LANDSCAPE ECOLOGY OF APICULTURE IN THE MAYA AREA OF LA MONTAÑA, CAMPECHE, MÉXICO

By

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By

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Apiculture is one of the most important economic activities for rural communities in the Yucatan Peninsula. In part, this results from the rich natural melliferous and polliniferous flora found in the area and from the beekeeping tradition of the Maya population. At La Montaña, Campeche, México, beekeeping is currently the number one income-generating activity. Honey production is currently carried out with Africanized bees (Apis mellifera L.), for marketing to national and international markets. An analysis of some economic aspects showed that profits are benefiting only a small sector of the population that has better management skills and investment capacity. Better technology and technical training, as well as the diversification of the activity could provide more benefits to the region. Nevertheless, for this to happen external investment is needed, particularly to increase the organizational, administrative and technical skills of beekeepers.
The landscape at La Montaña greatly benefits apiculture as the different vegetation types are rich in nectar- and pollen-yielding species. More than 100 species from at least 67 genera and 31 families of trees, shrubs, vines, woody-vines and annuals were found to be important for honey production. These species are present in the different vegetation types found in the region, including lowland and upland forests, fallow areas, recently disturbed sites, and savanna communities.

The “plant-pollinator landscape” where honey bees forage, is a function of the bees’ response to spatial and temporal variation in floral resources (Bronstein 1995). Floral resources are distributed in the landscape both in space and time, according to the distribution and abundance of melliferous and polliniferous species, and to their flowering periods. The patchy nature of the landscape at La Montaña offers diverse resources for bees to forage in, favoring apiculture.

An analysis of a 4-year period of Landsat Thematic Mapper remotely-sensed imagery showed that forest conversion may be intensifying at La Montaña, as cattle ranching becomes a management goal for people in the area; communication at the regional, national and international levels increases; and the population grows. As a buffer zone for the largest reserve in Mexico, the Calakmul Biosphere Reserve, management practices for La Montaña that favor forest conservation are of the utmost importance. Honey production at La Montaña and similar areas represents a promising activity that can favor both natural resources conservation and socio-economic development. Nevertheless, for this to occur, there needs to be a directed effort through the implementation of specific management practices. Alternative markets may also play a crucial incentive role.
CHAPTER 1
INTRODUCTION

Beekeeping in the Yucatan Peninsula has been a traditional activity since ancient times. Maya people are known to have practiced intensive management of stingless bee species, including *Melipona beecheii* Benneth (Chemas and Rico-Gray 1991). Although meliponiculture (beekeeping with native stingless bees of the subfamily Meliponinae) is now seldom practiced, beekeeping with *Apis* bees has become an important activity in the region. Beekeeping is now carried out with modern techniques (movable frames) and with bees of the species *Apis mellifera* L. Over 40% of Mexico’s honey production comes from this region, contributing to Mexico’s importance as one of the world’s leading producers and exporters of honey (Angulo-Carrera 1992, Crane 1990, Echazarreta et al. 1997, Guzman-Novoa 1996). Although comprising only 8% of the Mexican territory, the Yucatan Peninsula contributes nearly 40% of the national honey production (Echazarretta et al. 1997). Given that nearly 80% of the beehives are owned by small farmers, beekeeping constitutes an important activity for rural communities (Guzman-Novoa 1996).

The landscape in the Yucatan Peninsula is known to be rich in nectar (melliferous) and pollen (polliniferous) yielding species (Rico-Gray et al. 1991). This characteristic favors beekeeping, as nectar and pollen represent the major food sources for bees. Floral resources are distributed in the landscape both in space and in time, according to the distribution and abundance of melliferous and polliniferous species, and to their flowering periods. Foraging bees are favored by a diverse landscape where
patches of different types of vegetation offer flowering sources through time and space (Chemas and Rico-Gray 1991). In areas where forests are still a major component of the landscape, beekeeping has been recognized as having great potential for socio-economic development while preserving the natural forests (Acopa and Boege 1998, Galletti 2000).

The objective of this research is to analyze the social and ecological implications of beekeeping at the landscape level of the La Montaña area, in Campeche, México. This region is found north of the Calakmul Biosphere Reserve, and is a buffer zone for this protected region. At La Montaña, beekeeping represents one of the most important economic activities (Galletti 2000, Porter 1995). Through analyzing the social and ecological implications of beekeeping, it will be possible to assess beekeeping’s status as a management alternative that could favor the conservation of forested areas, and at the same time increase the well being of its population.

In the tropical areas of Mexico, as in other parts of the world, the need to implement alternative activities that may favor forest conservation is of outmost importance given the fact that forest conversion is rapidly occurring in the face of modern human activity. According to an FAO report from 1993, Mexico ranks first worldwide in deforestation, with an estimated annual rate of 1.9% for the tropical deciduous forests (Cairns et al. 1995). While the causes of deforestation in Mexico are multiple, forest conversion to agriculture, particularly cattle ranching, represents the leading factor.

Many tropical forests have been shaped to different extents by human societies, creating a mosaic of forest patches that have “recovered” from different disturbances (Browder 1996). Actually, in most “protected” tropical forests, archeological, historical and ecological evidence exists showing a high density of human population in the past
and sites of continuous occupation over many centuries; and also intensively managed and constantly changing environments (Gómez-Pompa and Kaus 1992). In that way, forest patches making up the tropical landscape are dynamic entities, where wildlife and vegetation are controlled and influenced by groups of interacting biotic and abiotic factors, of which historic and present land use patterns are of great importance (Lyon and Horwich 1996). Understanding the role of current human activity in this landscape is needed to understand how forests are changing over time and across space (McIntosh 1981) and is critically important for the management and conservation of tropical forests.

This research is divided into 3 parts. First, the status of the current landscape is analyzed, considering its history and its current trends. This information is presented in Chapter 2, and it sets the background of what the main economic activities are today and what their implications may be for the future landscape structure.

The second part of the research is presented in Chapters 3 and 4 and provides an understanding of the current status of apiculture in the region as well as some of its socio-economic implications. In Chapter 3, a literature review is presented in order to address different issues related to the honey industry in Mexico and specifically in the Yucatan Peninsula. The historical context and the changes that have resulted from the Africanization of *Apis mellifera* bees are discussed. Findings by different authors that have addressed the Africanization impacts are provided to show limitations and opportunities for beekeeping in different contexts. Chapter 4 includes an analysis of the socio-economic implications of beekeeping at La Montaña derived from information from local beekeepers through interviews and close collaboration for a period of two honey production seasons. Issues such as the benefits that the local families and
communities are obtaining from this activity, as well as the strengths and limitations of honey production and marketing are discussed.

Chapters 5 and 6 present the third part of the research and include issues related to the landscape ecology of apiculture, specifically flowering resource availability for bees through space and time and its relation to beekeeping. Chapter 5 deals with the time dimension and presents the results obtained from a community-level flowering phenology study to assess resource availability for bees and its relation to the beekeeping annual cycle. This chapter lists the most important melliferous and polliniferous species for this area, according to beekeeper’s information. Issues related to the implications for honey production and marketing, and related to forest conservation are also addressed.

In Chapter 6 the space dimension is analyzed and an assessment of the distribution and abundance of the melliferous and polliniferous species is presented. The objective is to analyze how the landscape structure favors apiculture (particularly the role of forested areas). The management given by beekeepers to vegetation for honey production is also discussed in order to increase the understanding of the role of this activity to the future structure and composition of forests.

Finally, in Chapter 7 some concluding remarks are made by integrating the information derived from the previous chapters. An understanding of the ecological implications of apiculture as well as the socio-economic characteristics involved in beekeeping provides some insight into the role of beekeeping as a management alternative that favors the conservation of this protected region.
CHAPTER 2
THE MAYA LANDSCAPE AT LA MONTAÑA: PAST AND FUTURE

Introduction

Forest systems in tropical areas are dynamic, and their structure and function are molded by different processes acting at different scales (Waide and Lugo 1992). According to Holling (1992) three different classes of processes operating in a hierarchical manner determine structure and function in ecosystems. Factors at the micro-scale of centimeters to tens of meters in space and days-to-decades in time, drive the vegetative processes that determine plant growth, plant form, and soil structure. At the other extreme, macro-scale factors drive the slow geomorphological processes that dominate the formation of topographic and edaphic structures at scales of hundreds to thousands of kilometers and centuries-to-millennia in time. In the middle, meso-scale factors drive the formation of patterns over spatial scales of hundreds of meters to hundreds of kilometers and on time scales of years to decades. Meso-scale factors include natural disturbances such as fire, insect outbreaks, plant disease, and human activities, that interact with topography and regional climate to form the ecosystem specific patterns on the landscape, shaping the structure and composition of plant and animal communities (Holling et al. 1996).

Meso-scale processes, therefore, lead to cycles of ecosystem development, disruption, and renewal, configuring structure and pattern (Holling 1986). Forman (1995) further differentiates between disturbance and stress. The latter refers to periodic
changes that become part of the ongoing background pattern of variation, while disturbances are events that significantly alter the pattern of variation in the structure or function of a system. Resilience is the ability of the system to maintain its structure and patterns of behavior in the face of disturbance, which at the same time is molded by the same pulses and variations of the system (Holling 1986).

There is increasing understanding of the role that disturbances (and stressors) play in determining the structure and composition of tropical forests. Disturbances and stressors differ in scales that vary in severity, spatial extent, frequency and duration (Waide and Lugo 1992). While cycles of disturbance are integral to the maintenance and generation of natural diversity (Asquith and Whittaker 1992, Goldammer 1992), tropical forest ecosystems are also drastically being changed in the face of contemporary human impacts and possibly climate change. Therefore, knowing the pattern, kind, frequency, and magnitude of disturbances (or stressors) in the landscape is important for understanding how forests are changing over time and across space (McIntosh 1981) and is critically important for the management and conservation of tropical forests.

Most tropical forests have been inhabited by human societies for millennia and have been submitted to numerous cycles of management and abandonment. Recent palynological evidence suggests that such disturbances may have occurred for much longer than previously believed (Binford et al. 1983, Flenley 1992). Many tropical forests can be regarded as human social spaces that have been shaped to different extents by human societies, creating a mosaic of forest patches that have “recovered” from different disturbances (Browder 1996). In most “protected” tropical forests, archeological, historical and ecological evidence exists showing a high density of human
population in the past and sites of continuous occupation over many centuries; and also intensively managed and constantly changing environments (Gómez-Pompa and Kaus 1992). In that way, forest patches making up the tropical landscape are dynamic entities, where wildlife and vegetation are controlled and influenced by groups of interacting biotic and abiotic factors, of which historic and present land use patterns are of great importance (Lyon and Horwich 1996).

The objective of this chapter is to assess the current status and trends of the landscape at La Montaña, Campeche, México, by interpreting remotely sensed digital image data combined with household-level information. A change detection analysis of two satellite images was used to assess forest clearing for agriculture from 1996 and 2000. The following questions were posed:

- What are the activities affecting land use that are being carried out by the local population?
- What are the impacts in the landscape in terms of forest clearing?
- And, how do current activities differ from traditional ones?

Through greater understanding of how the current landscape is being molded by human activity, considering its history of land use, it should be more possible to understand how current activities will affect future composition. Since La Montaña represents a “buffer zone” for one of the largest reserve areas in the neotropics, the Calakmul Biosphere Reserve, this has important implications for the search for management alternatives compatible with larger regional conservation goals.

**Study Area**

The study area is north of the Calakmul Biosphere Reserve, in the center of the Yucatan Peninsula, Mexico. The area is known as La Montaña and is part of the region
named Los Chenes in the state of Campeche (Figure 1). The study took place in the eastern portion of this region and included 8 of the 11 ejidos\(^1\) that constitute La Montaña: Xmejia, Ukum, Xmaben, Chan-chen, Chun-ek, Pachuitz, Nuevo Chan-yax-che, and Xkanha; it also includes the ejido of Belha belonging to the Municipality of Calakmul. The northeastern portion of the area is located at 19°14’45” latitude and 89°10’10” longitude, and the southwestern portion at 18°59’48” and 89°25’07”, respectively. The total land area is approximately 200,000 ha, with a total population of less than 2,800 inhabitants, of which only 620 are ejidatarios (the persons holding the land title, which in most cases include only the head of the family, most commonly adult males) (Galletti 2000).

La Montaña is considered a physiographic, economic and ethnic unit (Galletti 2000) with the population mostly Yucatec-Mayan. The land titles of these ejidos were legally established between 1920 and 1940, when the Mexican public policy for land was to grant forestlands to ejidal property (Galletti 2000). La Montaña is a forested area and has been relatively isolated until recent times. The primary economic activities are related to timber and nontimber forest products, together with subsistence agriculture.

North of La Montaña is the area known as La Milpa, a larger region constituting different communities including the central Municipality, Hopelchen. This is the economic and population center of the Los Chenes region. Topographic relief in this northern part is less abrupt and there is greater population density, with more

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\(^1\) An ejido is a tenure system in which the members forming the specific community have usufruct rights to the land. Generally land is worked individually, although in some cases (e.g., pastures or forest lands) rights are provided in common (Goldring, 1995). Ejidatarios (ejido members—not including their descendents or other family members) constitute a corporate group, the ejido assembly, which is the highest authority. Decisions on individual or collective use of land are made through this assembly. The State grants permits and determines rules and regulations that must be followed. A 1993 amendment to Article 27 of the Constitution changed the ejido legislature and now ejido lands can be privatized.
agriculturally oriented communities. The population in this area is also mostly Yucatec-Mayan, although there is a growing population of Mennonites.

South of La Montaña is the Calakmul Biosphere Reserve, created in 1989 and registered in the UNESCO Man and the Biosphere Program in 1993. The reserve, the largest tropical reserve in Mexico, totals 723,185 ha. It extends south into Guatemala, abutting with the Maya Biosphere Reserve, making a 1.2 million hectare corridor\(^2\) of permanent forest reserves, including the Sian Ka’an Biosphere Reserve at the northeastern end in the state of Quintana Roo (Acopa and Boege 1998). Most of La Montaña falls outside the Calakmul Biosphere Reserves boundaries, except for part of the territory of Xkanha, and Belha, but is considered a “buffer zone” for the protected region.

The climate of the area has been determined, according to the Köppen classification system as modified by Garcia (1973), to be a subhumid, warm tropical type, having marked rainy and dry seasons (Flores and Espejel 1994). The mean annual temperature is 26.2 °C (1984-2000). The mean annual precipitation is 1223 mm, with high variation from year to year, with a low of 648 mm (1986), and a high of 1807 mm (1999) (CNA, unpublished data). The rainy season lasts from summer (May or June to August) into fall (September to October).

Semi-evergreen and semi-deciduous upland forests cover most of the landscape in the area, although substantial portions are also covered with lowland forests. Lowland forests that are inundated for several months of the year, referred to as akalche', are found in poorly drained sites and are sometimes large, particularly in the northeastern

\(^2\) This proposed corridor is now being formally established through the PNUMA (Programa de las Naciones Unidas para el Medio Ambiente); La Montaña has been proposed to be the Focal Area #2 with high priority for conservation (Galletti, personal communication).
portion of La Montaña. Deciduous lowland forests also occur in the area. The mean tree height in the upland forests ranges between 25 and 35 m. During the dry season, 25 to 50% (semi-evergreen) or 50 to 75% (semi-deciduous) of the tree species shed their leaves. Deciduous lowland forests have a mean tree height that ranges from 6 to 15 m, and most trees shed their leaves during the dry season. Akalche forests have a mean tree height of 7 m and about 50% of the trees shed their leaves during the dry season (Flores and Espejel 1994). Patches of secondary vegetation in different successional stages as well as patches of agricultural areas are found throughout the area. Hydrophilic and savanna type vegetations are also found (Ucan et al. 1999). These vegetation types comprise mostly Gramineae and Cyperaceae with differing associations of shrubby and arboreal species. The distribution of these latter plant communities depends in part on the levels of inundation and periods of desiccation, which vary highly (Flores and Espejel 1994). Fire is an important disturbance, particularly in savannas (Pennington and Sarukhan 1998), as was reported to the author by people in the area who annually use fire to enhance sprout growth for cattle grazing, to attract deer for hunting, and to favor flowering of the melliferous tree Crecentia cujete.

Soils in the area were formed mostly by the dissolution of calcareous rocks and over time have resulted in a karst topography (Flores and Espejel 1994). The topography is typically undulating with few outstanding characteristics (Gates 1992). Drainage is subterraneous with no superficial flows of water, except in the rainy season during storms and periods of inundation, when rain can be very intense and water moves in temporary surface flow channels. Lowlands are water-nourished by filtration of Karst during the humid season and become dry to varying degrees depending on recharge through
Figure 1. La Montaña area at Hopelchen, Campeche, México
the dry season (Gates 1999). Some of the lowlands in the area have permanently humid soils and there are permanent or semi-permanent water bodies at some sites.

Water is the most limiting factor for the people in the area. In the dry season, people rely primarily on **aguadas**, small water bodies that fill up during the rainy season. **Aguadas** are formed by depressions originating from the collapse of part of the terrestrial crust, as a consequence of the existence of subterranean currents that dissolved underlying calcareous rocks. These depressions are then filled by sediments with fine textures that hold water and allow only slow drainage to occur (Morales 1992).

Flores and Espejel (1994) point out that the Maya, based on great knowledge, have developed soil and vegetation classification systems that are still in use today. The Mayan soil classification system is based on soil properties such as color, organic content, drainage, ferrous oxides, and rock content (including the distinction of anthropogenic rock remains), as well as associated vegetation (Table 1, Figure 2).

**Landscape History**

The structure and composition of the landscape at La Montaña has been molded to a great extent by different factors, both human-induced and natural occurring, that have played important roles in this forest ecosystem over space and time. According to Konrad (1999), hurricanes in the area are recurrent and can be considered a constant factor affecting the dynamics of succession as well as the stability of human settlement since pre-Hispanic times. Between 1871 and 1990, nearly 14 major cyclonic events affected the area (Konrad 1999). According to Flores and Espejel (1994), the return time of hurricanes considered “dangerous” in the region is from 8 to 15 years. People in the area commonly report the devastation of Hurricane Janet in 1955, which left large portions of the forests resembling “land recently felled for agriculture.” In their most
extreme cases, hurricanes create large natural clearings (Snook 1996), but these forceful storms also result in the extensive inundation of lowlands and cultivated areas, as well as defoliation and consequent forest fires, which can sometimes be very extensive (Konrad 1999).

Human intervention and management has shaped the landscape as well. Human activity has a long history with periods of increasing and decreasing populations with differing management goals. The four periods identified and described below are the Maya period, the colonial and post-colonial period, the modern period, and the current situation.

Maya Period

Vestiges of occupation in the Maya lowlands date to at least 1,000 BC, flourishing during its Classic period at approximately A.D. 250 to 850 (Deevey et al. 1979). This was the time when population densities were highest, reaching numbers greater than 100 per km$^2$ (Gómez-Pompa and Kaus 1992, Turner et al. 2001). Although much of the population was concentrated in urban centers such as Calakmul (located 190 km South of La Montaña), known to have been inhabited since the pre-Classic period and becoming the largest city of the Maya area during the late Classic times (Folan 1999), there is archaeological evidence of occupation throughout the entire region. Although not much archaeological exploration has been carried out at La Montaña, local people report the existence of archaeological remains throughout the area. Folan (1999) has described the northern part of the Rio Bec region and the Los Chenes area as one politically and economically organized in a decentralized manner, with many different governing groups distributed throughout the region.
Table 1. Major soil/vegetation types identified by local people at La Montaña, Campeche. Their association to the FAO soil classification system is provided.

<table>
<thead>
<tr>
<th>Mayan name</th>
<th>Characteristics</th>
<th>Vegetation type</th>
<th>Importance to agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ak'alche'</td>
<td>Yellowish soils, limy and deep, related to chromic vertisols and gleysols (1). Lowlands that inundate at certain periods where debris accumulates (2). People in the area distinguish different types of ak'alche' forests according to characteristics such as the soil type and the time it remains inundated.</td>
<td>Low stature forests are present, including perennial and deciduous. Aquatic vegetation and savanna type communities are also present (2). Some of the communities identified are: Suut* forests. This name is given by local people to describe lowlands sites that inundate for long periods of time and that often are found bordering savannas. Kat-luk* are ak'alche' forests where soil becomes very sticky when wet. Chichi'tok* are ak'alche' forests that do not inundate very often (dry ak'alche'). People also distinguish a different type of savanna community, named Xoch-chakan*, with a greater abundance of <em>Haematoxylon campechianum</em>. Chak'an* vegetation communities. These are savannas established in ak'alche' terrain with a distinctive vegetation community mainly of grasses from the Graminaceae and Ciperacea, as well as dispersed low stature trees (no greater than 4 or 5 m in height) (2). These communities have been related to anthropogenic activities and depend on continuous disturbances such as fire (3). Local people report that these areas are intentionally burned annually to encourage grass sprout in order to feed cattle, attract wild animals for hunting, and favor the flowering of <em>Cresentia cujete</em>, an important melliferous tree.</td>
<td>These soils are not good for agriculture although there is a recent trend to grow one year of milpa and after harvest establish pasture for cattle*.</td>
</tr>
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Table 1 Continued

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</tr>
</thead>
<tbody>
<tr>
<td><strong>Ya’axhom</strong></td>
<td>Dark-brown and dark reddish brown soils, limy and deep, related to chromic luvisols (2). Flat lands with greenish dark soil, with mud that absorbs water with great quantities of vegetative organic matter. They have limestone that water currents bring and that mixed with salt obtain a greenish color (1).</td>
<td>High, medium and low stature forests (subperennial and perennial) are found (1).</td>
<td>This type of soil is very fertile and often cleared for milpa establishment*.</td>
</tr>
<tr>
<td><strong>Tsek’el</strong></td>
<td>Stony dark or reddish soils, less than 30 cm deep. Moderate to rapid drainage and easily eroded. Lithosols and lithic rendzinas are associated (1). Tsek’el soils contain big stones or sheets of limestone with little organic soil content.</td>
<td>Medium and low-stature forests are present (2).</td>
<td>Not good for agriculture*.</td>
</tr>
<tr>
<td><strong>K’ankab</strong></td>
<td>Flat lands made up of red soil that when dry brake up, becoming hard and compacted. These red, or brownish-yellowish soils (from redzinas) have a silt texture, and are usually deep (&gt; 80 cm.), having a rapid internal drainage, and a superficial drainage from moderately slow to slow (1)</td>
<td>High and medium stature forests are present (1).</td>
<td>This is the favored soils type for mechanized agriculture*.</td>
</tr>
<tr>
<td><strong>Kakab or Ramonal</strong></td>
<td>These are places characterized by having anthropogenic remains of past times. They contain a deep layer of vegetative soil found over a limestone sheet usually fertilized by part of the lime from archeological sites, becoming very fertile soils (2)</td>
<td>Medium and high stature forests. Also called ramonal by local people because of the abundance of the ramon tree (<em>Brosimum alicastrum</em>). Other trees common to these areas are: guava (<em>Talisia olivaeformis</em>), beek (<em>Ehretia tinifolia</em>), cocoyol (<em>Acromia mexicana</em>) and ceiba (<em>Ceiba pentandra</em>). These trees are some of the most important trees for the Maya culture, past and present*.</td>
<td>This is the favorite soil type for milpa establishment although it is not often cleared for this purpose since these are areas containing many useful trees that serve as fodder, fruit, hunting areas, to name a few*.</td>
</tr>
</tbody>
</table>

(2) Flores and Espejel 1994.
(3) Penningrong and Sarukhan 1998.
*Personal communication from local informants at La Montaña, Campech
Studies of ancient Maya production systems indicate that the Maya managed and used a rich and diverse mosaic of ecosystems. A list of the different practices hypothesized to have been used by ancient Maya, though not exhaustive, includes terraces, raised fields and other hydraulic systems, sacred groves, door-yard gardens, other silvicultural systems such as the tolche’ and pet kot (see below), and the shifting agricultural system called milpa (Barrera et al. 1977, Caballero 1992, Gómez-Pompa 1991, Gómez-Pompa and Bainbridge 1995, Marcus 1982, Puleston 1982, Remmers and Koeijer 1992, Turner and Harrison 1981).

The use by ancient Maya of terraces and intensive hydraulic systems such as channels and raised fields has been observed in a large number of depressions in the Maya lowlands (Adams et al. 1981, Matheny 1978). The high population densities during Classic times are believed to have been sustained as a result of the implementation of these types of intensive systems (Fedick and Ford 1990, Turner and Harrison 1981). Although the abrupt collapse of the Maya civilization (at approximately A.D. 900) is not
well understood, it is believed to be due to a combination of different factors, including environmental strain, economic and political crisis, and climate change (Deevey et al. 1979, Hodell et al. 1995). This period of high occupation and intensive land use left a dramatic imprint on the landscape, as evidenced in pollen data that shows that forests were greatly disturbed (Deevey et al. 1979). However, there is also evidence that Maya production systems relied greatly on forest management systems, with a high degree of biological diversity. This helps to explain both why the flora and fauna of the area are still rich in species, and why the conservation of some natural ecosystems over their long span of use was possible (Gómez-Pompa and Bainbridge 1995).

After the Maya collapse, lower population densities and the absence of intensive agricultural systems gave way to forest recovery (Binford et al. 1987, Turner et al. 2001). Turner (1990) estimated population changes during the two centuries between A.D. 800 to 1000, to have decreased from 2.6 or 3.4 million to around 1 million people, representing a 53 to 65 % decrease.

Maya agrosilvicultural techniques persisted after the Maya collapse (Marcus 1982). Barrera et al. (1977) have argued that the present floristic composition of forests in the Maya area is a result of ancient silvicultural practices, where human selection processes have interacted with the regeneration of the natural system. Evidence for this is based on current traditional management practices and by the dominance in the mature vegetation of tree species that were and still are the same species protected, spared, or planted in the land cleared for crops in the practice of shifting agriculture (Gómez-Pompa and Kaus 1992).
The **milpa** is the traditional shifting agricultural method of a mixed agroforestry system where corn, beans, and squash are the main products. In this practice, uncontrollable fires are rarely caused but rather individual trees are saved from being burned for the purpose of attracting wild animals, for fruit or wood, or simply for shade (Barrera et al. 1977). The traditional **milpa** lasts for a period of 3 to 4 years, after which the land is left fallow. The Maya had extensive knowledge about the regeneration processes of vegetation. Different stages were identified according to the age of the fallow and were used and managed in different ways (Gómez-Pompa 1987).

Dooryard gardens or homegardens were managed in many ways to provide different goods and services: food, medicine, fodder, wood for construction, fuel, areas for beekeeping, recreational spaces, etc. They are regarded as centers for plant and animal experimentation. Dooryard gardens are managed through intensive silvicultural practices and are structurally very diverse (Remmers and Koeijer 1992).

The term **pet kot** means “enclosed vegetation in a wall of stones” and it is a reserved area in the forest, enclosed by stonewalls where numerous fruit trees and other edible or useful plants are concentrated (Remmers and Koeijer 1992). These places are chosen for the protection and cultivation of useful trees. They resemble forests in composition and structure but have been enriched and manipulated, either by favoring wild species coming from local forests, or by introducing different species from distant and more humid forests of the Maya region (Gómez-Pompa 1987). The **tolche’** is a 10-20 m wide strip of forest, usually created in the practice of making the **milpa**. These areas serve as boundary markers, providing protected status to corridors between forest patches. The management of the vegetation as a whole, not individually, characterizes
them, and their purpose is to provide multiple uses such as sheltered routes for moving between fields, firebreaks, sources of different plant and animal species, and areas of bee forage (Remmers and Koeijer 1992). Another practice that suggests that the Maya played an important role in structuring the vegetation is that of protecting natural areas through “sacred groves” (Gómez-Pompa 1987).

Colonial and post-Colonial period

La Montaña was still influenced by traditional land use systems. Nevertheless, external factors and land use changes occurred at different points in time as a result of several factors.

European contact and its resulting epidemics during the colonial period brought about yet another decrease of the population throughout the Maya area. This depopulation is estimated to have been greater than the depopulation after the Maya collapse. In a period of 100 years (during the 16th century) population decrease is estimated to have been as high as 75 to 95% (Crosby 1972 as cited by Faust 1998). The area of La Montaña, as well as much of the area that today makes up the Calakmul Biosphere Reserve, remained somewhat in isolation from European contact until recently. At the same time, though, it has still been an area where external interests have managed to constantly exploit natural resources (Konrad 1999).

During the Colonial period, the area of La Montaña was characterized by an indigenous, low density, nomadic population that appeared and disappeared, depending on the milpa's cycle. These so-called independent Mayas, known as huites, had little contact with the “white” population and maintained a traditional subsistence system based on the cultivation of corn and beans and on trade. Trade occurred to the north with population centers that had been established by Spanish friars --e.g., Hopelchen, which
was established in 1621 and by 1630 had grown to over 20,000 native people-- and to the south with English settlers. Some of the products which were traded included honey, wax, copal, cotton, tobacco, medicinal and aromatic plants, fibers, wood, live birds and bird products, meat and skin from deer and other animals, and spices such as pepper and annatto. In exchange, the Mayas obtained salt, rope, tools, and gunpowder (Ramayo-Lanz 1996).

After Mexican independence (1821), the Maya population throughout the Peninsula suffered the consequences of the new republic and its modernizing project. With the objective of integrating the milpa areas into modern agriculture, post-colonial agrarian policy formalized the dispossession of lands from native communities (Ramayo-Lanz 1996). The forests of the Yucatan Peninsula suffered from the increase of farming and ranching, where products such as rice and sugar cane were cultivated. The tribute system, mainly in the form of payments of cotton and beeswax, as well as forced labor, was maintained after independence from Spain. The imparting of justice, as well as clerical services, reflected a new government that remained profoundly racist (Ramayo-Lanz 1996). Ancient hierarchical forms of power, which the Mayas had been able to sustain throughout the colonial period, also fell to the new government’s social and political reforms. According to Ramayo-Lanz (1996), these factors, together with false promises made to the Mayas by different political groups of the then-forming government (“centralistas” and “federalistas”) in order to recruit them into their militias, led to the breakout of the so-called War of the Castes. This long and violent period lasted over 50 years (from 1847 to the beginning of the 20th century) and was decisive in the history of Mexico in many aspects; it also strongly affected the future of La Montaña. This area
became the settlement lands of the “pacificos,” a group of Maya willing to negotiate with the government, as opposed to the more radical group, the “rebeldes.” Manipulated by the government, this division among the Mayas ultimately reduced their strength and led to their eventual defeat (Ramayo-Lanz 1996).

