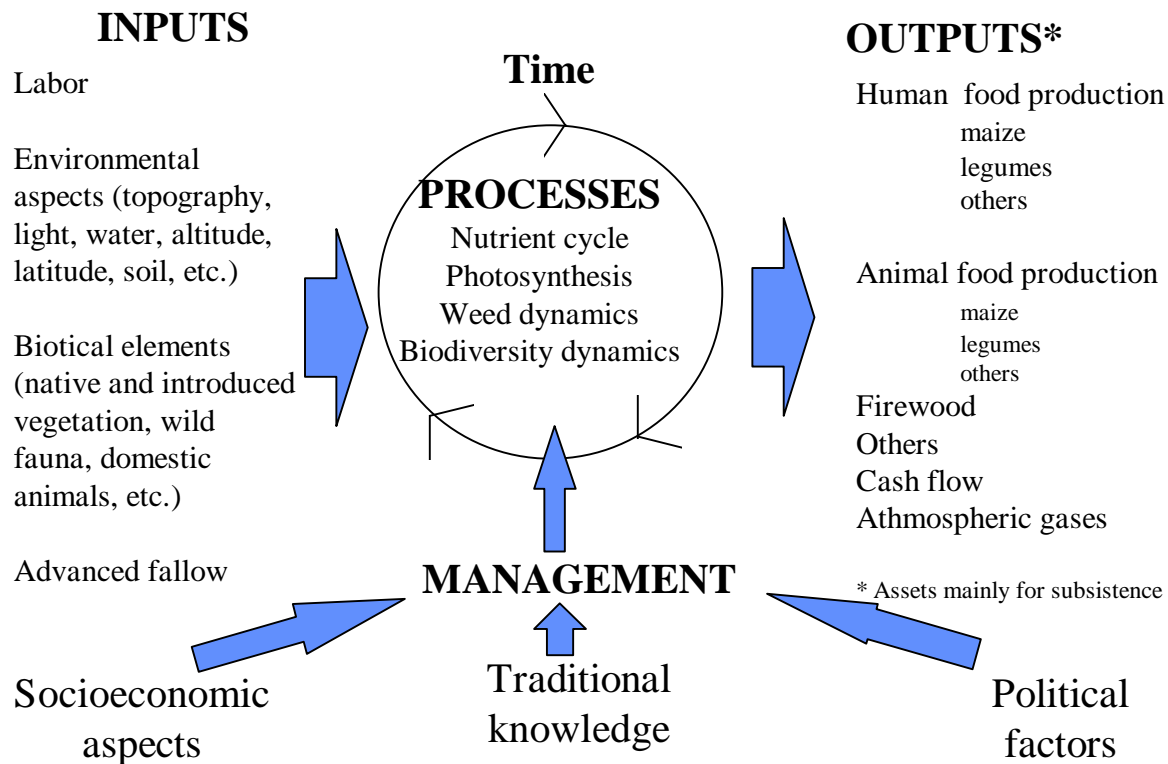
## **Dynamics of the traditional milpa system in Yucatán**

The milpa is a complex agroecosystem in which corn is grown in polyculture with annual legumes like beans, squashes and pumpkins, and other crops. It is based on the periodic slashing and burning of the forest vegetation with relatively long periods of fallow, and manual control of weeds and pests. The burning of the vegetation releases the nutrients held in the organic matter and provides the crops with available nutrients during a short-term period. The burning also is supposed to reduce the incidence of weeds during the cropping cycle. Traditional milpas are established usually on small areas (0.5-2.5 ha) and were cultivated manually for 2-3 consecutive

years, after which they were abandoned to fallow. Crops are planted together as a mixture of seeds at the establishment of the rainy season. Local varieties developed in the region through traditional selection are the varieties grown in the area. Fertilizers and insecticides are not commonly used and soil is not plowed throughout the cycle. There is differential management in the milpa depending on the years of cultivation, the type of soil, and the length of the fallow period. Crops are harvested manually a little at a time, as the *campesino* family requires it throughout several months.

