

Table 2.4: Secchi disc readings reported from previous limnological surveys in Lake Patzcuaro.

Reference	Secchi disc range (metres)
Yamashita (1939)	2.40 - 2.20
De Buen (1941b)	1.67 - 0.94
Herrera (1979)	1.85 - 1.15
Tellez y Motte (1980)	1.64 - 1.16
Velasco (1982)	1.18 - 0.41
Perez (1986)	0.95 - 0.19
Chacón Torres (1987)	0.50 - 0.29

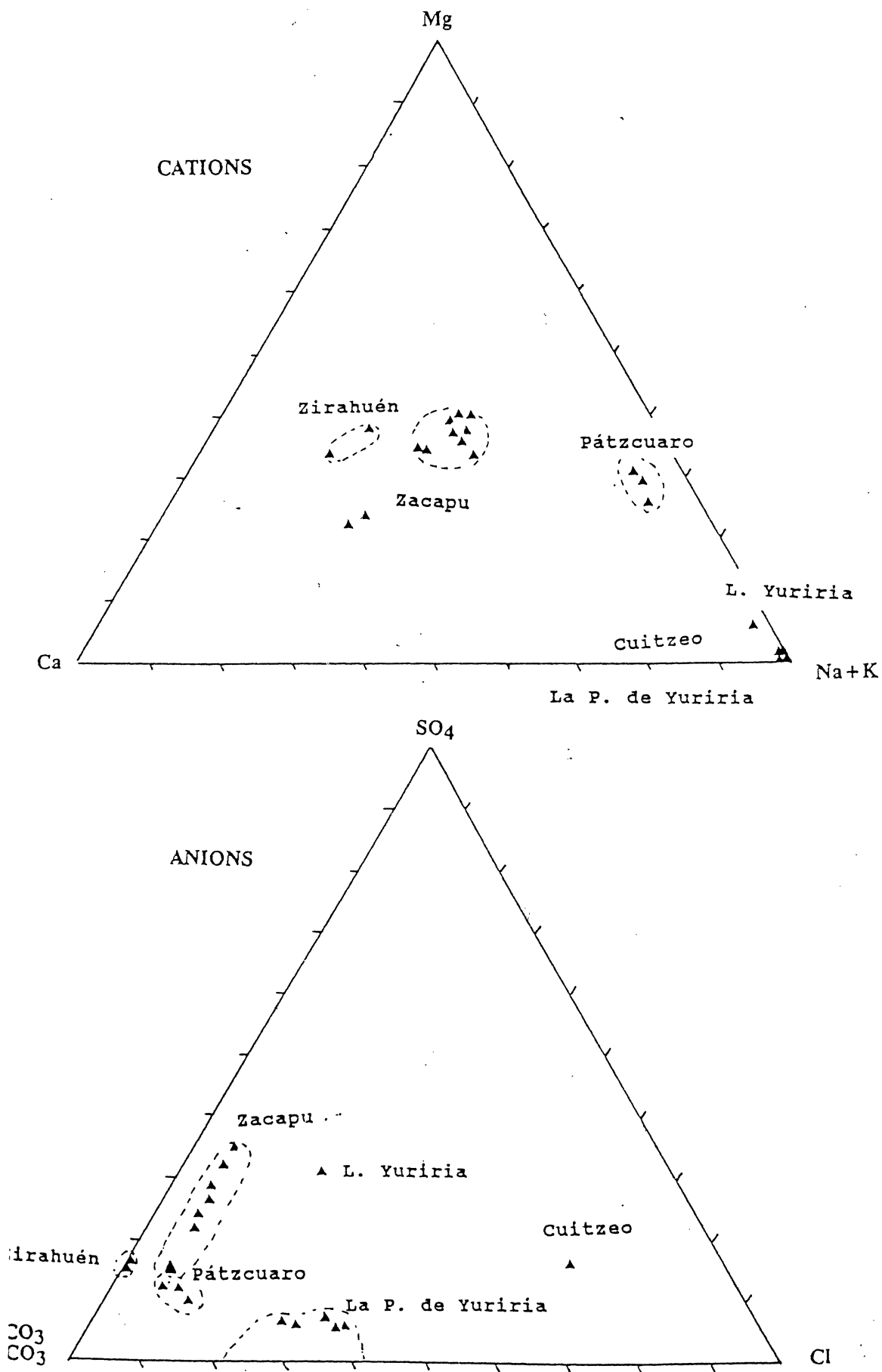
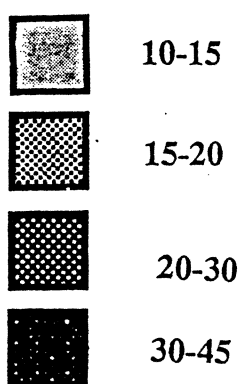
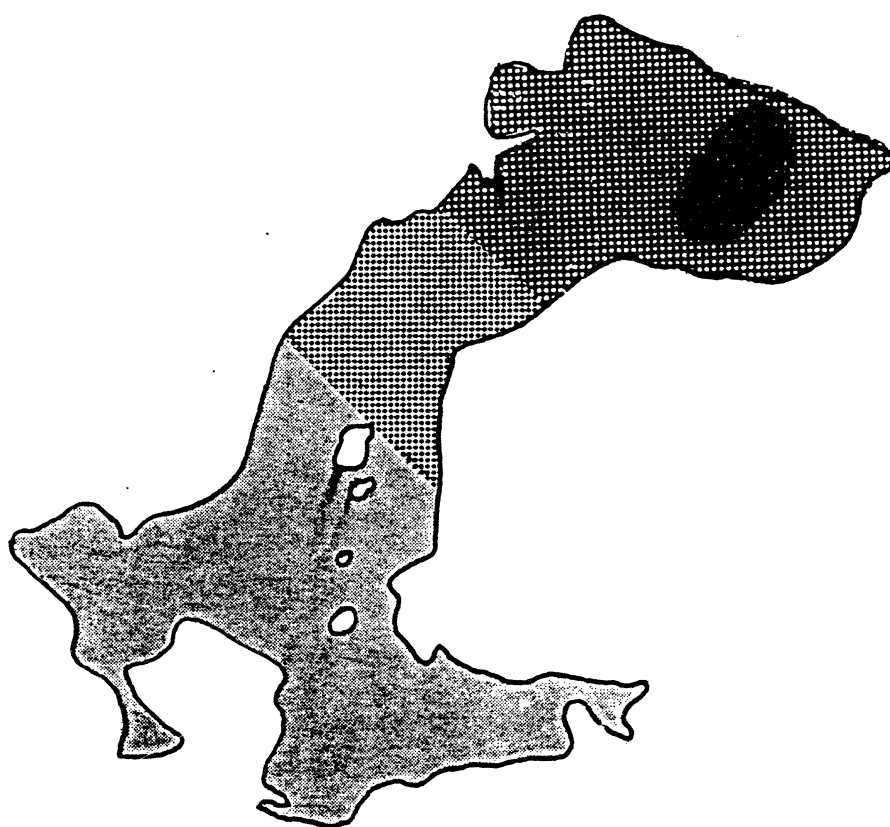


Figure 2.12 Water chemistry of Lake Pátzcuaro.



Suspended sediment mg/l

Figure 2.13 Variations in suspended sediment concentrations of Lake Pátzcuaro.

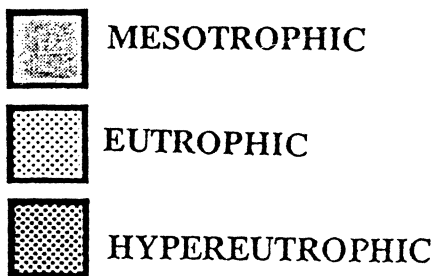
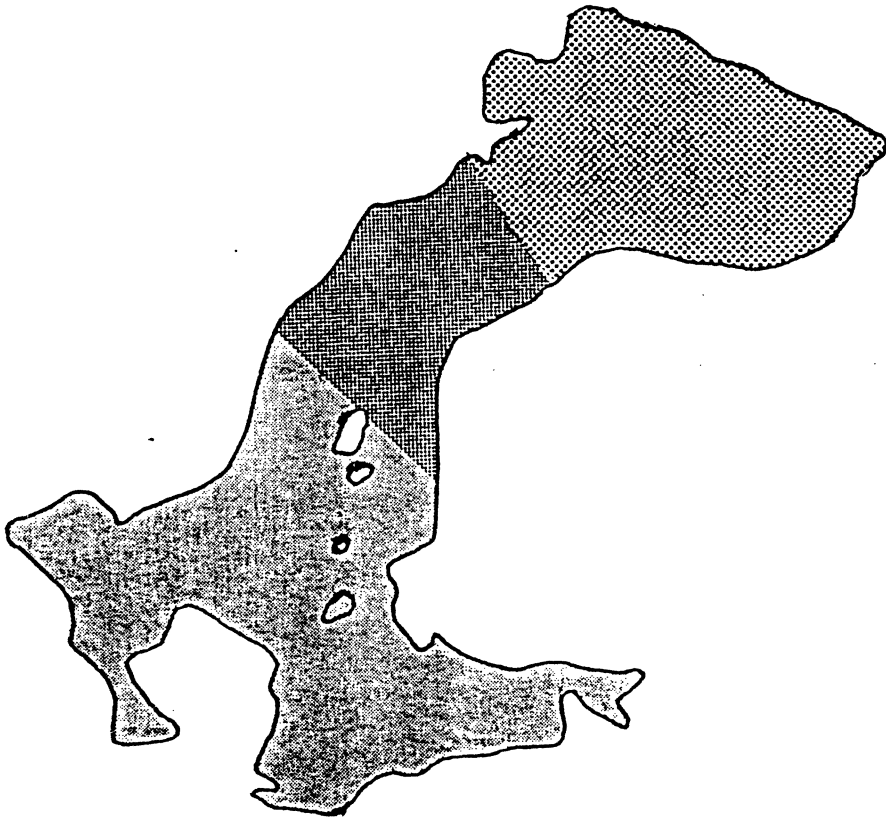


Figure 2.14 Variations in the trophic status of Lake Pátzcuaro.

CHAPTER THREE: BACKGROUND TO THE ARCHAEOLOGY OF MEXICO

3.1 INTRODUCTION

Human occupation of the Americas occurred relatively recently and even though there is still considerable controversy as to the exact timing of this event, there is an increasing body of evidence to suggest widespread occupation throughout North and South America by at least 15,000 years B.P. (Fig. 3.1). In México a number of sites of human occupation have been dated as early as 25,000 to 30,000 years B.P. (Fig. 3.1). Sufficient archaeological evidence that allows the prehistory of Mesoamerica (that part of México and neighbouring Latin America which was civilized at the time of the Spanish Conquest (Kirchhoff, 1943)) to be reconstructed, however, remains scant until the last 5,000-6,000 years.

Numerous cultural groups have risen to prominence at different times and places in Mesoamerica. The chronology of some of the most important cultures is shown in Table 3.1. While the archaeology of some areas has been established, in other areas relatively little is known. The prehistory of Mesoamerica is generally divided into several stages: the Archaic, Preclassic, Classic and Postclassic periods. The nomenclature and timing of these periods varies from one author to another, but what is given below is generally the most accepted division.