The Maya population known as “pacificos del sur” (coming from other parts of the Peninsula) congregated into settlements at La Montaña. The population in this area fluctuated throughout the second half of the 19th century, according to different events and circumstances. At that time, the valleys of the northern-most part of Los Chenes had already become prosperous agricultural areas that produced export goods, such as sugar cane, corn, rice, cotton and tobacco. This area was at the highest point of its economy, and was generating pressure to the south. Many Mayas fleeing from slavery increased population numbers in the southern hills of La Montaña, an area that maintained a certain autonomy (Ramayo-Lanz 1996). By 1860, the area of La Montaña was considered a municipality and had a population estimated at 14,400 (Dumond 1997).

By the second half of the 19th century, Campeche had become an international economic enclave. With its “proyecto agroexportador,” sugar-cane became an important industry that competed with that of Cuba (Ramayo-Lanz 1996). **Palo de tinte** or logwood (*Haematoxylon campechianum* L.) had already been an important export product since the end of the previous century, particularly for the English market. An important ingredient used for fixing dyes, logwood from Campeche was exported in vast quantities to supply England’s flourishing textile industry (Ferré-D’amaré 1997). La Montaña formed part of the commercial corridor that connected the southwest to the
southeastern English settlements through a network of paths where logwood, mahogany and other forest goods found their way to the old world (Ramayo-Lanz 1996).

Nevertheless, the Caste War had its effect on a growing economy, which was based to a large extent on slavery. Los Chenes was severely affected by the war, and its “proyecto agroexportador” failed because of a reduction in the labor force (Ramayo-Lanz 1996). At La Montaña, different confrontations both with the government and with the Maya “rebeldes” resulted in a decrease of the population as well. Whole towns were abandoned. By the end of the 1860s there were only two population centers of “pacificos” left: Xkanha and Ikaiche, and estimates are that the population had been reduced to 12,000 people. By 1900 estimates are that the population had been further reduced to around 8,000 individuals and the only remaining population center was Xkanha (Dumond 1997).

The agricultural project of Los Chenes was further affected by a devastating locust outbreak that occurred at the end of the 19th century. At La Montaña, hunger and disease greatly diminished the remaining population, and by the beginning of the 20th century, the government declared the forests of La Montaña to be “despoblados,” or uninhabited areas (Ramayo-Lanz 1996).

A new period began for the forests of Campeche, characterized by the exploitation of resources through foreign hands and a few local businessmen (since many had already gone north to invest in the henequen project of Yucatán). At the end of the 19th century, the government of Porfirio Diaz had already set the stage for forest

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1 The importance of “palo de tinte” in the textile industry ended after synthetic dyes were invented by William Henry Perking at the end of the 1850s (Ferré-D’amaré 1997).
2 The population remaining at that time is not estimated, but it stopped being considered economically important.
exploitation. Communication networks were built and forest concessions were granted to foreign companies, particularly from North America\(^3\) (Ramayo-Llanz 1998).

La Montaña was left in isolation for most of the 20\(^{th}\) century. During the first half of the 1900s the area was characterized by the exploitation of the *chicle* tree (*Manilkara zapota* L. Van Royen). The forests of Campeche and Quintana Roo produced approximately 80% of the world’s supply of the *chicle* resin used for making chewing gum, an important export product, particularly during the period of the two World Wars\(^4\) (Acopa and Boege 1998). The product was brought from the forests along a network of airplane landing strips, and *chicleros* (those who tapped the *chicle* trees) were imported seasonally to work in the area. According to Konrad (1999) between 1901 and 1910, 10 million km of *chicle* were exported from Campeche, representing 50% of all national exports. The benefits accrued during the early *chicle* period remained in the hands of the foreign companies and contractors, with little profit left for local people in the area. Nonetheless, the presence of *chicle* camps, together with water availability, guided the re-establishment of communities at La Montaña (Ramayo-Lanz 1996).

During the 1920s, after the Mexican revolution (1910-1917), the population at La Montaña was granted *ejidal* property rights. During the 1930s and 1940s, large forest tracts were provided to the communities (Galletti 2000). These forestry *ejidos* responded to *chicle* production needs and their large tracks were intended to guarantee good production rates per person. At times population density was as low as 400 ha per person

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\(^3\) In 1886 the Mexican government signed a contract in which several North American companies, including the Pennsylvania Campeche Land and Lumber Company, the Laguna Corporation, the Mexican Gulf Land and Lumber Company, the Campeche Timber and Fruit Company, and the Campeche Development Company were granted concession to approximately 10,000 km\(^2\) of Campeche’s territory (Ramayo Lanz 1996).

\(^4\) The U.S. Army provided chewing gum to its soldiers as part of their rations (Acopa and Boege 1998).
(Acopa and Boege 1998). After the 1930s, chicle production in the area was commercialized through the Cooperativa de Los Chenes (and later and until 1995, through the Banco Mexicano de Comercio Exterior –IMPEXNAL), regulated by the government. After the chicle boom ended (shortly after World War II, when synthetic gums replaced latex for making chewing gum), chicle trees continued to be tapped with up-and-down market demand, but to a much lesser degree.

According to Galletti (2000), timber exploitation at La Montaña began during the 1960s when the Zoh Laguna Mill extended its activities to the north. Over the following decades, the forests were mined, and the most valuable species, particularly mahogany (Swietenia macrophylla King) and spanish cedar (Cedrela odorata L.) were substantially reduced. This period of timber extraction also left little or no benefit to the area (instead reducing its economic potential), as lumbering was carried out with neither management plans nor the participation of the local population more than as seasonal workers. The result of this period of forest exploitation was the impoverishment of forests, and the creation of a network of roads with its future consequences for resource exploitation (Galletti 2000).

Modern period

During the 1970s and 1980s government initiatives were promoted with the objective of integrating the area into the national economy. At that time, the rural sector in Campeche was subject to a rash of agricultural development projects that promoted colonization, mechanized agriculture and cattle ranching that resulted in the deforestation of at least half a million hectares of forests in Campeche (Gates 1999a, 1999b).

Although the area of La Montaña remained somewhat inaccessible until the construction of the Dzibalchen-Xpujil road in 1995, this period set the stage for the
current situation in the area. Several agricultural projects were promoted, including beekeeping with *Apis* bees, which was adopted by traditional beekeepers in the early 1970s. In the early 1980s, a large-scale mechanized rice production project was established, which resulted in the deforestation of 1000 ha of lowland forests (information obtained from local people). Although this project failed and was abandoned shortly after it was established as a result of technical and organizational problems (as occurred with many other such projects in different areas of Campeche), it opened land for the introduction of cattle ranching, and brought expectations for mechanized agriculture to people in the area (Gates 1999b). These changes towards more agriculturally oriented production systems occurred slowly in the area, but greatly accelerated after the construction of the Dzibalchen-Xpujil road.

Pressure from areas surrounding La Montaña has occurred as a result of changes brought about by the “modern” period of the rural sector in Mexico. The Escarcega-Chetumal road that was built in 1967 brought thousands of settlers from all over the country to the area that today is the Calakmul Biosphere Reserve (Gates 1999b). Population in the region of Xpujil is estimated to have quadrupled from 1980 to 1990 (Ericson 1997). Human settlements within the Calakmul Biosphere Reserve and surrounding areas (an area that remained until the 1950s in greater isolation than La Montaña) have been estimated to total approximately 24,000 people settled in 72 establishments (Sanchez 1999). This population is very heterogeneous, coming from 23 different Mexican states, and including some Mayan ethnic groups such as Yucatec, Chol and Tzeltal (Acopa & Boege 1998). These farmers mainly farm for subsistence, practice forest extraction, grow commercial plantations of *chile serrano* (*Capsicum sp* L.), and
work as migrant laborers in nearby cities such as Campeche and Mérida (ECOMAT 1995). Cattle raising is a strong factor in some of these communities. Beekeeping and chicle extraction are also carried out, mainly by the Maya populations. Other “experiments” in conservation are taking place related to the promotion of alternative land use systems after the establishment of the Calakmul Biosphere Reserve in 1993, including the production of other non-timber forests products, such as allspice (*Pimenta dioica* (L.) Merrill), the establishment of agroforestry systems based on fruit tree plantations, the use of native legume species as green fertilizers, and the encouragement of ecotourism as an alternative industry (Acopa & Boege 1998).

North of La Montaña, a group of Mennonite settlements has been increasing in population and area. Mennonites first occupied lands among the territory of the old-established Maya population. During recent decades this population has increased, arriving from Canada and northern parts of Mexico. By 1995 Mennonites occupied a total land area of 45,000 ha and their population increased to 1,100 from 490 in 1990 (Ericson 1997). There are indications that this population is still increasing. In 2000, a group of Mennonites bought 5,000 ha from one of the communities at La Montaña, despite some disagreement within the community. This represents a major concern because the Mennonites pursue intensive agriculture, felling a large fraction of the forests, utilizing heavy machinery, and applying large loads of agrochemicals (Ericson 1997).

**Current situation**

The current population of La Montaña is about 2,800 (Galletti 1999), with some slight growth. In 1996, the ejido of Chan-yax-che’ was created by a relatively small and heterogeneous group of migrants (about 12 families of people from Tabasco and
Veracruz). Sporadic immigration into old ejidos also has been occurring, in some cases one or two migrant families asking the ejidos assembly for permission to occupy land, but in other cases, by having many outside families as much as double the ejido’s population (as was the case of Chan-chen) promoted by government intervention. Nevertheless, recent migration to the area as a whole has resulted in only limited total population growth, with densities still only 116 to 783 ha per ejidatario (Galletti 1999).

The economy of the area depends on the use of a wide array of ecosystems from which people obtain different goods and services. The traditional milpa is the basis for subsistence. Other types of agriculture, like various agroforestry combinations including homegardens, are also common and important for meeting family needs. People in the area obtain meat from animal husbandry in their homegardens and from hunting in the forest. Use of timber and non-timber products is important as well, as people obtain wood for fuel and construction, fruits, medicines and other goods. People conduct beekeeping and chicle extraction for cash income and occasionally sell timber to outside companies. Cattle raising also has been gaining importance in recent years (Porter 1995, Galletti 2000).

**Methods**

Remotely-sensed digital image data were used for describing the current landscape at La Montaña by means of a change detection analysis of two scenes taken at different dates. The objective was to monitor human activity as evidenced from forest clearing. The scenes used for this study were a Landsat 5 TM scene from February 5, 1996, and a Landsat 7 ETM scene from March 27, 2000 (WRS 2, Path 20, Row 47). According to Sader et al. (1994), who conducted an analysis of forest change estimates in
a similar area (northern Petén region of Guatemala), a 4 year time period between satellite data acquisition is a good one for monitoring forest-clearing patterns, because a fallow **milpa** site of two years can be clearly distinguished from active agricultural areas.

The scenes were analyzed by performing separate unsupervised multispectral classification for each, and then conducting a post-classification detection of changes. The softwares used for processing the data and conducting analyses were Envi and Arc View. Multispectral classification is the procedure of grouping image pixels into spectral clusters. This is carried out by assigning pixels with similar spectral levels into specific classes of known reference signatures (Sohn et al. 1999). The post-classification comparison change detection is used to compare the two classified images of the different dates on a pixel-by-pixel basis using a change detection matrix (Jensen 1996). This procedure creates “from-to” change class information that is used to create a change image map.

A conceptual diagram depicts the procedures for analysis that were followed (Figure 3). After resizing the two scenes to an area that included the extent of La Montaña, the 1996 scene was rectified to the already georeferenced Landsat 7, 2000 image, obtaining an RMS error of less than 0.5 pixels. An ISODATA classifier, one for each scene, was run using all but the thermal band. The classifier generated narrowly defined spectral clusters (the procedure was set to obtain a maximum of 100 clusters), 85 for the 1996 scene and 86 for the 2000 scene.

Spectral pattern matching using information from a classification conducted for the same 2000 scene but at a smaller scale at the University of Quintana Roo, and information derived from field work in the area during January 1999 to May 2000, were used to
merge classes and create a pre-classification of the study area. An image of this scene was taken to the field during June 2001 for verification. Participatory image analysis was conducted with 5 local people, and land/cover use types were assigned to the pre-classified image according to visual interpretation and to the identification of specific sites. This step was followed by transect walks conducted with the same people for observation, and at different sites spatial data was collected using a hand-held Garmin 12 Global Positioning System (GPS). A re-classification followed, using a total of 78 GPS points as reference points. Once each cluster was assigned to one of the reference classes, spectral clusters that belonged to the same land cover/use type were merged together to create a classified 2000 image. This image was re-evaluated by the group of participants in the field. The 1996 image was classified accordingly, using the information generated through the 2000 image classification. The two classified images were combined to conduct a post-classification comparison change detection. This generated a change detection matrix that was used to create a change image map.

**Surface Analysis**

A surface analysis was conducted to address different factors that may influence forest conversion. The factors analyzed were distance to roads, distance to settlement areas and soil type. For each of these factors several buffers were created and subsequently related to the change image map. For assessing disturbance as a factor of distance from roads buffers were created at 1, 3 and 5 km intervals. For assessing disturbance as a factor of distance from settlements buffers were created at 3, 5 and 8 km. For assessing the influence of soils, disturbed areas were quantified within a 0.5 and 1.0 km buffer from lowlands.
Figure 3. Conceptual diagram of procedures for conducting a post-classification comparison change-detection
Results

The classified land cover/use maps of 1996 and 2000 are shown in Figure 4. The 2000 image was classified into 7 types, including: 1) upland forest, 2) lowland forest, 3) advanced secondary succession/burned areas (“quemadal/acahual”), 4) secondary succession/agriculture (“acahual/agriculture”), 5) agriculture/urban, 6) aquatic vegetation/savanna, 7) and water. The classification of the 1996 scene included the same land cover/use types, with an additional cloud mask class added. The latter was created after performing a procedure to mask out clouds and their shadows; this was not done in 2000 since the scene was cloud-free.

Since the objective of the classification was to document forest-clearing, no attempt was made to more finely classify different types of upland (e.g., sub-perennifolius vs sub-deciduous), or lowland forests (e.g., akalche’ vs deciduous lowlands). Regarding the local people’s classification system, upland forest includes tzequel, kakab, kankab, and yash-hom; and lowland forest includes akalche’ and suut (Figure 2). Advanced secondary succession includes areas locally known as quemadales, which are areas that have undergone fire (either natural or intentionally set) and areas locally known as acahuales, which is a Spanish term used to refer to secondary vegetation. Secondary vegetation/agriculture refers to early stages of recovery after an intensive disturbance (e.g., agriculture). Since the spectral signatures of active agricultural areas and urban settings were not differentiated, they were placed together as a single class. Aquatic vegetation/ savannas, a class that includes areas with a distinctive vegetation cover, can sometimes also be spectrally confused with quemadales or acahuales.
The post-classification comparison yielded a change detection matrix (Table 2). Since the accuracy of the change detection in this type of procedure is dependent on the accuracy of the two separate classifications (Jensen 1996), several things should be taken into consideration. For change detection using remotely sensed digital image data, the date of data acquisition within the year is important, due to seasonal variations in the spectral signatures (Brondizio et al. 1994).

Both images were obtained during the dry season. But the 1996 image was taken at the beginning of February, when soil moisture was still high and trees had only begun to shed their leaves, while the 2000 image was taken at the end of March, when the dry season was advanced, soils dryer and the trees that shed their leaves had already done so. Additionally, the quality of the 1996 image was not very good, presenting radiometric error shown as striping. Although several filtering procedures were used to correct this error, the condition did not markedly improve. Nevertheless, a principal components analyses for the 1996 image showed that only 15% of the variation may have been the result of radiometric error.
Figure 4. Image classification of La Montaña portion of a) Landsat 5 TM image 02/05/96; and b) Landsat 7 ETM 03/27/00.
The 56 clusters generated in the post-classification comparison were merged to produce a change image map (Figure 5). This map was merged into 11 classes using the following criteria (the different colors in Table 1): 1) upland forest, 2) lowland forest, 3) recovered vegetation (including vegetation that has recovered to either upland or lowland forests) 4), new quemadal (including areas that have undergone a transition from lowland or upland forests to quemadal, 5) same quemadal/acahual (including areas that have remained as quemadal, and areas that are recovering from disturbance), 6) new agriculture/urban (areas that have been cleared either from upland, lowland, or from quemadal, including new urban areas), 7) Same agriculture/urban (areas that have remained under agriculture, acahual or urban), 8) cloud mask; 9) aquatic vegetation/savanna (this includes the areas previously identified as aquatic/savanna in the two images and areas that at either of the two dates were covered with water, suggesting that they may be aquatic vegetation or savannas and whose spectral signature when dry, is confused with acahual, quemadal, or agriculture (agriculture is very unlikely to occur in areas inundated for long periods); 10) water; and 11) suut (these areas were tentatively classified as suut –representing lowland forests that are inundated for long periods of time, since they were classified at either date as forest and in the other one as either water or aquatic vegetation. The three last classifications (aquatic vegetation/savanna, suut, and water) are indicative of the complex hydrology of the area.

Approximately 35.5% of the area classified either as upland or lowland forest was misclassified, as shown in Table 2 in the matrix boxes belonging to upland/lowland and lowland/upland. This probably resulted from environmental variations given by differences in the scene dates and from the low quality of the 1996 scene. Also, a vegetation sampling carried out in the area (Chapter 6) reviled that 90 species were common for both forest types, out of a total of 115 for lowlands and 112 for uplands, which could result in
Table 2. Change detection matrix obtained by combining classifications made of the La Montaña portion of Landsat 5 TM, 02/05/96 and Landsat 7 ETM 03/27/00 scenes. Numbers are in hectares

<table>
<thead>
<tr>
<th></th>
<th>1995</th>
<th>2000</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upland Forest</td>
<td>Lowland Forest</td>
<td>Quemadal/</td>
<td>Acahual/</td>
<td>Agriculture/</td>
<td>Aquatic veg./</td>
<td>Water</td>
</tr>
<tr>
<td>Upland Forest</td>
<td>61600.8</td>
<td>14849.9</td>
<td>2393.5</td>
<td>753.0</td>
<td>1394.6</td>
<td>66.2</td>
<td>338.8</td>
</tr>
<tr>
<td>Lowland Forest</td>
<td>43029.1</td>
<td>43091.2</td>
<td>4344.1</td>
<td>1061.6</td>
<td>3893.4</td>
<td>76.4</td>
<td>158.4</td>
</tr>
<tr>
<td>Quemadal/</td>
<td>1650.2</td>
<td>1576.5</td>
<td>1064.1</td>
<td>706.7</td>
<td>1286.0</td>
<td>2.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Acahual/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>agriculture</td>
<td>319.5</td>
<td>496.8</td>
<td>661.5</td>
<td>552.7</td>
<td>1272.5</td>
<td>5.3</td>
<td>2.9</td>
</tr>
<tr>
<td>Agriculture/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>urban</td>
<td>530.6</td>
<td>95.2</td>
<td>3557.5</td>
<td>1067.3</td>
<td>827.4</td>
<td>1.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Aquatic veg./</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Aquatic</td>
<td>Aquatic</td>
</tr>
<tr>
<td>savanna</td>
<td>168.5</td>
<td>725.1</td>
<td>67.7</td>
<td>24.0</td>
<td>94.2</td>
<td>355.5</td>
<td>129.6</td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td></td>
<td>Aquatic</td>
<td>Aquatic</td>
<td>Aquatic</td>
<td>Aquatic</td>
<td>Aquatic</td>
</tr>
<tr>
<td></td>
<td>Suñ.</td>
<td>Suñ.</td>
<td>Aquatic</td>
<td>Aquatic</td>
<td>Aquatic</td>
<td>Aquatic</td>
<td>Aquatic</td>
</tr>
<tr>
<td></td>
<td>Clouds</td>
<td>Clouds</td>
<td>Clouds</td>
<td>Clouds</td>
<td>Clouds</td>
<td>Clouds</td>
<td>Clouds</td>
</tr>
<tr>
<td>TOTAL</td>
<td>109968.5</td>
<td>61471.1</td>
<td>12352.5</td>
<td>4240.0</td>
<td>11052.9</td>
<td>796.7</td>
<td>966.1</td>
</tr>
</tbody>
</table>

difficulties for differentiating spectral signatures. Other areas such as those classified as 
quemadal or acahual, may also contain some errors. However, these errors do not affect our 
interpretation of land use change since the areas classified as agriculture and urban are 
unlikely to be in error, as their shape (e.g., squares, rectangles) and position in the landscape 
(e.g., near roads, settlement) are other good indications of their land use/cover types. For 
Figure 6 upland and lowland forests were classified according to the 2000 image.
Figure 5. Change map created by combining classification data of the La Montaña portion of Landsat 5 TM, 02/05/96, and Landsat 7 ETM 03/27/00 scenes.
Four percent of the area was cleared for agriculture or developed as urban areas during the four year period (Table 3). This includes areas that were in the early stages of recovery (acahual). Additionally, 2.6% of the area remained as agriculture, urban, or acahual. Together, areas in 2000 that were represented as active agriculture, urban development, or early stages of recovery (acahual), added up to 6.6% of the total area. Areas in advanced regeneration stages or that had undergone a fire (quemadal) represented 4.5% of the area, of which 3.5% were recently disturbed. Areas that had recovered to either upland or lowland forests represented 2.5% of the area. Not considered in the classification was 1.5% of the area masked out as clouds or shadows.

Table 3. Changes in pixel count, area, and percentage of total area of land use/cover types obtained from a post-classification analysis of Landsat TM, 02/05/96 and Landsat 7 ETM, 03/27/01.

<table>
<thead>
<tr>
<th>Land use/cover type</th>
<th>Pixel count</th>
<th>Area (ha)</th>
<th>Percentage of total area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upland Forest</td>
<td>1290611</td>
<td>104829.9</td>
<td>53.6</td>
</tr>
<tr>
<td>Lowland Forest</td>
<td>713340</td>
<td>57941.04</td>
<td>29.6</td>
</tr>
<tr>
<td>Recovered vegetation</td>
<td>61173</td>
<td>4968.78</td>
<td>2.5</td>
</tr>
<tr>
<td>New quemadal</td>
<td>82987</td>
<td>6740.6</td>
<td>3.5</td>
</tr>
<tr>
<td>Same quemadal</td>
<td>25282</td>
<td>2053.53</td>
<td>1</td>
</tr>
<tr>
<td>Same agriculture/early acahual</td>
<td>61628</td>
<td>343</td>
<td>2.6</td>
</tr>
<tr>
<td>New agriculture/early acahual</td>
<td>95778</td>
<td>7779.6</td>
<td>4</td>
</tr>
<tr>
<td>Aquatic vegetation/ savanna</td>
<td>16458</td>
<td>1336.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Suut</td>
<td>20585</td>
<td>1672.02</td>
<td>0.8</td>
</tr>
<tr>
<td>Water</td>
<td>4035</td>
<td>327.7</td>
<td>0.2</td>
</tr>
<tr>
<td>Cloud mask</td>
<td>36123</td>
<td>2934.1</td>
<td>1.5</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2408000</td>
<td>195589.8</td>
<td>100</td>
</tr>
</tbody>
</table>

Results from the surface analyses show that although proximity to roads and settlements may be a factor in forest clearing, most of it is occurring as a function of soil type. This corresponds with information obtained from local people who stated to choose their agricultural sites mostly on the basis of environmental conditions (soil type and vegetation cover), although accessibility to town was also considered important.
Buffers made at 1, 3 and 5 km from roads show that disturbance is not very related to proximity to roads (Figure 6 A). Approximately 7.7% of total area falls inside a 1 km buffer from major roads and only 1.7% of this area is disturbed, which corresponds to 16.7% of the total disturbed area in the image. A 3 km buffer accounts for about 26% of total area of which 3.9% is disturbed (38% of total disturbed area). A 5 km buffer from roads accounts for about 40% of the total area of which only 5.4% corresponds to disturbed areas, accounting for only 52% of total disturbed area in the image. It should be taken into consideration that the roads are relatively new and that people have been established in the area for at least a century.

Buffers from settlements were made at 3, 5 and 8 km (Figure 6 B). A 3 km buffer from settlements accounts for almost 13% of total area of which only 2.5% is disturbed, representing 24.3% of total disturbed area. A 5 km buffer from roads accounts for 28.5% of total area of which 4% is disturbed, corresponding to almost 40% of total disturbed area. An 8 km buffer accounts for almost 50% of total area of which little over 6% is disturbed, representing 60% of total disturbed area in the image. While proximity to settlements may be a factor in establishing agricultural areas, people do not limit themselves to areas close to their towns and almost 40% of total disturbed areas falls outside the 8 km limit from settlements. People in the area report that very often they establish their agricultural sites in areas where they have to camp, sometimes for over two weeks.
Figure 6. La Montaña area, Campeche, México. Buffers made at: A. 1, 3 and 5 km from roads; B. At 3, 5 and 8 km from roads; and C. At 0.5 and 1.0 km from lowlands.
Buffers from lowlands indicate that people largely choose their agricultural sites based on soil type since up to 53% of the total disturbed area falls within a 0.5 km buffer from lowlands, and up to 67% within a 1 km buffer (Figure 6 C). This corresponds with information provided by local people that indicated the yash-hom and kakab soil/vegetation types were preferred for milpa establishment (Figure 2, Table 1).

Discussion

Clearing Rate

If forest clearing at La Montaña is assumed to have occurred equally over the four-year period, an estimated annual clearing rate of 1% and an annual regeneration rate (also divided between the four year period) of 0.635% provides a net deforestation figure of 0.365% per year. This figure considers only the recently disturbed areas. Additionally, 2.6% of the area previously disturbed has not been allowed to recover, probably remaining under continuous use. If the latter figure is partitioned into the four year period, an additional 0.65% provides a clearing rate of a little over 1% per year. Another 4.5% of the area has been disturbed as quemadal, of which most, 3.5%, has occurred over the four-year period. Areas under quemadal either resulted from wildfires, or were burned or felled by local people, indicating that they may be in a transition to a more intensive use (when preparing agricultural areas from mature forest people in the area usually fell trees at the beginning of the year, during February or so). Quemadales may also be areas in an advanced stage of regeneration. They may also be misclassified and could be areas of very dry forest that shed most of their leaves (considering that the 2000 image was taken during the peak of the dry season).
Turner et al. (2001) reported annual deforestation rates caused by anthropogenic disturbance in the region of the Calakmul Biosphere Reserve to be between 0.32 and 0.39 % for the years 1969 to 1997. Sader et al. (1994) reported annual rates of forest clearing at the northern Peten region of Guatemala to have been 0.4 % at the end of the 1980s, with a regeneration rate of only 0.03%. They consider the clearing rate as low, which they attribute to the inaccessibility of the interior of the Maya Biosphere Reserve. Nevertheless, in a second study, Sader et al. (1997) reported annual clearing rates at the buffer zone of the Maya Biosphere Reserve (in the western and southern borders) to have been as high as 3 % at some sites during the early 1990s. They attribute the higher forest clearing rates to agricultural expansion and accessibility (e.g., roads, pipe lines, and rivers).

According to an FAO report from 1993, Mexico ranks first worldwide in deforestation, with an estimated annual rate of 1.3 % (Cairns et al. 1995). Considering the different forest types, tropical deciduous forests are second in their rate of forest clearing, after tropical evergreen forests, with an estimated figure of 1.9 % per year. The causes of deforestation in Mexico are multiple, with forest conversion to agricultural uses, particularly cattle ranching, the leading factor. Forest fires, hurricanes and commercial logging are also considered important factors (Cairns et al. 1995).

Although the estimated 1% annual forest clearing rate at La Montaña is lower than the average estimated figure of 1.9 % for deciduous tropical forest in other areas of Mexico and Guatemala, it is still higher than the rate estimated for the interior of the Calakmul and Maya Biosphere Reserves (0.4%) (Sader et al. 1994, Turner et al. 2001). This suggests that forest clearing may be intensifying, although further research would be
needed to understand more about the regeneration process of these forest ecosystems, and consequently more about their dynamics (e.g., through conducting a similar analysis utilizing images taken at a previous date –particularly before the construction of the Dzibalchen-Xpujil road).

**Land Use Change at La Montaña**

There are factors that indicate that land use may be intensifying and that management objectives for the local populations are changing. The **milpa** is traditionally established in upland forest preferably of the **yash-hom, kakab, and kankab** types (Figure 2) (note that much of the agricultural area in the images are shown bordering lowlands). None of it is established in **akalche’** forests, since the probability of losing the crop by inundation is high. Nevertheless, local people report that the recent trend is to establish the **milpa in akalche’** areas and, after the first year’s harvest, to plant grass. This new trend changes the traditional slash-and-burn system, where forests are left to regenerate, to a system where fallowed areas are replaced with grass for rearing cattle. It can be observed in the images that a large portion of the newly cleared areas is found within the lowland forest areas. Also the 2.6% of the area that showed continued use over the four-year period suggests that forests are not being left to recover (this could be further tested through analyzing images of more dates).

Cattle raising at La Montaña is an activity that has been gaining in importance in recent years. Government programs have aided in its promotion, and even though most people have only a few head of cattle, some individuals are investing much of their capital and labor into increasing their herds and pasturelands. Cattle raising is currently perceived as an activity important for accumulating capital and gaining social status, as well as a good source for quick cash. In recent times, the government has provided
considerable credit to some individuals for establishing cattle ranches (Porter 1995). There are also people who invest in pastures even though in some cases they still do not own cattle (Galletti 2000).