This system has been practiced for centuries as the main means of sustenance for the flourishing Mayan communities throughout the Peninsula. It may be a sustainable practice as long as the disturbance intervals of the native vegetation are large enough and the affected area small enough for the ecosystem to recover fully between disturbances. However, with the increase in population density and the need to intensify production because of scarcity of land, fallow periods prior to milpa establishment have been reduced from more than 30 years to 12-16 years (Castillo et al., 1998). This is reflected in the significant decrease of corn yields from 1500 kg/ha during the first year of cultivation to 750 kg/ha on average in the second years of cultivation (Pérez Toro, 1981; Mendoza, 1996 Castillo et al, 1998). Traditional milpa changes over time are also observed in the decrease of different crops and types of crops, yields of crops other than maize, number of milpas in different stages, and management practices. These changes will be discussed in detail in the following sections.

## THE MILPA SYSTEM

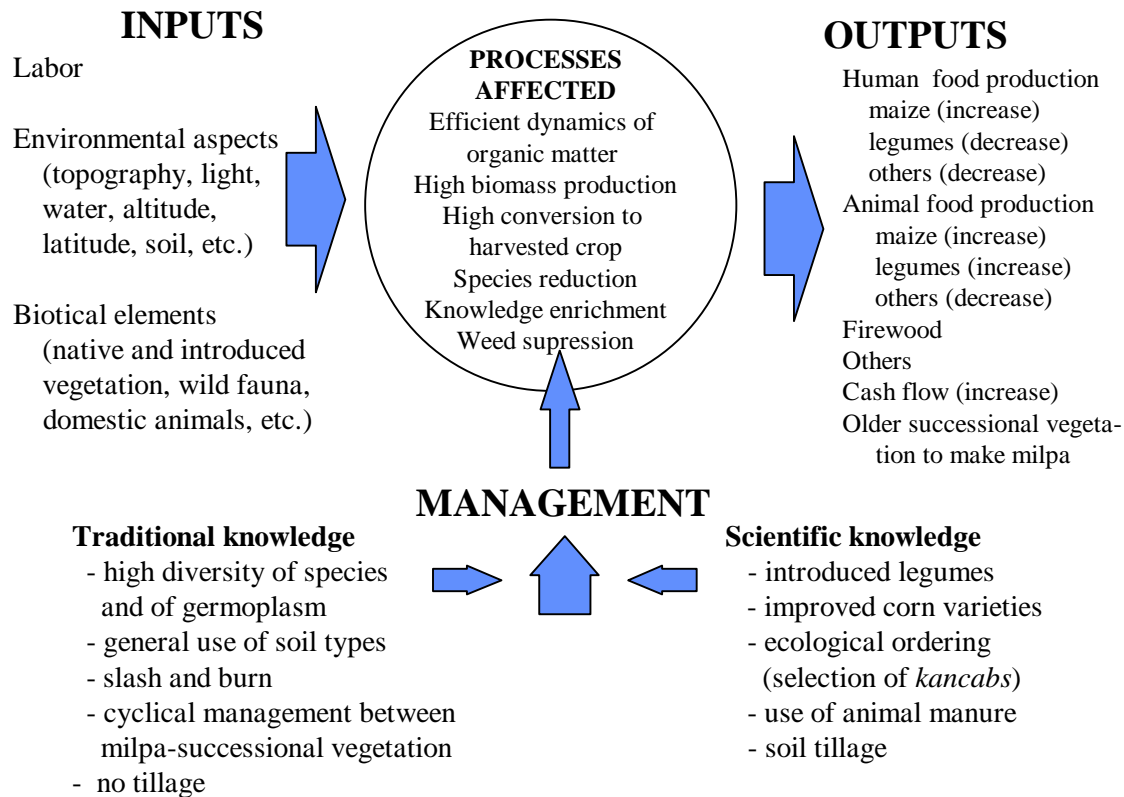


### **The intensive milpa system**

In order to provide an alternative corn production system to the traditional milpa, the Department of Management and Conservation of Tropical Natural Resources (PROTROPICO) of the University in Yucatán, started promoting since 1994 the intensive milpa in the community of Sahcabá and later, Hocabá. This maize production system is in process of adaptation in the Peninsula, and is based on the idea of cultivating the same area of land for years without the need to slash a new field while improving maize yields, and maintaining costs and external inputs low. It is based on the intensification of the deeper soils with little stones (*Kancab*) by removing most of the stones and rocks from the soil, manually tilling the soil to form rows to which animal manure is added. Short-cycled, improved open-pollinated varieties of corn adapted to the area are planted at the beginning of the rainy season at high densities in the rows above the manure, and fifteen days later, the fast growing tropical legume *Mucuna* (*Mucuna pruriens*) is planted between the rows. The idea is that the maize benefits from the effects of the mucuna (N addition due to fixation and decomposition of high biomass, and weed suppression due to biomass effect) but is able to grow without the competition of the legume.