3.1.1 The Archaic (ca 7,000-3,500 B.P)

The development of sedentary agriculture was one of the greatest achievements of the Prehispanic indigenous peoples of Mesoamerica. It made possible villages, then towns and eventually provided the basis for the rise of the major cultural groups that inhabited this area. In Mesoamerica the twin process of domestication and sedentism took place throughout the Archaic (Coe *et al.*, 1986). Our knowledge of this period is based on data from relatively few sites, the most important being the Valley of

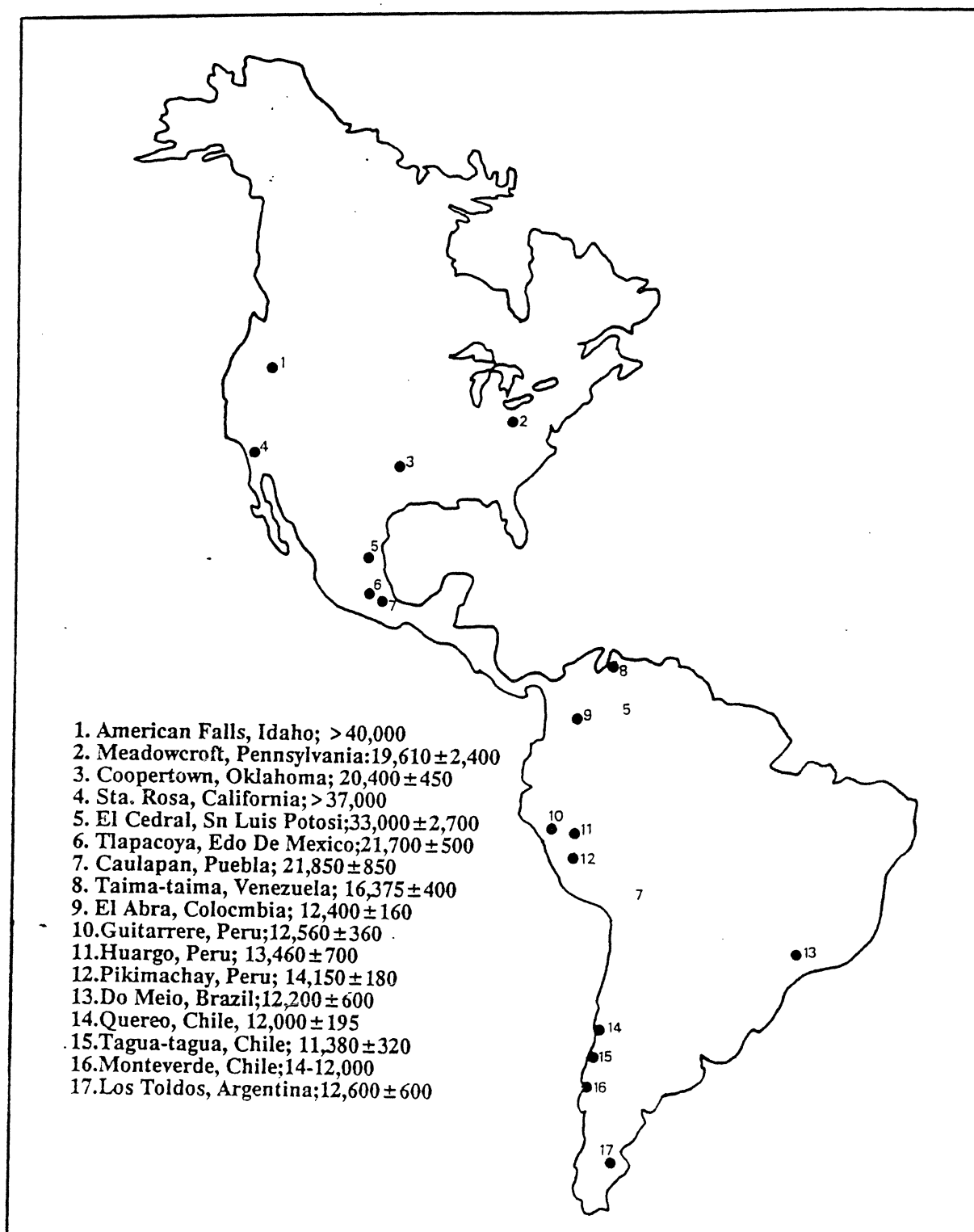


Figure 3.1 Early human occupation sites in the Americas.

Tehuacán in the state of Puebla, Tamaulipas in north eastern México, and the Valley of Oaxaca (Fig. 3.2).

Based on a series of cave sites in the Valley of Tehuacán, MacNeish (1964, 1972) has reconstructed the sequence of cultural development from approximately 11,500 to 450 years B.P. In the earliest stages the palaeoindians lived primarily by hunting and gathering, with food gathering becoming more important by approximately 8,000 years B.P. when many of the larger mammals became extinct. Although remains of avocado and squash suggest primitive agriculture was present in the area 5,000-6,000 years ago, it was not until 4,000-5,000 years B.P. that the first conclusive evidence of cultivation is found. Remains of maize (*Zea mays*), beans (*Phaseolus* Spp), courgette (*Cucurbita* spp), gourds, aramanth (*Amaranthus cruentus*), chili pepper as well as avocado have been discovered in sediments dating to this period. Agriculture played an increasingly important role in the production of food and by 1,400 years B.P. accounted for 75% of food production in this area (Fiedel, 1987).

At Tamaulipas (Fig. 3.2) the record of agricultural development extends back to 9,200 years B.P. and culminates with the establishment of sedentary agriculture and village communities at approximately 3,500 years B.P. The sequence and timing of the appearance of plants at this site differs from the Tehuacán sequence, the most important difference being the appearance of maize, albeit a slightly improved variety, at about 5,000 B.P., 2,000 years after it is first seen at Tehuacán.

More recently work has concentrated on sites in the Valley of Oaxaca (Schoenwetter, 1974; Fig. 3.2) and provides evidence of early incipient agriculture in this area. Pumpkin and squash seeds recovered from sediments at Guela Naquitz Cave have been dated between 8,700 and 6,900 years B.P. Remains from the neighbouring site of Cueva Blanca date to 3,300 years B.P. and have a similar assemblage to deposits of this age found in the Valley of Tehuacán, indicating an economy based on hunting, gathering and some agriculture (Fiedel, 1987).

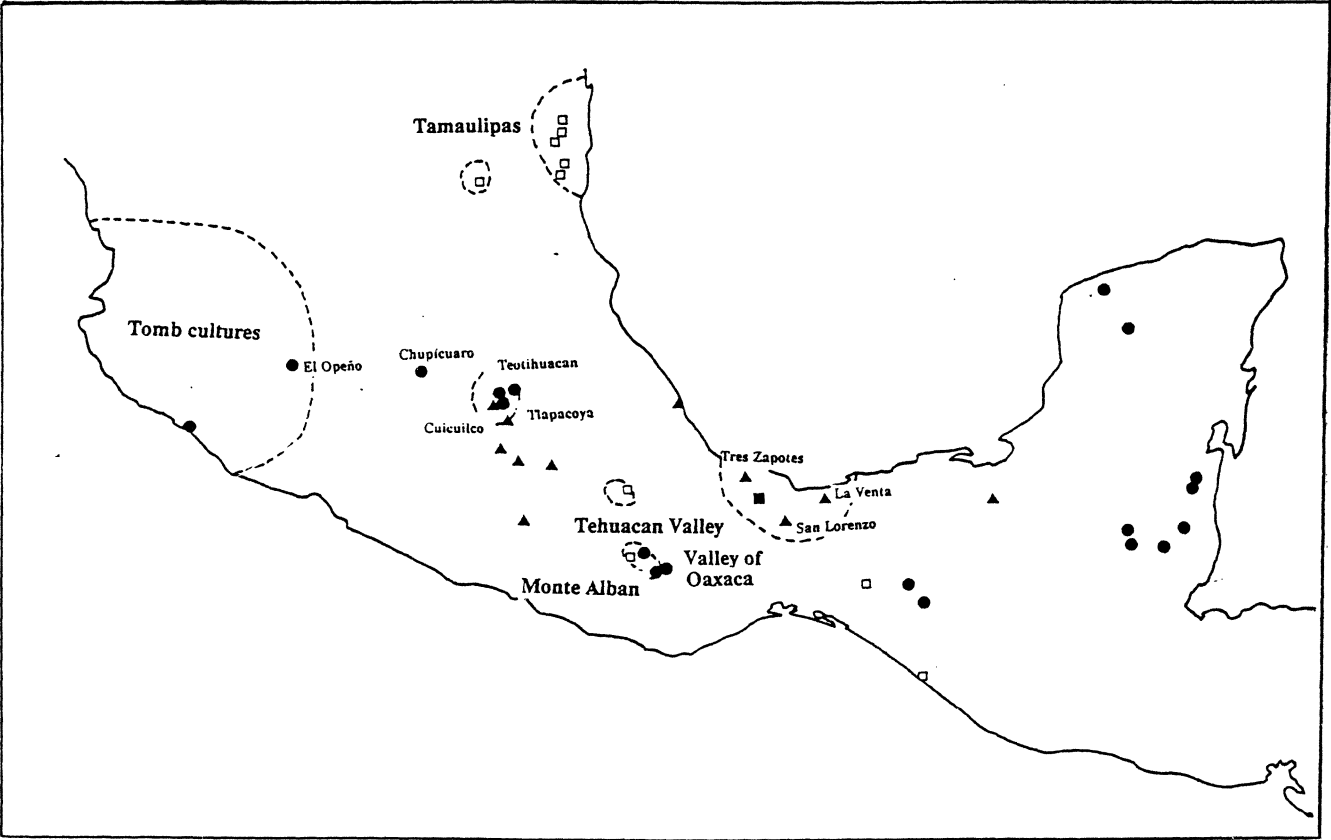


Figure 3.2 Major Archaic and Preclassic archaeological sites in Mesoamerica.

3.1.2 The Preclassic (ca 3,500-1,700 B.P.)

Even though evidence suggests that agriculture was practised in Mesoamerica as early as 7,000 years ago, it was not until 4,500 years ago that the first truly sedentary villages were established (Fiedel, 1987). A notable exception is Zohapilco in the Basin of México which appears to have been occupied on a near-permanent basis as early as 7,950 years B.P. (Niederberger, 1979). Niederberger (1979) suggested that the diverse flora and fauna of this region encouraged stability, allowing for a more sedentary way of life.

Although it is not easy to find Archaic sites in Mesoamerica, Preclassic sites are abundant (Fig. 3.2). Advances in agriculture during the Archaic resulted in improvements in maize cultivation and higher yields. These factors, together with increased population, probably resulted in permanent settlements being the norm rather than the exception.

A rapid spread in village-based farming occurred about 3,500 years ago (Flannery, 1976; Fiedel, 1987, and shortly after this time; around 3,200 years B.P., the first complex culture of Mesoamerica, the Olmecs, rose to prominence in the swampy lowland regions of Veracruz and neighbouring Tabasco (Fig. 3.2). Although it seems unlikely that Mesoamerica's first urban, class-divided society, would emerge in such an inhospitable area it has been suggested that the high productivity of the riparian areas occupied by the early Olmecs allowed for a surplus of food. Thus, fewer people were required to farm the land, allowing an elite division to emerge (Coe *et al.*, 1986; Fiedel, 1987).

The Olmecs occupied three major centres (Fig. 3.2): San Lorenzo (3,200-2,900 years B.P.); La Venta (2,900-2,500 years B.P.); and Tres Zapotes (2,600-2,000 years B.P.), reaching their apex between 2,900 and 2,500 B.P. At the time of the fall of Tres Zapotes the Olmecs had already been eclipsed by the rise of other cultures, and by the late Preclassic had all but disappeared (Fiedel, 1987).