Cattle raising at La Montaña has strong implications for forests in the region and may be the reason for the forest clearing rate observed here. According to Masera et al. (1997 citing FAO 1990) the deforestation process in Mexico is weakly correlated with population growth and, although the key driving forces of deforestation are varied, direct or indirect subsidies to cattle ranching have been one of the outstanding factors. Changes in the traditional agricultural systems may be posing more rapid threats to the current forest ecosystems at La Montaña than population growth.

However, people at La Montaña carry out other forestry related activities, which are economically important and which favor (or could favor) the conservation of a forested landscape. These activities include chicle production, timber extraction, beekeeping, traditional agroforestry systems, and the traditional milpa.

Chicle production continues to be an important economic activity in the area. This activity is favored and at the same time favors the conservation of forests, where large chicle trees are found. Although restrained by market fluctuations and by government permits, it is potentially important for the economy of the region.

Timber harvesting is limited by impoverished forests, where the most commercially valuable species (mahogany and Spanish cedar) have been extensively extracted. Nevertheless, timber harvesting still represents an important potential economic activity in the region, which given the necessary conditions could favor forest conservation. Species with commercial potential, such as granadillo (Platymiscum
yucatanum Standley), **siricote** (*Cordia dodecandra* A.DC.), **guayacan** (*Tabebuia guayacan*), and **chaka** (*Bursera simaruba* (L.) Sarg.), are currently being sold from forests at La Montaña. However, timber extraction is an activity limited by government permits and markets. Currently, there is no organization or structure in which the local population (or the forests) can benefit, and timber extraction is being carried out with no formal management plans. Usually, wood is sold as standing volume to companies that bring their trucks and equipment to extract the timber, many times illegally. Local people mainly receive money for the labor of felling the tree, but with not much other gain, and most of the time they are unaware of the volumes that are being extracted (Porter 1995). Timber extraction carried out in this way is clearly detrimental to forest conservation. Cairns et al. (1995) point out that the deforestation process in much of the Mexican forests typically begins with timber extraction in this unorganized way. The consequences are that the economic potential of forests is reduced after valuable timber species are depleted and the associated road infrastructure encourages colonization and agricultural expansion. However, timber extraction could become an incentive for forest conservation, provided the necessary conditions are created.

Honey production is currently an important income generating activity in the region. Although beekeeping is a traditional activity, beekeeping with *Apis mellifera* L. is relatively new and has been developing into an important economic activity in recent years, establishing market ties with national and international industries. In the region, beekeeping with *Apis* bees has been favored by a mosaic-like landscape formed by patches of different vegetation ages and types, rich in melliferous flora. The extent to which this activity favors (or could favor) forest conservation is an important question
that should be addressed in the search for sustainable management alternatives for the development of the region (see following chapters).

The traditional **milpa** as well as different agroforestry systems including home-gardens and the **parcela agroforestal**\(^1\), are important subsistence activities for people at La Montaña. These activities are inherited traditional practices based on solid environmental knowledge that result in a high degree of biological diversity. The slash-and-burn **milpa** system as practiced traditionally can be regarded as an agroforestry system where fallow and regeneration of the vegetation are part of the management practices (Gomez-Pompa 1987, Sohn et al. 1999) and where multiple products and services are obtained. While the **milpa** system itself does not guarantee forest conservation or a sustainable use of natural resources, as populations grow, forests are converted to other land uses and new technologies are adopted (e.g., use of chainsaws, use of agrochemicals, seed sources, etc.). This must be balanced by the wealth of knowledge that the Maya people have regarding vegetation, soil, hydrology, and climate that should not be disregarded when management alternatives are sought for forest conservation at La Montaña and similar areas in the tropics.

**Conclusions**

The forest landscape of La Montaña has been shaped by a range of factors, that include natural forces such as hurricanes and fires and human-induced disturbances, through the long span of history of occupation in the area. Human activity in the area of

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\(^1\) A traditional agroforestry system similar to that of homegardens but which may or may not be established next to the house, and that currently has been including the establishment of different native and non-native fruit and timber trees encouraged by NGO.
La Montaña has been constant, with episodes of higher and lower occupation. Since recovery of the forests from the high populations and intensive use during the Classic Maya period, forest cover has been steady. Human activities in the area until recently have been related to the use of timber and non-timber products, guided by internal and external interests that have molded the current status of the forested landscape. The traditional milpa agriculture, as well as other traditional agroforestry systems of the Maya, developed into management practices where regeneration of forests was part of the systems, becoming endogenous “stresses” to the forest ecosystems and very likely affecting the structure and composition of the vegetation and animal communities through time. Chicle extraction provided an incentive for the legal establishment of “forestry” ejidos in the area. Timber extraction, on the other hand, left an impoverished forest, depleted of the most valuable timber species.

Today, land use activities are changing towards more agricultural production, with potentially large implications for the forested landscape of La Montaña. This analysis of the four-year period of remotely-sensed imagery indicates that forest conversion may be intensifying, as cattle raising becomes more common; communication at the regional, national and international levels increases; and the population grows.

Although the economy in the region is still greatly dependent on the management of forest resources, changes are occurring which are visible at the landscape level. The question now is how will current decision making regarding land use affect the future structure and composition of forests at La Montaña. The following chapters will analyze beekeeping as an activity that could favor the conservation of a forested landscape in this area.
CHAPTER 3
BEEKEEPING IN THE MAYA AREA: HISTORY AND CURRENT STATUS

Introduction

Beekeeping in the Yucatan Peninsula has been a traditional activity since ancient times. Maya people are known to have practiced intensive management of stingless bee species, including *Melipona beecheii* Benneth. In Mayan philosophy, humans and bees were very related; the *Zayawinnicoob*, or first humans, were considered to be very industrious people and were represented as having bee-like eyes (Chemas and Rico-Gray 1991).

Although meliponiculture (beekeeping with native stingless bees of the subfamily Meliponinae) is now seldom practiced in the Maya area, beekeeping with *Apis* bees has become an important activity in the region. Beekeeping is now carried out with modern techniques (movable frames) and with bees of the species *Apis mellifera* L. Over 40 percent of Mexico’s honey production comes from this region, contributing to Mexico’s importance as one of the world’s leading producers and exporters of honey (Angulo-Carrera 1992, Crane 1990, Echazarreta et al. 1997, Guzman-Novoa 1996).

A literature review is presented to address issues related to the honey industry in Mexico and specifically in the Yucatan Peninsula, considering its historical context and the changes that have resulted from the Africanization of *Apis mellifera* bees. Findings by different authors that have addressed the Africanization phenomena are provided in order to illustrate limitations and opportunities for beekeeping in different contexts.
The beekeeping industry provides society with many important products and services. The traditional products, honey and beeswax, have been used since ancient times in all parts of the world (Crane 1990). Honey, the final product of nectar collected and modified by bees, is used as a sweetener, either served at the table, or in the food and drink industries. It also has many uses in medicine and cosmetic manufacturing. Beeswax, which is secreted by worker honey bees from wax glands, was more widely used in the past, before synthetic products were substituted (e.g., paraffin). Nevertheless, beeswax is still used as a component of cosmetics and pharmaceuticals, as well as for other minor uses. According to Crane (1990), most of the beeswax that is produced today is wasted, some of it is used in traditional ways, and a small part is used in the industry. A big portion of beeswax is re-used in the beekeeping industry for producing comb foundations.

Other products derived from beekeeping began to be produced after World War II, when low prices for honey, replacement of beeswax by other substances for many industrial purposes, new technologies, and a widespread new interest in health foods and dietary supplements led beekeepers to diversification. These products include pollen, propoli, royal jelly, bee venom, and bee brood (Crane 1990). The beekeeping industry is also important for providing pollination services for agriculture, and has become an integral part of production technology worth millions of dollars in industrialized countries (Basualdo 1996). Currently, the pollination of fruit and seed crops by bees (including bees other than honey bees) provides a greater economic benefit to agriculture
world-wide than the beekeeper’s income from honey and other hive products (Crane 1990).

The basis of today’s beekeeping industry is the honey bee *Apis mellifera* L. (order Hymenoptera; family Apidae; subfamily Apinae), even in areas of the world where this species is not native (such as the American continent). Honey is also produced in different parts of the world by other *Apis* species and by different species of the subfamily Meliponinae (the stingless bees), but mostly for local consumption or regional trade (Crane 1990). Honey production from *Apis mellifera* is the most widespread and has an established world trade market. Worldwide honey production from this species reaches numbers that approximate one million metric tons per year (Angulo-Carrera 1992).

Mexico is one of the principal countries in the world-wide beekeeping industry. In 1991, Mexico was the fourth honey producer, after the former USSR, China and the United States (Sánchez-Vazquez and Colli-Ucan 1992). Data obtained from the Centro de Estadística Agropecuaria¹ report an average annual honey production in Mexico of 60,000 metric tons of honey from 1980 to 1999, and an average annual production of 4,217 metric tons of beeswax for that same period. According to Angulo-Carrera (1992), Mexico was the leading exporter for the period of 1974 to 1984. In 1995, Mexico was the ninth honey producer, after China, USA, Argentina, the former USSR, and four other Asian countries, which together accounted for 46% of that year’s world production, and the fourth largest exporter, after China, Canada and Argentina (Troncoso 2000). The use of bees for pollination has also gained importance in some states of Mexico, mainly in the
northern states, and has been estimated to have a greater value than honey production and beewax for that area (Guzman-Novoa 1996).

The southeastern part of Mexico is one of the most important honey producing regions. This honey producing area is comprised of the Yucatan Peninsula (Campeche, Quintana Roo, and Yucatan). Representing only 8% of the national territory, this region accounts for 30 to 40% of annual national honey production (Echazarreta et al. 1997). The relevance of this area as a honey-producing region has been explained by Guzman-Novoa (1996) to be the result of its “exuberant” native melliferous/polliniferous flora, and because of the beekeeping tradition of the Maya people, who have been keeping bees since ancient times.

In Mexico, honey production is very important for the rural population as an alternative income activity and 80% of the beehives are owned by small farmers (Guzman-Novoa 1996). Therefore, the honey industry represents an important source of income and jobs for low-income families in the rural sector. Beekeeping has also been considered an alternative land use in areas where forests are to be conserved and as a way to provide added value to secondary vegetation and mature forests (Acopa and Boege 1998). Being a profitable non-timber forest product with an established market, beekeeping is considered to have great potential in protected regions such as the Calakmul Biosphere Reserve and its surrounding areas (Acopa and Boege 1998, Galletti 2000).

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1 The Centro de Estadística Agropecuaria (Agricultural Statistical Center) is part of the Secretaría de Agricultura, Ganadería y Desarrollo Rural (SAGAR), the Mexican Secretariat of Agriculture and Rural Development.
History of Beekeeping in the Maya Area.

Although there are no native honey bees (*Apis*) in the American continent, Mesoamerican cultures managed stingless bees of the genera *Melipona* and *Trigona* (order Hymenoptera; family Apidae; subfamily Meliponinae) for over 3,000 years (Guzmán-Novoa 1996). Of particular importance is the management given to the species *Melipona beecheii* Bennett by the Mayas. Management of the *xuna’an kab* (*xuna’an* = queen or princess, and *kab* = bee or honey), the Mayan name given to *Melipona beecheii*, developed into an extensive bee culture, where honey and wax were used for trade, religious ceremonies, and medicinal purposes (Sanford 1973). Bishop Diego de Landa (who arrived in Yucatan in 1549) described the life and customs of Maya Indians, including beekeeping and the different festivities and offerings dedicated to bee gods (Weaver and Weaver 1981). The Troano Codex also refers to different aspects related to beekeeping in the Yucatan Peninsula (Labougle and Zozaya 1986). Weaver and Weaver (1981) describe some of the bee-related festivities dedicated to gods that were still practiced until recently by current Mayas. Honey produced by the *xuna’an kab* is still (in few cases) used for making balche’, an alcoholic drink used in religious ceremonies.

Balche’ is prepared using the bark of the balche’ tree (*Lonchocarpus longistyulus* Pittier) and honey made by *Melipona beecheii*. Honey was paid as tax since pre-Hispanic times and was the subject of an intense commerce that took place from Tabasco to different areas of the Peninsula, by sea to Honduras and Nicaragua, and to the west with the Mexica Empire. Mayas traded beeswax and honey probably for cacao seeds and precious stones (Labougle and Zozaya 1986).

After the Spanish conquest, honey and wax produced from *xuna’an kab* were paid as taxes to the Spaniards. During this time, beeswax was particularly important in
religious activities carried out by the Spaniards. Honey as a sweetener was gradually replaced by sugarcane. Nevertheless, the beeswax produced from stingless bees supplied a vast area of the Spanish Empire practically for the entire duration of the Colonal period (Labougle and Zozaya 1986). Labougle and Zozaya (1986) reported taxes paid to Spaniards by the Maya population in the year 1547; of 173 settlements in the state of Yucatan, only 5.8% did not pay with honey or beeswax. Total production in this area during that year approximated 29,300 kg of wax and 3,300 kg of honey; every 20 persons contributed 12 kg of wax and every 295 persons, 12 kg of honey.

European honey bees (*Apis mellifera*) were not introduced into the Yucatan Peninsula until the end of the 19th and beginning of the 20th centuries. Although there are reports of their presence in the center of Mexico at the end of the 18th century, this did not prove to be the introduction to the Yucatan Peninsula. Modern apiculture (carried out with *Apis mellifera* bees and using movable frames) began to be practiced after the 1920s (Labougle and Zozaya 1986). In the 1930s and 1940s, large amounts of *Apis* honey started to be produced in the Yucatan Peninsula (Chemas and Rico-Gray 1991). During the 1960s and 1970s beekeeping with *Apis mellifera* by the Maya population gained importance, becoming one of the principal economic activities for the rural sector (Echazarreta et al. 1997).

Beekeeping in the area is now carried out primarily with *Apis* bees using modern techniques (Sanford 1973), although management of Meliponinae bees is still practiced by a decreasing number of Maya people. The arrival of the Africanized bees (see below) into Mexico in the last half of the 1980s has brought different challenges and opportunities for beekeepers in the area.
Beekeeping with the Africanized Bee

The Africanization of the European races of *Apis mellifera* in the American continent in the last fifty years has resulted in profound changes in the beekeeping activity in a very vast area of tropical and subtropical America. These changes bring different challenges and opportunities for beekeepers that will be briefly discussed in the next section. These changes also raise important questions regarding the role of exotic honey bees as pollinators in natural areas and the possible effects that may occur on the native flora and fauna populations.

**Africanized Bee**

Africanized bee is the name given to races of European *Apis mellifera* bees that have hybridized with an African race of *Apis mellifera* (*Apis mellifera scutellata* Ruttner) in the American continent (Crane 1990, Daly 1991). The Africanization process began in 1956, when 26 absconding swarms of *Apis mellifera scutellata* escaped from an apiary in Camaquan, São Paulo, Brazil. These bees had been brought from Africa in order to conduct breeding experiments. By 1991 Africanized bees were found in many different habitat types in an area about 20 million km² that extended from northern Argentina to Mexico (Roubik 1991). In the last decade these bees also reached parts of the southern United States and in all likelihood will continue to expand in North America.

The Africanized bee has been able to quickly occupy most of tropical and subtropical America. This astonishing success is in part due to a highly evolved capacity to exploit unpredictable and varied resource conditions and in part due to its unique reproductive biology (Ratnieks 1991). It has been calculated that the “colonizing front” of Africanized bees has moved at an average rate of 300 to 500 km/year (Crane 1990, Otis 1991).
The African bee that was brought to Brazil was adapted to arid and semi-arid environments ranging from tropical East Africa to subtropical South Africa. The environmental conditions in this area are varied, but the major selection pressure for the bees was likely the unpredictability of rainfall which influences flowering. On the other hand, the European bee evolved in a much more predictable environment where annual snow melt provided a secure source of moisture for flowering to occur (Rinderer and Hellmich 1991). This adaptation to unpredictable conditions has provided a great advantage to the Africanized bee when colonizing new areas.

A summary of the characteristics of the reproductive biology that have helped the colonizing success of the Africanized bee (and that affects traditional beekeeping schemes) is as follows (Otis 1991, Ratnieks 1991, Rinderer and Hellmich 1991):

- **Swarming.** This is the process by which bees reproduce (through colony fission). European colonies usually swarm once a year, while Africanized bees can swarm up to four times annually.

- **Absconding.** Africanized bees tend to abandon their nests or abscond. Absconding occurs either as a result of disturbance to the colony, or as a result of shortages in resources. The latter occurs in periods of extended dearth (when there are no flowering resources or water available), or when other resource rich areas have been identified. European bees rarely abscond; it is more common that the colony perishes when faced with resource shortages or external threats.

- **Differential reproductive rates.** Africanized bees develop large populations in short periods in response to the existence of harvestable resources (as a result of their adaptation to unpredictable resource availability). They have higher fecundity and shorter development times than European bees.

- **Social reproductive parasitism.** This is a term that includes different behavioral characteristics of African races of *Apis mellifera*. A form of social reproductive parasitism is the capacity of reproductive females of this subspecies to take the place of the queen of a different colony, accelerating Africanization. Another form of social reproductive parasitism is that drone populations (drones are male bees whose basic function in the colony is to mate queens) are larger in African colonies. Therefore, during mating flights there is a greater probability that the queen will mate with drones of the Africanized population.
As a result of these collective characteristics, Africanized bees have now spread to most of the American continent, replacing European honey bees. Africanized honey bees are now found not only in areas where traditional beekeeping existed, but also in natural areas forming numerous feral populations (wild colonies), where before they were relatively scarce (Michener 1973, 1975). One of the characteristics that makes the Africanization process even more striking is the fact that African traits of the *Apis mellifera* subspecies have persisted almost entirely. Genetic studies indicate that Africanized bees resist changes in gene frequency toward the European type through partial reproductive isolation between European and Africanized bees. This partial reproductive isolation operates in ways that perpetuate the African ancestry and give the Africanized bee further advantage over European bees (Daly 1991, Fletcher 1991, Ratnieks 1991, Spivak 1991).

**New Challenges and Opportunities**

Changes in honey bee populations have brought about many challenges to beekeepers. Behavioral characteristics of the Africanized bee, such as their defensive nature and their tendency to swarm and abscond, have destabilized beekeeping and honey production. At the same time, it has become common that after an initial period of adjustment, the Africanization actually favors beekeeping, at least in some tropical and semitropical settings.

The behavioral trait of Africanized bees that has made them widely known among the common public, and one of the biggest challenges for beekeepers, is their defensive behavior (Breed 1991, Rinderer and Collins 1991). Africanized bees show greater sensitivity to colony disturbance, have a greater ability to communicate alarm within and
between colonies, and have a greater capacity to respond quickly by mounting massive
attacks on intruders (Michener 1973). This defensive nature of the Africanized bee
makes their management even more difficult. Beekeepers have had to understand
different aspects of the Africanized bee biology in order to modify management practices
and adapt to these new conditions.

To deal with the defensive nature of the Africanized bee, beekeepers have learned
to relocate apiaries away from homes, barns, animals and roads (Kent 1991). They also
now need to use more appropriate clothing. Beekeepers have learned when to work in
the apiary, since the temperament of a colony varies depending on weather and foraging
conditions, food stores, prior treatment, colony size, etc. (Michener 1973). The
tendencies of the Africanized bee to frequently swarm and abscond have made
beekeeping a more intensive activity, requiring more visits to apiaries than before.
Beekeepers have learned to capture swarms in bait hives as a procedure to increase
colony numbers and reduce wild populations (Helmich and Rinderer 1991). Beekeepers
have also learned to select toward mildness by destroying and requeening the most
defensive colonies (Michener 1975). Africanized populations do not represent a well-
declared phenotype, but rather display a wide range of behavioral characteristics, ranging
from relatively gentle and manageable to extremely defensive and difficult to manage
and productive Africanized colonies with intermediate characteristics have been
successfully maintained by beekeepers who have modified their management practices
and requeen or kill undesirable colonies.
According to Michener (1973), most of the beekeepers in Brazil have learned how to handle the new honey bee and actually prefer it in spite of its drawbacks, because of its high productivity. He found that Africanized bees in Brazil are reported to produce more honey per colony than European bees. According to Gonçalves et al. (1991), beekeepers in Brazil, with the aid of government technicians and university scientists, have been able to adapt. Brazil began producing large quantities of honey and became one of the largest honey producers in the world only after the introduction of the Africanized bee. Most beekeepers in Brazil are happy working with Africanized bees because it is easy to obtain bees and because of their higher productivity (Gonçalves et al. 1991).

Kent (1991) reviewed the impact of Africanized bees in Peru, comparing areas with and without Africanized bees. He concluded that average colony production was consistently greater in Africanized regions. He found that it is common after an initial period of adjustment when honey yields may decline, that yields then tend to increase notably. Small beekeepers tended to abandon beekeeping, while commercial beekeepers with greater financial resources and technical knowledge were more likely to continue. To adapt, beekeepers became better equipped and more progressive in their management practices as well as more involved in information networks to share experience and knowledge.

Spivak (1991) concluded that in different regions of Costa Rica, the Africanized bee caused beekeepers who were not willing to modify their practices and adapt, to abandon beekeeping. Nevertheless, other beekeepers were able to reduce the impact of the Africanized bee by employing good management and selection practices. She states that if beekeepers are willing to follow advice from other beekeepers and researchers who
have had positive experiences with Africanized bees, the Africanization process can have a positive effect overall.

Hellmich and Rinderer (1991) show that the introduction of the Africanized bee to Venezuela greatly decreased beekeeping initially. However, after a decade, beekeepers began to learn to manage the Africanized bee. These authors conclude that a new generation of beekeepers has emerged in Venezuela, better informed and prepared. However, they report that honey yields were still greater before the Africanized bee, attributing lower present productivity to the increased competition for nectar sources by the numerous feral colonies.

It has been the general case that beekeeping in many areas of South and Central America has been favored by Africanization. However, it is important to note that beekeepers that have been able to adjust and take advantage of the new situation have been those with the capacity of acquiring equipment and becoming better informed, either by technical training or through different media channels (by personal means or through government programs).

In Mexico, the effects of Africanization on total national honey production have been minimal, basically because beekeepers have had time to adapt to the new management conditions (Echazarreta et al. 1997). Governmental programs such as the Programa Nacional para el control de la Abeja Africana (PNPCAA) formed as an agreement between the Agricultural Secretary (at that time SARH²) and the United States Department of Agriculture (USDA), has aided in the mitigation of the impact of Africanization (Sánchez-Vazquez and Colli-Ucan 1992). Data from the Centro Estadístico Agropecuario show that national annual honey production decreased slightly
in the 1990s, averaging approximately 58,000 metric tons from 1990 to 1999, as opposed to an average of 60,000 for the previous decade. Part of this decrease may be the result of Africanization, but other factors such as deforestation, intensive use of agrochemicals, national and international low prices, market competition, and the spread of Varroa jacobsoni (an exotic mite that affects honey bees and that has been spreading in recent years negatively affecting honey production), have also been used to explain such decreasing tendency (Angulo-Carrera 1992, Sánchez-Vazquez and Colli-Ucan 1992). Nevertheless, certain areas, such as La Montaña (see chapter 4), have actually increased honey production in recent years, favored by Africanization and other factors.

**Conservation Concerns**

There is increasing concern about possible effects that introduced bee species may have on native fauna and flora. Exotic honey bees may compete with other species of flower-feeding animals, such as nectar-feeding birds and other bees (Sugden 1996, Sugden et al. 1996). One concern is the effect that the increasing number of Africanized bees, particularly as feral populations, may have on the natural assemblage of pollinators (Buchmann 1996, Corbet 1996). Not only is there evidence that the Africanized bee displaces native pollinators (Roubik 1978, 1996a, 1996b; Roubik et al. 1986), but also that they may be ineffective at pollinating native flowers and may interact in complex ways with native pollinators, reducing the amount and efficiency of pollen transfer (Kearns and Inouye 1997). Although the direct effect that this may have on the faunal and floral compositions in the mid- and longer terms is hard to measure (Buchmann 1996, Roubik 1996a, Sugden 1996), it is unlikely that it will have no effect. It is

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2 Secretaría de Agricultura y Recursos Hidrálicos
important to keep this considerations in mind when promoting beekeeping as an activity compatible with forest conservation.

Research regarding the biology, reproduction and ecological relation with other organisms of stingless bees in the Yucatan Peninsula and in Mexico is only beginning (Quezada-Euan 2001). Not only does beekeeping with stingless bees represent part of a cultural wealth of indigenous populations in Mexico, including the Maya area, but it is also considered to have great economic potential for honey production and for pollinization of commercial products. Appropriate technology could make this activity a viable and profitable one (Quzada-Euan and González-Acereto 1994) and should be promoted in the context of current honey production.

Conclusions

Apiculture is an important economic activity in Mexico and the Yucatan Peninsula is one of the most important areas within the country (Echazarreta et al. 1997, Sánchez-Vazquez and Colli-Ucan 1992). In part, this results from the rich natural melliferous and polliniferous flora found in the area (Chapter 5) and from the beekeeping tradition of the Maya population. Beekeeping with native bees of the subfamily Melinponinae began with the Mayas over 3000 years (Guzman-Novoa 1996). Intensive management of certain species, particularly *Mellipona beechei*, resulted in a bee culture important in religion, medicine, food, and trade (Labougle and Zozaya 1986, Sanford 1973). During the 20th century, beekeeping with *Apis mellifera* started in the Yucatan Peninsula, increasing in importance throughout the century. During the 1960s and 1970s beekeeping with *Apis mellifera* by the Maya population also gained importance, becoming one of the principal economic activities for the rural sector (Echazarreta et al.
During the last half of the 1980s, the arrival of the Africanized honey bee resulted in new challenges and opportunities for beekeepers, as it did throughout most of the American continent (Spivak et al. 1991). In the Yucatan Peninsula and the rest of Mexico, beekeepers have had time to adapt to the new management conditions and the effects of Africanization have been minimal.

While beekeeping in the Yucatan Peninsula with *Apis mellifera* results in a viable and profitable economic activity, more efforts should be made to promote beekeeping with stingless bees. Future studies should address the impacts that beekeeping with Africanized *Apis mellifera* may have on native pollinators, and ultimately to the function and structure of flora and fauna.
CHAPTER 4
SOCIO-ECONOMIC IMPORTANCE OF BEEKEEPING IN THE MAYA FORESTS:
THE EXAMPLE OF THE LA MONTAÑA AREA

**Introduction**

Beekeeping in the Yucatan Peninsula has been a traditional activity since ancient times. Maya people are known to have practiced intensive management of stingless bee species such as *Melipona beecheii* Benneth. Although meliponiculture (beekeeping with native stingless bees of the subfamily Meliponinae) is now seldom practiced, beekeeping with *Apis* bees is an important activity in the region. Beekeeping is now carried out with modern techniques (movable frames) and with bees of the species *Apis mellifer* L. Over 40% of the national honey production comes from this region, contributing to a large honey production industry with world-wide importance, since Mexico is one of the leading producers and exporters of honey (Angulo-Carrera 1992, Crane 1990, Echazarreta et al. 1997, Guzman-Novoa 1996).

In the Yucatan Peninsula, about 80% of the beehives are owned by small farmers, making beekeeping an important source of income and jobs for the rural sector (Guzman-Novoa 1996). In protected regions such as the Calakmul Biosphere Reserve and surrounding areas, honey production is considered to have great potential for development (Acopa and Boege 1998, Galletti 2000). The Maya landscape hosts a very rich melliferous and polliniferous flora found in the different forests types, yielding abundant nectar and pollen for honey production, and representing an important economic resource (Rico-Gray et al. 1991).
The objective of this research is to analyze the socio-economic implications of beekeeping at La Montaña, an area found north of the Calakmul Biosphere Reserve. Beekeeping in this area is the number one income generating activity (Galletti 2000, Porter 1995). Through conducting research with beekeepers from the area for a period of two honey productive season, information was sought to understand the socioeconomic importance of beekeeping, the benefits that the local families and communities are obtaining from this activity, as well as the strengths and limitations of honey production and marketing.

**Methods**

**Study Site**

La Montaña is an area north of the Calakmul Biosphere Reserve in the state of Campeche, Mexico. It is formed by a group of eight ejidos occupying an area of approximately 185,000 ha, and having a population of about 2700 inhabitants mostly of Yucatec-Mayan origin (Galletti 1999). The type of climate for the area has been determined, according to the Köppen climate classification system as modified by Garcia (1973), to be subhumid, warm tropical (Flores and Espejel 1994). The mean annual temperature is above 22°C and the mean annual precipitation is 1,223 mm. The most dominant vegetation type is medium-stature subperennifolious forests, where the mean height for trees is 25m and where from 25 to 50% of the tree species shed their leaves during the dry season. This type of vegetation is mixed with high-stature subperennifolious forests, low-stature forests that inundate periodically, aquatic vegetation, and secondary vegetation in different successional stages (Ucan et al. 1999).
Soils in the area have been formed mostly by the dissolution of calcareous rocks that over time has resulted in a karst topography (Flores and Espejel 1994). Drainage is subterranean with no superficial flows of water, except in the rainy season during storms and inundations when rain can be very intense and water is transported in temporary surface flow channels (Gates 1999).

Research Conducted

The field study lasted from November 1998 to June 2000 and included two honey production seasons. The research was facilitated by Oxfam/Comadep, a non-governmental organization working in the area, which was assisting a group of beekeepers to develop a legally established cooperative to commercialize and increase honey production. Formal and informal interviews with 94 beekeepers, many of them members of the cooperative formed with the assistance of Oxfam/Comadep (Sociedad de Solidaridad Social, Productores Unidos Lol k’ax –from now on I will refer to them as Lol k’ax), provided information about honey production and marketing, as well as about other relevant issues related to beekeeping in the area. Information was also derived by assisting the cooperative in their financial and organizational tasks. The members of Lol k’ax are representative of beekeepers from seven different localities (Xmaben, Ukum, Chunek, Pachuito, Xmejia, Belha, and the ranch of Xnoha) that have been organized since 1998. Other beekeepers in the area are members of different cooperatives or market their honey through the informal honey market. Informal interviews were also conducted with external key people, such as the veterinarian working in the area, Victor

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1 Data for temperature and precipitation were obtained from the Comision Nacional del Agua for the period from 1984 to 2000.
Camara, who has worked in the Yucatan for more than 30 years, and with members of Miel Maya (the company that has bought honey from Lol-K’ax). Regular assistance to the training sessions carried out with subgroups of beekeepers in the different localities, especially a group of women beekeepers from the Belha community, provided information about different issues of beekeeping management practices in relation to honey marketing.