Even though the maize yields were increased to about 2500-3000 kg/ha without decreasing much in the three years time, the farmers that have adopted this method so far are very few in both communities (see Jiménez Osornio et al, 1997, for a description of the case study in Sahcabá). However, the system is still in the phase of promotion and adaptation, and other farmers are showing interest in adopting it.. Because of the few intensive milpas in the communities and the relatively early phase of adoption, it is difficult to generalize the impact of the intensive milpa on campesino production systems, but there are trends that can be pointed out.

## THE INTENSIVE MILPA SYSTEM



### Factors affecting milpa production:

Changes in traditional milpa production are the result of a complex interaction of factors. Embedded in a less than favorable environment for conventional agriculture, traditional milpas are established on the poor soils characteristic of the northern Yucatan Peninsula, in a hot-semihumid weather with inconsistent rainy seasons. As their main material resource, they depend on the fallow vegetation present on the site, which needs several decades to reach maturity. At present, native vegetation in the northern Yucatan Peninsula is formed of a mosaic of different stages of growth, with a predominance of young fallows (Mizrahi, 1998). The high heterogeneity of the soils, their low fertility and impossibility of being mechanized, the fragile equilibrium with the vegetation and the inconsistency with the rainy seasons, reduce the possibilities for agriculture in the area, making crop production a challenge.

In addition to the environmental context, the changing socioeconomic context affects milpa production. Since mid 1800, henequen production became the main axis of Yucatan's economy, but receded since the 1950-60, concluding with the ceasing of government subsidies for campesinos in 1992. This led to strong socio-economic and ecological impacts in the Henequen Zone, resulting, on one hand, in rural people migrating to Cancun and Mérida in search for employment, and on the other hand in the intensification of the traditional swidden agriculture in the area, resulting in high land pressure and low yields, and long-term degradation of resources and quality of life (Baños Ramírez, 1989). This was coupled with the demand during the 1950-60 of the Mexican public education system for all children to attend school, and the resulting need for

*campesino* children of many smaller rural communities to live during weekdays in larger neighboring towns to be able to attend schools. This impaired the transmission of knowledge of milpa management from the older to the newer generations. In addition, the increasing availability of food and goods for sale in rural communities diluted the need to cultivate milpa as main subsistence means. This, in the face of the increasing demand of workforce in the larger cities has resulted in the proletarianization of much of the young rural population in the Henequen Zone in the last years.

### **Diversity changes in Milpa management in the Henequen Zone**

Diversity in milpa production occurs in many levels, and may be considered one of the resource bases in *campesino* agriculture. At the functional level, biological diversity is as important as diversity in management practices in traditional milpa systems, which may be termed agrodiversity. The function of agrodiversity is to provide the farmer with a variety of options, and the flexibility to use them according to the changing environmental and socioeconomic contexts. As the traditional system has needed to adapt to the changing conditions of the present, the levels of the different types of diversity have changed as well. On the other hand, the intensive milpa has different functional bases, and diversity may play a minor role compared to the traditional milpa. In short, intensive milpa systems may allow less room for biological and management diversity. However, intensive milpas represent a small portion of the agricultural land, and the combination of intensive and traditional milpas at the landscape level may have different effects on biodiversity than the direct effect of the intensive milpa system.

In this section the discussion will focus on the changes in the different levels of agrodiversity, including biodiversity and diversity in management and destination of production, as affected by the changing traditional milpa and the intensive milpa production systems in the Henequen Zone. The information for this paper originates from a community survey to 56 farmers, which represent 19% of the farmer population in Hocabá (Castillo, 1998), semistructured interviews to 10 farmers in Sahcabá and Hocabá, and field observations done between 1995 and 1997, as well as the available studies in this area.