Very few Preclassic sites have been found in Western México, the most

distinctive feature being the hundreds of shaft-and-chamber tombs that have been found in Colima, Nayarit and Jalisco. In Michoacán, only a few such sites have been found and excavated. Several tombs were examined near Jacona at El Opeño on the border of Michoacán and Colima (Fig. 3.2) (Noguera, 1931, 1939; Oliveros, 1971). These tombs were cut into calcrete, to a depth of 1.1 m. with an entrance down steps leading into an underground antechamber, connected to a stone-lined tomb. The pottery at these sites shows marked similarities to that of the Chupícuaro culture whose main centre is found at Chupícuaro in the state of Guanajuato (Fig. 3.3).

The Chupícuaro occupied a number of sites along the banks of the Río Lerma and remains have been found at Cuitzeo, Queréndaro and Zinapécuaro (Fig. 3.3). They lived in small agriculturally-based communities, complimenting their diet by hunting and fishing. Given the distribution of ceramics associated with the Chupícuaro culture, it is believed that their influence stretched over a considerable area, artefacts extending as far north as La Quemada (Fig. 3.2) and south as far as Oaxaca (Fig. 3.2). However, our knowledge of the way of life of these people is limited and the main archaeological sites associated with this culture were drowned when the Solis Dam was impounded in 1949 (Porter Weaver, 1981).

A detailed investigation by French archaeologists from the Centre D'études Méxicaines et Centraméricaines (CEMCA) is providing new and interesting data on Preclassic sites in the Basin of Zacapu (Fig. 3.3). This basin is located 15 km north-west of the Basin of Pátzcuaro. Their study suggests that this basin was more densely populated in the late Preclassic, than in the Postclassic period (C. Arnould, pers. comm., 1989).

3.1.3 The Classic (ca 1,700 - 1,100 B.P)

The Classic period was the high point of Mesoamerican civilization, with the emergence of true city states in both the highlands and lowlands of México. During this period there was a significant northward expansion in the frontier of Mesoamerica with

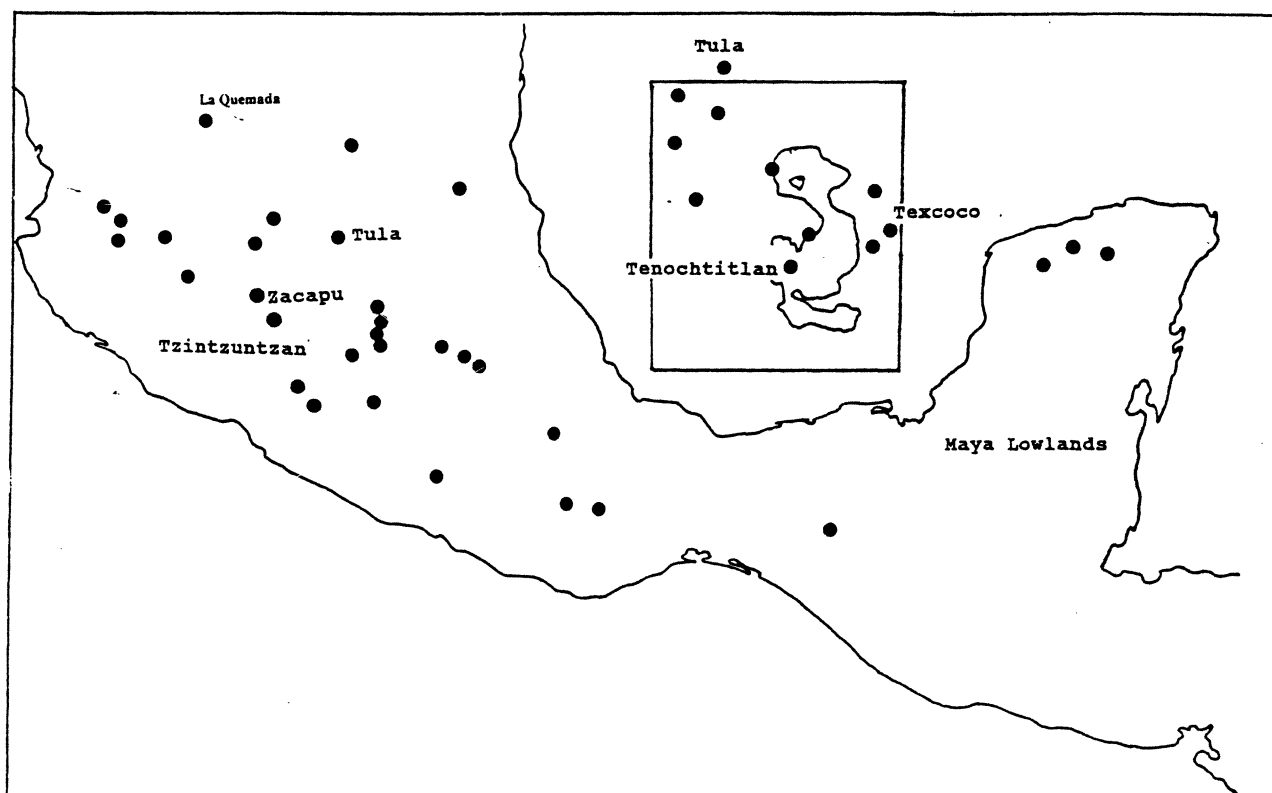


Figure 3.3 Location of major Classic and Postclassic archaeological sites in Mesoamerica

settlements located as far north as Chihuahua. It is believed that this expansion was in response to greater precipitation at this time (Armillas, 1969; Porter Weaver, 1982).

Areas of particular importance were at Monte Alban, the valley of Puebla, Cuicuilco and Teotihuacán in the Basin of México and the numerous sites associated with the Mayan civilization which flourished in the Yucatán and neighbouring parts of Guatemala and Belize (Fig. 3.3).

Although there is evidence to suggest that Archaic villages may have been established in the Basin of México as early as 5,000 years B.P. (Niederberger, 1979), it is not until 3,500 years ago that truly agricultural villages are found. Once sedentary agriculture was established this region experienced a dramatic increase in population. Between 2,650 and 2,300 years B.P., the estimated population of the basin rose from 25,000 to 75,000 (Fiedel, 1987). During the late Preclassic, Cuicuilco, situated in the southern part of the Basin of México (Fig. 3.2), emerged as the major centre in the Basin. However, it had been superseded by Teotihuacán by 2,150 years B.P. and was finally destroyed by the volcanic eruption of Xitle and abandoned in 1,700 years B.P.

Teotihuacán ruled most of México and was possibly the first truly urban state, with an estimated population of 125,000 (Millon, 1967, 1970). Its economy was based on craft and trade together with an intensive agricultural system. It remained the dominant centre in Mesoamerica until approximately 1,400 to 1,300 years B.P. when it collapsed. It has been suggested that Teotihuacán may have been abandoned as a result of civil unrest and it is clear that much of the city had been burned and vandalized (Coe *et al.*, 1986). Vaillant (1944), however, suggested that the use of wood in producing lime to cover buildings resulted in widespread deforestation and subsequent environmental degradation in this region.

Even though occupation of a number of the Chupícuaro sites continued into the Classic period (Ruíz, 1987), few other sites dating to this period have been found in Michoacán. Sites that have been excavated appear to have been strongly influenced by Teotihuacán. The most well-known Classic site in this region is found at Tingambato

(Fig. 3.4) a mid-late Classic settlement situated between Pátzcuaro and Uruapan. The architecture here shows a distinct resemblance to that seen at Teotihuacán, although no Central Mexican ceramics have been found to date (Porter Weaver, 1982). Ruíz (1987) suggested that with the fall of Teotihuacán, people migrated from the Basin of México to this area. While this may be true, Tingambato is situated at the boundary of the *Tierra Caliente* and *Tierra Fria*. Thus, it served as an important trading post between the two zones, and may have been a trading outpost for the Teotihuacáños long before their collapse.

Likewise, the Maya civilization which had reached its zenith during the Classic period experienced a sudden and spectacular collapse approximately 1,200-1,100 years B.P. Although many hypotheses have been proposed to explain this collapse it has not been possible to pin-point any specific causal mechanism. One group, like Vaillant (1944), suggest that widespread environmental degradation resulted in the failure of agricultural production (Hammond, 1982), while other researchers suggest that social revolution may have resulted in the elite being overthrown and in the breakdown of social structure (Culbert, 1973; Hamblin and Pitcher, 1980).

3.1.4 The Postclassic (ca 1,100 - 470 B.P.)

After the fall of Teotihuacán, one of the major sites in the highlands of México developed at Tollan (Tula; Fig. 3.3). Tollan was the city of the Toltecs, whose short-lived empire influenced a large area of Central México and the Yucatán. The collapse of this civilisation and destruction of the city of Tollan about 820 years B.P. was possibly due to civil unrest triggered by a drought-induced famine (O'Shea, 1980). This drought brought nomadic invaders (Chichimeca) from the more arid northern parts of México into the central highlands.

One of these nomadic groups, the Méxica or Azteca, eventually settled in the Basin of México approximately 800 years B.P.. Initially they paid tribute to other groups already occupying the region, but rapidly grew in importance eventually establishing their

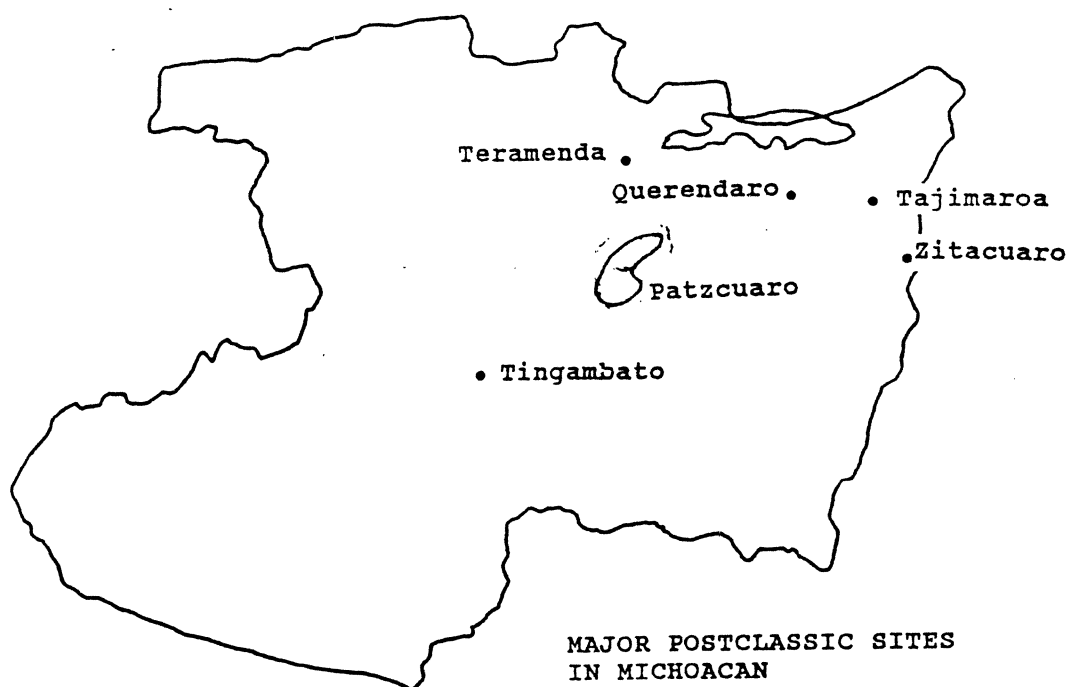
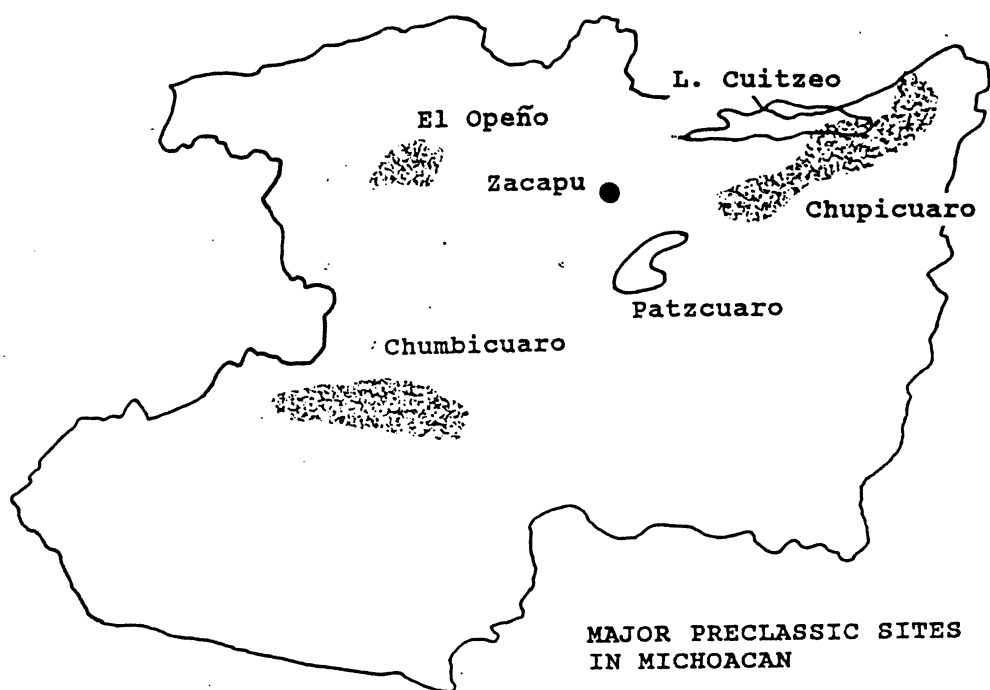