Results

Beekeeping at La Montaña

The inhabitants of La Montaña, of Mayan descent, have had a tradition of beekeeping for many generations. People in the area remember their parents, or themselves when young, keeping large numbers of colonies of xuna’an kab. These bees are traditionally kept in specially made hollow logs (called in Mayan, hobones) in thatched structures within the solar (the Maya homegarden), or near their agricultural plots (the milpa). Wax and honey from these bees are greatly valued for different religious and medicinal attributes. Meliponiculture (the termed used for beekeeping with bees from the subfamily Meliponinae) is now seldom practiced. Even though occasionally some still keep a few hobones of these bees, beekeeping activity has changed to be a more commercial one, directed towards regional, national, and international markets, and carried out with Africanized strains of Apis mellifera. Currently, beekeeping is the number one income generating activity at La Montaña, bringing considerable amounts of capital into the area (see below).

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2 Oxfam/Comision Mesoamericana de Asistencia Para el Desarrollo Popular, Asociación Civil, at that time Oxfam-Belgium who began a project in the area in 1993 funded by the European Community and by the Oxfam office in Belgium, that has extended until recently.
Modern beekeeping was promoted in the area during the early 1970s by government initiatives (specifically by the PIDER – the Programa de Infraestructura para el Desarrollo Rural) through an effort to integrate the area into the national economy (Camara, personal communication). During that time beekeeping was carried out with the “Italian” bee (Apis mellifera ligustica), one of the European subspecies. The arrival of Africanized strains of Apis mellifera (Apis mellifera scutellata) into this area occurred during the last half of the 1980s (Crane 1990; Camara, personal communication). With this, many people discontinued beekeeping. Numerous stinging incidents, fatal in some cases, are reported to have occurred. Nevertheless, beekeeping continued, especially among the younger population.

During the 1990s, beekeeping actually gained importance. Two main factors made this possible. First is the construction of the Hopelchen-Xpujil road, which was finished in the early 1990s. This road opened access to the area and led to many changes particularly in communications and market accessibility, and with these, the involvement of the population in the regional economy. Changes have been astonishingly visible from year to year in many different social, economical and political aspects. For beekeeping in particular, alternatives to the traditional commercialization scheme have emerged. For example, instead of one or a few intermediaries (the coyote) with absolute control over markets (buying the honey from individual producers and re-selling it to a buyer), many people are now organized into beekeeping cooperatives, although the coyote scheme also remains in operation. The road has also meant access to information and awareness of the different limitations and possibilities for commercializing bee products (aided by non-governmental organizations that have established in the area). Second, the arrival of the
Africanized bee, with high numbers of feral colonies, has meant greater bee availability. A prospective beekeeper needs only to acquire the basic equipment (mainly wooden boxes which are produced in the area) to establish a productive unit. Many of the local population (particularly younger people) have taken advantage of the opportunities for producing and commercializing honey.

**Socioeconomic Importance of Beekeeping**

Honey production has traditionally been part of a larger natural resources management system in which activities complement each other in space and time. Segregation in space is accomplished by the use of different ecosystems for different productive activities, and in time by the distribution of different activities throughout the year according to season (Porter 1995). In this way, people follow the strategy indicated by Toledo (1991) to be typical of indigenous management systems, maximizing the utilization of all available ecosystems and getting a number of essential products throughout the year. The strategy buffers households and communities against market fluctuations and environmental hazards.

People at La Montaña practice a type of slash-and-burn agriculture, called the **milpa**, in which corn, beans and squash (among other perennial and annual crops) are planted. This is an important traditional activity carried out by all men in the area. It is a subsistence activity and most food consumed by families, or used for feed for domestic animals, is produced in this way. Other types of agriculture, like agroforestry plots and homegardens, are also common and important for meeting family needs. Agricultural activities are mainly for subsistence and play only a small role in bringing direct cash to the families, since only a few of the products are sold.
Cattle raising is an activity that has recently gained in importance. Government programs have aided in its promotion and even though most people have only a few head of cattle, some individuals are investing much of their capital and labor into increasing their herds and pasture lands. A socioeconomic analysis conducted in the community of Xkanha showed that about 68% of the families owned cattle, although, of these, 75% had <10 head, 22% had >10 but <16, and only 4% had >40 animals (Porter 1995). Nevertheless, cattle raising is an increasing trend and an activity perceived as important for accumulating capital and gaining social status. Also, cattle are a source for quick cash and used in emergencies. In recent times, the government has given considerable credit to some individuals for establishing cattle ranches. Currently, cattle is at an investment stage with many people investing their surplus income in preparing pasture lands; there are people who invest in pastures even though in some cases they still do not own cattle. According to Galletti (2000), the last 5 years at La Montaña have shown potrerización (pasture growth) and cattle raising continues to gain importance.

Use of timber and non-timber resources is important for people in the area to different extents. Timber extraction is not a very important economic activity for these communities in general. Most of the commercial species, mainly cedro (Cedrela odorata L.) and mahogany (Swietenia macrophylla King), have already been eliminated from the forests by logging. Other native species with commercial potential such as granadillo (Platymiscum yucatanum Standley), siricote (Cordia dodecandra A.DC.) and chaka (Bursera simaruba (L.) Sarg.), among others, are being currently extracted. Although timber extraction is limited by government permits and markets, there is no official organization or structure in which the local populations can benefit. Usually, wood is
sold as standing volume to companies that bring in their own trucks and equipment to extract the timber. Local people often receive money for the labor of felling trees, but not for much else, and most of the time they are unaware of the volumes that are being extracted. Usually people obtain very little revenue from this activity, which favors companies or only a few of the local people involved in woodshops for making furniture and beekeeping equipment. The only community that is currently benefiting in a significant economic sense from timber harvesting is Xkanha, where most of the timber extraction is being done in an illegal manner with no management plan. Even in this case, extraction has again favored only a few specific families (Porter 1995).

**Chicle** extraction has historically been an important economic activity in the area. **Chicle** is the gum tapped from the *Manilkara zapota* tree, which is used for making chewing gum. Historically, this activity has been very important in the area and until recently it was the activity that generated the most income. **Chicle** has always been an export product. At different points during the last century (specifically during the periods of the World Wars), **chicle** camps guided the establishment of communities. Nevertheless, most of the income benefited outside companies and contractors and little benefit was felt by the local people (Ramayo-Lanz 1998). After the **chicle** boom ended (shortly after World War II), basically when synthetic gums replaced latex for making chewing gum, **chicle** trees continued to be tapped with an up-and-down market demand, but still constituting an important source of income. Now, **chicle** production is the second income generating activity after honey production. In an interview conducted by Galletti (2000), 43% of total ejidatarios at La Montaña were reported to be practicing **chicleros** (many **chicleros**, although skilled, stopped conducting the activity because of
age or other reasons, since it is a highly dangerous job), and in some of the communities practically all ejidatarios are chicleros (e.g., Xkanha, and Pachuitz). Annual chicle production in the region ranges from 17 to 26 metric tons of dried gum (Galletti 2000, Porter 1995). As a result of the Asian economic crisis, starting in 1997, chicle has not been bought from the area because the Japanese company that bought most of the product went bankrupt. Chicleros are now waiting for a new contract to continue with this activity.

Other economic activities contribute in different degrees to the economies of La Montaña families and communities. Some individuals have woodshops or other commercial establishments, or own a car or a chainsaw. People may also work for wages either within or outside the communities. Women make embroidery and other crafts, which although limited by market availability and low prices, sometimes represent an important income to the family (mainly because it goes directly to family use). Other activities such as hunting may also be important for increasing the well being of families, mainly because meat is an important protein source. Government subsidies can also contribute greatly to total family income, but this depends on the specific government programs at the moment (Galletti 2000, Porter 1995).

Beekeeping is currently the number one income-producing activity in the area. As explained before, it is a relatively recent activity as practiced today with Africanized Apis mellifera and given the current marketing possibilities through better accessibility to the area. In a survey conducted in the region, 76% of the men interviewed reported practicing beekeeping (Galletti 2000). In a study conducted in Xkanha in 1995, over 60% of ejidatarios were involved in beekeeping (Porter 1995). An average of about 200
metric tons of honey are produced annually in the region, depending on weather conditions (Galletti 2000). Prices vary greatly (from 1994 to 2000 it varied from 1 to 12 pesos/km), but considering a common current price in the region of $0.7 USD/km, yields an annual income of $140,000USD/year. Only about 40% is re-invested into the activity, but considering that the minimum wage can be as low as $3.00 USD/day, it is a considerable amount of money.

Most of the population has only small productive units, with few colonies and involving a minimum of investment. In interviews carried out with 63 beekeepers of four different communities conducted as part of this research in 1999, 32% of the producers had <10 colonies, 46% had 11 to 20, 17% had 21 to 30 and only 5% had >30 colonies. In a study conducted in Xkanha, 60% of total income made from beekeeping in 1995 was generated by only three producers (Porter 1995). Thus, beekeeping revenues still largely benefit a relatively small sector of the population. As practiced today, beekeeping is limited by technical knowledge and the investment capacity (time and money) to increase colony numbers. Nevertheless, current programs established in the area (e.g., Oxfam/Comadep, and EDUCE, A.C.) aim at increasing the potential in the region, by assisting in the organization of beekeepers’ cooperatives, establishing markets and providing technical advice.

Honey Production and Marketing

Honey harvest season at La Montaña runs from mid- to late February through late May or early June. This timing varies from year to year depending on the winter rains and their timing. There are several factors that determine production success, besides the
necessity of having the skills to work with Africanized bees. The length and regularity of precipitation controls the flowering period (Chapter 3). Also, beekeepers need to know how to manage their colonies to prevent absconding and swarming. People report that it was as easy to expand the number of colonies by catching moving swarms, as it was to lose them all because of lack of assistance or an external factor that led colonies to abandon their nests. Of the 63 beekeepers that I surveyed during 1999, only 14% reported no change in colony numbers from 1998 to 1999 (Figure 7). Actually one producer reported to have gained 100% of his colonies during 1999 and another one reported to have lost 100%, so that colony numbers can clearly change greatly from year to year.

The main cause of colony loss was reported to be absconding during the dearth period. Other factors that affect colony numbers included pests and predators that either lead colonies to abscond or to perish. The most threatening predators were reported to be ants, especially army ants of the Ecitoninae subfamily, locally known in Mayan as xulab, and the oso colmenero or hive eater (Eira barbara senex) a mammal of the Mustelidae, known by its Mayan name as sanjol. These predators are also reported in the literature to disturb beekeeping in other parts of the Peninsula (Echazarreta et al. 1997, Sánchez-Vazquez and Colli-Ucan 1992). The varroa mite (Varroa jackobsoni) is a recent pest that can greatly affect colonies. According to Echezarrieta et al. (1997) the varroa mite has become an increasing problem in the Yucatan Peninsula since 1995. At La Montaña, all beekeepers reported to have problems with varroa to different degrees and needed to treat

3 Educacion, Cultura y Ecología, A. C., a non governmental organization based in Hopelchen assisting the organization of the beekeepers cooperative named Kabi-tah, of which some of the beekeepers of the La Montaña region are members.
colonies either with chemical products (e.g., fluvalinate or flumethrin) or organic ones (e.g., formic acid). Other diseases are reported to affect the well-being of apiaries to lesser degrees.

The absconding of colonies can be avoided to a certain extent by applying appropriate management practices (e.g., killing ants before they attack the colony; feeding; removing or providing frames; Camara, personal communication). The effects of diseases can also be diminished through management. Factors other than colony number, such as the age of the queen and colony size and strength, are also important in determining productivity. These factors can also be controlled with management (Camara, personal communication).

![Figure 7. Number of beekeepers that gained, lost, or had no change in their colony numbers from 1988 to 1999, according to a survey of 64 beekeepers of the communities of Chunek, Pachuitz, Ukum and Xmaben conducted during 1999.](image)

In summary, production is determined by both natural factors and management practices which depend on the beekeepers’ skills and the resources invested in the activity (both in time and supplies). The average kg of honey produced per colony was
reported by a group of 64 beekeepers of four different communities to be 60 kg/colony, although some reported to have produced 10kg/colony and some up to 150 kg/colony. As mentioned above, honey is commonly sold through a coyote (the intermediary), who buys honey directly from a producer and re-sells it to a buyer. The intermediary, thus determines price. The coyote also has the role of providing credit to producers for maintaining and managing apiaries throughout the year. Credit provided during the off-season benefits the coyote, who then sets the prices, terms and conditions. Within this commercializing scheme, there is little room for capitalization or re-investment.

Most recently, some producers have organized themselves into cooperatives, with assistance of non-governmental organizations (NGOs). The purpose is to create a system where members are provided with social and administrative mechanisms in order to (1) increase their technical knowledge and productivity (through technical assistance facilitated by the non governmental organizations), (2) obtain government credit, (3) negotiate directly with markets, and (4) create mechanisms of capitalization that increase the cooperative’s capacity (technical, organizational and administrative) and ultimately create structures that benefit members in the mid- and long terms.

Cooperatives have also been formed for chicle production, with assistance from the Plan Piloto Chiclero. The objective of the Plan Piloto Chiclero is to organize chicleros to create a “commercialization front”, in which producers are empowered to negotiate directly with the buying companies, establishing terms and conditions in their favor. The cooperative also has the role of creating services to benefit members in the mid- and long terms, such as employing new technology, and offering loans, life insurance, and retirement funds (Aldrete, personal communication).
The Lol-K’ax Cooperative Example

The cooperative of Lol-k’aax was formed at the beginning of 1999 with the assistance of Oxfam/Comadep, which started a program of technical assistance for beekeepers in 1998. The initiative for forming the cooperative came both from Oxfam/Comadep and from a group of young beekeepers who had already participated in the Kabi-tah cooperative, but had renounced their membership. Kabi-tah is a cooperative whose headquarters are in Hopelchen (formed through the assistance of EDUCE, A.C.) which has been in operation for some years. The Kabi-tah cooperative incorporates a much larger region, particularly in the north. Some of the people at La Montaña found that they were in at a disadvantage because their harvest season begins later than in the north. At the end of the harvest season, people at La Montaña are affected the most if resource shortages occur at the cooperative (cooperatives function in a way that they need capital to buy honey from individual producers before receiving payment from the buying company). Also, after a Kabi-tah experience in which a shipment of honey exported to Germany was found to be contaminated with chemical residues and rejected (something that at that time resulted in a general crisis), beekeepers realized the importance of having adequate technical training and a more regulated supervision of quality control.

Oxfam/Comadep assisted Lol-K’ax to legally establish the cooperative, to obtain credit, and to locate markets. It has also carried out a formal technical assistance program. Nevertheless, Lol-k’aax has been in charge of much of its own management. Currently, Lol-K’ax has 72 members from 6 communities (Xmaben, Ukum, Pachuitz, Chunek, Xmejia, and Belha) and one settlement (Xnoha –a group of people that have settled in National Territory for over 50 years). During the last two years, they have sold
part of their product to Miel Maya Honing, part of the Fair Trade Market\(^4\), with headquarters in Belgium. The experience of Lol-K’ax in their export enterprise has not been an easy one. For example, Lol-k’ax has had to establish mechanisms of self-financing for product commercialization. They also have had to cope with strict quality control norms established by the international market. Miel Maya buys honey of the best quality: no more than 18% water content and free of chemical residues. This has resulted in a very strict program of quality control and has necessitated increased technical training for cooperative members.

Contamination of honey usually results from use of chemicals and antibiotics for pest control, so that producers have had to use alternative pest control measures. Water content in honey can vary greatly, based on natural causes such as nectar type and weather conditions, as well as management practices. High water content results in fermentation. Although the international market usually only buys honey with a water content 18%, 20% water content is considered to be good quality honey within the national market.

In 1999, Lol-k’aax established a contract for 20 tons of honey with Miel Maya, although the cooperative was able to only gather <12 tons, mainly because Lol-k’ax did not find mechanisms to finance the commercialization until the end of the season, when the honey had a naturally high water content. The honey that arrived in Belgium had a water content >18 % and failed to meet the terms of the agreement. Nevertheless, Miel

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\(^4\)Fair Trade markets belong to the International Federation of Alternative Trade (IFAT) whose “code of practice” establishes: “To trade with concern for the social, economic and environment well-being of marginalized producers in developing countries. This means equitable commercial terms, fair wages and fair prices. Unfair trade structures, mechanisms, practices, and attitudes will be identified and avoided. To cooperate and not compete. To promote fair trade and social justice in the interest of the producer, and not to maximize profit at the producer's expense” (taken from internet web page [http://www.goedwerk.nl/engels/en_page2.html](http://www.goedwerk.nl/engels/en_page2.html)).
Maya gave Lol-k’aax a second opportunity and established a new contract for another 10 tons of honey for the year 2000. After one of Miel Maya’s representatives came to the area to supervise and test honey quality, Lol-k’aax shipped to Belgium almost 12 metric tons of honey of excellent quality.

Lol-k’ax produced approximately 44.5 metric tons of honey in the year 2000 (Figure 8), of which 26% was honey with 18% water content (that sold to Miel Maya). The rest was honey of <19% water content (47% of total honey produced), or <20% water content (27% of total honey produced). Honey of 19 and 20% water content was marketed nationally. Quality control in this case was much lower and Lol-K’ax was able to sell honey of < 20% water content at the same price and were also exempted from conducting lab tests for chemical residues. The price of honey sold to Miel Maya (the honey of best quality) was set at $10.50 pesos per kilogram (approximately $1.05 USD), with Miel Maya paying for shipment and containers. The price of honey sold to the national company was also $10.50, but Lol-K’ax had to pay for shipping and containers, which resulted in a net price of $9.00 pesos per kilogram of honey sold (approximately $0.9 USD).

The amount of honey produced during 2000 is not representative of the production capacity of Lol-K’ax. That year was droughty, with only 22.3 mm of precipitation for the months of January to May compared to a 17 year mean of 56 mm (SD 22.1). People complained about the lack of flowering especially at some locations.
Total production for Lol-K’ax in 1999 was not recorded, since most of the people sold their honey in that year to the coyote. In my survey conducted after the harvest season of 1999, 65 beekeepers reported that they had produced 69 tons in 1999, and 58 tons of honey in 1998. These figures are only estimates and more years of production records are needed before production capacity for Lol-K’ax can be reliably predicted.

An assessment of the advantages of selling honey internationally through alternative markets such as Miel Maya is critical. Although prices have been better when honey is sold to Miel Maya, this has been achieved only through a large effort by the cooperative and through subsidies from Oxfam/Comadep. Although the “Fair Market” provides better prices, the cooperative needs to find mechanisms for self-financing.

Producing the high-quality honey demanded by the international market means increased investment, not only by producers who need to use alternative products for pest control, more intensive management, etc., but also from the cooperative, which lacks
mechanisms for self-financing and does not have adequate infrastructure. Much of the Lol-K’ax failure to produce 18% honey in 1999 was the result of poor handling practices due to a lack of infrastructure (containers were not well sealed and were stored in the open). Competing in the highest quality honey market with no infrastructure places the cooperative at a disadvantage and in a very fragile position. The Miel Maya experience resulted in relationships of trust-and-distrust among the different parties. The company has not been sure of the cooperative’s capacity to produce good quality honey, but has nevertheless given it the opportunity to do so. The cooperative is wary of the company’s fairness, because it has not shown sensitivity to the cooperative’s current situation and has not paid in advance, even while knowing that there is a lack of self-financing capacity and the infrastructure needed to meet the strict quality control terms. There is also some mistrust from Lol-k’ax members towards the cooperative itself, given that the Lol-K’ax enterprise of selling honey to alternative markets has implied eliminating the coyote-producer relationship without sufficient alternative financing. Lol-k’ax membership has changed from year to year; about 36% of the members resigned in 1999, while 50% of the members were new in 2000.

It is commonly agreed that the cooperative-Miel Maya business relationship has potential to bring great benefits in the future. However, for this to happen Lol-K’ax needs to strengthen its self-financing mechanisms, develop a trustworthy relationship with all of its members, and understand and predict production capacity. For Miel Maya, Lol-K’ax as a supplier is still an “experiment,” and it will not consider the cooperative as part of the enterprise until further demonstrations of production capacity are completed. Lol-K’ax 2000’s commercialization was largely a failure, because although it was able to
purchase honey produced from all of its members (through state credit\(^5\)) and fulfilled its agreement with Miel Maya successfully, this represented only 25% of the total production. The rest of the honey was sent to a national market under a previous “word agreement”. This honey was not paid for as of 2000, and Lol-k’ax has also delayed paying the state government. Thus, Lol-K’ax is in a very fragile position. However, the cooperatives’ experience and knowledge about honey commercialization is increasing and perhaps moving it closer to achieving production and commercialization goals.

**Prospects for Lol-K’ax**

Regardless of the problems that have come about with establishing markets, Lol-k’ax has begun to create mechanisms for establishing their enterprise by investing with the only capital they have: bees and equipment. With the contribution of one brood chamber of bees per member, the cooperative established several apiaries at the beginning of 2000. The idea was to create self-sustaining production systems to support the cooperative. Apiary production for 2000 was very low (4.2% of total production) because the apiaries were still in the establishment phase. Nevertheless, they were established with the supervision of an apiculture specialist, using advanced techniques for obtaining high production. Some of the production practices carried out in the cooperative’s apiaries and presented in technical training programs to Lol-K’ax members are provided in Table 4.

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\(^5\) The credit was provided by the Fondo Nacional de Apoyo a la Empresa Social (FONAES), which translates into National Fund for Aiding Social Enterprise.
Table 4. Some production practices taught at the Technical Training Program for Lol-K’ax members and used in the cooperative’s apiaries at La Montaña.

- Harvest management methods specifically to control water content
- Control of contamination of honey from the use of chemicals and antibiotics used in conventional pest and parasite control.
- Use of organic alternatives for controlling pests and parasites.
- Queen rearing.
- Queen systematic replacement.
- Use of queen excluders.
- Adequate supervision of brood and honey supers.
- Use of organic wax foundations (made from beeswax rather than synthetic alternatives).
- Use of adequate clothing and equipment.

The cooperative’s apiaries are intended to provide a source of cash for the cooperative itself, as well as to serve as models and learning centers. As explained before, beekeeping skills in the area are low and technical support for increasing productive capacity in the region is very important. Only a small group of beekeepers are substantially contributing to production. 2000’s production is very illustrative of the latter. Only 15% of the members of Lol-K’ax produced over 44.4% of the total production for the year. The rest, about 85% of total producers, accounted for only 55.6% of total production (Figure 9).

Another objective of the cooperative’s apiaries is to establish productive units where organic honey can be produced. This will potentially bring added value or market share to production. At the same time, it is intended that in the mid- to long-term, the apiaries can serve as models for producing other bee products for sale in alternative markets.
Figure 9. Metric tons of honey produced in 2000 by each of the 74 producers belonging to the Lol-K’ax cooperative. Data obtained from Lol-k’ax financial summary of 2000.

Benefits for Lol-k’ax so far, in addition to the new technology and commercialization, have been the acknowledgment from members that beekeeping can provide a viable alternative income for beekeepers and their families, provided there is an investment. Another issue is the inclusion of women in honey production, especially if they want to be part of the Fair Market. Generally, Maya culture does not encourage the participation of women in these types of businesses. Currently, the beekeepers of the community of Belha are women, who were only given the opportunity of belonging to the cooperative after Lol-K’ax learned about the advantages of having women as members. They now intend to include more women in beekeeping in the region.

Lol-K’ax goals are to be able to strengthen the cooperative and to reinforce its ties with Miel Maya, as well as with other markets. Ties with domestic markets are also important, since a large part of their production is not export quality honey. Other

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6 The IFAT’s “code of conduct” also includes a section under Equal Employment Opportunities, which states “to oppose discrimination and ensure equality of employment opportunities for both men and women who suffer from the exploitation of their labor and effects of poverty and racial, cultural or gender bias” (taken from internet web page http://www.goedwerk.nl/engels/en_page2.html).
alternative markets, such as the organic market and the market for other bee products, could expand possibilities for Lol-K’ax and for the region in general.

**Conclusions**

At La Montaña, honey production is currently the number one income generating activity. Although there are traces of traditional beekeeping, as some individuals still keep colonies of native bees, this is becoming less and less common. A large proportion of the economically active population manage *Apis mellifera* bees, with the objective of commercializing their products through the regional, national and international markets. The arrival of the Africanized bee (with its high numbers of feral populations), together with better communication and transportation systems, has brought new prospects for beekeeping in the region.

At La Montaña, the use of timber and non-timber forest products has been the major land use type. Today, timber resources do not bring much profit to the communities, as most of the valuable species (e.g., *Cedrela odorata* and *Swietenia macrophylla*) have already been logged out and the use of other species has not developed. Non-timber forest products, such as chicle extraction and honey production, represent the current best alternatives for making a profit from forest resources. As agricultural activities gain importance (e.g., ranching and mechanization), it is important to consider their impacts on apiculture, as well as their viability of non-timber forest products as economic options for development in the region, if the forest cover is to be conserved.

Chicle has been a major export commodity in the region throughout the 20th century, but current market trends have not been favorable. On the other hand,
Beekeeping has recently developed, and much of the honey produced is being sold nationally and internationally. Unfortunately, profits are benefiting only a small sector of the population that has better management skills and investment capacity.

Beekeeping could provide a better economic benefit to a larger sector of the population. An example of this is provided by Lol-k’ax, a cooperative formed recently by a small number of beekeepers from different communities. Lol-k’ax was formed with the assistance of Oxfam/Comadep with the objective of providing technical training to increase productivity and also to facilitate commercialization. Lol-k’ax is beginning to establish market ties with the international “Fair” market which provides better prices. Nevertheless, the experience has not been an easy one as Lol-k’ax needs to find mechanisms of self-financing and comply with high quality standards at a time when skills and resources are still extremely limited. Better technology and skills, as well as the diversification of the activity (e.g., to include the production of organic honey, pollen, royal jelly, propoli, etc.) could provide more benefits to the region. Nevertheless, for this to happen there needs to be external investment such as from NGOs or other agencies, particularly to increase the organizational, administrative and technical skills of beekeepers.

In spite of the limitations, there are strong prospects for beekeeping in the area. The next chapters will deal with the implications of beekeeping at the landscape level and its status as a non-timber forest product that favors the conservation of the forest cover. It is important to keep in mind that beekeeping as practiced today favors the increase of an exotic bee species that has proven to displace natural pollinators with unknown consequences for floral and faunal composition (Buchmann 1996, Roubik 1996a, Sugden
1996). Nevertheless, beekeeping at La Montaña and other similar areas in the Yucatan Peninsula presents an economic alternative to other land uses that will surely produce a great impact on forest composition, such as ranching.
CHAPTER 5
FLOWERING PHENOLOGY OF MELLIFEROUS SPECIES AND ITS RELATION TO THE BEEKEEPING CYCLE

Introduction

Throughout the Maya area, honey production has been part of management systems since ancient times. Maya people are known to have carried out intensive management of native bees of the subfamily Meliponinae, especially the stingless bee species *Melipona beecheii* Bennett (Chemas and Rico-Gray 1991). The current landscape is now populated by introduced honey bees (*Apis mellifera* L.) that share many of the same resources with native bee species, particularly of the genus *Melipona* (Roubik 1991, Roubik and Buchmann 1984, Roubik et al. 1986). Today, beekeeping with *Apis mellifera* represents an important economic activity for the Yucatan Peninsula. Although comprising only 8% of the Mexican territory, it contributes nearly 40% of national honey production. This figure is more significant in light of Mexico as one of the most important global honey producers and exporters (Echazarreta et al. 1997).

The landscape in the Yucatan Peninsula is known to be rich in nectar (melliferous) and pollen (polliniferous) yielding species (Rico-Gray et al. 1991). This characteristic favors beekeeping as nectar and pollen represent the major food sources for bees. Floral sources are distributed in the landscape both in space and time. In space, according to the distribution and abundance of melliferous and polliniferous species, and in time, according to the flowering periods of these species.
Flowering phenology among species varies in timing, duration and intensity, as well as in between-year variability in response to shifts in exogenous cues (Bronstein 1995). From a “plant-pollinator landscape” perspective, flowering phenology can be viewed as the regional flowering sequence of the entire set of acceptable plant species for a particular pollinator. According to Bronstein (1995), the plant-pollinator landscape is determined by an interacting set of plant and pollinator attributes, including flowering phenology and the pollinators’ search behavior and dietary specificities. For generalist pollinators, such as the honey bee, inter-annual variation in flowering patterns of a single species makes little difference, but rather it is the entire set of acceptable plant species that is important. Honey bee colonies adjust their foraging patterns in time and space, tracking the changing mosaic of nectar sources (Sneyd and Camazine 1991). Therefore, foraging decisions are made at a spatial scale other than the one at which phenology varies within a single species and foragers are likely to switch to a different species instead of searching out phenologically retarded patches or individuals of the same species (Bronstein 1995).

Flowers provide bees with the food sources they require in the form of nectar and pollen, although extrafloral nectar, honeydew produced by insects from plant sap, and exposed sap may contribute to some extent in certain settings (Crane 1990). Nectar is produced by plant species as a reward to visitors and therefore not all flowering species produce nectar and not all nectar produced by flowers may be accessible to honey bees (Bastiaan 1984). According to Crane (1990), only 16% of the world’s flowering plant species contribute to honey bees as a food source and only 1.6% are the source of most of the world’s honey. Nevertheless, the latter figure represents as many as 4000 different
flowering species that produce nectar. Nectarless flowers that produce large loads of pollen and that are known to be visited by bees may also be important bee resources (Roubik 1991; Villanueva 1994).