## **BIODIVERSITY**

### **· Diversity of crops**

As Terán and Rasmussen (1995) report, the structural bases of the milpa system has changed little from pre-Columbian times to the present, characterized by a high diversity of genetic resources and non-agricultural activities. However, there is evidence that some of this diversity has been lost over the time, as the traditional milpa system has needed to change in time to form the present milpa.

The traditional milpa is based on corn (*Zea mays*) as the main crop, but includes also legumes, cucurbits, root crops and other crops. In general, the traditional milpa has two main sections: the *pach pakal*, which is established in the deeper soils with less rocks (*kankabs*), and which constitutes only 2-6% of the milpa surface; here mostly horticultural crops are cultivated in absence of maize. In the rest of the milpa, the main crop is maize and is cultivated in presence or absence of other crops.

In the majority of the milpa, corn is planted in association with one or several of three main legumes: *xpelón* (*Vigna unguiculata*), *ibes* (*Phaseolus lunatus*), and *xcolibu'ul* (*Phaseolus vulgaris*), and two cucurbits: *xnuc kuum* (*Cucurbita moschata*) and *xtop* (*Cucurbita argyrosperma*) (Castillo, 1998), as can be deduced from Table 1. Even though few farmers associate all five of these crops with maize, most farmers include 2 of these in their seed mixture. Of these, the crops most planted in polyculture with maize are one legume (*Phaseolus lunatus*), and one cucurbit (*Cucurbita moschata*).

Table 1. Crops associated with the maize in the milpa

Crops	Scientific name	# of farmers that planted it	% of farmers that planted it
<i>Xnuc k'uuum</i>	<i>Cucurbita moschata</i>	46	82
<i>Xtop</i>	<i>Cucurbita argyrosperma</i>	10	17
<i>Espelón</i>	<i>Vigna unguiculata</i>	34	60
<i>Ibes</i>	<i>Phaseolus lunatus</i>	49	87.5
<i>Xcolibu'ul</i>	<i>Phaseolus vulgaris</i>	30	53.5

Corn is planted at a density of around 20,000 plants per hectare, with beans and squashes usually growing between corn plants at much lower plant densities (1000-3000 plants per hectare). Even though the milpa of the present includes more or less the same crops associated with maize as the milpa in the past, according to the farmers, crops do not develop as well in the present, and for that reason lower densities of these crops are planted. Farmers comment on the milpa in the past that “usually all crops planted in the milpa were harvested, but the present milpa does not support as many”; the inconsistency in the weather and the bad development of the crops, make farmers plant less variety of crops. In most cases at present, maize is planted as a monoculture in the milpas of second year of cultivation.

In the survey, 64% of the farmers had a *pach pakal* in their milpa, whose surface averaged 720 m<sup>2</sup>. Normally the *pach pakal* is planted only in the milpas of first year of cultivation, where the soils are fertile and deep. Weeding is done manually, and farmers take extra care of the crops grown in the *pach pakal*. In the survey, seventeen different crops were mentioned by the farmers that had *pach pakals* during 1996. Each farmer had between 1 and 6 crops, with an average of 2.8. Some *pach pakals* had single species, in most cases, root crops. Table 2 shows the most common crops and their frequencies in the *pach pakals* of the farmers surveyed.

Table 2. Crops cultivated in the *pach pakal* (pp.) according to the farmers surveyed in Hocaba

Crop	Scientific Name	# of pp. in which it was present	% of pp. in which it was present	% of pp. planted with this crop without association	Crop most frequently associated with:
Watermelon	<i>Citrullus lanatus</i>	25	69.4	0	Cucumber, melon, squash, <i>makal</i> , <i>espelón</i>
<i>Makal</i>	<i>Xantosoma yucatanense</i>	13	36.1	11.1	Watermelon, <i>jícama</i> , sweet potato
Cucumber	<i>Cucumis sativus</i>	13	36.1	0	Watermelon, squash, melon
Melon	<i>Cucumis melo</i>	10	27.8	0	Cucumber, squash, watermelon
<i>Ibes</i>	<i>Phaseolus lunatus</i>	9	25	0	Watermelon, <i>espelón</i> , sweet potato
<i>Espelón</i>	<i>Vigna unguiculata</i>	9	25	2.8	Watermelon, <i>ibes</i> , sweet potato
Sweet potato	<i>Ipomoea batatas</i>	5	13.9	0	Watermelon, <i>ibes</i> , <i>espelón</i>
Squash	<i>Cucurbita moschata</i>	5	13.9	0	Watermelon, cucumber, <i>makal</i>
<i>Mensejo</i>	<i>Cucurbita pepo</i>	3	8.3	0	Melon, cucumber