Figure 3.4 Major archaeological sites in the vicinity of the study area.

own settlement on the Island of Tenochtitlán approximately 660 years B.P. By the middle of the 15th century, the Aztecs had increased their power and together with the city-states of Texcoco and Tlacopan, formed the Triple Alliance. From this vantage point the Aztecs went on to control a large part of Mesoamerica and at the time of the Spanish Conquest (1521) ruled much of México.

The best archaeological information available for Postclassic cultures in Western México comes from the Basin of Pátzcuaro itself, which formed the focal point of the Purépechan culture, which rose to prominence at the same time as the Aztecs rose to power in the Basin of México. There have been a number of investigations in the basin which were begun in the late 19th century by the Norwegian explorer Lumholtz (1904). The available archaeological and historical information from the Basin of Pátzcuaro will be discussed in greater detail below.

3.2 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND TO THE BASIN OF PATZCUARO

The Basin of Pátzcuaro is one of the most studied areas in México. Aguerra (1979) listed over 500 publications relating to the area covering 17 different disciplines. The majority of these deal with social, political and historical issues although several are relevant to this study and will be discussed in context.

As indicated above, our understanding of the archaeology of Western México is scant and few Preclassic and Classic sites are known. No archaeological remains dating to these periods have yet been found within the Basin of Pátzcuaro, although there is evidence that during the late Preclassic the adjacent Basin of Zacapu was densely populated.

Although no Preclassic or Classic sites have been found, there is evidence to suggest that human occupation of the Basin of Patzcuaro dates to at least 3,600 years B.P. Watts and Bradbury (1982) reported the appearance of maize in the pollen record implying that agriculture was being practised in the basin at this time. In addition, an

investigation of a 2.49 m high colluvial section in the north-western part of the basin led Street-Perrott et al. (1989) to conclude that this area had suffered at least two phases of disturbance over the last 2,300 years. They suggested that the first phase of disturbance may have been a result of the introduction of sedentary agriculture in this region while the second phase may have begun in the late Postclassic and was intensified by the introduction of European farming techniques by the Spanish.

There have been a number of archaeological investigations in the Basin of Pátzcuaro which began in the late 19th century. One of the earliest studies was by the Norwegian explorer Lumholtz (1904), but it was not until the 1930s and 1940s that more systematic excavations began (Rubin de la Barabolla, 1939, 1941). More recently a detailed analysis of the socio-economic conditions during the late Postclassic to early – Hispanic periods has been made (Gorenstein and Pollard, 1983). Undoubtedly, the most important source of information on the Purépecha, their rise to social and military power and their style of life is the '*Relacion de Las Ceremonias y Ritos y Poblacion y Gobernacion de Michoacán*' (1541;1956), hereafter referred to as the *Relación de Michoacán*. The *Relación de Michoacán* is believed to have been written between 1539 and 1541 (Glass, 1975), by the Franciscan friar Jeronimo de Alcala based on information provided by Purépechan informants (Warren, 1971).

From the time of the Conquest until Independence in 1821, the Spanish monarchs requested geographical and historical information about the cultures of the New World. These Relaciones and Chronicles were generally compiled by members of the various religious orders and provide interesting, if not important information on México over this period. After Independence, another important source of geographical and historical information are the numerous published diaries and monographs of nineteenth century travellers and explorers. Because of the importance of such documents to the current study, the following section reviews some of the main findings from these historical sources.

3.2.1 The Purépecha

At the same time as the Aztecs came to power in the Basin of México, the Purépecha (Tarascans) emerged as a major cultural group in Western México. The Purépecha settled in the Basin of Pátzcuaro and by the time of the Conquest ruled an area comparable to the modern state of Michoacán (Fig. 3.4). Like the Aztecs, it is believed that they entered the lake area of Central México from the north having been forced southwards by a period of prolonged drought. One of the popular legends states that the Purépecha were part of the original Aztec migration from the mythical place of Azaltán. When they reached Lake Pátzcuaro some went in to bathe and on coming out found their belongings stolen and their companions gone. The thieves went on to settle on the Island of Tenochtitlán, in the Basin of México. Whatever the source of this legend, it is certain that there was considerable animosity between the Aztecs and the Purépecha, for although they met in battle several times neither group would surrender its sovereignty.

The Relacion de Michoacán, however, gives a much different account of the arrival of the Purépecha in the Pátzcuaro region. It states that a group of semi-nomadic (Chichimec) Purépecha under the leadership of *Hire Ticatame* separated from the main group in the Zacapu-Naranja area to the north-west of Pátzcuaro sometime in the early part of the twelfth century. This group settled in the northern portion of the basin and for approximately four generations occupied a site at Uayameo, the present day Santa Fé de la Laguna (Fig. 2.2).

When the Chichimec Purépecha entered the Basin of Pátzcuaro they found the region occupied by two groups who spoke a language not dissimilar to their own. These were the Islanders centred on the Island of Jarácuaro and a group settled in the area of Quiríngaro, the present day San Simon Quiríngaro. Over the years the newcomers intermarried and made alliances with other groups in the region and eventually became united under the rule of *Tariacuri* ca 610 years B.P. (Toissant, 1942). The capital at this time was at Pátzcuaro, but moved firstly to Ihuatzio (Fig. 2.2) and eventually to

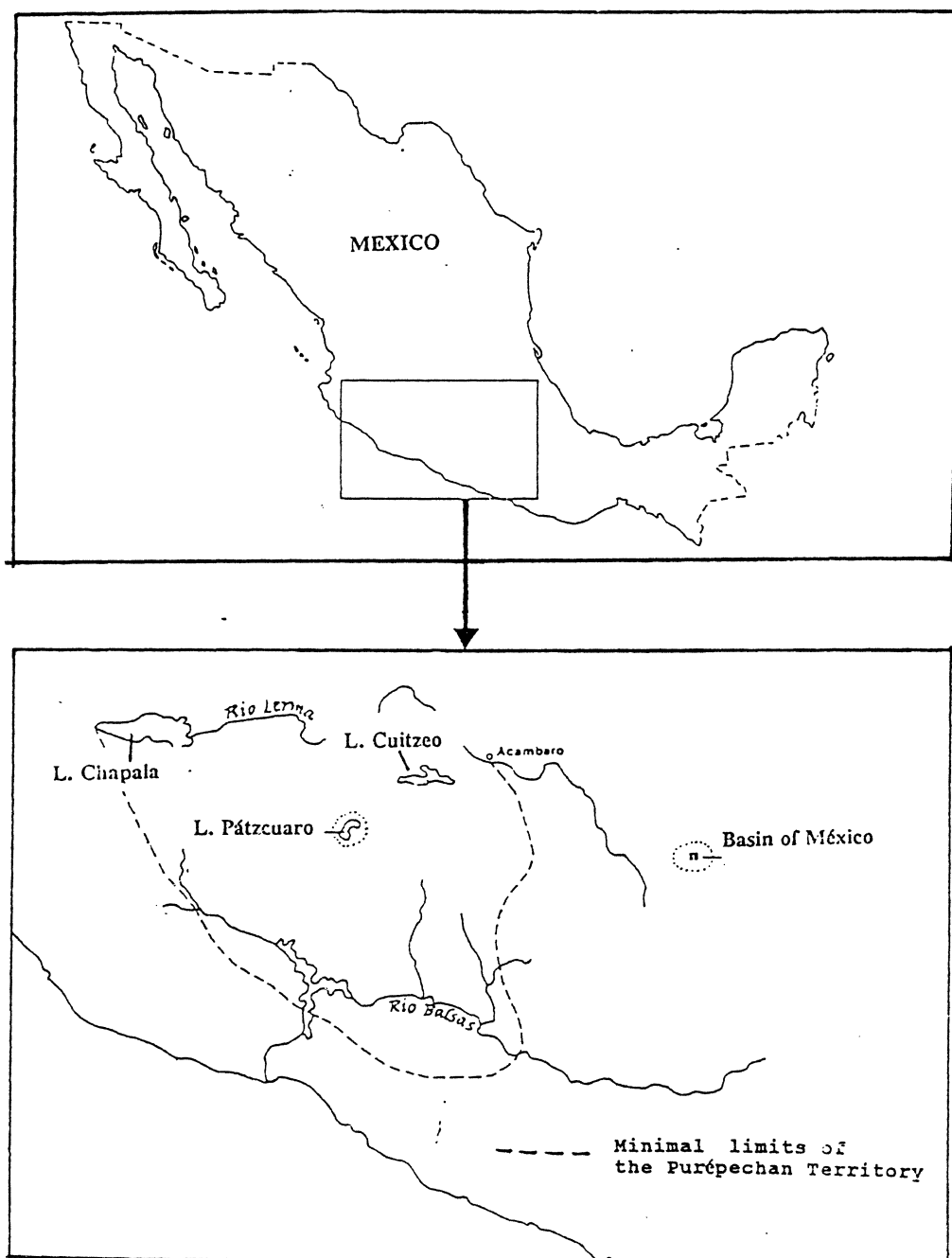


Figure 3.5 Limits of the Purépecha empire at the time of the Spanish Conquest.

Tzintzuntzan (Fig. 2.2). *Tariacuri* and his sons and nephews began a series of campaigns to conquer the surrounding area and in time conquered a large part of Michoacán and adjacent parts of Jalisco and Guanajuato (Fig.3.5).

When the Spanish arrived (470 years B.P.; 1522) the Purépecha reigned supreme over a large area. Their skill on the battle field was acknowledged to the extent that in the sixteenth century the Aztec emperor Montezuma declared the Purépechan civilization the only other polity in the world legitimized by the gods and recognised by himself (Gorenstein and Polard, 1983). Likewise the Spaniards were impressed by the manner in which the Purépechan rulers maintained control over their territory.