Lists of important melliferous/polliniferous species in the Yucatan Peninsula and other tropical areas have been compiled by a number of researchers (Crane 1990, Espina and Ordetx 1983, Lopez-Palacios 1986, Roubik 1991, SAGAR 1998, Sarah Workman, unpublished, Souza-Novelo 1981, Villanueva 1994). These species may be identified by conducting melissopalynological studies (pollen analysis in honey samples in order to determine the nectar sources of honey bees) (Roubik 1991, Villanueva 1994), or by using “scale-hive records”, measuring changes in the weight of a colony of bees and relating it to flowering sources (Crane 1990). However, the opinion of experienced beekeepers can serve just as well, if not better, in forming an idea of which nectar sources are of importance to honey bees (Chemas and Rico-Gray 1991, Roubik 1991).

The contribution of a species to honey production is not only a product of its flowering phenology, but also varies according to nectar quality and load. The energy value of nectar and the nutritional value of pollen vary markedly among plant taxa. Nectar sugar concentrations in flowers range from 10 to 80 percent, with concentrations varying not only according to plant species, but also at the flower level throughout the day (Roubik 1991). The composition of pollen also varies greatly according to the plant source; for example, protein concentrations range from 7 to 30 % (Crane 1990). Relative abundance may also be important in determining a species’ contributions to honey production. Nevertheless, many flower visitors such as honey bees have ranges that include many patches in which they forage very selectively. For example, Roubik (1991)
estimated that honey bees can exploit an area up to 300 km². So total resource availability is not directly correlated to resource availability per unit area (Corlett 1993).

At La Montaña region, north of the Calakmul Biosphere Reserve in Campeche, Mexico, beekeeping represent one of the most important economic activities (Porter 1995, Galletti 2000). The objective of this research was to establish what are the most important melliferous and polliniferous species in this area according to beekeepers’ information and to conduct a community-level flowering phenology study in order to assess resource availability for bees through time. The questions leading this research were:

- What is the relation between flowering patterns and the beekeeping annual cycle in this forested area of the Maya landscape?
- How does this relation differ from other more agriculturally oriented areas?
- And, what are the implications for honey production and marketing and for forest conservation?

Knowing the importance of the different species for honey production will help us understand the role of biodiversity for beekeeping, and the implications of this role for forest conservation.

**Study Area and Methods**

La Montaña is an area north of the Calakmul Biosphere Reserve in the state of Campeche, Mexico. It is formed by a group of eight ejidos occupying an area of approximately 184,340 ha and having a population of about 2700 inhabitants, mostly of Yucatec-Mayan origin (Galletti 1999). The climate of the area has been determined, according to the Köppen climate classification system as modified by Garcia (1973), to be of the sub-humid, warm tropical type (Flores and Espejel 1994). The mean annual
temperature is above 22°C and the mean annual precipitation is 1,223 mm (1984 to 2000, data obtained from the Comisión Nacional del Agua). The most dominant vegetation type is medium-stature subperennifoleus forests, where the mean height for trees is 25 m and where from 25 to 50% of the tree species shed their leaves during the dry season. This type of vegetation is mixed with high-stature subperennifoleus forests, low-stature forests that are inundated periodically, aquatic vegetation, and secondary vegetation in different successional stages (Ucan et al. 1999). Soils in the area have been formed mostly by the dissolution of calcareous rocks, which over time has resulted in a karst topography (Flores and Espejel 1994). Drainage is subterranean with no superficial flows of water, except in the rainy season during storms and periods of inundation, when rain can be very intense and water moves in temporary surface flow channels. Generally, lowlands are nourished by filtration of karst during the humid season and become dry to varying degrees depending on recharge through the dry season (Gates 1999).

A list of the most important melliferous/polliniferous species for the La Montaña region was developed on the basis of information from beekeepers. The field research period lasted from November 1998 through June 2000. The list was constructed over the entire field period, during which time I was studying the beekeepers’ management process through formal and informal interviews and interacting with local beekeepers for two honey production seasons, as well as learning about the vegetation. For most of the species, I collected a sample and took it for identification to the Alfredo Barrera Marin Herbarium at the Universidad Autónoma de Yucatán.

Data on flowering phenology were derived utilizing three techniques: 1) regular monitoring of marked individuals of 32 of the most important species for honey bees, 2)
daily observations of flowering during my 18 months of living in the forest, and 3) through informal and formal interviews with beekeepers.

For the mark-and-monitor study, five individuals (the minimum number suggested by Frankie et al. (1974) for conducting phenological studies on plant populations) of each of 32 different species were tagged and monitored every 15 to 30 days for 14 months. These species were chosen on the basis of preliminary interviews with 10 beekeepers, although as research progressed, the list of important melliferous and polliniferous species grew. The marked individuals were located along two transects. One transect was 7 km long and ran along a west-east line, starting from the major road, north of the Xmaben intersection. This transect was characterized as running through upland forests of different age classes, including recently abandoned milpas or fallow areas, then an older lowland forest, and ending with an open area characterized by savanna vegetation. The second transect was 2 km long and ran through an upland forest of intermediate age, northeast of the community of Xmaben. Every other week, walks along the two transects were made and flowering of selected species was recorded as: 0 = no flowering, 1= presence of flower buds, and 2= flowering. Similar studies were conducted by Alencar (1998), Bullock and Solis-Magallanes (1990), Carabias and Guevara (1985) and Hilty (1980) (among others) for describing population or community reproductive phenological patterns of groups of selected species in different seasonal tropical settings.

The 32 monitored species represent only a sub-sample of the important melliferous and polliniferous species, and my knowledge increased over time as I interacted with beekeepers in the different seasons. Therefore, the mark-and-monitor
data were complemented by recording flowering observations. These were made during regular visits to the different ejidos and supplemented by information provided by beekeepers at the different sites. I conducted monthly visits to 13 different apiaries in 5 different ejidos, made regular drives along the major road (going 40 km north to south) from Xmaben to Belha, and through the new Chanchen-Chunek road, a 16 km road that had just been made the previous year by cutting through older forest. Examples of phenological studies conducted in such semi-qualitative manner have also been reported by Corlett (1990 and 1993), who stated that making repeated observations on marked trees, even though it provides more detailed individual and specie’s level phenologies, limits the number of species that can be monitored.

Observations of flowering periods were annotated with information derived from informal talks with local beekeepers. At each visit to an apiary, which were made every two to three weeks over 18 months, I asked beekeepers what plants had flowered, which were flowering at the moment, and which were about to flower. This also provided information that related the flowering phenology to the beekeeping cycle. This ancillary information was judged to be reliable, since local beekeepers require this knowledge and their ultimate failure or success depends on it to a large degree. Beekeepers need to know, for example, when it is time to introduce new combs, raise supers, get ready for harvest, or provide artificial “feed” to their bees to prevent their absconding. Thus, knowledge about flowering events, as well as other related ecological and climatological processes, is derived through personal observation and trial and error, life-long education, myths and tradition, and the everyday exchange of information, and becomes part of their overall management system.
With this information, as well as with data collected through my mark-and-monitor study, I made a final “flowering chart” that was reviewed and corrected in formal interviews made with five key informants at the end of the field study. The “flowering chart” that I present here was constructed in collaboration with these 5 local beekeepers (although it includes information provided by many others). Their knowledge and input enabled me to extend this assessment to a period greater than the 18 months of my observations and data recording.

**Results and Discussion**

**Melliferous/Polliniferous Species and Their Relation to the Beekeeping Cycle**

The list of the most important melliferous/polliniferous species in La Montaña includes more than 100 species from more than 67 genera and 31 families of trees, shrubs, vines, woody-vines, and annuals found in the different vegetation types of the area (Annex 1). The importance of the different species as nectar or pollen sources depends on their abundance over the landscape, their nectar or pollen quality and load, and on their flowering phenology in relation to the beekeeping cycle.

The “flowering chart” depicts the flowering periods of the different species, and its relation to the beekeeping cycle (Figures 10 and 11). These include data from both my qualitative and quantitative observations (Annex 2) as well as the input from local beekeepers.

Four distinct seasons in the beekeeping management cycle are identified in relation to flowering patterns:

1. The **honey harvest season** occurs during the dry season, from mid-February to early May, when there is a burst of flowering and conditions are good for bee foraging. This is the time when high-quality honey is harvested.
2. The **high-water content honey season** occurs from the end of the dry season through the beginning of the rainy season, in May and June. Flowering peaks during this time, but honey produced may not always be marketable due to high water content. At the same time, weather conditions may constrain bee foraging since, according to local beekeepers, bees do not forage on rainy days and heavy rains may also wash out the nectar produced in the flowers before bees are able to access it. Beekeepers at this time prepare for the dearth period by making honey reserves either by not harvesting it or by saving it in containers for feeding it back to bees later.

3. The **dearth season** is the period when there is little flowering. This period occurs from August to October when only less than 10% of the species may be in flower. The little flowering that occurs at this time becomes critical for colony maintenance, although beekeepers may also need to provide feed to their bees.

4. The **recovery period** lasts from November to January or the beginning of February, the end of the rainy season and is characterized by having an increase in flowering (mostly by annual shrubs and vines). During this time, bee colonies recover strength and prepare for flower abundance. The extent in which bee colonies recover during this time varies from year to year, not only depending on flower availability, but also on weather conditions given that bees reduce their activity on cold days (Mendes and Camargo 1991), and on management by beekeepers, who need to supply colonies with resources such as comb foundations. Another factor that affects recovery is the flowering of a tree species, *Casimiroa tetrameria* (Rutaceae), the nectar from which is poisonous to the exotic bees.

A study conducted by Chemas and Rico-Gray (1991) in the area of Tixcacaltuyub, Yucatan, reported that the annual honey production cycle in that area starts in October (after the rainy season), with a good-quality honey harvest period from November to March, and a period of high water content honey harvest from mid-May to mid-September. They also report that during the rainy season only a few species flower and bees may be threatened by a shortage of resources, forcing beekeepers to feed them sugar and honey with more frequency than at La Montaña. In the north, the beekeeping cycle is advanced (i.e., the honey harvest season starts and ends earlier). Site differences, such as more dry conditions and particularly the absence of mature forests, explain part of the differences observed in the beekeeping cycle of the northern Yucatan Peninsula.
Even in areas closer to La Montaña, such as the northern Hopelchen area that is more agriculturally oriented, beekeepers report that the honey harvest begins and ends earlier. Flores (1990) reported the flowering periods of Leguminosae (the family with the most number of melliferous species at the Peninsula level) in relation to honey production in the Yucatan Peninsula. He found that, in general terms, shrubs flower at the end of the rainy period, annuals and climbers bloom in the rainy to dry period, and trees, even though different species flower during the different seasons of the year, mainly flower in the dry to rainy transition period. This pattern also seems evident in other families. The higher abundance of shrubs and climbers in the more agricultural northern areas may also help explain the earlier honey harvest pattern there, since honey production depends greatly on these species that flower earlier. The reduced abundance of flowering trees during low-flowering periods may explain the higher reliance of artificial bee feeding in these areas. Honey in the northern, more agriculturally oriented areas, may produce larger quantities of single-species honey (particularly from Viguiera dentata, Gymnopodium floribundum, and Turbina corymbosa; Flores et al. 1990), a characteristic appreciated by the honey market, as opposed to the honey produced in the La Montaña region that relies more on multiple flowering species of the forest. Production of high-water content honey may also be greater at La Montaña because of its reliance on tree species whose flowering occurs closer to the rainy season.
Figure 10. Flowering phenology of melliferous and polliniferous species at La Montaña, Campeche, México.
Figure 11. Number of flowering melliferous and polliniferous species and their relation with the beekeeping annual cycle at La Montaña, Campeche, México.
Community Level Flowering Phenology

Community level flowering phenology at La Montaña is highly seasonal, with most species flowering in the transition from the dry to rainy seasons, but with many flowering through the entire dry period (Figure 12). Although mean annual precipitation in the area is 1223 mm, there are significant variations from year to year that influence phenological patterns. For example, annual rainfall was registered as 648 mm in 1986 and as 1807 mm in 1999. The rainy season lasts from May/June through August and into September-October. Southeastern winds with a strong eastern influence predominate, resulting from the northern shifting of the Intertropical Convergence Zone and the High Pressure Subtropical Zone. Summer rains, although abundant, are characterized as calm, and during the fall rainfall is characterized by strong storms influenced by hurricane events. The dry period extends from November to April or May, during which time the influence of cold winds from the north causes light rains that total 30% of annual precipitation (Flores and Espejel 1994). These rains are locally known as cabañuelas.

Flowering during the dry season at La Montaña (February to April), when 31% of the species may be in flower, contributes the most to annual honey production. Cabañuelas at this time are of great importance and flowering or nectar yields of many species are greatly dependent upon them. These rain events are generally very localized, so that flowering episodes for many species vary from site to site. Bullock and Solis-Magallanes (1990) also reported the importance of cabañuelas for phenology in other tropical deciduous forests in México, where soil water retention capacity is not likely to play a role. As a consequence of yearly variations, honey production in the area may vary greatly from year to year.
During the early rainy season, flowering may contribute to good-quality honey production, depending on early rainfall intensity; people report that good-quality honey can be harvested as late as June in some years. At the beginning of the rainy period (May) and extending into July, as many as 47% of the species may be in flower. Once wetter conditions in the area are established and during the September and October, only 10% of the species may be in flower. At the beginning of the dry season or the end of the rainy season, flowering increases and gives way to the bee recovery period. During this time, 12% of the species may be in flower, but many of them yield large quantities of nectar, strengthening bee colonies and contributing to a good honey harvest during the following season. Thus, the general pattern presented in Figure 3 varies from year to year. Furthermore, the contribution of each of the flowering species to honey production
at any given productive unit will also depend on its specific location and site characteristics.

The general flowering pattern of the most important melliferous and polliniferous species at La Montaña resemble the pattern reported by other reproductive phenological studies carried out elsewhere in the dry tropics. Dry tropical lowlands generally peak in flowering activity during the end of the dry season and the early wet season (Bullock and Solis-Magallanes 1990, Croat 1975, Daubenmire 1972). However, this does not hold true for all life forms, as was reported by De Steven et al. (1987) for phenological patterns of a palm assemblage in Barro Colorado Island, Panama, where flowering peaked during the mid-rainy season. It also is not geographically uniform, as shown by Lieberman (1982), who reported that flowering of most species in a dry tropical forest in Ghana also occurred in the rainiest periods. Frankie et al. (1974) found that flowering peaked during the dry season but had a less important peak at the onset of the rainy season in a dry forest lowland area in Costa Rica.

Although flowering may peak at a certain time in dry tropical lowlands, usually there are other important flowering events that relate either to the dry period or to second and shorter dry-wet or wet-dry transitions (Borchert 1995, Bullock and Solis-Magallanes 1990, Croat 1975, Daubenmire 1972). This pattern also corresponds with observations at La Montaña, where many species flowered either during the transition from the rainy to the dry season, or during the dry season.

Generally, phenology in tropical areas correlates with the seasonality of rainfall and in less seasonal rainfall areas, phenological patterns are also less seasonal (Frankie et al. 1974, Hilty 1980, Koptur et al. 1988, Putz 1979, ). Nevertheless, phenological patterns
differ widely among species and also among conspecific trees under the same set of climatic conditions (Borchert 1995). These differences are attributed to various factors that may play a role in determining a specie’s phenological pattern, which may be biotic or abiotic and can either be endogenous or exogenous to individuals (Leigh 1990). Natural selection and co-evolution with pollinators, dispersers, predators and competitors have been suggested to play a role (Bawa 1974, Janzen 1967, Koptur et al. 1988, Lieberman 1982). Variations in tropical environments such as temperature, humidity, rainfall, wind speed and daylight, may also be important in triggering phenological events (Lieberman 1982). Nevertheless, there is strong evidence that the driving force of phenological patterns particularly in dry or seasonal areas of the lowland tropics is water availability, which depends not only on rainfall and its intensity, but also on soil conditions and hydrology (Borchert 1994, Bullock and Solis Magallanes 1990) and on the physiological status and vegetative morphology of plant species (Borchert 1994, Reich and Borchert 1984). For any given species, tree water status varies according to factors such as the structure and life-span of leaves, time of leaf shedding, wood density and capacity for stem water storage, and depth and density of root systems (Borchert 1995). According to Borchert (1995), the wide variation of tree phenology found in dry forests within the same climatic regime is caused by variations among these components of the soil-plant-atmosphere continuum. Differences in flowering patterns of the different populations of the most important melliferous and polliniferous species at La Montaña may be explained by such factors.

Flowering patterns of the different species and their contribution to apiculture.

Observations on some species regarding their flowering phenology and their contribution to the beekeeping cycle are given below to exemplify the variation that
exists among the different species. Most of these species have an annual flowering pattern (according to the classification given by Newstrom et al. 1994), with variation among populations where flowering is more closely linked to rainfall events. The four seasons identified for beekeeping are used to order the discussion (honey-harvest, high-water-content honey, dearth period and recovery period). Species that have either subannual or continuous flowering patterns (Newstrom et al. 1994) are described in a separate section as multi-flowering species. The descriptions also indicate where (i.e., vegetation type, soil conditions, topography) species are found in most abundance (this latter information was obtained mostly from beekeepers but also from vegetation sampling conducted by the author as described in Chapter 6).

**Honey-Harvest Flowering**

During the honey harvest season, from mid-February to mid- or late May, 41 different forest species are considered to be important sources of nectar and/or pollen for beekeepers at La Montaña. They are members of at least 15 families and 29 genera (Annex 1, A). Families that were represented by more than one species are Bignoniaceae (3 species, 2 genera), Bombacaceae (2 species, 1 genera), Boraginaceae (3 species, 2 genera), Euphorbiaceae (5 species, 2 genera), Leguminosae (10 species, 7 genera), Polygonaceae (2 species, 1 genera), Sapindaceae (3 species, 2 genera) and Sapotaceae (2 species, 1 genera). Genera that were represented by more than one species included *Tabebuia* (Bignoniaceae), *Cordia* (Boraginaceae), *Croton* (Euphorbiaceae), *Caesalpinia* and *Haematoxylon* (Leguminosae) and *Talisia* (Sapindaceae). The species considered to be of most importance for honey production in the Yucatan Peninsula, *Viguiera dentata* (Compositae), *Gymnopodium floribundum* (Polygonaceae) and *Piscidia piscipula*
(Leguminosae) (Chemas and Rico-Gray 1991, Flores 1990, Villanueva 1994), are also among the species considered to be most important at La Montaña.

During the honey-harvest period, beekeepers usually harvest honey every 15 or 20 days from mid-February to mid- or late May, depending on the timing of the beginning of the rainy season. Furthermore, the honey harvest season is a period of intensive work for beekeepers, because they have to visit their apiaries as often as every eight days. During this time they need to provide provisions to bee colonies, such as comb foundations, frames and supers, since populations are increasing very rapidly. Beekeepers also need to be aware of swarming and when necessary (usually at a later time) make colony divisions. In addition, beekeepers are often busy capturing feral swarms during this time, in order to increase colony numbers that may have been reduced during the dearth period.

The first honey harvest commences in early to mid-February and it is honey produced mainly from nectar of the annual *Viguiera dentata* (tajonal), and includes honey from other nectar sources that accumulated during the recovery period. During this time and beginning in December, numerous other annuals and herbaceous plants are also in bloom, many of which are visited by honey bees. Nevertheless, *Viguiera dentata* is considered the major nectar source at this time, since its massively blooming yellow flowers are abundant in recently disturbed areas, along roads and in abandoned agricultural areas.

Usually, the first honey harvest is considered by local beekeepers as “limpieza” honey, generally regarded as low-quality. Local beekeepers reported that this honey may have a bitter flavor, as a result of nectar from flowers of the previous season (presumably *Verbesina gigantea*) and sometimes has high water content. Most beekeepers prefer to
discard it before honey has ripened in the combs. This conservative management may also benefit consumers since early honey may contain residues of chemical treatments applied earlier against varroasis (a sickness produced by a mite) or other parasites.

*Viguiera dentata* is a good source of pollen and honey provided there is sufficient humidity. Its flowering period can last from mid-January to the end of February, although flowering in the 2000 season lasted only until the beginning of February because of an unusual drought. Two or three harvests from this nectar source can be obtained, including the “limpieza” harvest, especially from apiaries found near the most disturbed areas. Nevertheless, *Viguiera dentata* is not as good a nectar source as it is in other areas of the Yucatan Peninsula, where agriculture is the major land use type. At La Montaña, activities have been traditionally more linked to forestry and agroforestry and therefore this species is not very abundant. *Viguiera dentata* is considered a weed that retards tree regeneration (Turner et al. 2001).

Several leguminous species are important nectar and pollen sources at the beginning of the honey harvest season. *Caesalpinia gaumeri*, a nectar yielding tree species found in secondary vegetation and upland forests, flowers massively during January and February. Its conspicuous yellow flowers open after trees have completely shed their leaves regardless of rains, although it may not always yield nectar. *Caesalpinia yucatanensis*, a small tree found in secondary vegetation mainly in lowland areas, produce large yellow and orange flowers during February while bearing leaves. Although this tree produces only small amounts of nectar, it is a major source of pollen and is important at this time because bees are increasing their populations and therefore require large amounts of pollen for feeding their young. *Haematoxylon campechianum*
and *H. brasiletto*, two trees found in lowland areas and savannas that often form large single species stands known as *tintales* (Flores and Espejel 1994), are important nectar sources in the bajos. They produce large amounts of flowers from the end of January to the middle of March, although *H. brasiletto*, the species mainly found in savanna areas, may flower later. *Gliricidia sepium* is a nectar yielding species found in all types of soils and vegetation ages, and flowers from mid-February to April. This species, like *C. gaumeri*, shows massive white to pink flowers that are very conspicuous among its leafless branches. In areas where it is abundant, it can be an important source of nectar, and beekeepers in the Xnoha area reported having harvested large amounts of honey produced while *Gliricidia* was in flower. Nevertheless, its nectar yields are highly rain dependant (Espinosa and Ordex 1983). *Platymiscium yucatanum*, a timber species with valuable wood that has been extensively logged in some areas, may sometimes be another good nectar source. It flowers massively after a rainfall event between mid-February and mid-March, but lasts only a few days. Although it has large amounts of flowers that produce large quantities of nectar, it may not contribute much to honey production since it is not very abundant and its flowering period is very short; in the absence of a rain event it may not flower at all. Flower buds were observed in 1999, but because of drought they seemed to abort before they opened. Another species that has a flowering behavior similar to *P. yucatanum*, with a short synchronized flowering period after a rainfall event, is the **susuyuk** tree, a *Croton* species (Euphorbiaceae) that may flower sometime after the end of February. This species is the first of several *Croton* species that may contribute substantially to honey production, since they yield abundant nectar provided there are sufficient rains.
One of the most important nectar sources in the La Montaña area is the tree *Bucida buceras* (pukte’). It has an extended flowering period that lasts from mid-January to mid-May, encompassing the entire harvest period. Pukte’ is a common tree in the lowland forests where it can grow to be very large, reaching up to 35 m in height and having diameters at breast height (dbh) of up to 1.5 m, sometimes forming single species stands known as puktales (Pennington and Sarukhan 1998). It is reported by the local people that this tree is one of the few species that withstands strong hurricanes. It produces large quantities of nectar yielding flowers for long periods of time and is considered to be a prime nectar yielding tree.

Very large individuals *Ceiba pentandra* (ceibo), the sacred tree of the Maya, are found in areas where human settlement is likely to have occurred in the past, such as near water bodies, or in kakabales or ramonales (vegetation communities characterized by local people as growing in areas with archeological remains). The ceibo tree is also very common in urban areas. This is a bat-pollinated tree with high flower production that yields abundant nectar and pollen, but which is also known to be visited by birds, small mammals and insects including honey-bees (Toledo 1977, Espina and Ordetx 1983). At La Montaña, it flowers during January and February.

Other important nectar sources at the beginning of the harvest season are *Tabebuia chrysantha* and *T. roseae*. These are large trees that grow in secondary vegetation, or quemadales (areas that have experienced wildfires) of lowland areas or near savannas. Their large yellow (*T. chrysantha*) or whitish-pink to dark pink (*T. rosea*) flowers displayed on bare branches, are nectar yielding and have been reported to be adapted for insect-pollination (Toledo 1977). Different individuals or stands of
individuals may flower at any time during an extended period that lasts from mid-February to mid-June. Gómez-Figueroa and Fournier (1996) report that differences in flowering phenology observed in two populations of *T. rosea* found in different sites of Costa Rica were produced by differences in temperature and soil moisture, since this species requires high temperatures and a dry period to flower. This may explain why trees of *T. rosea* at La Montaña found in different areas were seen to flower at different times.

*Crescentia cujete* (*güiro*), an abundant species in lowland areas and particularly in savanna communities, is another nectar yielding species that has an extended flowering period lasting as long as from January to May. Few flowers are commonly produced by each individual tree for a long period of time, although local people report that flowering greatly increases in intensity after the savanna has burned. Savanna burning is carried out every year according to local people as a management practice, to encourage grass resprouting for cattle and to enhance deer hunting, as well as to increase flower production. This species is characteristically bat pollinated, although it is reported in the literature that other insects, including bees, forage on its abundant nectar loads (Bestmann et al. 1997), as has been observed by local people at La Montaña.

Among the nectar sources that flower in March are *Talisia olivaeformis* and *Ehretia tinifolia*. *T. olivaeformis* (*guaya*), and *E. tinifolia* (*beek*), are two evergreen species found in the upland forests that are also widely found in urban settings. These two trees are commonly found in the *kakabales* or *ramonales*, for which it is alleged that they were cultivated by the Mayas since ancient times. *Guayas* are appreciated for their
fruits and the **beek** tree because of its shade and because animals forage on its fruits. **Beek** is also used for medicinal purposes. These trees produce abundant flowers on which many bees can be observed imbibing nectar. The **beek** tree flowers from March to April. **Guaya**, a dioecious species, flowers during March but it was observed by local beekeepers to hold flowers on male trees for a longer period of time.

One of the most important species for honey production is *Gymnopodium floribundum* (tsitsilche’), the species considered to be of most importance for apiculture in the Yucatan state. Honey produced from this species is of very high quality. This small tree is found in abundance in secondary vegetation and to some extent in upland and lowland forests, where it flowers massively producing very perfumed nectar-yielding greenish flowers. At la Montaña, it may flower from March to June, depending on rains. After a rain event, a burst of flowering occurs that lasts for a period of about one or two weeks. It may have several episodes of flowering in relation to rain events, as was observed in 1999 when the same stand of *Gymnopodium floribundum* flowered both in April and in June. On the other hand, even where this species is abundant it did not flower until June in 2000, when it started to rain.

Some of the pollen sources during March are *Chrysophyllum mexicanum*, *Dipholis salicifolia*, *Pseudobombax ellipticum*. *Chrysophyllum mexicanum*, (Sapotaceae), is a forest tree that grows in upland and lowland forests. It flowers in March and although it yields little amounts of nectar, it is a major pollen source. Another pollen yielding member of the Sapotaceae is *Dipholis salicifolia*, a tree that grows in upland forests but that can also be found in secondary vegetation of well drained areas. According to local beekeepers, it flowers during March and April, although I observed
flower buds in February. It is not an abundant tree, but is reported to be important for apiculture because of its extended flowering period. Another upland forest tree, *Pseudobombax ellipticum*, is a bat-pollinated species with large flowers that contain several hundred stamens each. This species has been reported to be a pollen source for Africanized honey bees in central lowland Panama and Quintana Roo (Roubik 1991, Villanueva 1994). It is also reported by local beekeepers at La Montaña to be a major pollen source. It flowers during March and April when its conspicuous flowers are visible on bare branches.

*Metopium brownei* is an abundant tree in secondary and upland forests. It has an extended flowering period that begins in March and can last until the beginning of May. It produces racemose axillary flowers on leaf bearing branches that produce abundant nectar. This dioecious species is a secure source of nectar at La Montaña. *Metopium brownei* was observed flowering even in drought periods in which other species had delayed flowering.

Flowering of several *Croton* species is important for honey production. These species are very abundant in secondary vegetation and yield large amounts of nectar, although their flowering depends on rain events that cause massive synchronous flowering. *Yash-p’eres*, (*Croto sp.*) is found in moderately to well-drained sites and flowers sometime between March and early May. This species can also be found in more mature vegetation conditions. According to local beekeepers, *yash p’eres* trees require only a light rain in order to flower. On the other hand, *Sak p’eres* (*Croton glabellus*) flowers after a heavy rain, which occur sometime from the end of March to the beginning of June. This species grows mainly in moderately drained areas. *P’eres de ak’alche’* (*C.
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*guatemalensis*, another abundant species, is only found in secondary vegetation on mainly poorly drained soils. It is reported that this species flowers sometime from the end of March to the beginning of May and that it requires a heavy rain to flower.

From April until May, the flowering of *Piscidia piscipula* (*jabin*) constitutes an important nectar source. Actually, many local beekeepers consider it to be the most important nectar source in the region. According to local beekeepers *Piscidia piscipula* flowers regardless of rains and always yields large quantities of nectar from its massive flowers that are formed on leafless branches. It is a leguminous tree found in secondary vegetation and mature forests on all soil types, where it is very abundant.

Other forest species that may contribute to honey production are species that flower several times during the year. These will be discussed in a different section below as multi-flowering species. There are also other species commonly found in agroforestry plots or agricultural areas that yield large amounts of nectar and/or pollen during the honey harvest season. Examples are mango (*Magnifera indica* L.), avocado (*Persea americana* Miller), many *Citrus* species, guano (*Sabal yapa* C. Wright ex Beccari), cocoyol (*Acrocomia mexicana* Karw. Ex Wart) and many others that are found in the diverse traditional Maya homegardens.

**High-Water-Content Honey Flowering**

The beginning of the rainy season is a time when many nectar or pollen yielding species are in flower. At this time, water content in honey is too high to be considered good quality. However, beekeepers may sometimes harvest the honey produced during this time and either sell it to the local market at lower prices, or store it for family use or for feeding bees during critical periods. Also, nectar and pollen produced during this time are important for bee colonies during the dearth period. Honey not harvested is
regarded by beekeepers as “maintenance honey”. Some of these flowers may contribute
to good-quality honey harvest but only for a short period of time, depending on the
intensity of the beginning of the rainy season.