Farmers in Hocabá and Sahcabá mentioned that there are several crops that were planted in the *pach pakal* in the milpa in the past (referring to their grandparent's time: 1940-1960), but that are not to be found in the milpas anymore. These include three legumes, two root crops, a vine similar to the potato, of which the fruits were harvested, cotton and sesame. None of these were mentioned in the study by Terán and Rasmussen (1995), either in the ancient milpa or in the present milpa. The main reason farmers gave for these crops not being planted at present anymore is that the seed was lost, either by bad years where the crop could not be harvested anymore, the death of the owner of the milpa and therefore loss of some milpa resources, or because the crops did not develop well in the milpas anymore. There are several crops that were grown in the milpa in previous times, but now are mainly grown in the homegarden, where the crops can be fertilized, irrigated and can be better attended than in the milpa. These include the *chaya* (*Cnidoscolus*

*chayamansa*), papaya (*Carica papaya*), chile (*Capsicum annum*) and tomato (*Lycopersicon esculentum*).

The intensive milpa is centered in maize, and therefore, the only crops grown are maize and the legumes. Originally, the system was promoted with two legumes: mucuna (*Mucuna pruriens*) and Canavalia (*Canavalia ensiformis*). This was done by establishing in the first year a demonstrative intensive milpa plot in the community, where half the maize was planted with mucuna and the other half of canavalia. Accompanied by farmer workshops and technical and material support (manure and seeds), some farmers started preparing their intensive milpa field, based on the original system, but with their own variations (see Jiménez Osornio et al., 1997 for a complete description of the process).

Even in the earlier years, the most common variations of the intensive milpa system were the inclusion of other crops, especially the ones planted in the traditional *pach pakal*. In this way, they included three cucurbits: watermelons, melons and cucumbers starting the first year. The simulation of *pach pakal* crops in the newly adopted intensive milpa is logical since this system is done on the soils normally chosen by the farmers to establish their *pach pakal*, and manure is a highly valued resource for *pach pakal* crops. Because of the dense coverage of the mucuna foliage, the mentioned cucurbits were planted in the edges of the rows of the intensive milpa, and directed to grow outside the milpa. Native legumes (usually vines) were not planted in the intensive milpa, because they would be suppressed by the fast growing and highly productive mucuna. Farmers preferred to leave out the canavalia, and just focus on the mucuna as accompanying crop, because of the perception of possible pest problems in the canavalia, and the low biomass production of this erect species. In the next years, farmers focused less on cucurbits in the edges of the milpa, and instead started reducing the area planted with the mucuna, or decreasing the plant density. They started experimenting in trying to substitute the mucuna by some native legumes grown traditionally in the milpa (*espelón, ibes, frijolillo*), especially the types that are grown with the maize, but also some types that are grown in the *pach pakal*. The reason they gave is mainly that the seeds of the mucuna are not edible by humans or animals (unless they are treated). The smaller biomass production achieved by the native species was not a discouragement for farmers, and the main focus of experimentation of the farmers at present is to find edible legume species that can be grown in the intensive milpa with the corn, and that produce adequate amounts of biomass. Following this interest, different seeds of tropical legumes were distributed between interested farmers to continue the experimentation in their intensive milpas. This has resulted in intensive milpas with a variety of legume climbing species, in patches of single species, or mixed. The mucuna is still planted in most of the milpas, but in lower degree. Some farmers also have planted sweet potato and peanuts between the maize, which also results in biomass accumulation, but in the lower stratus. Many farmers also increased the density of maize plants. At this point, farmers are still in the process of adaptation and are experimenting with many different milpa crops in the intensive milpa. It is too early to know how diverse the intensive milpa will be when it is stabilized, but while looking at the way crops have been included in the system, it is likely that it will remain diverse. However, the system by itself is less flexible than the traditional milpa, because it is based on several fixed components that allow little changes, and therefore possibilities are reduced. The possible outcome searched for by farmers is to resemble certain aspects of the traditional milpa - with higher productivity - but mixed with others of the *pach pakal*.