Like the Aztecs the Purépecha worshiped many gods and had a well developed religious hierarchy. The main Purépechan god was *Caricaueri*; 'the great bonfire', who was identified with the sun. One of the principal religious duties of the Purépecha was the burning of a perpetual fire in the temples in honour of *Curicaueri*. The god was served by five priests, the chief of whom was *Curita-Catieri*; 'the lord who is in charge of the fire' (Nuñez, 1984). In addition, one of the most important positions within the Purépechan hierarchy was *Pucur cuara* who was the person in charge of the guardians of the forests whose job it was to collect wood to keep the fires going. The importance of wood and fires to this culture is affirmed by the continual mention of wood and the collection of wood in the *Relación de Michoacán*.ie

'... Señor Tariacuri, ya tienes discrecion, trai leña para las cues; da de comer leña a Caricaueri...'

'... Lord Tariacuri, now you are wise, bring wood to the cues and give it to Caricaueri to eat...'

Cues (temples) were located all around the basin and over the period that the Purépecha occupied the area must have consumed considerable quantities of wood.

3.2.2. The Hispanic Period

When the Spanish arrived in the Basin of Pátzcuaro 469 years ago under the leadership of Cristobal de Olid, the Purépecha readily relinquished control of their empire

to the Spanish conquerors. As a result of their immediate surrender the Purépechan nobility were able to retain a considerable amount of power, influence and land. Documentary sources indicate that important Purépechan families continued to sell land and make grants until as late as 1722 (Brand, 1951).

In the immediate post-Conquest period Pátzcuaro was of considerable importance, being both the capital of Michoacán and the place of the Bishops' See. The translation of both these administrative centres to Valledollid (Morelia) in the 1580s marked the beginning of a period of depression for the Basin of Pátzcuaro. Many Spaniards left the region to set up their home in the new capital and Pátzcuaro lost most of its former importance.

During the early years of the colonial period the Spanish introduced a practice of entrusting towns and their population to Conquistadors who were allowed to collect tributes from the indigenous people; there were called *encomiendas*. Cortés assigned himself Tzintzuntzan and all the towns dependent on it, which effectively included the entire Basin of Pátzcuaro. He held them until he was relinquished of his lands in 1528-1529. The *encomienda* system never really worked in the Pátzcuaro Basin and after 1554 no part of the basin was included in an *Encomienda* (Brand, 1951).

The *Encomienda* system in México as a whole was short-lived and by the end of the 16th century ranches or *haciendas*, which often comprised great tracts of land, were being established. The development of the *hacienda* system in The Basin of Pátzcuaro was slow. The *Inspeccion Occular* (1789) reports only four *haciendas* in the region. This was possibly the result of a number of factors, firstly, many Spaniards had migrated away from this region meaning that the population was dominated by indigenous people. The areas had no mines, and the lands around the lake were not suitable for ranching. *Haciendas* of particular importance at the end of the 1700s were the *Hacienda San Nicolas de Sanabria*, which belonged to the Augustine monks and was mainly involved in the production of maize and had a few head of cattle, and the *Hacienda of Chapultepec*, which belonged to the Jesuits and produced maize, wheat and had 500 head of cattle

(Inspeccion Occular, 1789). During the 18th century the number of haciendas increased dramatically and by 1822 Lejarza (1824) reported the presence of 18 haciendas and 6 ranches in the basin. The Hacienda system was abolished after the Mexican Revolution of 1910-1920 and today much of the land in the basin belongs to communities rather than individuals.

3.2.3 Changes in the population

Based on archaeological and ethnohistorical sources, Gorenstein and Pollard (1982) estimated that at the time of the Conquest there were ninety-one settlements in the basin, sixty-three of which were located in the lacustrine zone, twenty on the lower slopes and eight in the sierras. The total population of the Basin was believed to have been between 60,000 and 105,000 with 25,000-30,000 inhabitants in Tzintzuntzan alone (Pollard, 1972). The mean population density of the catchment was 103 km^{-2} with densities of up to $7,000 \text{ km}^{-2}$ in some parts of Tzintzuntzan.

Gorenstein and Pollard (1983) went further, delimiting several different land-use categories, and determined that the basin could support a population of 41,000-60,000, considerably less than their estimates of the population at that time. These figures, however, are based on the lake standing at an estimated level of 2050 m a.s.l. compared to the present level of ca. 2037 m a.s.l. Evidence presented in Chapter Six, however, suggests that the level of the lake at the time of the Conquest was not as high as suggested by Gorenstein and Pollard (1983) and thus their figures may underestimate the production potential of this area.

In the immediate post-Conquest period the population of this region was decimated by disease and maltreatment of the indigenous people by their Spanish conquerors. Population estimates for the Basin of Pátzcuaro for the period 1500 A.D. to when the first reliable census was made in 1822 (Lejarza, 1824) have been made by Gorenstein and Pollard (1983). Many of these figures are based on estimates of the population of Central México derived from tribute and baptism numbers (Cook and

Simpson, 1948; Cook and Borah, 1971, 1974). These data are shown in Table 3.2.

Within sixty years of the Conquest the population of the basin had fallen approximately 75% to an estimated 14,000 to 25,000 people. This downward trend continued until the beginning of the seventeenth century at which time the number of inhabitants is believed to have been between 7,300 and 13,300 (Table 3.2). It was during this period that many villages were forced to amalgamate. In December 1612 the villages of San Juan Apupuato, San Pedro Chenanz and San Fransisco Echene were forced to resettle at present day Tzuramutaro (AGN, 1730), while in the northern part of the basin a number of villages around Quiroga were made to amalgamate (Brand, 1951).

It was not until the nineteenth century that the population of this region began to increase again. Even then the increase was relatively slow and continually halted by periods of famine and civil unrest. During the twentieth century the population of the basin has risen considerably, doubling between 1940 and 1980. Today there are an estimated 111,000 inhabitants in the basin (INEGI, 1990). Thus, it has only been in the last twenty to thirty years that the population of the Basin of Pátzcuaro has returned to pre-Conquest levels.

3.2.4 Pre- and Post Hispanic agriculture

The appearance of maize in the pollen record of Lake Pátzcuaro indicates that agriculture was practiced in the Basin as early as 3,500 years ago (Watts and Bradbury, 1982). Our understanding of Prehispanic agricultural practices in this area is derived from a number of sources: archaeological information, written and pictorial descriptions, and most importantly the continued use of many Prehispanic cultivation techniques throughout Central México.

Prehispanic agriculture relied entirely on hand instruments, the main tools being the digging or planting stick, with a blade (if any) in the same plane as the handle, and the hoes or mattocks where the blade is set at an angle to the handle. The digging stick often comprises nothing more than an unbranched stick, pointed and fire-hardened,

Table 3.2 Population changes in the Lake Patzcuaro basin.

Date (AD)	Population (to near- est 100)	Major Plagues	Source of Population estimate
1500-20	60-100,000		Gorenstein & Pollard (1983) Protohistoric Period
1550	40-75,000	1545*	Gorenstein & Pollard (1983) Early Hispanic Period
1568	19-35,000		Cooke & Borah (1971): plateau ratio 1548-1568 of 2.13
1580	14,000-25,400	1576*	Cooke & Borah (1971): plateau ratio 1568-1580 of 1.38
1595	9,700-17,500		Cooke & Borah (1971): plateau ratio 1580-1595 of 1.45
1608	7,300-13,300		Cooke & Borah (1971): plateau ratio 1595-1608 of 1.32
1650	10-20,000		Cook & Simpson (1948); ratios based on entire New Spain
1700	14-26,000	1690s**	Cook & Simpson (1948); ratios for New Spain
1742	7,500		Villaseñor y Sánchez (1746- 1768) in Brand (1951)
1805	13,000	1786**	Cooke & Borah (1974): tributaries
1822	17,500		Lejarza (1824)
1860	31,000	1833-36** 1850	Romero (1862)
1900	30-39,000	1860-80	Brand (1951): extrapolation to basin - Mexican National Census
1940	40,000		Mexican National Census
1970	70,000		Mexican National Census
1990	111,000		Mexican National Census

Note: * Epidemics, ** Famine; from Brand (1951)

although some late Postclassic examples from Central México were tipped with metal (West, 1948; Donkin, 1979). The main use of the digging stick was in planting and it was often restricted to this purpose after other implements became available (Donkin, 1979). Its uses are depicted in a number of Mexican codices, most notably in the Codex Florentino where it is shown being used in the planting and hilling of maize, planting and harvesting of metl (maguey), general cultivation and diversion of irrigation waters (Fig.3.6).

At the time of the Spanish Conquest, quite intensive agriculture was practised in the Basin of Pátzcuaro. It is likely, however, that prior to the rise of the Purépechan culture shifting cultivation was the main form of farming. This type of farming was practiced throughout Central America and involved clearing a small patch of land which could then be cultivated for 3-5 years. The underbrush was removed together with small saplings and larger trees during December and January. These were left until March when the dried brush and wood were burned and the ashes dug into the land to act as a fertilizer.

Prehispanic farming techniques in the Basin of Pátzcuaro will have been based on this technology and today, on steeper slopes and on small patches of soil within lava flows, the Purépecha have retained their ancient ways of soil preparation and planting. A description of traditional farming techniques from the early colonial period suggests that the Purépecha preferred to farm the steep slopes rather than the more gently sloping areas in the valleys. A report from Corundapan (which no longer exists) in the sierras near Tingambato states:

'...no tienen en los llanos y así siembran en el monte como acostumbra toda la nación tarasca en lo que es tierra fría por abrigar sus sementeras de los yelos...'

'...they do not farm the planes, they cultivate the slopes as is the custom throughout the cold regions of the entire Tarascan nation, to protect the seedlings from frost...'

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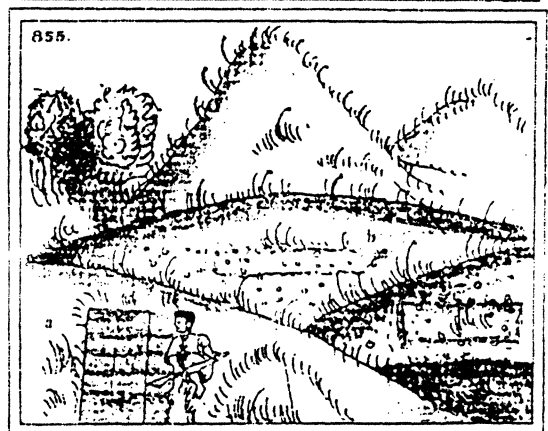
There is evidence that the steeper slopes in the Basin of Pátzcuaro were utilised



Coa, used as a planting stick and for hilling maize (Codex Florentino, c. 1570)



Planting and harvesting metl with coas (Codex Florentino, c. 1570)



Coas used in directing irrigation water and in general cultivation (Codex Florentino, c. 1570)



Coa used in transplanting flowers (Codex Florentino, c. 1570)

Figure 3.6 Uses of the Coa in Prehispanic agricultural practices.

by the Purépecha. Extensive areas of abandoned terraces are seen around Tzintzuntzan and Icupio. In the vicinity of Tzintzuntzan these features are quite large (Plate 3.1) while on the steeper slopes around Icupio and stones have been used to form small retaining walls and terrace like forms (Plate 3.2).

The native trilogy of maize, beans and squash formed the basic crop complex. The three crops were planted together in the same field, cultivated together and harvested at similar times (West, 1948). Other indigenous crops included amaranth (*Amaranthus cruentus*), sweet potato (*Ipomoea batatas*) and jicama (*Pachyrhizus erosus*). In addition to field cultivation, a large variety of crops were grown in small garden plots using very intense farming.