From late May to July, 39 species are considered to be good sources of nectar and
pollen (Annex 1, B). These species are members of at least 16 families and 27 genera.
The families that are represented by more than one species are: Anacardiaceae (2 species,
1 genera), Euphorbiaceae (2 species, 1 genera), Leguminosae (9 species, 7 genera),
Malpighiaceae (2 species, 2 genera), Myrtaceae (3 species, 2 genera), Polygonaceae (3
species, 1 genera) and Rubiaceae (4 species, 4 genera). Families represented by one
species are: Ebenaceae, Lauraceae, Meliaceae, Nyctaginaceae, Olacaceae, Rhamnaceae,
Sterculiaceae, Ulmifera and Verbenaceae.

*Enterolobium cyclocarpum* (**piich**), is one of the species that flowers at the end of
the dry season and the beginning of the rainy season and therefore at times may
contribute to good-quality honey harvest. This is a legume species not very abundant in
the natural forests, but whose huge individuals (may grow up to 30 m in height and 3 m
in DBH, Pennington and Sarukhan 1998) can be found in upland forests in sites with rich
soils, as well as in **ramonales** or **kakabales**. A species widely appreciated by people, it
is also commonly found in urban areas. The flowering period of the **piich** tree lasts from
May or late April to early June. Each tree produces many nectar-yielding flowers.

*Lysiloma latisiliqua*, on the other hand, is a common tree growing in secondary
vegetation of well-drained areas as well as in upland forests that flowers from May to
June. Once this tree begins presenting its abundant high-nectar yielding flowers, even at
periods with low intensity rainfall, beekeepers know they will start collecting high-water content honey.

Important *Croton* species at this time are *C. reflexifolious* and *C. campechianus*. *C. reflexifolious*, a small tree that grows in abundance in secondary vegetation and is sometimes found in more mature forests, produces large amounts of highly-perfumed creamy colored flowers that yield large amounts of nectar. It flowers during June and July. *C. campechianus*, on the other hand, is not very common and is mainly found in upland sites with deep soils. This species is a source of nectar and pollen for bees during the months of May and June, although they are not produced in large quantities by the flowers.

A group of *Coccoloba* species from the Polygonaceae, an important family for honey production, are nectar sources during this time. *C. spicata*, a tree that can reach large sizes and found both in secondary vegetation and more mature forests in well-drained areas and flowers during May and June. *C. reflexiflora*, on the other hand, is a small tree that grows in lowland areas, flowers from the end of May to July. These two species are abundant in the area and their flowers are rich in nectar contributing to high-water-content honey production. A third *Coccoloba* species (unidentified) grows in savannas or near the savannas (areas distinguished by local people as specific vegetation communities, named *suuts*, which are described as lowland forests that inundate for long periods of time and border savannas). This is a bush or small tree that produces nectar-yielding flowers during July and August.

Some of the important pollen sources during this time are *Caesalpinia violaceae* and *Zea mais*. *Caesalpinia violaceae* flowers during the months of May and June. It is a
tree found mostly in upland forests. It is not very common but its bright yellow flowers produce large loads of pollen. *Zea mais* is cultivated in the agricultural plots or milpas scattered in different areas of the forest. This wind-pollinated species produces high quantities of pollen which is foraged by honey bees generally in August and September.

**Dearth Period Flowering.**

After the abundant flowering at the beginning of the rainy season, flowering drops dramatically for a long period of time that lasts from August to November. This is a critical period for beekeepers, since bee populations may decline or colonies may abscond in search of floral sources. The little flowering that occurs is very important at this time and in its absence beekeepers may need to provide external feed to their bees in the form of diluted honey or sugar, or by providing a pollen substitute. Management during the previous season is also important in determining the extent to which bee colonies will be affected by this dearth period, since colonies whose last honey production was harvested will be more vulnerable. At this time, beekeepers usually need to visit their apiaries every 15 days. It is also a time when many pests, parasites and predators may threaten and diminish bee colonies (Echazarreta et al. 1997).

A total of nine flowering species were identified as sources of honey or pollen during this extended time (Annex 1, C). The species are members of at least 5 different families. The most represented family is, again, the Leguminosae, contributing three different species. The remaining families are the Araliaceae, Malvaceae, Sapotaceae and Sapindaceae.

Although several plants flowering in the previous season may still be in flower in August, there is a noticeable drop (Figure 2). Species that may produce flowers during this time are *Colocarpum mammosum, Dendropanax arboreus* and an unidentified
species commonly known as Inche’. *Calocarpum mammosum*, a member of the Sapotaceae, is a nectar-yielding tree found in upland forests, which may only be common in areas with deep soils (kankabales). Another nectar-yielding tree common in upland forests with good drainage, is the timber species *Dendropanax arboreus*. This species flowers during August, although it did not set flowers during 1999. Another species that flowers during August is Inche’, a nectar-yielding bush or small tree found in the areas bordering the savannas or suuts.

*Hampea trilobata*, a dioecious species, is considered important because of its extended flowering period that lasts from August to September and because it yields large loads of nectar. This tree is common in secondary vegetation and in upland forests. Two leguminous species are also important during the month of September. *Lonchocarpus rugosus* is a nectar- and pollen-yielding species found in secondary vegetation and upland forests with a short flowering period in September. *Mimosa bahamensis*, a common bush in secondary vegetation, on the other hand, has an extended flowering period. It begins flowering during September and lasts until the beginning of December. This bush yields only small quantities of nectar but it produces large loads of pollen. Although this species is considered a good source of pollen for bees during the dearth period, some consider it to affect adversely their health.

During the month of October, an unidentified species of tree commonly known as Kaan chan, sets nectar-yielding flowers. This small tree is found in restricted areas of upland forest usually in deep soil areas (kakabales). Two important nectar sources at this time are *Allophyllus cominia* and *Bouhinia herrerae*. *Allophyllus cominia*, a bush member of the Sapindaceae, grows in young secondary vegetation derived from well-
drained areas. This is a good source of nectar but it also yields pollen during October and November. *Bouhina herrarae*, a leguminous climber, grows over secondary vegetation mostly in moderate- to poorly-drained areas. It is a source of nectar and its flowering period extends from October to early December.

**Recovery Period Flowering**

Flowering increases during the transition from the wet to the dry period. Of major importance is the flowering of annual vines and shrubs common in disturbed areas, mostly from the Compositae and Convolvulaceae families. At this time bee colonies may be weak and their populations greatly diminished. Many beekeepers may have lost many colonies that absconded from their apiaries. Flowering during this time, generally from November to mid-January (after which many other species start flowering) may contribute to strengthening bee populations, although it depends on weather conditions (e.g., since temperatures may drop during December and January and adversely affect bee colonies), factors such as the flowering of *Casimiroa tetrameria* that apparently obstructs the digestive tract of the bees (Victor Camara, personal communication), and the attention beekeepers give to their colonies.

Eleven species were observed to flower during this period, including five families (Annex 1, D). The most important species at this time, as already mentioned, are members of the Compositae and Convolvulaceae. Other families represented are the Rutaceae, Sapotaceae and Tiliaceae.

The increase of flowering in the region begins in the month of November, when *Allophyllus cominia* and *Bouhina herrarae* (two species already mentioned as important in the dearth period) are still in flower. This period is characterized by a noticeable boom of several annual shrubs and vines. This includes a *Viguiera* species very similar to
Viguiera dentata but which grows less abundantly, found also in secondary vegetation and in areas that have undergone a wildfire. This nectar- and pollen-yielding annual usually flowers for an extended period from November to December. Verbesina gigantean (Compositae), is an annual shrub that produces abundant flowers in its large individuals (can grow up to 5m in height). This shrub grows abundantly in secondary vegetation and is commonly visible along roads and other disturbed areas. Its flowering period extends from December to January and it yields abundant nectar and pollen.

Several people in the area consider that the nectar of its flower imparts a bitter flavor to honey. Other less abundant herbs, shrubs and vines of the Compositae are seen to start flowering at this time and probably contribute as nectar and pollen sources to bees.

Several vine species contribute substantially during this period. Turbina corymbosa, locally known as Xtabentun, is an annual vine very common throughout the Peninsula. It is considered to be one of the most important species for apiculture and sometimes provides a harvest of honey in some areas (Flores 1990). The abundant white flowers of this vine, growing in secondary vegetation and in recently disturbed areas, yield large loads of high quality nectar. At La Montaña, its flowering period lasts from December to January, although it was noted that in the Belha area (the southern-most part of the research area) flowering of Xtabentun also occurred during March in the year 2000. According to the people in Belha, Xtabentun may flower two times, but for people of the northern part of the region that was observed as a very strange event. It is important to note that weather conditions may vary much from north to south and in 2000 the Belha area experienced a rain event that people in the north did not.
Another annual vine species is *Jacqemontia pentantha*, locally known as **Solen ak**. This vine has blue flowers that are present for an extended period of time from December to mid-February and yield large quantities of nectar. **Solen ak** grows in recently disturbed areas and in secondary vegetation. People in the area reported that there is another **Solen ak** species that has white flowers and also is important as a nectar source.

Some of the trees that flower during this time that are reported to provide nectar and pollen to bees are *Manilkara zapota*, and *Luehea speciosa*. *Manilkara sapota*, a tree whose individuals are sparsely represented in the forests, sometimes attains very large sizes since it is a protected species for the extraction of **chicle**. It flowers during November and is reported to provide nectar to bees. *Luehea speciosa* is a common tree in disturbed areas that may also be found in more mature forests and has large white flowers from November to December. Although local beekeepers were not sure of its importance as a source for bees, beekeepers observed during 2000 that bees were obtaining nectar and pollen from its flowers.

Another tree that flowers during the recovery period is the already mentioned *Casimiroa tetrameria*, a tree that is reported to be detrimental to bee colonies. This is readily observed by beekeepers who report that while in flower, numerous bees are found dead near the apiaries. The flowering of this tree, which occurs from November to December and sometimes January (as observed in 1999), can be a major threat to beekeeping in the area. It is reported that the species may flower more than one time. Local beekeepers treat their bees with salt during this time as a preventive mechanism,
since it seems to lessen the effect that this nectar has on the bee’s health. Nevertheless they constantly report serious losses resulting from the flowering of this tree.

**Multiple Flowering Species**

There are a few other species that contribute to beekeeping in different times but that are considered separately because they flower several times during the year (Annex 1, E). *Lonchocarpus xuul* is a Leguminosae tree with a biannual flowering mode. This tree is found in secondary vegetation and in more mature vegetation of poorly-drained areas and has some of the largest individual trees in the *bajo* areas. It is reported by local beekeepers to flower at two times, in March-April, contributing to honey harvest, and in November, as a source of nectar for the recovery period. Another species with a biannual flowering mode is *Brosimum alicastrum* (Moraceae). This tree is considered to be one of the most important species in the region for the multiple services it provides, since it is used for feed for horses and cattle and its fruits are edible. It is found in abundance in the areas known as *kakabales* or *ramonales* (actually the word *ramonales* is derived from the common name of *B. alicastrum*, *Ramon*, which is very abundant at these sites and can sometimes be present in large single-species stands). This is another tree presumed to have been widely cultivated by people in the past and which is still being cultivated; it is very common in urban areas and agroforestry plots. Although *B. alicastrum* does not produce nectar, it is a rich source of pollen, as reported by local beekeepers and by Espina and Ordetx (1983). Flowers are produced during August and for a second time in November.

Species that flower multiple times during the year, sometimes more than three, which could characterize them as continuous flowering species include *Thouinia paucidentata* and *Cissus sicyoides*. *Thouinia paucidentata* (Sapindaceae) is a species that
flowers at least three times a year, provided there are strong rainfall events that induce it. It was observed that flower buds were ready most of the time and in the event of a rain, individuals massively flowered with abundant nectar and pollen. People reported that this tree may flower up to five times in one year depending on weather conditions. It is a tree found in upland forests and can be locally abundant. It is considered to be a very important species for apiculture in the area since it can contribute both to honey harvest and to maintenance during periods of scarce flowering. *Cissus sicyoides*, a perennial climber of the Vitaceae family flowers at multiple times during the year also. It is abundant in the area and produces nectar-yielding flowers.

**Conclusions**

The plant-pollinator landscape of La Montaña, where honey production has been an important economic activity from ancient times, can be characterized as highly seasonal. Most plant species important as nectar or pollen sources flower at the end of the dry period or beginning of the rainy season, although many species flower for the entire duration of the dry season. Little flowering occurs during most of the rainy season, and at the transition to the dry period there is an increase in flowering. For the beekeeping cycle, the dry period represents the good-quality honey harvest season, followed by a period (the beginning of the rainy season) when honey has a high water content. Most of the rainy season is a dearth period for bees, followed by a recovery period during the transition to the dry season.

The list of the most important melliferous/polliniferous species includes more than 100 species from at least 67 genera and 31 families of trees, shrubs, vines, woody-vines and annuals. These species are present in the different vegetation types found in
the region, including lowland and upland forests, fallow areas and recently disturbed sites (Chapter 6). Several important species are also found in savanna communities and in urban and traditional agricultural areas (better described as agroforestry systems). Most of the species have an annual flowering pattern, although some exhibit biannual or continuous flowering. Different species contribute to honey production to different extents, but they all may play a role over the annual beekeeping cycle.

The soil-plant-atmosphere continuum that determines tree water status in the different species determines flowering phenology to a large extent. Cabañuelas, the winter rains that sporadically occur in the dry period, seem to be of great importance for flowering events during the honey harvest season. Therefore honey production is subject to high variation from year to year and from site to site. Timing of the onset of the rainy season also affects the extent to which high-water-content honey is produced each year.

The beekeeping cycle in this forested area of the Maya landscape contrasts to more northern areas where modern agriculture has shaped the landscape to a larger degree. At La Montaña, the great diversity of forest species contributes substantially to honey production. The honey harvest season occurs later than in agricultural areas, since it is most dependant on species that flower later in the dry season and at the beginning of the rainy season (i.e., forest trees). On the other hand, in more agriculturally oriented areas honey is produced mostly from the flowering of shrubs and creepers characteristic of recently disturbed areas. These species flower earlier during the beginning of the dry season. Much of the harvest season in the more agricultural areas is the recovery period in La Montaña.
These characteristics have implications for regional honey production and marketing. Honey from forested areas like La Montaña is produced from multiple forest species, as opposed to larger quantities of honey that are produced from single species in agricultural settings, which is a characteristic generally appreciated by consumers. Honey produced from forests may also be darker than honey produced from single species, another attribute not favored by the current market that prefers light colored honey. Also, more honey produced at La Montaña has a high-water content, since it is dependant mainly on species that flower later in the dry season and at the beginning of the rainy season. Nevertheless, there are great benefits to be realized from honey production in forested areas. For example, honey from these areas is produced from plants that have not been treated with pesticides or herbicides, as they often are in agricultural areas. Also, beekeepers at these sites depend less on external sugar feeding, since the diversity of plant species provides a wider array of sources where bees may obtain nectar and pollen. More research is needed on the relative nutritional qualities of honey produced from multiple-flowering plants in forests. Honey from La Montaña and similar areas can also be regarded as a non-timber forest product obtained from trees that are used for other economic activities and that present other complementary benefits.

Beekeeping *per se* does not necessarily ensure a focus on forest conservation, since many important species are found in secondary vegetation, and agricultural areas may be as productive. But there is no doubt that beekeepers benefit from the multiple flowering afforded by forests. External factors, such as the development of alternative markets and increased consumer demands for honey produced in these areas, could contribute significantly to the role of beekeeping in forest conservation. Through market
development, beekeepers could obtain added product value, as well as better conditions for business negotiations, for cooperative organizations, and for obtaining new investments. These factors could induce beekeepers to practice forest conservation as part of their management system. Beekeepers are already starting to form cooperatives to commercialize honey through alternative markets. Also, some certified organic honey is being produced through the support of NGO’s, which in some cases has led to the establishment of forest reserves as “bee-foraging” zones (Acopa and Boege 1998).

Honey production at La Montaña and similar areas represents a promising activity that can favor both the conservation of natural resources and socio-economic development. Nevertheless, for this to occur, there needs to be a directed effort through the implementation of specific management practices. Alternative markets may play a crucial incentive role.
CHAPTER 6
BEEKEEPING AND THE LANDSCAPE

Introduction

The resource landscape in which pollinators live is characterized by a combination of plant and pollinator attributes, such as the timing and synchrony of flowering, the dietary flexibility of pollinators and their ability to fly among patches. The “plant-pollinator landscape” therefore, is a function of the response of pollinators to spatial and temporal variation in floral resources (Bronstein 1995). In that way, pollinators, such as the honey bee (*Apis mellifera* L.), adjust their foraging patterns in time and space, tracking the changing mosaic of nectar sources (Sneyd and Camazine 1991).

*Apis mellifera*, both temperate and tropical, can forage in an area up to 300 km$^2$. However, foraging ranges and flight direction are constrained by the distribution of forage patches. Other factors such as competition with other pollinators and density of honey bee colonies also restrain the foraging behavior of honey bees (Roubik 1989).

Generalist species such as the honeybee have broad diets and forage relatively indiscriminately. As introduced species in many parts of the world, they have become adapted to forage in native floras (Bronstein 1995). At La Montaña, an area near the Calakmul Biosphere Reserve in Campeche, Mexico, where this research took place, beekeepers consider that more than 100 species from at least 67 genera and 31 families of trees, shrubs, vines, woody-vines and annuals, are sources of nectar and pollen for honey
bees. These species are present in the different vegetation types found in the region, including lowland and upland forests, fallow areas and recently disturbed sites. Several important species are also found in savanna communities and in urban and agricultural settings (Chapter V).

The objective of this research is to understand the distribution of melliferous species throughout the landscape of La Montaña, and particularly understand the role that forests have for apiculture. Honey production in this area is an important economic activity (Galletti 2000, Porter 1995). Being part of the buffer zone of the Calakmul Biosphere Reserve, beekeeping has been recognized as having great potential for socio-economic development while preserving the natural forests (Acopa and Boege 1998, Galletti 2000). An understanding of the role of forests for honey production will aid in understanding how beekeeping could favor forest conservation in this area. The questions guiding this research were:

- How are melliferous and polliniferous plant species distributed in the landscape?
- How does the structure of the landscape favor or hinder apiculture, and particularly, what is the role of forested areas?
- How do beekeepers manage vegetation for honey production?
- And, what are the implications of apiculture with regard to vegetation dynamics? Or in other words, how is beekeeping likely to affect the future composition of forests in the area?

A vegetation survey was conducted to understand the distribution and abundance of the important melliferous and polliniferous woody species in the forest types of the area. Interviews with local beekeepers were conducted to understand management of vegetation for honey production.
Methods

Study site

La Montaña is an area north of the Calakmul Biosphere Reserve in the state of Campeche, Mexico. It is formed by a group of eight ejidos occupying an area of approximately 184,340 ha and having a population of about 2700 inhabitants, mostly of Yucatec-Mayan origin (Galletti, 1999). The climate of the area has been determined, according to the Köppen climate classification system as modified by Garcia (1973), to be of the sub-humid, warm tropical type (Flores and Espejel 1994). The mean annual temperature is above 22°C and the mean annual precipitation is 1,223 mm\(^1\). The most dominant vegetation type is medium-stature subperennifoleus forests, where the mean height for trees is 25 m and where from 25 to 50% of the tree species shed their leaves during the dry season. This type of vegetation is mixed with high-stature subperennifoleus forests, low-stature forests that are inundated periodically, aquatic vegetation, and secondary vegetation in different successional stages (Ucan et al. 1999). Soils in the area have been formed mostly by the dissolution of calcareous rocks, which over time has resulted in a Karst topography (Flores and Espejel 1994). Drainage is subterranean with no superficial flows of water, except in the rainy season during storms and periods of inundation, when rain can be very intense and water moves in temporary surface flow channels. Generally, lowlands are nourished by filtration of Karst during the humid season and become dry to varying degrees depending on recharge through out the dry season (Gates 1999).

\(^1\) Data for temperature and precipitation from 1984 to 2000 were obtained from the Comision Nacional del Agua for the station of Chunchintok, the closest station to the study area.
Distribution and abundance of melliferous species

A stratified random sample to assess the distribution and abundance of melliferous and polliniferous species was conducted according to forest type and to the age of the vegetation (years lapsed since recovering from a disturbance). Forest type was based on the local vegetation/soil classification. Kankab and Tzequel soil types were grouped into the upland forest type, and akalche’ and yash-home soil types were grouped into the lowland forest type. Perez-Salicrup and Foster (2000) have also identified two major natural forest types in the Calakmul Biosphere Reserve area: lowland or bajo forests in seasonal wetlands possessing deep clay soils, and upland forests on well drained terrain. Vegetation age was divided into three classes: young (less than 19 years since abandonment), intermediate (from 20 to 29 years since abandonment) and older (30 and above years since abandonment). The criteria used to differentiate age classes was based on information for forests of the area that indicate that forests recover a tree species community indistinguishable from extant mature forest in about 25 to 30 years (Turner et al. 2001) and by information from local beekeepers that consider a 20-year fallow to be ready for slash and burn cultivation. Forty-five transects 6 m wide x 30 m long (180 m² each) were surveyed. At each transect, all trees with a diameter at breast height greater than 3 cm were recorded and their DBH measured. Botanical voucher specimens for identification of the melliferous and polliniferous species were collected and taken to the Alfredo Marin Herbarium in Mérida, Yucatán.

For assessing the importance of the different species in each of the different forest/vegetation age types (e.g., lowland young, intermediate, and older, and upland young, intermediate and older) the Importance Value Index (IVI –sum of relative density, relative dominance, and relative frequency) was calculated for each species and for all the
trees at each transect. The IVI places the species in a hierarchical order in the community and the most important species are identified. A species has a high IVI when it has a high density, high basal area and high frequency, or when one or two of these parameters is much higher than those for the other species at a site (Felfili and Da Silva 1993).

A Melliferous Importance Value Index (MIVI) for each species and all trees at the different sampled transects was also calculated. The MIVI was obtained by multiplying a melliferous value (MV) to all calculated IVIs. The MV for each species was obtained from a flowering phenology study that provided information regarding the flowering periods for each of the important melliferous/polliniferous species (Chapter 5). The flowering periods that make up the beekeeping productive cycle are classified into four classes: 1) harvest season; 2) high water-content honey period; 3) dearth period, and; 4) recovery period. Each class has a different importance in relation to the beekeeping annual cycle according to the amount of species flowering at each season or period. Since most species flower during the high water-content honey period, each single species flowering during this time contributes only slightly to the beekeeping annual cycle, therefore an arbitrary value of 1 was assigned. Species flowering during the honey-harvest period are the second in number and their contribution to the beekeeping annual cycle is greater, therefore a value of 2 was assigned. During the dearth and the recovery periods not many species flower, therefore their contribution is even greater and a value of 3 was used. The MIVI calculation was performed in order to identify the most important species contributing as melliferous and/or polliniferous sources at each forest/vegetation age types.
Dominance (sum of basal area of all species in a transect), melliferous dominance (MD) (sum of basal area of melliferous and polliniferous species in a transect), and the proportion of melliferous dominance (MP, the percentage of dominance occupied by melliferous species in a transect) were used to assess differences between forest/vegetation age types regarding melliferous importance. Also, the proportion of the dominance accounted for species flowering at the different period of the beekeeping annual cycle (high-water content honey period, honey-harvest period, and dearth and recovery periods) was calculated to assess differences between forest/vegetation age types. Finally, the dominance of pollen yielding species vs. dominance of nectar yielding species was tested to further assess differences among forest/vegetation age types regarding their contribution as melliferous or polliniferous yielding vegetation types.

Dominance instead of the IVI was used for comparing forest/vegetation age types since the former is an absolute number rather than a relative one and therefore can be used for this purpose. Dominance was also chosen after assessing its high correlation with IVI (r=0.88). Analysis of variances (F-test) and multiple comparison tests (Tukey-Kramer) were used to assess statistical significant differences among forest/vegetation age types.

Beehive location

Using a hand-held Garmin 12 Global Positioning System (GPS), the coordinates of beehives of a sample of beekeepers from La Montaña were obtained and located in a land cover/use classification map made with remotely-sensed digital image data from a portion of the Landsat 7 ETM 2000 scene (Chapter 2). Interviews of 32 beekeepers were conducted to understand beehive location criteria as well as information regarding the importance of different vegetation types to apiculture as perceived by beekeepers. The interviews were conducted either with individuals or with groups of individuals during a
one and a half year period that lasted from January 1999 to June 2000. The interviews were made during visits to the different apiaries. Results from this study were complemented with results obtained from a study carried out in the area during the same time about the important melliferous and polliniferous species and from a flowering phenology study (Chapter 5).

Results

Distribution and abundance of melliferous and polliniferous species

A total of 135 species were found to occur in the different transects sampled for all forest/vegetation age classes. The number of species found in the lowland forest type was 115 and in the upland forest type 112. Ninety of the species were present in both lowland and upland forests. The total number of important melliferous and/or polliniferous species found in all forest/vegetation age classes was 80. Approximately 59% of the woody species found in the different forest/vegetation age types was found to have a melliferous and/or polliniferous importance. Of these, 69 species were present in lowland forests, and 64 in upland forests. The number of melliferous and/or polliniferous species shared by both forests types was 53.

Regarding the structure of the different forest/vegetation age types and its relation to apiculture, the analysis of data showed that there were no significant differences between the upland and lowland forest types with respect to the dominance of melliferous species and dominance in general (Table 5). Nevertheless, there were significant differences among vegetation ages. For both forest types, the intermediate vegetation age tended to be lower both in dominance of melliferous species and in dominance in general. As for the proportion of dominance of melliferous species with regards to total
dominance, the analysis of results showed that there was also no significant difference between forest types but that there was a significant difference regarding vegetation ages, with the older vegetation ages tending to have a lower proportion of melliferous dominance.

Table 5. Average of dominance (D\*) , dominance of melliferous species (MD**) and proportion of MD (MP***) for transects sampled for the different lowland young, intermediate and older, and upland young, intermediate and older forest types at La Montaña, Campeche. Values significantly different for each row, according to an analysis of variance and a multiple comparison test with a 95% confidence interval, are marked with an ‘*’.

<table>
<thead>
<tr>
<th>Average values</th>
<th>lowland</th>
<th>Upland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Young</td>
<td>Intermediate</td>
</tr>
<tr>
<td>D (m² ha)</td>
<td>56.28</td>
<td>33.26</td>
</tr>
<tr>
<td>MD (m² ha)</td>
<td>54.01</td>
<td>28.10</td>
</tr>
<tr>
<td>MP (%)</td>
<td>95.70</td>
<td>85.95</td>
</tr>
</tbody>
</table>

*D= Dominance (Sum of basal area for all species)
**MD= Sum of basal area of melliferous and polliniferous species
***MP= Percentage of dominance of melliferous and polliniferous species or the proportion of MD with respect to D.

Regarding the importance of the different forest/vegetation age types for the different periods that make up the beekeeping annual cycle, results show that there are differences between both forest types and vegetation ages (Figure 13, Table 6). For the proportion of melliferous species that flower during the high water-content honey period, the older age of the upland forest type was significantly different than the rest, tending to hold lower proportions of dominance of species flowering during that period. For the honey-harvest period, the older vegetation class for both forest types was significantly different from the rest, tending to have lower dominance of melliferous species flowering at that period. Lowland forests showed more variation than upland forests. For the
dearth and recovery periods no significant difference was found for the proportion of the dominance of melliferous species that flower at that time for any forest or vegetation age types.

Figure 13. Percentage of melliferous dominance partitioned according to the important periods identified for the beekeeping annual production cycle: High water-content honey period, Honey Harvest Period, and Dearth and Recovery periods, at La Montaña, Campeche.

Regarding the contribution of pollen as opposed to nectar yielding species (Table 7) results showed that there are differences between forest/vegetation age types. The oldest forest type of the upland forest is significantly different from the rest, tending to have higher values of dominance corresponding to species that yield only pollen.
Table 6. Average proportion of species that flower during the high water-content honey period (MP1), of species that flower during the honey harvest period (MP2), and of species that flower during the dearth and recovery periods (MP3) for transects sampled for the different lowland young, intermediate and older, and upland young, intermediate and older forest types at La Montaña, Campeche. Values significantly different for each row, according to an analysis of variance and a multiple comparison test with a 95% confidence interval, are marked with an .

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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Young</td>
<td>Intermediate</td>
</tr>
<tr>
<td>MP1 (%)</td>
<td>26.96</td>
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</tr>
<tr>
<td>MP2 (%)</td>
<td>64.82</td>
<td>41.45</td>
</tr>
<tr>
<td>MP3 (%)</td>
<td>3.92</td>
<td>10.82</td>
</tr>
<tr>
<td>MP*</td>
<td>95.70</td>
<td>85.95</td>
</tr>
</tbody>
</table>

*MP = MP1+MP2+MP3 = the proportion of dominance accounted for melliferous and polliniferous species with respect to total dominance.

Table 7. Dominance of pollen yielding species (PD), and dominance of nectar yielding species (ND) for transects sampled for the different lowland young, intermediate and older, and upland young, intermediate and older forest types at La Montaña, Hopelchen, Campeche. Values significantly different for each row, according to an analysis of variance and a multiple comparison test with a 95% confidence interval, are marked with an or .

<table>
<thead>
<tr>
<th>Average values</th>
<th>lowland</th>
<th>Upland</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Young</td>
<td>Intermediate</td>
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<tr>
<td>PD (m² ha)</td>
<td>2.34</td>
<td>3.15</td>
</tr>
<tr>
<td>ND (m² ha)</td>
<td>51.67</td>
<td>24.86</td>
</tr>
<tr>
<td>MD* (m² ha)</td>
<td>54.01</td>
<td>28.10</td>
</tr>
</tbody>
</table>

*MD = PD + ND

Differences regarding dominance of nectar yielding species are provided by the intermediate vegetation age types that tend to have lower values than young vegetation age types, although not significantly different from older types. The pattern of the nectar yielding species resembles the tendency of the melliferous dominance in general as most of the species are nectar yielding.
For ranking the importance of the different species both with regard to the vegetation structure and with regard to their importance as melliferous species, the average of all IVI and MIVI values for each forest/vegetation age type was used (Tables 8 and 9). Generally, species that ranked highest regarding IVI are important melliferous species as well. Both forest types shared some of the most important species, although their importance regarding IVI or MIVI varied in some cases. Species shared by both forest types that are present among the first 10 ranking species according to the sum of MIVI values for all vegetation ages within each forest type (sum of MIVI) are a group of *Croton species*, *Bursera simaruba*, *Piscidia piscipula*, *Gymnopodium floribundum*, and *Hampea trilobata*. Of these, the first four are among the most important species during the harvest season period, and the latter one is an important species during the dearth period.