· **Varieties of Crops**

A large amount of crop varieties are still planted in the traditional milpa. It is difficult to define how many of these were actually planted in the milpas in the past every year, even though the germplasm was available and farmers knew these varieties. Terán and Rasmussen (1996) report 16 different species of crops that belong to 9 different families and with 67 varieties planted nowadays, and report more varieties available today than in the pre-Columbian milpa (although it is impossible to know with certainty the amount of varieties in pre-Columbian times). Most crops grown in the milpa have different varieties, which farmers distinguish as different types, each one with a name. They were formed through the selection of certain traits in the milpa crops by the Mayans over centuries. The main differences farmers perceive between varieties are color and length of cycle, and in the case of maize, the thickness of the center of the corn-ear, which is related to the ability of the variety to support water stress (the thicker, the better it can hold water stress). According to the interviews, farmers described several corn varieties of which very few are lost at present. For example, some farmers mentioned that the *e hu* variety was not to be found anymore in the communities, but others had doubts about this one and other varieties. Different maize varieties are related to different soil types, and year of cultivation of the milpa. Table 3. summarizes the characteristics of the maize varieties described by the farmers in the interview.

Even if the germplasm of these varieties still exists in the communities, few farmers keep many different corn varieties in their milpa. According to the survey, all farmers plant the *xnuk nal* variety either of white or yellow grain, but some farmers have small areas where one or more of the other varieties are planted. Of the other varieties, the most common ones are the *xchunya* (32% of the farmers had it in their milpa) and the *xmejen nal* (14.3% of the farmers had it in their milpa). Farmers mentioned that many of these varieties are not planted anymore, or much less than before in the milpas, because the plants did not develop well anymore, with the main reason being the prolonged water stress in the milpas now. Very few farmers use commercial varieties in their traditional milpa.

Table 3. Maize varieties as described by farmers

Name of the variety	Length of cycle (days)	Color of the grain	Thickness of ear center
<i>K'an kan</i>	120	red	
<i>E hu</i>	100	purple	
<i>K'an xnuk nal</i>	100-115	yellow	thick
<i>Sak xnuk nal</i>	100-115	white	thick
<i>Xchunya</i>	90	white , yellow (purple stalks)	
<i>Xnuk xmejen-nal</i>	60-75	white, yellow, red	thin
<i>Nal t'el</i>	50	white, yellow	thin

In the intensive milpa, farmers use commercial improved varieties of maize, like the V-528 or Blanco Uxmal, but some farmers have planted the *xnuk nal* variety when they have not had the improved varieties available. The improved maize varieties were used in the intensive milpa

system because of their high performance in optimal conditions (deep, fertilized soils, appropriate management of weeds, low water stress, etc.), which were sought in this system.

According to the interviews with the farmers, of the other crops in the traditional milpa, the legumes *ibes*, *espelón* and *jícama*, and the squash have both long and short cycle varieties, that are still planted in the milpa at present. In addition, in certain crops – *ibes*, *espelón*, squash, yuca and sweet potato – the varieties were based on different colors. Farmers mentioned also other crops whose varieties are based on growth habit – *makal*, *ibes* and common bean –, and others based on different forms – squash and chile –. It is difficult to know the proportion of the genetic diversity within species that has been lost over time in the milpa, but it is a fact that the traditional milpa is the source of a great variety of different crop types, which are still known and cultivated at present, but few of them are planted year by year in the milpa.

Due to the large source of genetic diversity among species in the traditional milpa and the germplasm introduced in the community in this adaptation process, farmers have an array of options to try in the intensive milpa system, of which they can select the ones that are more appropriate in the process of adaptation of the system. However, it is probable that the possibility of adapting a large diversity of crops to the system is reduced, due to the narrow niches that come from the very specific functional roles of the mucuna and other components in the intensive milpa system.