The arrival of the Spanish in the Pátzcuaro area saw the introduction of new farming techniques and crops, one of the most significant introductions being the plough. As the plough is best suited to low gradients, its introduction may have resulted in a shift from farming the slopes to the valley floors. The plough introduced into the Pátzcuaro region in the immediate post Conquest period was the Egyptian plough which is still used extensively throughout the basin today (Nuñez, 1989). Together with new agricultural technology, the Spanish, introduced new crops, most notably wheat and barley, as well as a large variety of vegetables and fruits.

Another important introduction to México and the New World in general, was domestic animals. Pigs, cows, sheep and horses became quickly established. Sheep, in particular, flourished away from their natural predators. Their numbers increased to such an extent that even the Spanish were surprised (Frank, 1979). Although pigs were introduced into the Basin of Pátzcuaro on a large scale as early as 1525, other animals, were not as important. Cattle ranching was never important in this region because of the lack of suitable grazing land and also quite importantly the large indigenous population. To own cattle a licence was required. These were rarely given to indigenous people and cattle were never introduced into this region in large numbers.

3.2.5 Evidence of environmental degradation

The Basin of Pátzcuaro is mentioned in various documents and descriptions that have been written since the Conquest. The earliest description of the region was provided by Cortés in his Third letter to Charles V (1522) who in giving his reasons for not establishing a colony in the Basin of Pátzcuaro stated that;

'...since the land was not very satisfying to them for colonizing, they showed ill will towards it...'

(Cortés, 1522)

Hence, it is possible that environmental degradation in the Pátzcuaro basin had become quite severe under the extreme population pressure at the time of the Conquest. Certainly a number of the drawings which accompany the *Relación de Michoacán* (1541;1956) depict the areas surrounding Tzintzuntzan to be barren of trees, the only vegetation shown being xerophytic scrub (Plate 3.3). It is impossible, however, to determine whether this was the case for the basin as a whole. When Pátzcuaro was settled in the late fourteenth century it was necessary to clear the slopes of forest indicating that at this time the southern part of the basin was heavily forested. Although it is not possible to estimate the degree of deforestation in this region by the time of the Conquest, there must have been a huge demand for wood, not only for keeping the fires in the Cues alight and for cooking purposes, but also for use in buildings, roofs and fences (Castro-Leal, 1989).

Most of the descriptions from the colonial period do little more than describe the town and its position in relation to the lake (eg. Ponce, 1585).

Villaseñor y Sanchez (1748) described Pátzcuaro as been

'...cercada de montes la poblacion tupidos arboles de crecida magnitud y.... a la parte norte una gran laguna, que mide de circunferencia doce leguas'.

('... the settlement is surrounded by very large and closely growing trees and...to the north there is a great lake that is twelve leagues in circumference').

Forty years later the *Diccionario Geografico-Historico* (Alcedo y Bexarano, 1786-1789) also described Pátzcuaro as being;

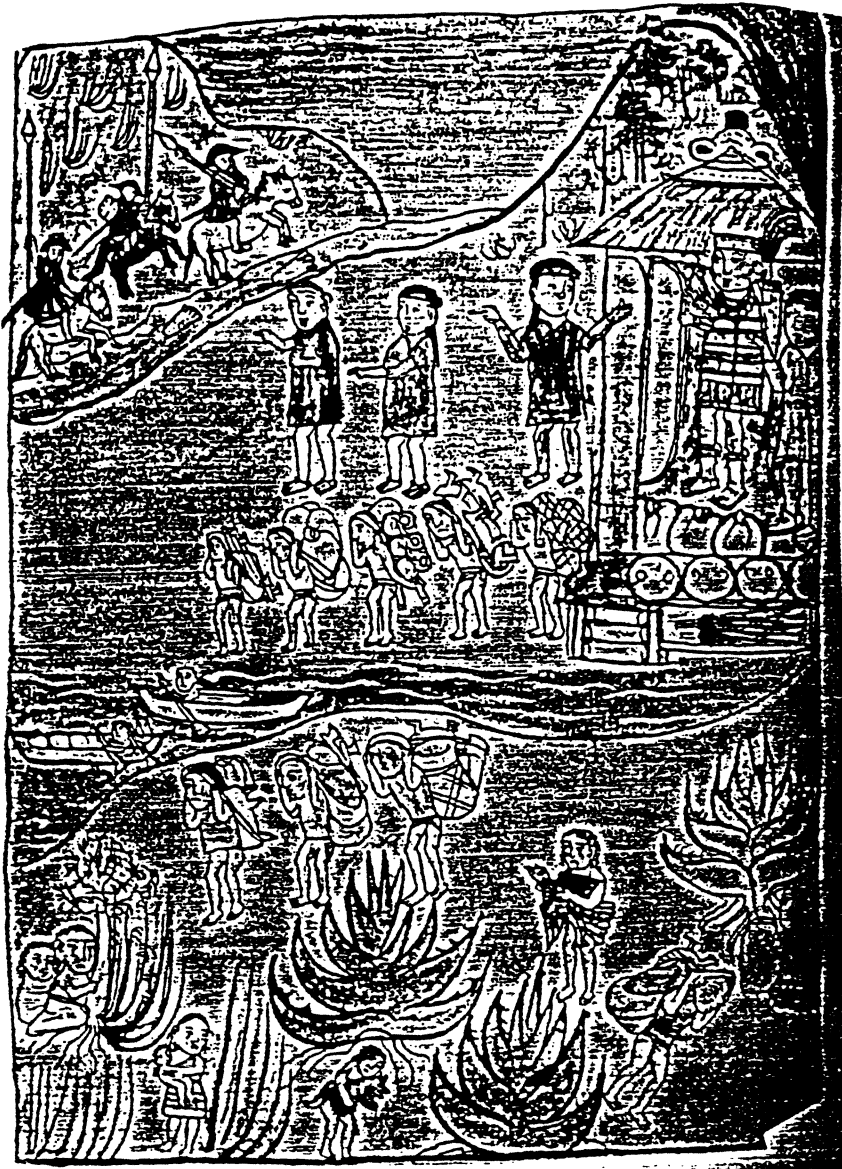


Plate 3.3 Scenes from the Relación de Michoacán. (Note that few trees are depicted on the hillslopes).

'...cercado de montes que estan cubiertos de arboles muy crecidos...'

('surrounded by mountains that are covered by very tall trees..')

These colonial description suggest that the basin was well forested by the late 1700s. Yet it would appear that at the time of the Conquest deforestation was quite severe. It is possible that the massive reduction in the population which the area experienced in the immediate post Conquest years allowed the forests to recover although it is likely that the forest described were in fact secondary.

It is believed that the forests within the Basin of Pátzcuaro remained relatively intact until the end of the nineteenth century. González (1896) description of the region states;

'Por un lado, la perspectiva del pintoresco lago con sus islas cubierto de flores y por el otro los montes y bosques que la rodean... Las principales especies que hay en los bosques, son pino, encino, brasil...'

('On one side is the picturesque view of the lake with its islands covered by flowers and for the other the mountains and forests that surround it....The principal species within the forests are pine, oak, brazil...')

In 1886, the railway arrived in the Basin of Pátzcuaro. Its arrival heralded the beginning of mass exploitation of the forests of this region. There are various comments as to the extent of this destruction.

Manuel Santillan (cited in Guzman Avila, 1982) stated:

'Mientras que las vias de comunicacion fueron escasas y dificiles, estos bosques permanecieron casi intactos a traves de los años, pero tan pronto iban avanzando los tramos de ferrocarril con distintos rumbos dentro de esta porcion del territorio nacional, se iniciaron explotaciones...'

('While communication lines were difficult and scarce these forests remained intact over the years, but as soon as the railway cut distinct tracts into the centre of this part of the national territory exploitation of the forests began...')

while one North American traveller who visited the area shortly after the arrival of the railway commented that:

'it is not only the journey that has suffered changes, the destruction of the forest,

the drying of mountain springs and the climate of the region including the regularity of rains and that which depends on the prosperity of agriculture suffered a profound perturbation'

(La Libertad, 1894 cited in Ramirez, 1988)

Much of the forest exploitation during the late nineteenth and early twentieth centuries was by foreign companies. Documentary evidence clearly indicates that a number of haciendas in the Basin sold large tracts of forest to foreign investors during this period (Guzman Avila, 1982), the main exploiters being English and American timber companies. It appears that there was considerable concern amongst the indigenous people of this area, their sentiments been expressed in songs written at this time.

*'A que canalla este gringo!
 Ahora sī entro
 por Pichataro
 cuando menos pensamos, el tren
 se oyó su silbato
 Cerrito chiquito Por ti,
 Me da mucha lástima
 que bonito, cerro azul
 para Santiago Ysley que
 le cuadras tanto...
 A que canalla este gringo!'*

*'What a bastard this American
 When we least expected it we
 hear his chainsaw and the
 train has entered Pichataro
 Little blue mountain
 it saddens me that for Santiago
 Ysley they cut down so much...
 What a bastard this American!'*

(cited in Guzman Avila, 1982)

In 1936 the issue of deforestation in the Basin had reached such a critical level that the President, Lazaro Cardenas, instructed M.A. de Quevado to investigate the problem (Quevado, 1936a, 1936b). This resulted in a major programme of reafforestation within the Basin. This positive action, however, was short-lived, and in the fifty years since this initiative an estimated 75% (Toledo et al, 1981; CESE, 1986) of the remaining forest cover has been lost.

Today, soil erosion is so widespread that in some parts of the Basin of Pátzcuaro the top soil has been completely removed exposing the underlying core stones.

Considerable efforts have been made to reduce the impact that the population is having on the environment. This has involved prohibiting the clearing of forest and introducing soil conservation methods. It is apparent, however, that these measures are still not sufficient to prevent this problem, and with the huge increase in the population in recent years even greater land-use pressure and degradation can be expected.

CHAPTER FOUR: LATE PLEISTOCENE-EARLY HOLOCENE ENVIRONMENTAL CHANGE IN MEXICO: A BRIEF REVIEW

4.1 INTRODUCTION

As discussed in Chapter 1, the aim of this thesis is to determine late Holocene environmental change in the Basin of Pátzcuaro. Attention here will focus on assessing the impact of cultural development in this area and determining what, if any, inference can be made about climatic conditions during this period. To place this work in its appropriate context, this chapter will review the more pertinent palaeoenvironmental research undertaken in this region to date.

Attempts to reconstruct the palaeoenvironmental history of México began in the 1940s with investigations in the Basins of México (Deevey, 1943; Sears, 1947, 1951a, 1951b, 1952a, 1952b, 1953 ; Sears and Clisby, 1955) and Pátzcuaro (Deevey, 1944, 1957). The aim of these early studies was to reconstruct past vegetation assemblages based on the fossil pollen record. These data were then used to infer past climatic conditions. Even though these studies suggested that changes in the climate had occurred in the past, the lack of absolute dating control limit their usefulness. In addition, it was evident that the long history of human disturbance in México had significantly altered the pollen spectra (Deevey, 1944) and consequently efforts to determine climatic change in this region based on such data were severely limited.

Even with the development of absolute dating techniques and improved methods of determining palaeoenvironmental change, the reconstruction of the late Holocene climate of Central México continues to frustrate researchers, and many, like Markgraf (1989), hold the belief that

'After 6 ka B.P, palaeoenvironmental change in Central America can no longer be ascribed to climatic change alone...'