For the young vegetation age in the lowland forest type the most important species both regarding IVI and MIVI is the *Croton spp.* group, the second is *Bursera simaruba*, also ranking second in both values. The third MIVI ranking species is *Caesalpinia gaumeri*, another important species during the harvest season, although *Coccoloba reflexiflora* ranks third regarding IVI value. This latter species, although melliferous, has a limited value for MIVI since it flowers during the high-water content season. The 4, 5 and 6 MIVI ranking species for this forest/vegetation age type are *Gymnopodium floribundum*, *Piscidia piscipula*, and *Metopium brownei*, having an IVI ranking of 5, 6, and 8, respectively. Fifty percent of all MIVI values are constituted in the mentioned top 6 MIVI ranking species.
For the young vegetation age in the upland forest type eight species account for the first 50% of MIVI values. The first three species are *Piscidia piscipula*, *Bursera simaruba* and *Croton spp.*, all important species for the honey-harvest period. Their IVI ranking is 2, 3 and 4. *Hampea trilobata* is the fourth species in importance regarding MIVI and although it ranked 9 for IVI, it has an increased importance for MIVI because it is a dearth period flowering species. *Gymnopodium floribundum*, an important honey-harvest period species has a MIVI rank of 5 and an IVI rank of 6. *Coccoloba spicata*, a species that flowers during the high-water content honey period, although ranked first regarding the IVI has a MIVI rank of 6. *Vitex gaumeri* and *Metopium brownei* were placed 8 and 9 both for MIVI and IVI.

For the intermediate lowland forest type nine species account for the first 50% MIVI values. *Croton spp.* and *Gymnopodium floribundum* ranked 1 and 2 for MIVI, and had a 3 and 4 rank for IVI, respectively. *Coccoloba reflexiflora* and *Eugenia mayana* ranked 3 and 4 regarding MIVI. These are species that flower during the high-water content honey period but that have important IVI ranking (1 and 2 respectively), enhancing their melliferous importance. *Bursera simaruba* and *Metopium brownei* are ranked 5 and 6, with an IVI rank of 6 and 7. Kakawche (unidentified), and *Luehea speciosa*, although having low IVI ranks of 13 and 12 respectively, have a MIVI rank of 7 and 8 given their importance of flowering during the recovery period. *Caesalpinia gaumeri* a species flowering during the honey-harvest season is the 9th species that makes up the first 50% of MIVI values and has an IVI rank of 5.

For the intermediate upland forest type only four species account for the first 50% of MIVI values. *Croton spp.* ranked first both for MIVI and IVI. *Bursera simaruba*
Table 8. Melliferous importance value index and its ranking (MIVI and MIVI Rank), importance value index and its ranking (IVI and IVI Rank), and the sum of MIVI values for lowland species of young, intermediate and older vegetation ages. Species are ordered according to the Sum of MIVI values. Red numbers are the species that account for the top 50% values.

<table>
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<th>SPECIES</th>
<th>LOWLAND/ YOUNG</th>
<th>LOWLAND/ INTERMEDIATE</th>
<th>LOWLAND/ OLDER</th>
<th>SUM MIVI</th>
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</thead>
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<td>MIVI (%)</td>
<td>MIVI Rank</td>
<td>IVI</td>
<td>MIVI (%)</td>
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<tr>
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<td>4</td>
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<tr>
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Table 9. Melliferous importance value index and its ranking (MIVI and MIVI Rank), importance value index and its ranking (IVI and IVI Rank), and the sum of MIVI values for upland species of young, intermediate and older vegetation ages. Species are ordered according to the Sum of MIVI values. Red numbers are the species that account for the top 50% values.

<table>
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<th>UPLAND/ INTERMEDIATE</th>
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<td>MIVI</td>
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ranked 2 for MIVI and 3 for IVI. *Gymnanthes lucida* ranked 3 for MIVI and 4 for IVI. This is a pollen yielding species that flowers during the harvest-honey season. *Lysiloma latisiliqua* ranked 4 for MIVI, although it ranked 2 for IVI. The melliferous value of this latter species is lowered because it flowers during the high water-content honey period.

For the older vegetation age class of the lowland forest type six species account for the first 50% of MIVI values. The 1\(^{st}\) ranking species regarding MIVI is *Coccoloba reflexiflora*, a species that flowers during the high water-content honey period but that had a very high IVI value, ranking also 1\(^{st}\) in this category. *Manilkara zapota* ranked 2\(^{nd}\) for MIVI, although 6\(^{th}\) for IVI. The latter is a species that yields pollen during the recovery period therefore its melliferous importance is increased. *Gymnopodium floribundum* ranked 3\(^{rd}\) both for MIVI and IVI and *Croton spp.* ranked 4\(^{th}\) for MIVI and 5\(^{th}\) for IVI. *Metopium brownei* ranked 5 regarding MIVI and 7 regarding IVI, and *Chrysophyllum mexicanum* ranked 6 for MIVI and 11 for IVI. For this forest/vegetation age type some of the highly ranking species regarding IVI are not melliferous and therefore do not show in Table 7.

For the upland older vegetation age type, five species account for the first 50% of MIVI values. *Gymnanthes lucida* ranks 1\(^{st}\) both for MIVI and IVI. *Piscidia piscipula*, *Gymnopodium floribundum* and *Croton spp.* ranked 2\(^{nd}\), 3\(^{rd}\) and 4\(^{th}\) respectively also for both values. The latter most important species is *Luehea speciosa* ranking 5 for MIVI and 8 for IVI. For this species the melliferous value is increased given that it flowers during the recovery period.

**Beehive location**

The apiaries observed for this study are distributed throughout La Montaña region aggregated according to the different communities where the sampled beekeepers live
The apiaries shown in Figure 14 do not constitute all apiaries in those areas but are only a sample. The general distribution of the different apiaries is clumped in areas either near roads or in areas where active agriculture is occurring.

According to interviewed beekeepers, the criteria to establish apiaries are based on the vegetation that surrounds the apiaries and the distance to other apiaries. The distance to other apiaries is considered in order to reduce bee competition to floral sources. Most people consider a minimum of 1 km to be sufficient, although some people place their apiaries at a minimum distance of 3 km from other apiaries.

Some people prefer to locate apiaries near water bodies although most people provide this source themselves. Accessibility is also a constraint since beekeepers need to visit apiaries often and transport heavy loads, including water, honey and equipment (e.g., extractors), most often by bicycle or horse. However, people in the area are used to traveling long distances and transporting heavy loads.

In most cases, people establish their apiaries close to their agricultural plots to concentrate work in a single place (as all beekeepers also depend on the milpas for their subsistence). Nevertheless, it is often the case that people may have two agricultural plots (a newly felled milpa and a second or third year milpa), very often located in different and distant areas. It is also often the case that the apiary is located where the milpa used to be, as a milpa only lasts from 2 to 4 years.

According to interviews, the vegetation surrounding the apiaries is the most important criterion for locating beehives. People need to make a choice as different vegetation types have different advantages. According to local beekeepers, recently abandoned or disturbed areas are important at the beginning of the beekeeping annual
cycle, specially for the recovery period since many species, particularly climbers such as *Turbina corymbosa* (L.) Raf. and *Jacquemontia pentantha* (Jacq.) G. Don, bloom at this time, yielding abundant nectar. *Viguiera dentata* (Cav.) is another important species at the beginning of the beekeeping annual cycle that yields abundant nectar and that generates the honey usually harvested in the first period of the honey-harvest season. However, the flowering of this species and others found in disturbed and recently abandoned areas ends early. On the other hand, flowering of species present in secondary vegetation of more advanced stages of recovery, as well as in older forests, is also considered by beekeepers to be rich in species abundance important for apiculture. Flowering in this older vegetation type is known to begin later but to last for a longer period of time.

Besides the different advantages presented by the different vegetation ages, people consider different vegetation types to offer differing flowering sources. Lowlands and uplands, and the subtypes identified by local beekeepers, differ to some extent in the sources they offer. Savanna types of vegetation are also important nectar sources. Although all of these types of vegetation are considered by beekeepers to be rich in melliferous species abundance and very often share some of the most important species, the different forest types may respond differently to dry or very wet years. Beekeepers consider that to a large extent, nectar flows are not dependent on the vegetation but rather on the particular rainy season.

As a strategy for taking advantage of the different vegetation types, people either locate their apiaries in an area that is close to patches of different types of vegetation, or establish two apiaries, each having access to different types of vegetation types. This
latter strategy is considered by some people as a way to make use of the advantages that different vegetation types offer. They would, for example, rely on the harvest provided by an apiary surrounded mostly by recently disturbed vegetation at the beginning of the harvest season, and rely on the harvest provided later in the season by beehives established in an older vegetation type. On the other hand, failure of one apiary could be
offset by relying on the second one. This strategy also buffers against bad seasons, as the rains can vary greatly from location to location, even if they are only a few kilometers apart.

Direct management of the vegetation is very seldom practiced. Only a few people stated that they coppice melliferous trees while felling for milpa with the intention of promoting future flowering or to destroy species detrimental to apiculture, such as *Casimiroa tetrameria* Millsp., a species that affects bees during the recovery season. One of the informants was once seen bringing seeds of the vine *Jacquemontia pentantha* (Jacq.) G. to his apiary. Nevertheless, vegetation management by beekeepers is mostly selection of the location of the apiary.

Different communities follow different landscape management strategies according to the vegetation that predominates in the specific communities, which favor honey production in different ways. In a study conducted in Panama, the foraging range for Africanized *Apis mellifera* has been established to be from 7.5 to 10 km with a mean flight range of about 1.7 km, and with most foraging occurring between 2 to 5 km from the nest (Roubik 1989). Beekeepers must therefore choose the location of their apiary according to the landscape they have available. For example, Xnoha (Figure 15), a very isolated area where only one family has lived for more than 50 years, has a landscape very advantageous for honey production. Although there is not much active agriculture, this area contains large patches of savanna type vegetations, as well as patches of lowland and upland forests that local beekeepers consider to be very rich in melliferous and polliniferous species. Beekeeping in this area also has the advantage that few people share the landscape and therefore competition between apiaries is not a constraint. In this
area honey production is the most important economic activity, followed by cattle ranching, which is also favored by the extensive savanna areas.

Figure 15. A sample of apiaries at Xonha in La Montaña, Campeche, Mexico. Red boxes represent beehive locations. Roubik (1989) has determined that most foraging by Africanized honey bees occurs between 2 and 5 km from nest, with 1.7 km the average flight distance for foraging.

At Xmaben (Fig. 16) on the other hand, people rely more on the flowering of species found in disturbed and agricultural areas, such as *Viguera dentata*, and other species present in early successional stages and along road-sides. People in this area lack the advantage of having a higher diversity of patch types in the landscape so they need to rely mostly on these species. People in this type of landscape must also deal with beehive overcrowding. Some people were also concerned about the problems that may arise if people start using pesticides and herbicides in agricultural production.
Figure 16. A sample of apiaries at Xmaben in La Montaña, Campeche, Mexico. Red boxes represent beehive locations. Roubik (1989) has determined that most foraging by Africanized honey bee occurs between 2 and 5 km from nest, with 1.7 km the average flight distance for foraging.

**Discussion**

Rico-Gray et al. (1991) calculated that nearly 30% of total flora found in natural vegetation and homegardens at two different sites in Yucatán is important for apiculture. In this study, the percentage of species important for apiculture was greater, although only woody species in natural vegetation were analyzed. Eighty melliferous species were found in all transects sampled for all forest/vegetation age types, representing 59% of all species recorded. This accounted for about 80% of all species listed by beekeepers as important for honey production in the area, according to interviews and reported
elsewhere (Chapter 5). The portion of the species not encountered in this sampling are species found in vegetation types not included in the sampling design, such as disturbed areas, recently abandoned agricultural sites and savanna type vegetation, and are mostly represented by vines and other annuals. A few species are also found only in urban areas or agroforestry plots.

The species that stand out as the most important melliferous or polliniferous species, or that make up the first 50% of the MIVI values (which is a function of the importance value index and their flowering period) and that flower during the honey harvest season are a group of *Croton spp.* that are located in all forest/vegetation age types, *Gymnopodium floribundum* in all forest/vegetation age types except upland intermediate, *Bursera simaruba* in the young and intermediate age classes of both forest types, *Metopium brounei* in all vegetation ages of the lowland forest type and the young vegetation age of the upland forest type, *Piscidia piscipula* in the young vegetation age of both forest types and the older vegetation age for the upland forest, *Caesalpinia gaumeri* in the young and intermediate age classes of the lowland forest, *Gymnanthes lucida* in the intermediate and older forests of the upland forest type, *Vitex gaumeri* in the young vegetation age of the upland forest type, and *Chrysophilum mexicanum* in the older vegetation age of the lowland forest type.

The species that stand out as the most important melliferous or polliniferous species, or that make up the first 50% of the MIVI values and that flower during the high water-content honey period are: *Coccoloba reflexiflora* for all vegetation ages in the lowland forest, *Coccoloba spicata* for the young vegetation age of the upland forest type, *Eugenia mayana* for the intermediate vegetation age of the lowland forest type, and
Lysiloma latisiliqum for the intermediate vegetation age of the upland forest type. Their importance regarding MIVI values of these species is given primarily by their high IVI values, since flowering during this period provides little melliferous value according to the criteria used for this analysis.

The most important melliferous or polliniferous species according to MIVI values and that flower during the recovery period were found to be *Luhea speciosa* for upland old and lowland intermediate, Kakawche (unidentified) for lowland intermediate, and *Manilkara zapota* for lowland old. Only *Hampea trilobata* was amongst the most important species regarding MIVI values that flower during the dearth season, and only for the young vegetation age of the upland forest.

Although the relative values of melliferous species are good indicators of their role for apiculture, this does not consider other factors that may be important such as flowering density or their response to weather. For example, *Piscidia picipula* is considered to be one of the most important species and people report that this species flowers regardless of rains, contrary to many species that will flower only with adequate precipitation (Chapter 5).

Results show that dominance of melliferous and polliniferous species is high in all vegetation age class and forest types included in the sampling. Most of the dominant species in the vegetation contribute as melliferous and/or polliniferous. Therefore, the importance for each of the forest/vegetation age types regarding the dominance of melliferous species, parallels the dominance of all species, showing no difference between forest types but differences regarding vegetation ages, with the intermediate vegetation ages showing lower values. Studies by Turner et al. (2001) within the
Calakmul Biosphere Reserve have shown that both forest types (lowlands and uplands) share 80% of their tree species, but that distinctions can be made regarding the relative abundance of each tree species, and in their structural appearance. Differences in vegetation age can be explained as a result of having included the smaller stems in the sampling, resulting in a high dominance in the younger vegetation age given by a higher number of small stems which in the intermediate ages presumably have died out. Older ages where the trees have had time to grow in size increase their dominance values again. Chemas and Rico-Gray (1991) also report that there is a strong relationship between the relative importance values of plants in the forests (young or old) and their importance as melliferous species. The proportion of dominance accounted for melliferous and polliniferous species with regards to dominance in general shows a different pattern. The difference is also provided by vegetation age rather than forest type, and in this case the older vegetation age shows lesser values for the proportion of dominance of melliferous and polliniferous species.

The above results indicate that all forests/vegetation age types may be important flowering sources for bees, although the younger vegetation ages are most favorable. Younger vegetation is high in dominance and most of the species are nectar or pollen yielding. In intermediate ages, although most of its components are melliferous and/or polliniferous, dominance values of the vegetation in general are lower. On the other hand, although vegetations of older ages are high in dominance as many of the individuals have grown in size, the proportion of dominance belonging to melliferous or polliniferous species is lower. Many of the species that have become important components of these vegetation types do not have melliferous or polliniferous
importance. The latter is also shown in the MIVI and IVI values, since many of the species that make up the first 50% of IVI have no MIVI value.

As for the proportion of dominance of the species according to flowering periods and therefore to their contribution as melliferous or polliniferous species during the different periods identified for the beekeeping annual cycle, older forests also tend to be less important as nectar and/or pollen yielding during the high water-content honey period and the honey harvest period. Nevertheless, all forest/vegetation age types hold the same proportion of dominance of species that flower during the dearth and recovery periods. Flowering during these periods, although minimal, is important for the maintenance of bees, and therefore older forests contribute as important sources during this period. Older vegetation ages are also higher in their dominance of species, contributing as pollen yielding species only, particularly for the upland vegetation type. This result can be explained by the high dominance value of Gymnanthes lucida at this forest/vegetation age type, a species that yields only pollen.

This study demonstrated that woody species that flower during the recovery period are as scarce as species flowering during the dearth period. Nevertheless, the recovery period is called so because an increase in flowering strengthens bee populations. Most of the species important during this period are species found in other vegetation types, such as disturbed and agricultural areas and include species such as vines and other annuals. Thus, at La Montaña, these latter vegetation types are important for the recovery period in the beekeeping annual cycles, as are fallow and forest areas for the other periods.
Beekeepers in the area are aware of the advantages presented by the different vegetation types found in the area, as reflected by the choices they make when selecting the beehive location. For beekeepers, a landscape that favors honey production is one where different forest types are present, particularly of different ages. If they are not able to locate an apiary that has access to different vegetation types, they choose to have apiaries at different sites, even if this means having to work in two different, distant places. The latter is done as a strategy for taking advantage of what different vegetation types have to offer. Nevertheless, all beekeepers stated that disturbed sites are very important.

In a study conducted by Chemas and Rico-Gray (1991) in Tixcacaltuyub, Yucatan, it was found that the mixture of plant species present in different vegetation patches (a combination of young and old vegetation) surrounding the beehive is a guaranty of year-round flowering. In that area, patches of older vegetation have become rare, a condition that according to beekeepers has resulted in a set-back for apiculture. Although they also report that it is considered that about 80% of the honey produced in the Yucatan comes from young successional stages and road-side plants, they consider that the lack of older forests prevents beekeepers from enjoying better production.

The high abundance of melliferous and polliniferous species in the area may be a relic of past management practices as beekeeping has been an important activity in the region for over 3000 years (Chemas and Rico-Gray 1991, Guzmán-Novoa 1996). Traditionally, beekeeping by the Mayas was part of an agrosilvicultural system (Remmers and Koeijer 1992). During land clearing for the milpa, some small areas are presumed to have been selected where the melliferous tree species were left undisturbed.
and hives found inside logs in the forest were retained (Sanabrias 1986). Important areas for keeping the beehives were the tolche’, special forest tracts of different ages and sizes protected alongside roads, corn fields, and communal land. These areas not only provided resources for bees, but also served as fire protection for the hives during burning of corn fields (Remmers and Koeijer 1992). Chemas and Rico-Gray (1991) point out that some authors consider these practices to be a form of silviculture and a key factor in the successional process.

Today, beekeeping may affect the future structure and composition of forests in the region as the value of forests for beekeeping is perceived by local producers and outside markets. A question that should be raised is how will the flora and fauna composition be affected by an increase in foreign pollinators (Buchmann 1996, Corbet 1996). Not only is there evidence that the Africanized bee displaces native pollinators (Roubik 1978, 1996a, 1996b; Roubik et al. 1986), but also that they may be ineffective at pollinating native flowers and may interact in complex ways with native pollinators, reducing the amount and efficiency of pollen transfer (Kearns & Inouye 1997). For beekeepers in the region, beekeeping with Apis bees has negatively affected management of native bee species, since according to local informants, Apis mellifera has displaced the native bees they were used to managing.

Conclusions

According to the analyses of lowland and upland Maya forests of different ages (e.g., young fallow areas from 8 to <19 years old, intermediate ages from 20 –30 years old, and areas >30 years old), 80 species were found to have melliferous and/or polliniferous value. This represents 59% of the woody species encountered in all
forest/vegetation age types sampled and comprises about 80% of the species considered important for beekeepers in the region. The other 20% of the important regional species considered important for beekeepers are found in disturbed areas, recently abandoned agricultural sites, urban settings or in other vegetation types (e.g., savannas).

Important melliferous and polliniferous species, ranked by their dominance and harvest-season flowering, are: a group of *Croton spp.*, *Gymnopodium floribundum*, *Bursera simaruba*, *Metopium brounei*, *Piscidia piscipula*, *Caesalpinia gaumeri*, *Gymnanthes lucida*, *Vitex gaumeri* and *Chrysophilum mexicanum*. Important species for the high-water-content honey period are: *Coccoloba reflexiflora*, *C. spicata*, *Eugenia mayana* and *Lysiloma latisiliqum*. *Hampea trilobata* was an important species that flowers during the dearth season and that has high dominance. *Luhea speciosa*, Kakawche (unidentified) and *Manilkara zapota* are important dominant species that flower during the recovery period.

The dominance of melliferous and polliniferous species was high in all forest/vegetation age types sampled. In fact, most of the dominant species have melliferous and/or polliniferous value. Therefore, all forests/vegetation age types sampled may be important flowering sources for bees, although the younger vegetation ages are most favorable. In terms of dominance according to flowering periods, older forests also tend to be less important as nectar and/or pollen yielding during the high-water-content honey period and the honey-harvest period. All forest/vegetation age types have similar proportions of dominance of species that flower during the dearth and recovery periods. Flowering during these periods, although minimal, is important for the maintenance of bees and therefore, older forests contribute as important sources during
this period. Older vegetation ages are also higher in their dominance of pollen only yielding species, particularly the upland forest type.

The patchy nature of the landscape at La Montaña offers diverse sources for bee foraging. While many of the important melliferous and polliniferous species are found in recently disturbed, agricultural and urban areas, particularly contributing to the recovery and early harvest season periods, forests of different ages contribute in the remaining of the beekeeping annual cycle periods. While forests of older ages are restricted nectar sources, they contribute to increasing the options that bees have during the dearth period and are also important pollen sources.

The advantages of having a diverse landscape in which different vegetation types have different melliferous and/or polliniferous values is recognized by local beekeepers, who try to obtain the most of what the landscape offers by carefully selecting their apiary location. Each beekeeper either locates an apiary where bees can have access to patches of different vegetation types, or locate two or more apiaries at different sites that have access to different vegetation types. The latter strategy also helps buffer against seasonal adversities.

The location of apiaries is also constrained by the occurrence of other apiaries to avoid over-crowding and by accessibility (so that apiaries are usually located near where beekeepers perform their agricultural tasks). Apiary establishment also depends on the particular community and its surrounding landscape. As a result, beekeepers that live in more isolated, less populated areas rely mostly on flowering from the forest, and beekeepers that live in more agricultural and populated areas rely mostly on flowering
sources from disturbed sites. The latter have more problems with overcrowding and risks that their honey may be contaminated with pesticides and herbicides.

Direct management of the vegetation by beekeepers is minimal; only a few beekeepers reported direct manipulation of vegetation to favor honey yielding species. Since land is not limiting in the area, they have not needed to manage forest patches (e.g., reserve certain areas specifically for bee forage). However, much of the honey produced in other similar regions comes solely from disturbed areas, so it seems likely that beekeepers can adjust management practices to fit the available vegetation. While beekeepers perceive a benefit of having a diverse landscape where forests are present, conservation of forested areas will occur only if it becomes an objective for beekeepers and producers in general. This could occur as a result of market incentives (Chapter 4).

The high abundance of melliferous and polliniferous species in the area has been proposed to be a relic of past management practices, since beekeeping has been an important activity in the region for over 3000 years (Chemas and Rico-Gray 1991, Guzmán-Novoa 1996). Today, beekeeping may affect the future structure and composition of forests in the region. Forest conservation could be favored by apiculture, if the value of forests for beekeeping is perceived by local producers and outside markets and directed management is provided (e.g., certain areas are set aside as bee forage). On the other side, beekeeping as practiced today with *Apis mellifera* may affect the future composition of forests by favoring the population of exotic pollinators, which could lead to the displacement of natives and result in unknown consequences to floral and faunal assemblages.
CHAPTER 7
CONCLUSIONS

The landscape of La Montaña, a buffer zone to the Calakmul Biosphere Reserve in Campeche, México, has been shaped by natural and human-induced disturbances through time. Human activity in the area has been constant, and different episodes of occupation have modified this landscape in different ways. After forests recovered from the high populations and intensive use during the Classic Maya period, forest cover has remained steady, with the people relying mostly on timber and non-timber forest products for income and survival. Today, land use activities are changing towards more agricultural production, having potentially important implications for the forested landscape of La Montaña. An analysis of a four-year period using remotely-sensed imagery indicated that forest conversion may be intensifying, as cattle raising becomes a management goal for people in the area; communication at the regional, national and international levels increases; and the population grows (Chapter 2).

In view of the fact that forest conversion in Mexico is occurring very rapidly and that La Montaña represents a buffer zone to one of the largest protected areas, the Calakmul Biosphere Reserve, it is of the utmost importance that the implementation of management practices that favor forest conservation are encouraged. Beekeeping, a long practiced activity, has been recognized as having great potential for bringing greater benefits to the local communities while preserving a forested landscape (Acopa and Boeje 1998, Galletti 2000, Porter 1995).
In Mexico, apiculture is an important economic activity and the Yucatan Peninsula is one of the most important areas within the country (Echazarreta et al. 1997, Sánchez-Vazquez and Colli-Ucan 1992). In part, this results from the rich natural melliferous and polliniferous flora found in the area (Chapter 5) and from the beekeeping tradition of the Maya population. Beekeeping with native bees of the subfamily Meliponinae began with the Mayas over 3000 years ago (Guzman-Novoa 1996). Intensive management of certain species, particularly *Mellipona beechei*, resulted in a bee culture important in religion, medicine, food and trade (Labougle and Zozaya 1986, Sanford 1973). During the 20th century, beekeeping with *Apis mellifera* started in the Yucatan Peninsula, increasing in importance throughout the century. During the 1960s and 1970s beekeeping with *Apis mellifera* by the Maya population also gained importance, becoming one of the principal economic activities for rural communities (Echazarreta et al. 1997). During the last half of the 1980s, the arrival of the Africanized honey bee resulted in new challenges and opportunities for beekeepers, as it did throughout most of the American continent (Spivak et al. 1991).

At La Montaña, honey production is currently the number one income generating activity. Although there are traces of traditional beekeeping, as some individuals still keep colonies of native bees, this is becoming less and less common. A large proportion of the population manages *Apis mellifera* bees, with the objective of commercializing the products through the regional, national and international markets. The arrival of the Africanized bee (with its high numbers of feral populations), together with better communication and transportation systems, has brought new prospects for beekeeping in the region.
The use of timber and non-timber forest products has been the major land use at La Montaña. Today, agricultural activities are gaining importance as the area has become regionally accessible through better infrastructure and communication systems. Timber resources do not generate much profit, as most of the valuable species (e.g., *Cedrela odorata* and *Swietenia macrophylla*) have already been harvested and markets for other species have not developed. Non-timber forest products, such as chicle extraction and honey production, represent the current best alternatives for profiting from forest resources. Current market trends for chicle have not been favorable. On the other hand, as beekeeping has recently developed, increasing amounts of the honey are being sold nationally and internationally. Unfortunately, so far profits benefit only a small sector of the population that has better management skills and investment capacity.

Beekeeping could provide economic benefits to a larger sector of the population. An example of this is provided by Lol-k’ax, a cooperative formed recently by a small number of beekeepers from different communities. Lol-k’ax is beginning to establish market ties with the international “fair market” which offers better prices. Nevertheless, the experience has not been easy, as Lol-k’ax needs to find mechanisms of self-financing and complying with high quality standards at a time when skills and resources are still extremely limited. Better technology and skills, as well as the diversification of the activity (e.g., to include the production of organic honey, pollen, royal jelly, propoli, etc.) could provide more benefits to the region. Nevertheless, for this to happen there needs to be external investment from NGOs or other agencies, particularly to increase the organizational, administrative and technical skills of local beekeepers.
The landscape at La Montaña is well suited to apiculture, as the different vegetation types making up the landscape are rich in nectar and/or pollen yielding species. More than 100 species from at least 67 genera and 31 families of trees, shrubs, vines, woody-vines and annuals were found to be important melliferous and/or polliniferous sources by beekeepers (Chapter 5). These species are present in the different vegetation types found in the region, including lowland and upland forests, fallow areas and recently disturbed sites (Chapter 6). Several important species are also found in savanna communities and in urban and traditional agricultural areas (better described as agroforestry systems). Most of the species have an annual flowering pattern, although some exhibit biannual or continuous flowering. Different species contribute to honey production to different extents, but they all may play a role in the annual beekeeping cycle.

The “plant-pollinator landscape” where honey bees forage, is a function of their response to spatial and temporal variation in floral resources (Bronstein 1995). Floral sources are distributed in the landscape both in space and time, according to the distribution and abundance of melliferous and polliniferous species and according to the flowering periods of these species.

A flowering phenology study found that La Montaña is highly seasonal and that most plant species important as nectar or pollen sources flower at the end of the dry period or beginning of the rainy season, although many flower for the entire duration of the dry season. Little flowering occurs during most of the rainy season and at the transition to the dry period there is an increase in flowering. For the beekeeping cycle, the dry period represents the best-quality honey harvest season, followed by a period (the
beginning of the rainy season) when honey has a high water content and is therefore of lesser value. Most of the rainy season is a dearth period for bees, followed by a recovery period during the transition to the dry season.

The soil-plant-atmosphere continuum that determines tree water status in the different species determines flowering phenology to a large extent. Cabañuelas, the winter rains that sporadically occur in the dry period, seem to be of great importance for flowering events during the honey harvest season. Therefore, honey production is subject to high variation from year to year and from site to site. Timing of the onset of the rainy season also affects the extent to which high-water-content honey is produced each year.