#### · **Diversity of other organisms**

##### **Weeds:**

It is of common farmer knowledge that in traditional milpas that are established the first year after slashing of old fallow native vegetation, weeds do not affect the development of the milpa. Weeds do need to be controlled, but they appear slowly and in lower numbers. Meneses et al. (1997) report high numbers of sprouts of the slashed and burnt woody species in the first year milpas, especially the ones generating of older fallows. In the second year of cultivation of the traditional milpa, there is a significant increase in herbaceous weeds that develop faster, making the weeding process more intensive, to the degree that many farmers prefer to use herbicides during the second year of cultivation, which is a reason for the need to cultivate the maize alone. This is especially evident in milpas that are established on short fallow stands, where weed biomass accumulates rapidly, competing with the crops. This increased weed incidence is one of the reasons for farmers needing to abandon the milpa plot after the second year of cultivation. In the milpas of shorter fallows, species richness is similar to milpas from longer fallows, but there is a dominance of a few herbaceous species (Meneses et al., 1997). Some of the weeds in the milpa are used by farmers to feed the domestic animals kept in the home garden, for ritual and for medicinal purposes. However, the amount used for this is small.

In the intensive milpa, weed biomass and diversity diminish proportionately with time, and in general, intensive milpas show less species diversity compared with the traditional milpa system. This pattern was also reflected in the seed bank, where intensive milpas had less species diversity than traditional milpas. This effect can be attributed to the physical control provided by the accumulation of biomass of mucuna (Gordillo, 1997).

## **Trees:**

In a study comparing fallow vegetation of different ages in the Henequen Zone, Mizrahi et al. (1997) report that species richness and diversity were greater as the stand grew older. As milpa agriculture intensifies, and older fallow stands become more scarce, native tree species diversity may be diminishing at the landscape level, possibly reducing the probability for certain species to recover.

During the establishment of the milpa, the farmer may select some woody species during the slashing process, which are left to grow in the milpa if they are useful. This is frequently done with certain trees that are adequate for construction, fruit trees, shade trees and trees growing around the cenotes (water holes). In addition, during the slashing process, the trees from the fallow vegetation are slashed, leaving part of the stems standing (1-1.5 m), to be used later as firewood. In the intensive milpa, no woody vegetation is left, generally, so that the crops do not have competition of other plants and can use the resources more thoroughly.

## **Animals:**

As long fallow stands are adequate habitats for wildlife species, the dominance of the younger fallow stands and the impact of humans in the environment has resulted in a diminution of native fauna. Even though the intensive milpa is less favorable habitat to some native fauna than traditional milpas, their impact on wildlife may be positive if the intensive milpa indeed aided in reducing the size of the forest slashed each year. However, because there are few areas where the intensive milpa can be practiced in the Henequen Zone, and because the trend is that farmers do the intensive milpa additional to the traditional milpa, this impact may not be as strong.

Nevertheless, large numbers of birds and other small animals can be found in intensive milpa as a result of the concentrated source of food they represent. The densely growing crops, and large amount of grain available at crop maturity in the intensive milpa can lead to more pest problems than in the traditional milpa, which would imply a disproportion of some animal species compared to others.

Soil fauna is stimulated in the intensive milpa compared to the traditional milpa, due to the favorable microenvironment that is provided by the high biomass of mucuna and corn leaves. It is visible in the fields that the increase of decomposing organic matter also promotes an increase in earthworms, chilopodes and other detritus-eating arthropods in intensive milpas, which is also described in parallel studies that have been done with legumes in the Henequen Zone (Estrada, 1997; Delgado, 1998)

## **DIVERSITY IN MANAGEMENT**

### **· Number of milpas (diversity in space)**

In the past, many farmers tended to keep two or more milpas in different areas, as it was mentioned in the interviews. This was done to increase the possibility of successfully obtaining crop production at any year, in face of the variability of the rains in the land area, and the differential spatial effects of hurricanes, storms, and pest damage. At present, many farmers still keep several milpas, especially because adequate land for milpa production is not concentrated in

one area, and farmers have to search for adequate land in a wide geographical area. Usually, when farmers adopt the intensive milpa, they keep making their traditional milpa. With the intensive milpa, and the intensive labor it represents, the tendency of several farmers in Sahcabá is to keep their milpas as close as possible, even if this implies shorter fallow stands as sources for their milpas. It is unclear how this will change in the future at the landscape level, but it is unlikely that farmers will focus on intensive milpas exclusively, especially because of the scarcity of the resources in the area.