The realization that palaeoecological evidence can be used to document human disturbance within this region has resulted in such studies taking on a new aim. Today,

palaeoenvironmental investigations in Middle America concentrate on two areas: those attempting to reconstruct the late Pleistocene-Holocene climate and those trying to assess long-term human impact on the environment. As both areas of investigation are important to this thesis, the main findings from both sets of studies will be discussed. Those studies which have focussed on Lake Pátzcuaro will be discussed in greater detail at the end of this chapter.

4.2 RECONSTRUCTION OF LATE PLEISTOCENE-HOLOCENE CLIMATES IN CENTRAL MEXICO

There have been relatively few attempts to reconstruct late Pleistocene-Holocene climates of México, but undoubtedly the most important records to date come from investigations in the highlands of Central México. The majority of these studies have concentrated on former and present lake basins, and have utilized a variety of palaeolimnological techniques, with additional data from geomorphological and archaeological investigations.

The locations of several of the most important study sites are shown in Figure 4.1. Of these, the Basin of México has been investigated in most detail (see summaries in Brown, 1984, 1985; Lorenzo and Mirambell, 1986; Bradbury, 1989; Markgraf, 1989). The following discussion is based largely on these works.

Prior to any discussion, however, it is important to note that there are still problems with the dating framework in this region. Correlation between many cores has been based on tephra layers, in particular the Tripartite ash (TPT) and the Upper Fine Pumice (UFP) which are present both in the Basin of México and the Upper Lerma basin (Bloomfield and Valastro, 1974; Metcalfe *et al.*, 1986, 1991). While these provide important marker horizons, researchers have adopted different ages for these deposits. Dates on the TPT have varied from 12,900±400 years B.P. (Mooser, 1967) 9,920±200 years B.P. (Watts and Bradbury, 1982), while in the Upper Lerma Basin the equivalent tephra deposit (referred to as the Upper Toluca Pumice-(UTP) has been dated to

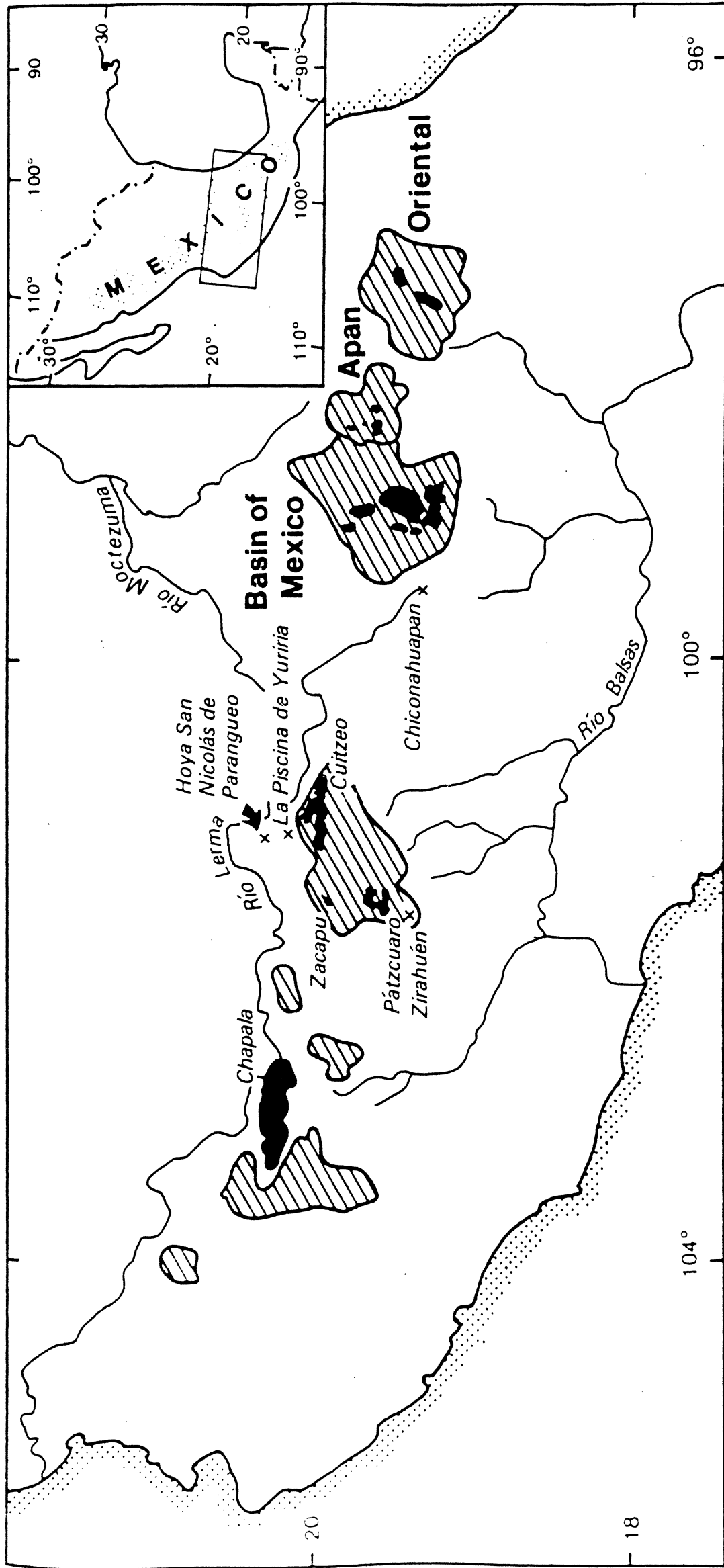


Figure 4.1 Location of the main paleolimnological investigations in Central Mexico



x Small lake (labelled)

11,580[±]70 years B.P. (Bloomfield and Valastro, 1974). The latter date is an average of four radiocarbon assays on charcoal fragments found immediately below the UTP. This charcoal layer is probably vegetation burned when the UTP fell and is consequently the most reliable date for this tephra layer. Therefore, this date will be used in this study. Studies that have used other dates for this tephra will be corrected accordingly.

The UFP in the Basin of México is bracketed by two dates 4,250[±]110 years B.P. and 4880[±]120 years with a mean date of 4,565[±]85 years B.P. This corresponds closely to the date of 4,570[±]60 years B.P. obtained from organic muds immediately underlying the Yellow Ash in the Upper Río Lerma Basin (Metcalf *et al.*, 1986, 1991) and will be accepted as the correct date in this thesis.

One of the earliest palaeoecological investigations in México was that of Paul Sears (*ibid.*) who analysed the pollen sequence of a number of cores collected from Lake Texcoco. Using these data he concluded that:

'The rise and fall of populations within the Basin of México has been profoundly influenced by the changing availability of moisture.' (Sears, 1951b).

Although Sears published extensively on his work in the Basin of México (Sears, *ibid.*) his studies have met with considerable criticism. Brown (1984, 1985) commented on the small number of pollen grains counted for each sample and concluded that in many instances the number was so low that attempts to make climatic inferences from such data would be invalid. He went on to conclude that although this was *'...an interesting and very provocative first try..'* it provided *'...little data that can be used today.'*

After the preliminary analysis by Sears (*ibid.*) it was not until the 1970s that further palaeolimnological work was carried out in the Basin of México. Bradbury (1971) published the diatom record from a long core collected from Lake Texcoco. While this added substantially to our understanding of the Late Pleistocene climate, it provided little additional information on the Holocene other than that conditions during the early Holocene had been wetter than during the late Pleistocene period.

Bradbury (1989) went on to reinterpret these data together with data from other

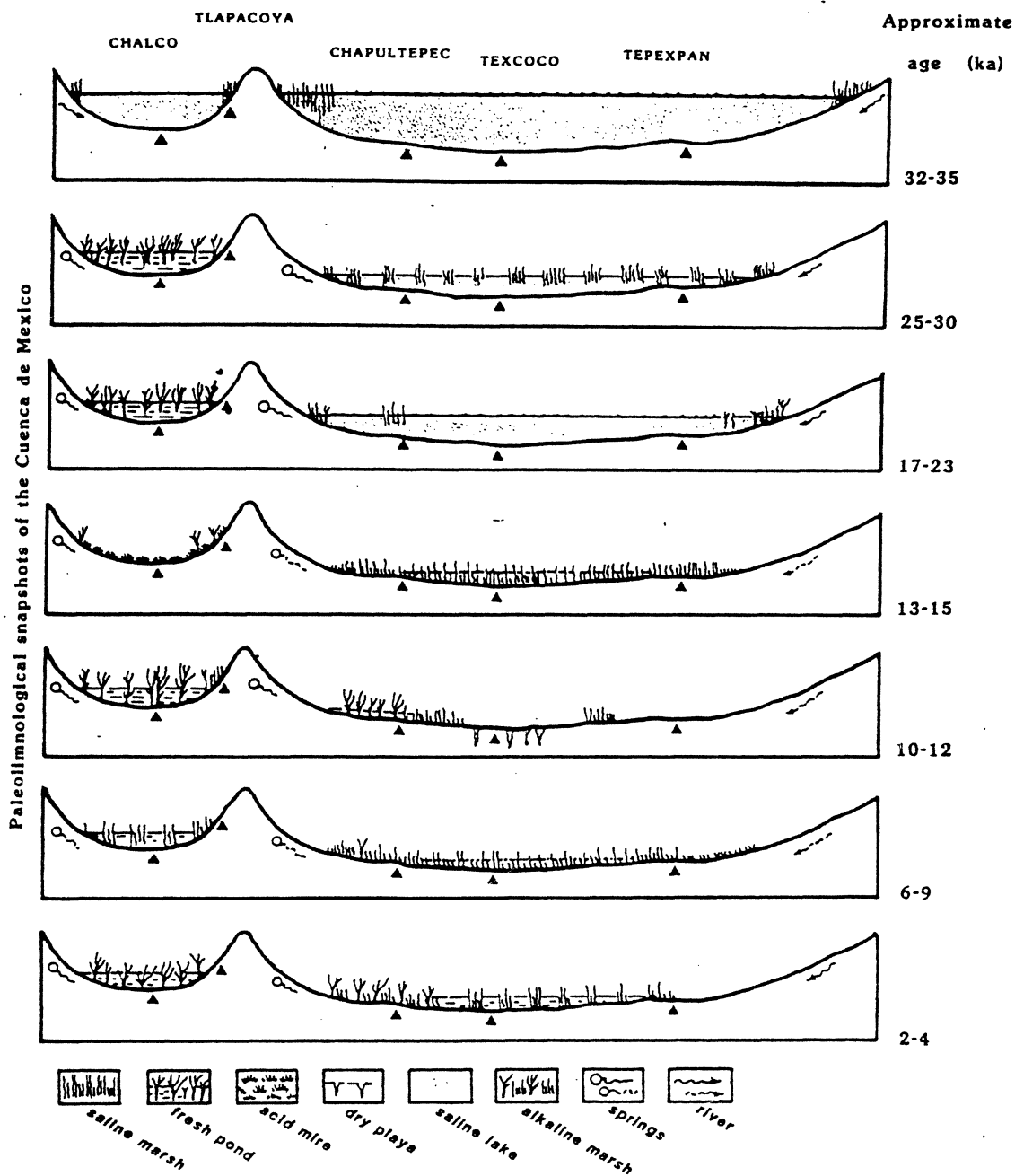


Figure 4.2 Paleolimnological stages in the Basin of Mexico during the last 35,000 years BP.

sites in the Basin of México, to reconstruct lacustrine change over the last 35,000 years. This record is summarized in Figure 4.2 and clearly indicates that the level of the lakes fluctuated considerably over this period. Based on his diatom record, he concluded that the early Holocene was relatively arid, with the onset of more humid conditions occurring approximately 7,000 years B.P. In the record from Lake Chalco, drier conditions approximately 4,000 years ago are indicated by a peak in saline and aerophilous diatoms shortly after deposition of the UFP (Bradbury, 1989). After this time the diatom record suggests that wetter conditions associated with the "modern" climate became established in this region. The artificial drainage of the basin and subsequent disturbance of the upper sediment layers means that the last 2,000 years of the record have been lost. In conclusion, Bradbury (1989) commented that while there had been changes in the hydrological regime in the basin, there was no evidence of major climatic change over the last 30,000 years.