The beekeeping cycle in this forested area of the Maya region contrasts to more northern areas where modern agriculture has shaped the landscape to a larger degree. At La Montaña, the great diversity of forest species contributes substantially to honey production. The honey harvest season occurs later than in agricultural areas, since it is most dependent on species that flower later in the dry season and at the beginning of the rainy season (i.e., forest trees). On the other hand, honey in more agriculturally oriented areas is produced mostly from the flowering of shrubs and creepers characteristic of recently disturbed areas. These species flower earlier during the beginning of the dry season. Much of the harvest season in the more agricultural areas is the recovery period in La Montaña.

These characteristics have implications for regional honey production and marketing. On the negative side, honey from forested areas like La Montaña is produced from multiple species, as opposed to larger quantities of honey that are produced from single species in agricultural settings, the latter a characteristic generally favored by
consumers. Honey produced from forests may be darker than honey produced from single species, another attribute not favored by the current market that prefers light colored honey. Also, more honey produced at La Montaña has a high-water content, since it is dependent mainly on species that flower later in the dry season and at the beginning of the rainy season. On the positive side, there are also benefits to be realized from honey production in forested areas. For example, honey is produced from plants that have not been treated with pesticides or herbicides, as they often are in agricultural areas, so that contaminant risk is low. Beekeepers at these sites depend less on external sugar feeding, since the diversity of plant species provides a wider array of sources where bees may obtain nectar and pollen. More research is needed on the relative nutritional qualities of honey produced from multiple-flowering plants in forests. Honey from La Montaña and similar areas can also be regarded as a non-timber forest product obtained from trees that are used for other economic activities and thus present other complementary benefits.

According to my analyses of lowland and upland forests of different ages (e.g., young fallow areas from 8-19 years old, intermediate from 20-30 years old, and >30 years old), 80 species were found to have melliferous and/or polliniferous value. This represents 59% of the woody species encountered in all forest/vegetation age types sampled and comprises about 80% of the species considered important for beekeepers in the region. Other important melliferous and polliniferous species are found in disturbed areas, recently abandoned agricultural sites, urban settings or other vegetation types such as savannas.
Important melliferous and polliniferous species ranked by their dominance and that flower during the honey-harvest season are: a group of *Croton* spp., *Gymnopodium floribundum*, *Bursera simaruba*, *Metopium brounei*, *Piscidia piscipula*, *Caesalpinia gaumeri*, *Gymnanthes lucida*, *Vitex gaumeri* and *Chrysophilum mexicanum*. Important species for the high-water-content honey period are *Coccoloba reflexiflora*, *C. spicata*, *Eugenia mayana* and *Lysiloma latisiliqum*. *Hampea trilobata* was an important species that flowers during the dearth season and that has high dominance. *Luhea speciosa*, Kakawche (unidentified) and *Manilkara zapota* are important dominant species that flower during the recovery period.

According to results, the dominance of melliferous and polliniferous species was high in all forest/vegetation age types sampled. In fact, most of the dominant species have melliferous and/or polliniferous value. Therefore, all forests/vegetation age types sampled may be important flowering sources for bees, although the younger vegetation ages are most favorable. In terms of the proportion of dominance according to flowering periods, older forests tend to also be less important as nectar and/or pollen yielding during the high-water-content honey period and the honey-harvest period. All forest/vegetation age types have similar proportions of dominance of species that flower during the dearth and recovery periods. Flowering during these periods, although minimal, is important for the maintenance of bees and, therefore, older forests contribute as important sources during this period. Older vegetation ages are also higher in their dominance of pollen-only yielding species, particularly the upland forest type.

The patchy nature of the landscape at La Montaña offers diverse sources for bee foraging. While many of the important melliferous and polliniferous species are found in
recently disturbed, agricultural and urban areas, particularly contributing to the recovery and early harvest season periods, forests of different ages contribute in the remaining of the beekeeping annual cycle periods. While forests of older ages are restricted nectar sources, they contribute to increasing the options that bees have during the dearth period and are also important pollen sources.

The advantages of having a diverse landscape in which different vegetation types have different melliferous and/or polliniferous values is recognized by local beekeepers, who try to obtain the most of what the landscape offers by carefully selecting their apiary location. Each beekeeper either locates an apiary where bees can have access to patches of different vegetation types, or locate two or more apiaries at different sites that have access to different vegetation types. The latter strategy also helps buffer against seasonal adversities.

The location of apiaries is also constrained by the occurrence of other apiaries to avoid over-crowding and by accessibility (so that apiaries are usually located near where beekeepers perform their agricultural tasks). Apiary establishment also depends on the particular community and its surrounding landscape. As a result, beekeepers that live in more isolated, less populated areas rely mostly on flowering from the forest, and beekeepers that live in more agricultural and populated areas rely mostly on flowering sources from disturbed sites. The latter have more problems with overcrowding and risks that their honey may be contaminated with pesticides and herbicides.

Direct management of the vegetation by beekeepers is minimal; only a few beekeepers reported direct manipulation of vegetation to favor honey yielding species. Since land is not limiting in the area, they have not needed to manage forest patches (e.g.,
reserve certain areas specifically for bee forage). However, much of the honey produced in other similar regions comes solely from disturbed areas, so it seems likely that beekeepers can adjust management practices to fit the available vegetation. While beekeepers perceive a benefit of having a diverse landscape where forests are present, conservation of forested areas will only occur if it becomes an objective for beekeepers and producers in general. This could occur as a result of market incentives (Chapter 4).

Beekeeping *per se* does not necessarily ensure a focus on forest conservation, since many important species are found in secondary vegetation and agricultural areas. However, there is no doubt that beekeepers benefit from the multiple flowering afforded by forests. External factors, such as the development of alternative markets and increased consumer demands for honey produced in these areas, could contribute significantly to the role of beekeeping in forest conservation. Through market development, beekeepers could obtain added product value, as well as better conditions for business negotiations, for cooperative organizations, and for obtaining new investments. These factors could induce beekeepers to practice forest conservation as part of their management system. Beekeepers are already starting to form cooperatives to commercialize honey through alternative markets. Also, some certified organic honey is being produced through the support of NGO’s, which in some cases has led to the establishment of forest reserves as “bee-foraging” zones (Acopa and Boege 1998).

Honey production at La Montaña and similar areas represents a promising activity that can favor both the conservation of natural resources and socio-economic development. Nevertheless, for this to occur, there needs to be a directed effort through
the implementation of specific management practices. Alternative markets may play a crucial incentive role.

It is important to keep in mind that beekeeping as practiced today favors the increase of an exotic bee species that has proven to displace natural pollinators, with unknown consequences for floral and faunal composition (Buchmann 1996, Roubik 1996a, Sugden 1996). More efforts should be made to promote beekeeping with stingless bees. Future studies should address the implication that beekeeping with Africanized Apis mellifera may have on native pollinators, and ultimately on the structure and composition of the flora and fauna. Nevertheless, beekeeping at La Montaña and other similar areas in the Yucatan Peninsula presents an economic alternative to other land uses such as ranching, that surely produce a greater impact on forest composition.
APPENDIX A
LIST OF THE IMPORTANT MELLIFEROUS AND POLLINIFEROUS SPECIES
ACCORDING TO THEIR FLOWERING PERIODS IN RELATION TO THE
ANNUAL BEEKEEPING CYCLE AT LA MONTAÑA, CAMPECHE, MEXICO,
<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Family</th>
<th>Common Name</th>
<th>N/P</th>
<th>Flowering period</th>
<th>Habit</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bucida buceras L.</td>
<td>Combretaceae</td>
<td>Pukte'</td>
<td>N</td>
<td>mid-Jan. to mid-May</td>
<td>tree</td>
<td>lowland forest</td>
</tr>
<tr>
<td>Bursera simaruba (L.) Sarg.</td>
<td>Burseraceae</td>
<td>Chaka</td>
<td>N</td>
<td>April to May</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Caesalpinia gaumeri Greenman</td>
<td>Leguminosae</td>
<td>Kitinche'</td>
<td>N</td>
<td>Jan. to Feb.</td>
<td>tree</td>
<td>upland forest/secondary veg.</td>
</tr>
<tr>
<td>Caesalpinia yucatanensis</td>
<td>Leguminosae</td>
<td>Taak'inche'</td>
<td>P</td>
<td>February</td>
<td>tree</td>
<td>secondary veg., lowlands</td>
</tr>
<tr>
<td>Greenman</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceiba pentandra (L.) Gaertn</td>
<td>Bombacaceae</td>
<td>Ceibo/Ya'ax che'</td>
<td>N</td>
<td>Jan. to Feb.</td>
<td>tree</td>
<td>upland forest and urban areas</td>
</tr>
<tr>
<td>Chrysophyllum mexicanum</td>
<td>Sapotaceae</td>
<td>Chil keel/Caimito de</td>
<td>P</td>
<td>March</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td>Brandegee ex Standley</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cochlospermum vitifolium (Willd.) Spargel</td>
<td>Combretaceae</td>
<td>Chu'um</td>
<td>P</td>
<td>Feb. to March</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Cordia dodecandra A. DC.</td>
<td>Boraginaceae</td>
<td>Siricote</td>
<td>P</td>
<td>April to May</td>
<td>tree</td>
<td>lowland forests/urban areas</td>
</tr>
<tr>
<td>Cordia geraschanthus L.</td>
<td>Boraginaceae</td>
<td>Bojom</td>
<td>N</td>
<td>April to May</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td>Crescentia cujete L.</td>
<td>Bignoniaceae</td>
<td>Güíro/Was</td>
<td>N</td>
<td>Jan. to May</td>
<td>tree</td>
<td>lowland forests and savannas</td>
</tr>
<tr>
<td>Croton glabellus L.</td>
<td>Euphorbiaceae</td>
<td>Sak p'eres</td>
<td>N</td>
<td>end March to big.</td>
<td>tree</td>
<td>secondary veg.</td>
</tr>
<tr>
<td>Croton guatemalensis Lotsy</td>
<td>Euphorbiaceae</td>
<td>P'eres de akalche'</td>
<td>N</td>
<td>end March to big.</td>
<td>tree</td>
<td>secondary veg./lowlands</td>
</tr>
<tr>
<td>Croton sp.</td>
<td>Euphorbiaceae</td>
<td>susuyuk</td>
<td></td>
<td>end Feb to mid-March</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Croton sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dipholis salicifolia</td>
<td>Sapotaceae</td>
<td>Tsists yaj</td>
<td>P</td>
<td>March to April</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Ehretia tinifolia L.</td>
<td>Boraginaceae</td>
<td>Beek/Roble</td>
<td>N</td>
<td>March to April</td>
<td>tree</td>
<td>upland forest and urban areas</td>
</tr>
<tr>
<td>Exothea diphylla (Standley) Lundell</td>
<td>Sapindaceae</td>
<td>Wayum koox</td>
<td>N</td>
<td>February</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td>Gliricidia sepium (Jacq.) Steudel</td>
<td>Leguminosae</td>
<td>Baiche kej</td>
<td>N</td>
<td>mid-Feb. to April</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Gymnanthes lucida Sw.</td>
<td>Euphorbiaceae</td>
<td>Bak'ayum/Yaytil/Xpij</td>
<td>P</td>
<td>April</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Gymnopodium floribundum Rolfe</td>
<td>Polygonaceae</td>
<td>'Tsitsiche'</td>
<td>N</td>
<td>March to June</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Haematoxylon brasiliito Karsten</td>
<td>Leguminosae</td>
<td>Sak tinto/Tinto de</td>
<td>N</td>
<td>end Jan. to mid-March</td>
<td>tree</td>
<td>lowland forests</td>
</tr>
<tr>
<td>Haematoxylon campechianum L.</td>
<td>Leguminosae</td>
<td>Sabana</td>
<td></td>
<td></td>
<td>tree</td>
<td>lowland forests/savannas</td>
</tr>
<tr>
<td>Lonchocarpus hondurensis Benth.</td>
<td>Leguminosae</td>
<td>Burro che'/Balche k'aax</td>
<td>N</td>
<td>March</td>
<td>tree</td>
<td>near water bodies</td>
</tr>
<tr>
<td>Metopium brownei (Jacq.) Urban</td>
<td>Anacardiaceae</td>
<td>Chechem</td>
<td>N</td>
<td>March to April</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Neomillsphaugia emarginata (Gross.) Blake</td>
<td>Polygonaceae</td>
<td>Sa'itsab</td>
<td>N</td>
<td>March</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>No identificada</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>No identificada</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>No identificada</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>No identificada</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Piscidia piscipula (L.) Sarg.</td>
<td>Leguminosae</td>
<td>Ja'abin</td>
<td>N</td>
<td>April to May</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
</tbody>
</table>
Table A-1. (continued)

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Family</th>
<th>Common Name</th>
<th>N/P</th>
<th>Flowering period</th>
<th>Habit</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Pisonia acuelata</em> L.</td>
<td>Nyctaginaceae</td>
<td>Be'eb</td>
<td>N</td>
<td>February</td>
<td>climber</td>
<td>secondary veg./lowland forest</td>
</tr>
<tr>
<td><em>Pithecellobium platylobum</em> (DC.) Urb</td>
<td>Leguminosae</td>
<td>Sak muk</td>
<td>N</td>
<td>mid-April to mid-June</td>
<td>climber</td>
<td>upland forest</td>
</tr>
<tr>
<td><em>Platymiscium yucatanum</em> Standley</td>
<td>Leguminosae</td>
<td>Granadillo</td>
<td>N</td>
<td>mid-Feb. to mid-March</td>
<td>tree</td>
<td>upland forest/lowlad forest</td>
</tr>
<tr>
<td><em>Pseudobombax ellipticum</em> (Kunth) Durand</td>
<td>Bombacaceae</td>
<td>Chulte/Amapola</td>
<td>P</td>
<td>March to April</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td><em>Swartzia cubensis</em> (Britton &amp; Wilson) Standley</td>
<td>Leguminosae</td>
<td>K'ataloox</td>
<td>P</td>
<td>mid March to mid-May</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td><em>Tabebuia chrysanth (Jacq.) Nichols.</em></td>
<td>Bignoniaceae</td>
<td>Jo'ok'ab/makulis</td>
<td>N</td>
<td>Feb. to mid-June</td>
<td>tree</td>
<td>secondy veg./lowland savannas</td>
</tr>
<tr>
<td><em>Tabebuia roseae</em> (Bertol.) Donn Smith</td>
<td>Bignoniaceae</td>
<td>Jo'ok'ab/makulis</td>
<td>N</td>
<td>Feb. to mid-June</td>
<td>tree</td>
<td>secondary veg.</td>
</tr>
<tr>
<td><em>Talisia floresii</em> Standley</td>
<td>Sapindaceae</td>
<td>Kolok</td>
<td>P</td>
<td>mid April to mid-May or June</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td><em>Talisia olivaeformis</em> (HBK.) Radik.</td>
<td>Sapindaceae</td>
<td>Guaya/guayum</td>
<td>N</td>
<td>March</td>
<td>tree</td>
<td>upland forest/urban areas</td>
</tr>
<tr>
<td><em>Vitex gaumeri</em> Greenman</td>
<td>Verbenaceae</td>
<td>Ya'ax nik</td>
<td>N</td>
<td>mid April to mid-July</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td><em>Viguiera dentata</em> (Cav.) Sprengel</td>
<td>Compositae</td>
<td>Tajonal/Tah</td>
<td>N/P</td>
<td>January to February</td>
<td>annual</td>
<td>recently disturbed areas</td>
</tr>
</tbody>
</table>

Table A-2 High water-content honey period flowering species

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Family</th>
<th>Common Name</th>
<th>N/P</th>
<th>Flowering period</th>
<th>Habit</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Acacia angustissima</em> (Miller) Blake</td>
<td>Leguminosae</td>
<td>K'aantemo’</td>
<td>N</td>
<td>May</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td><em>Acacia argustifolias</em></td>
<td>Leguminosae</td>
<td>Subintul</td>
<td>N</td>
<td>May to June</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td><em>Acacia gaumeri</em> Blake</td>
<td>Leguminosae</td>
<td>Box kaatsim</td>
<td>P</td>
<td>June to July</td>
<td>shrub</td>
<td>secondary veg.</td>
</tr>
<tr>
<td><em>Byrsonima bucidafolia</em> Standley</td>
<td>Malpighiaceae</td>
<td>Sak paj/Nance agrio</td>
<td>N</td>
<td>end May to mid August</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td><em>Caesalpinia violacea</em> (Miller) Standley</td>
<td>Leguminosae</td>
<td>Chakte viga</td>
<td>P</td>
<td>May to June</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td><em>Cedrela odorata</em> L.</td>
<td>Meliaceae</td>
<td>Cedro/K’uj che</td>
<td>N</td>
<td>May to June</td>
<td>tree</td>
<td>upland forest/urban areas or agroforestry plots</td>
</tr>
<tr>
<td><em>Coccoloba reflexiflora</em> Standley</td>
<td>Polygonaceae</td>
<td>Boob chich</td>
<td>N</td>
<td>end May to July</td>
<td>tree</td>
<td>lowlands</td>
</tr>
<tr>
<td><em>Coccoloba sp.</em></td>
<td>Polygonaceae</td>
<td>Boob de sabana</td>
<td>N</td>
<td>July to August</td>
<td>shrub</td>
<td>savanna or suuts</td>
</tr>
<tr>
<td><em>Coccoloba spicata</em> Lundell</td>
<td>Polygonaceae</td>
<td>Boob</td>
<td>N</td>
<td>May to June</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td><em>Colubrina greggi</em> S. Watson</td>
<td>Rhamnaceae</td>
<td>Puk'in</td>
<td>N</td>
<td>end June to July</td>
<td>arbusto</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td><em>Comutia pyramidalata</em> L.</td>
<td>Verbenaceae</td>
<td>Lot che’</td>
<td>N</td>
<td>April to May or June</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Scientific Name</td>
<td>Family</td>
<td>Common Name</td>
<td>N/P</td>
<td>Flowering period</td>
<td>Habit</td>
<td>Habitat</td>
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</tr>
<tr>
<td>Croton campechianus Standley</td>
<td>Euphorbiaceae</td>
<td>Kushu che’</td>
<td>N</td>
<td>May to June</td>
<td>tree</td>
<td>upland forest (secondary veg.? )</td>
</tr>
<tr>
<td>Dalbergia glabra (Miller) Standley</td>
<td>Leguminosae</td>
<td>Chak muk</td>
<td>N</td>
<td>July to August</td>
<td>climber</td>
<td>lowlands and savannas</td>
</tr>
<tr>
<td>Diospyros cuneata Standley Griseb.</td>
<td>Ebenaceae</td>
<td>Siliil</td>
<td>N</td>
<td>May to June</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Enterolobium cyclocarpum (Jacq.) Standley</td>
<td>Leguminosae</td>
<td>Piich</td>
<td>N</td>
<td>End April or May to big.Juneio</td>
<td>tree</td>
<td>upland forest /urban areas</td>
</tr>
<tr>
<td>Eugenia mayana Standley</td>
<td>Myrtaceae</td>
<td>Sak loob</td>
<td>N</td>
<td>June to July</td>
<td>tree</td>
<td>lowlands</td>
</tr>
<tr>
<td>Eugenia yucatanensis Standley &amp; Schultes</td>
<td>Myrtaceae</td>
<td>Wirich</td>
<td>N</td>
<td>May</td>
<td>tree</td>
<td>secondary veg.</td>
</tr>
<tr>
<td>Exostema caribaum (Jaq.) Roem.</td>
<td>Rubiaceae</td>
<td>Chak sabak che’</td>
<td>N</td>
<td>June</td>
<td>tree</td>
<td>lowlands near savannas or suuts</td>
</tr>
<tr>
<td>Guazuma ulmifolia Lam.</td>
<td>Sterculiaceae</td>
<td>Piixoy</td>
<td>N</td>
<td>May to June</td>
<td>tree</td>
<td>secondary veg.</td>
</tr>
<tr>
<td>Guettarda combsii Urban</td>
<td>Rubiaceae</td>
<td>Tasta’ab</td>
<td>N</td>
<td>June to July</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Havardia albicans</td>
<td>Leguminosae</td>
<td>Chukum</td>
<td>P</td>
<td>June to July</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td>Lonchocarpus longistylis Pittier</td>
<td>Leguminosae</td>
<td>Xu'ul</td>
<td>N</td>
<td>End June to July</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td>Lysiloma latisilicu (L.) Benth.</td>
<td>Leguminosae</td>
<td>Tsalam</td>
<td>N</td>
<td>May to June</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td>Machaonia lindeniana Baillon</td>
<td>Rubiaceae</td>
<td>Kuchel</td>
<td>N</td>
<td>June to July</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Nectandra coriacea (Sw.) Griseb.</td>
<td>Lauraceae</td>
<td>Xochyuc/Laurellilo</td>
<td>N</td>
<td>End May to July</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Neea fagifolia Heimerl.</td>
<td>Nyctaninaceae</td>
<td>Ta’tsi</td>
<td>N</td>
<td>Mid May to July</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>No identificada</td>
<td>-</td>
<td>Kiis yuk</td>
<td>N</td>
<td>April to May</td>
<td>tree</td>
<td>lowlands</td>
</tr>
<tr>
<td>No identificada</td>
<td>-</td>
<td>Kan chulul/Palo amarillo</td>
<td>N</td>
<td>May to June</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td>No identificada</td>
<td>Malpighiaceae</td>
<td>Chaka ni’ ka’</td>
<td>N</td>
<td>May to June</td>
<td>trepadora</td>
<td>recently disturbed areas/secondary veg./upland forest</td>
</tr>
<tr>
<td>No identificada</td>
<td>-</td>
<td>Chok che’</td>
<td>P</td>
<td>May to July</td>
<td>tree</td>
<td>secondary veg./lowlands/savannas</td>
</tr>
<tr>
<td>No identificada</td>
<td>-</td>
<td>Pakal che’</td>
<td>P</td>
<td>Mid-May to July</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Psidium sartorianum (Berg.) Niedenzu</td>
<td>Myrtaceae</td>
<td>Pichiche/Guayabillo</td>
<td>N</td>
<td>June to July</td>
<td>tree</td>
<td>older forests</td>
</tr>
<tr>
<td>Shoepfia schereberi</td>
<td>Rubiaceae</td>
<td>Chakte kok</td>
<td>N</td>
<td>June to July</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Sickningia salvadorensis Standley</td>
<td>Rubiaceae</td>
<td>Kiinim</td>
<td>N</td>
<td>May to July</td>
<td>tree</td>
<td>lowlands and savannas</td>
</tr>
<tr>
<td>Spondias mombin.</td>
<td>Anacardeaceae</td>
<td>Ju’ujub/Jobo</td>
<td>N</td>
<td>June to July</td>
<td>tree</td>
<td>lowlands/savannas/suuts</td>
</tr>
<tr>
<td>Spondias sp.</td>
<td>Anacardeaceae</td>
<td>Ju’ujub/Jobo</td>
<td>N</td>
<td>June to July</td>
<td>tree</td>
<td>lowlands/savannas/suuts</td>
</tr>
</tbody>
</table>
Table A-3 Dearth period flowering species

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Family</th>
<th>Common Name</th>
<th>N/P</th>
<th>Flowering period</th>
<th>Habit</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trema mycrantha (L.) Blume</td>
<td>Ullifera</td>
<td>Sak pixoy/capulin</td>
<td>N</td>
<td>June to July</td>
<td>Shrub</td>
<td>Recently disturbed and secondary vegetatopm</td>
</tr>
<tr>
<td>Allophyllus cominia (L.) Sw.</td>
<td>Sapindaceae</td>
<td>Ik bach</td>
<td>N</td>
<td>Oct to November</td>
<td>shrub</td>
<td>secondary veg.</td>
</tr>
<tr>
<td>Bouhnia herrerae (Britton &amp; Rose)</td>
<td>Leguminosae</td>
<td>Kibix</td>
<td>N</td>
<td>Shrub August to big. December</td>
<td>Annual climber tree</td>
<td>upland forest</td>
</tr>
<tr>
<td>Dendropanax arboreus (L.)</td>
<td>Araliaceae</td>
<td>Sak chaka/Shunan che'</td>
<td>N</td>
<td>August</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td>Planch. Et Decne.</td>
<td>Malvaceae</td>
<td>Puk/Majagua/Jool</td>
<td>N</td>
<td>September tree</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Hampea trilobata Standley</td>
<td>Araliaceae</td>
<td>Sak katsiim</td>
<td>N</td>
<td>December tree</td>
<td>shrub</td>
<td>secondary veg.</td>
</tr>
<tr>
<td>Lonchocarpus rugosus Benth.</td>
<td>Leguminosae</td>
<td>Kanasin</td>
<td>N</td>
<td>October</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td>Mimosa bahamensis Benth.</td>
<td>Leguminosae</td>
<td>Kanasin</td>
<td>N</td>
<td>September</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Misidentified</td>
<td>-</td>
<td>Inche’</td>
<td>N</td>
<td>August tree</td>
<td>tree</td>
<td>near savanna (suuts)</td>
</tr>
<tr>
<td>No identified</td>
<td>-</td>
<td>Kan chan</td>
<td>N</td>
<td>October tree</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td>Pouteria campechiana (H.B. &amp; K.)</td>
<td>Sapotaceae</td>
<td>K'aaniste'</td>
<td>N</td>
<td>August tree</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td>Baehni ; Calocarpum mammosum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table A-4. Recovery period flowering species

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Family</th>
<th>Common Name</th>
<th>N/P</th>
<th>Flowering period</th>
<th>Habit</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casimiroa tetrameria Millsp.</td>
<td>Rutaceae</td>
<td>Yu'uy</td>
<td>N</td>
<td>November to December</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Jacquemontia perantartha (Jacq.) G. Don</td>
<td>Convolvulaceae</td>
<td>Solen ak</td>
<td>N</td>
<td>December to mid-Feb.</td>
<td>annual climber tree</td>
<td>recently disturbed and secondary veg.</td>
</tr>
<tr>
<td>Luehea speciosa Wild.</td>
<td>Tiliaceae</td>
<td>Kas kaat</td>
<td>N</td>
<td>November to December</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Manilkara zapota (L.) Van Royen</td>
<td>Sapotaceae</td>
<td>Zapote or Ya'</td>
<td>N</td>
<td>November to December</td>
<td>tree</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td>Unidentified</td>
<td>-</td>
<td>Kakaw che'</td>
<td>N</td>
<td>December tree</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td>Unidentified</td>
<td>-</td>
<td>Chakte k'aax</td>
<td>N</td>
<td>November tree</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td>Unidentified</td>
<td>-</td>
<td>Sak oox</td>
<td>N</td>
<td>December tree</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td>unidentified</td>
<td>-</td>
<td>Chamilbox</td>
<td>N</td>
<td>January tree</td>
<td>tree</td>
<td>upland forest</td>
</tr>
<tr>
<td>Turbina corymbosa (L.) Raf.</td>
<td>Convolvulaceae</td>
<td>Xtabentun</td>
<td>N</td>
<td>December to January</td>
<td>Annual climber tree</td>
<td>recently disturbed and secondary veg.</td>
</tr>
<tr>
<td>Verbesina gigantea Jacq.</td>
<td>Compositae</td>
<td>Chulke</td>
<td>N</td>
<td>December to January</td>
<td>Annual climber tree</td>
<td>secondary veg.</td>
</tr>
<tr>
<td>Viguiera sp.</td>
<td>Compositae</td>
<td>Sak tah</td>
<td>NN</td>
<td>November to December</td>
<td>Annual</td>
<td>secondary veg.</td>
</tr>
<tr>
<td>Scientific Name</td>
<td>Family</td>
<td>Common Name</td>
<td>N/P</td>
<td>Flowering Period</td>
<td>Habit</td>
<td>Habitat</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------</td>
<td>-------------------</td>
<td>-----</td>
<td>------------------</td>
<td>---------</td>
<td>------------------------------</td>
</tr>
<tr>
<td><em>Brosimum alicastrum</em> Swartz</td>
<td>Moraceae</td>
<td>Ramón/Oox</td>
<td>P</td>
<td>twice a year</td>
<td>tree</td>
<td>upland forest and urban</td>
</tr>
<tr>
<td><em>Cissus sicyoides</em> L.</td>
<td>Vitaceae</td>
<td>Ta'ka'nil</td>
<td>N</td>
<td>several times</td>
<td>climber</td>
<td>secondary veg./upland forest</td>
</tr>
<tr>
<td><em>Lonchocarpus xu'ul</em> Lundell</td>
<td>Leguminosae</td>
<td>Kan chikin che'/Kan xu'ul Kaanchunup</td>
<td>N</td>
<td>twice a year</td>
<td>tree</td>
<td>lowland forest</td>
</tr>
<tr>
<td><em>Thouinia paucidentata</em> Radlk.</td>
<td>Sapindaceae</td>
<td>several times</td>
<td>N</td>
<td></td>
<td>tree</td>
<td>upland forest</td>
</tr>
</tbody>
</table>
APPENDIX B
FLOWERING EPISODES OF SELECTED SPECIES OBSERVED FROM JANUARY 1999 THROUGH MARCH 2000 AT LA MONTAÑA, CAMPECHE, MÉXICO
Flowering episodes of selected species observed from January 1999 through March 2000 at La Montana, Campeche, Mexico. [0 = no flowering; 1 = flower buds; 2 = flowering; for at least one of the five marked individuals of each species]
LIST OF REFERENCES


BIOGRAPHICAL SKETCH

Luciana Porter-Bolland was born and raised in Mexico City. She conducted her bachelor’s degree studies with a major in biology at the Universidad Autónoma Metropolitana–Unidad Xochimilco in Mexico City, and graduated in 1992. In 1993 she moved to Syracuse, New York to conduct a Master of Science program at the State University of New York–College of Environmental Science and Forestry. In 1995 she received her degree and returned to Mexico to continue working in the Maya area, where she had conducted research for her thesis. In 1996 she returned to the U.S. to pursue a Ph.D. program at the School of Forest Resources and Conservation at the University of Florida. After graduation she plans to continue working in the management and conservation of tropical resources area.