- **Milpa age (diversity in time)**

As the strategy of having a variety of milpas, the different planting times in milpa management was a common practice in the past, as a strategy to increase the probability of crop production despite the possible inconsistency of the rainy season and pest incidence. Usually farmers plant their milpa starting when the rainy season establishes well (end of May, beginning of June). However, it is common to find farmers that plant part of their milpa with the first rains, in end of April or May, with the hope that the crops will develop. This way, there are frequently parts of the milpa in different stages of development. In the interviews, farmers mentioned that it was a common practice to plant a small plot of corn in August, when the rainy season is well advanced. In this form, a short cycled variety of corn was planted in a milpa, called *pach nal*, practically obtaining two cycles in a year. This practice is also documented in the early Spanish chronicles (Landa, 1560). This type of milpa is no longer established in the Henequen Zone; the main reason for this being, according to the farmers, that the rains are not sufficient anymore after August to support a crop. The fixed planting dates is more evident in the intensive milpa because of the need to plant the mucuna seeds approximately 15 days after the corn was planted, to decrease competition.

- **Diversity in other types of management practices**

There are evident differences in traditional milpa management according to soil types, weeding needs, type of *pach pakal*, etc. They consist of a rearrangement of the different possibilities of practices, available resources and seeds, labor requirement, time available, etc. achieved through a decision making process involving the traditional knowledge of the environment and present needs. They result in complex diverse systems, flexible to changes.

### **Variability in the destination of milpa production**

The traditional milpa used to be mainly a means of subsistence for the rural family. At present, the milpa has become in addition, another of the many strategies to generate cash in the campesino production systems. However, even if it is acquiring more change-value, the essence of milpa production in rural communities is of use-value, to assure that the family will not have to buy at least some of the needed food and other goods (firewood, etc.). However, the intensive milpa may be more directed to be a cash generator. In Sahcabá, several of the farm families that keep an intensive milpa have harvested greater quantities of immature corn ears to cook them and sell them locally in the community as “corn on the cub”. This market niche is favorable because the improved short cycle maize varieties grown in the intensive milpa mature before the longer cycled

traditional varieties that most of the farmers have in the community. Other variants that farmers are developing for cash purposes is to cultivate crops of higher commercial value than corn with the principles of the intensive milpa system, in the absence of corn.

### **Overall assessment of changes in diversity in milpa production**

The need to intensify traditional slash and burn milpa while using younger immature fallow stands for milpa establishment is causing the slow degradation of the milpa system. Decreasing crop yields are an immediate result of this. Because of poor crop development, the number and types of crops, and presumably species' genetic diversity, are being reduced. This results in the possible simplification of the system maintaining only certain key species and types. Even though some milpas might be a good source of conservation of some of the diversity of milpa germplasm, most farmers do not have access to it, which could result in genetic erosion in the community in the long term.

Comparing the intensive milpa with the traditional milpa directly in the system level, the traditional system allows more conservation of biodiversity and diversity of management, because diversity is one of its functional pillars. There are less niches for variability and diversity in the intensive milpa system, as the components combine closely with each other and may not be altered very much. However, the intensive milpa system will never substitute the traditional milpa farming system because of scarcity of adequate soils (Cano, 1997), the need of manure – which is by itself a scarce resource, too –, the need of improved commercial varieties, and the requirement of labor during the first years of establishment (Mendoza, 1997). In addition, the traditional milpa system is deeply rooted in the culture of rural Mayan communities in Yucatan.

Therefore, the intensive milpa in this context becomes another strategy in the complex Mayan production system, complementing the traditional milpa. In the long term and from a aggregated landscape level, if the intensive milpa is adopted considerably it may increase diversity, especially in management, by creating a patchwork of different management systems. This in turn may maintain biological diversity, as long as the labor requirement of the intensive milpa does not compete with the labor requirement of the traditional milpa, and the Mayan campesino production system is maintained diverse.

The main concern at this point in the conservation of agricultural biodiversity in the milpa system is in the conservation of the traditional milpa itself. The elevated migration of the rural population to the cities and the interruption of the traditional milpa knowledge (know-how) from the older to the younger generations may diminish considerably milpa agriculture in future years. At present the average age of the farmer in Hocabá and Sahcabá is 55.5 (Castillo et al., 1998), with the majority of them saying that their “sons do not live in the community and do not know how to make a milpa”. The flow of the traditional knowledge in milpa production, which implies the “know-how” and the germplasm associated with it, is the base of the continuation of the system, and of agricultural biodiversity in Yucatan.

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