Flores Díaz (1986), while in general agreement with these findings, presented a much more detailed curve for fluctuations in the level of Lake Chalco based on his analysis of sediments from the lakeside archaeological site of Tlapacoya (Fig. 4.1). He concluded that the level of the lake was low at approximately 10,500 years B.P. rising slightly by 9,500 years B.P. before dropping to low levels by ca. 8,500 years B.P. With the exception of a slight drop in lake level at 6,000 years B.P., the level of the lake rose between 8,500 years B.P. and 5,000 years B.P. Low lake levels are recorded between 4,800 years B.P. and 4,250 years B.P. that coincide with a period of increased erosion within this area. A second period of erosion occurred after 3,000 years B.P., during which time the level of the lake also rose. Approximately 1,000 years ago the level of the lake began dropping again and has remained at a lower level until the present.

Although it has been suggested that changes in the hydrological regimen of the Basin of México were a result of minor variations in the climate (Bradbury, 1989), the pollen record for a site at Tlapacoya IV site (González Quintero, 1986) suggests that these climatic variations over the last 30,000 years may have been more significant than

Bradbury (1989) suggests. These data show that approximately 7,000 years ago, temperate deciduous forest with some subtropical elements developed in the southern parts of the Basin of México. Their presence of these subtropical species indicates that the mean annual temperature at this time was around 20°C, while mean annual rainfall was in excess of 1400 mm (González Quintero, 1986); both higher than at present. The presence of xerophytic pollen between 4,850 and 4,200 years B.P. indicates that very dry conditions prevailed in the Basin of México during this time interval. A return to more humid conditions is indicated by the re-establishment of mixed forest between 4,200 and 2,600 years B.P. A reversal in this trend between 2,600 and 1,900 years B.P. is suggested by an abrupt increase in herbaceous pollen. Whether this reflects human disturbance within the basin or a change to more arid conditions is uncertain.

During the 1980s, limnological records from a number of small closed lake basins in the highlands to the west of the Basin of México have been obtained by present and former members of the Tropical Palaeoenvironments Research Group (TPRG) based at the University of Oxford (Fig. 4.1). Using a variety of analytical techniques including diatom and pollen analyses, sediment chemistry, mineral magnetics, ^{and} $\delta^{13}C$ analysis, they have reconstructed the environmental history of the Upper Río Lerma Basin (Fig. 4.3 Metcalfe, 1985, Metcalfe *et al.*, 1989, 1991), Laguna Zacapu (Fig. 4.4; Metcalfe, 1985, 1986, Mss; Metcalfe *et al.*, 1989) La Piscina de Yuriria (Fig. 4.5; Metcalfe *et al.*, 1989, Metcalfe and Hales, in press), La Hoya San Nicolás de Parengueo (Fig; 4.6 Steininger, 1988; Metcalfe *et al.*, 1989) and Lake Pátzcuaro (Street-Perrott *et al.*, 1989). These studies have added considerably to our understanding of Holocene climates and anthropogenic disturbance in this region.

The longest record, from Lake Chiconahuapan in the Upper Río Lerma Basin (Figs. 4.1 and 4.3), covers the last 11,600 years. The diatom record indicates that the lake level increased at approximately 8,200 years ago and appears to have remained relatively high until 4,600 years B.P., although the record for the period 5,000-6,000 is difficult to interpret (Metcalfe *et al.*, 1991). A considerable drop in lake level occurred

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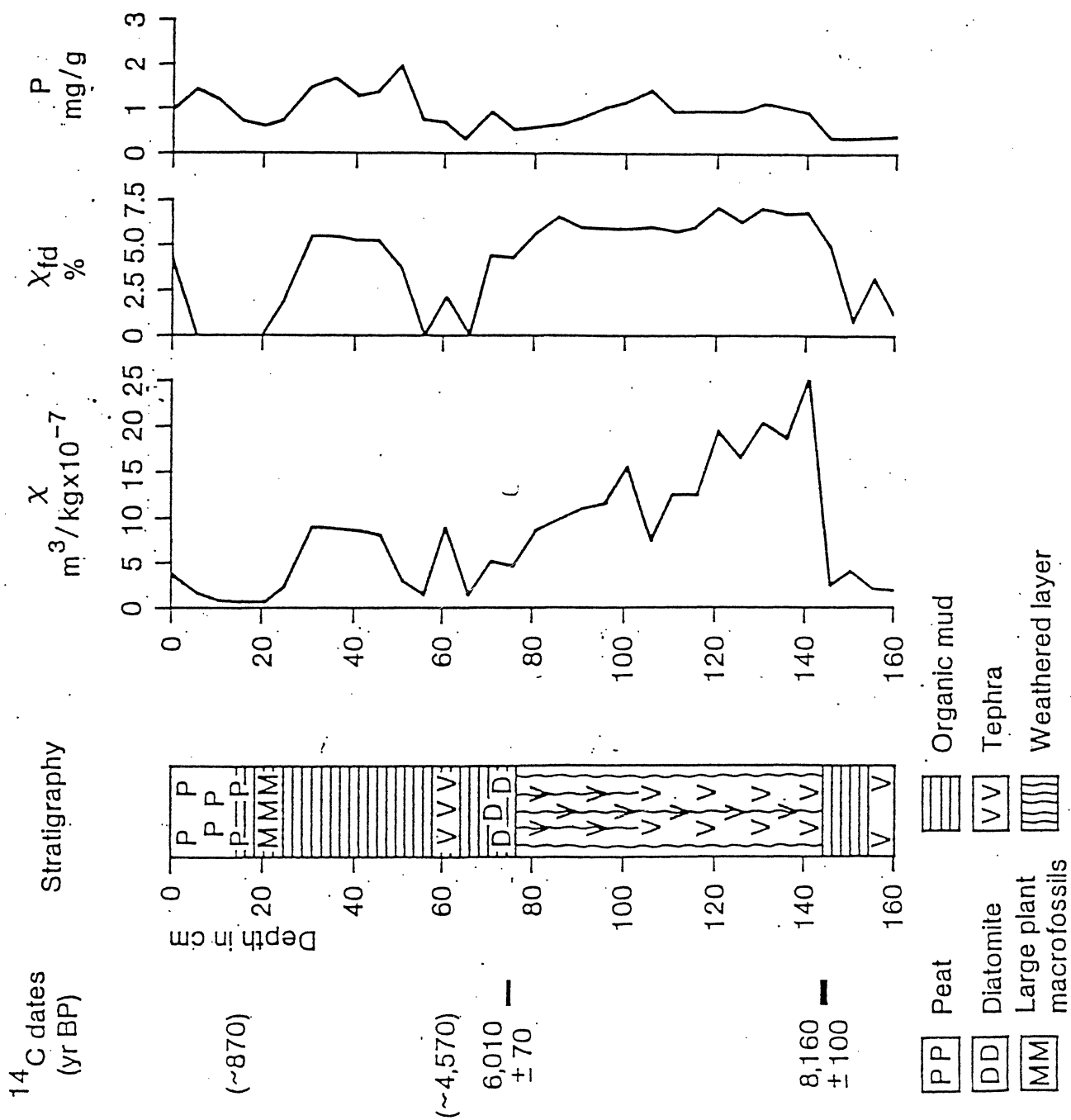


Figure 4.3 Palaeolimnological record of the Upper Lerma Basin

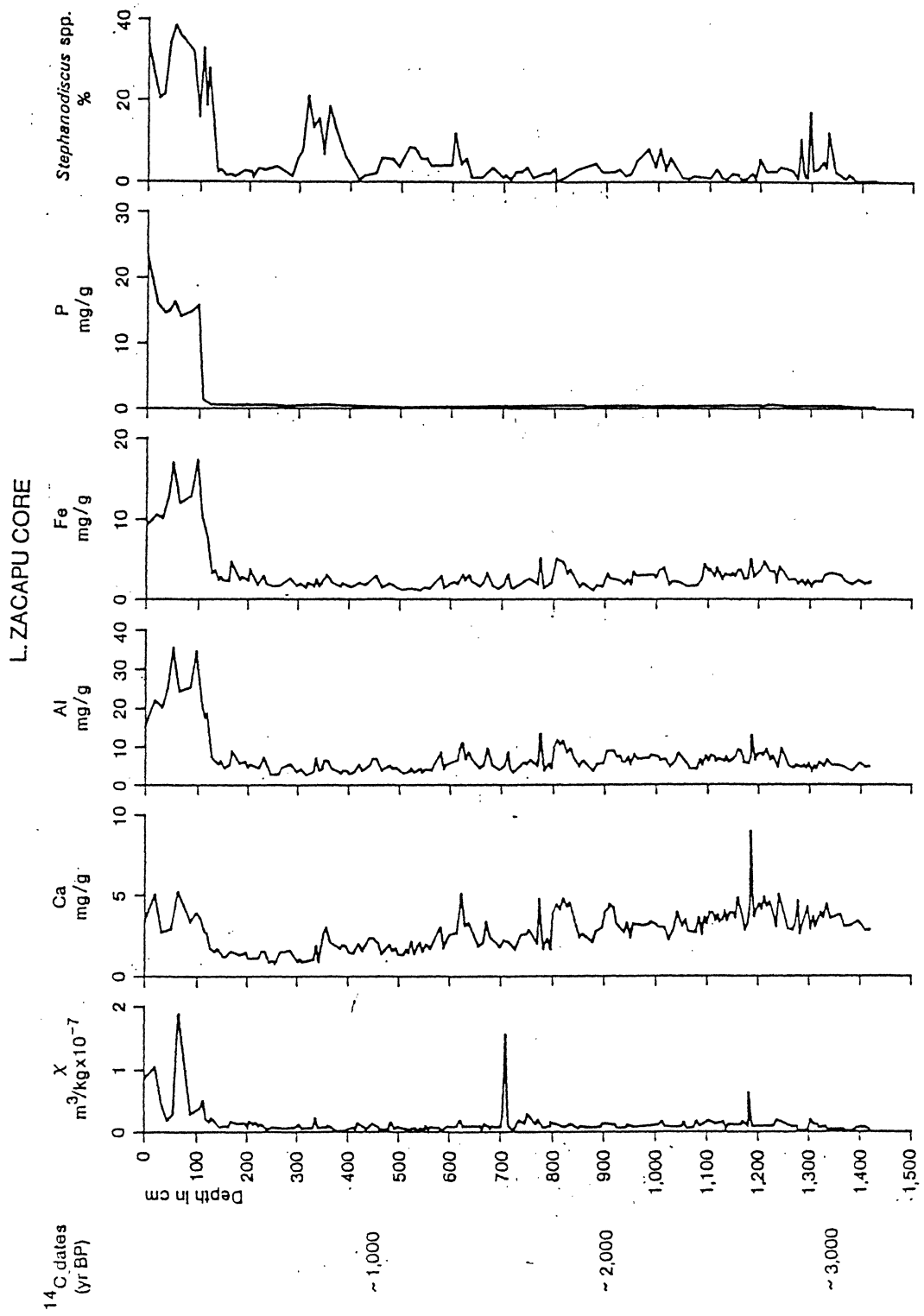


Figure 4.4 Palaeolimnological record of Lake Zacapu

LA PISCINA DE YURIRIA CORE

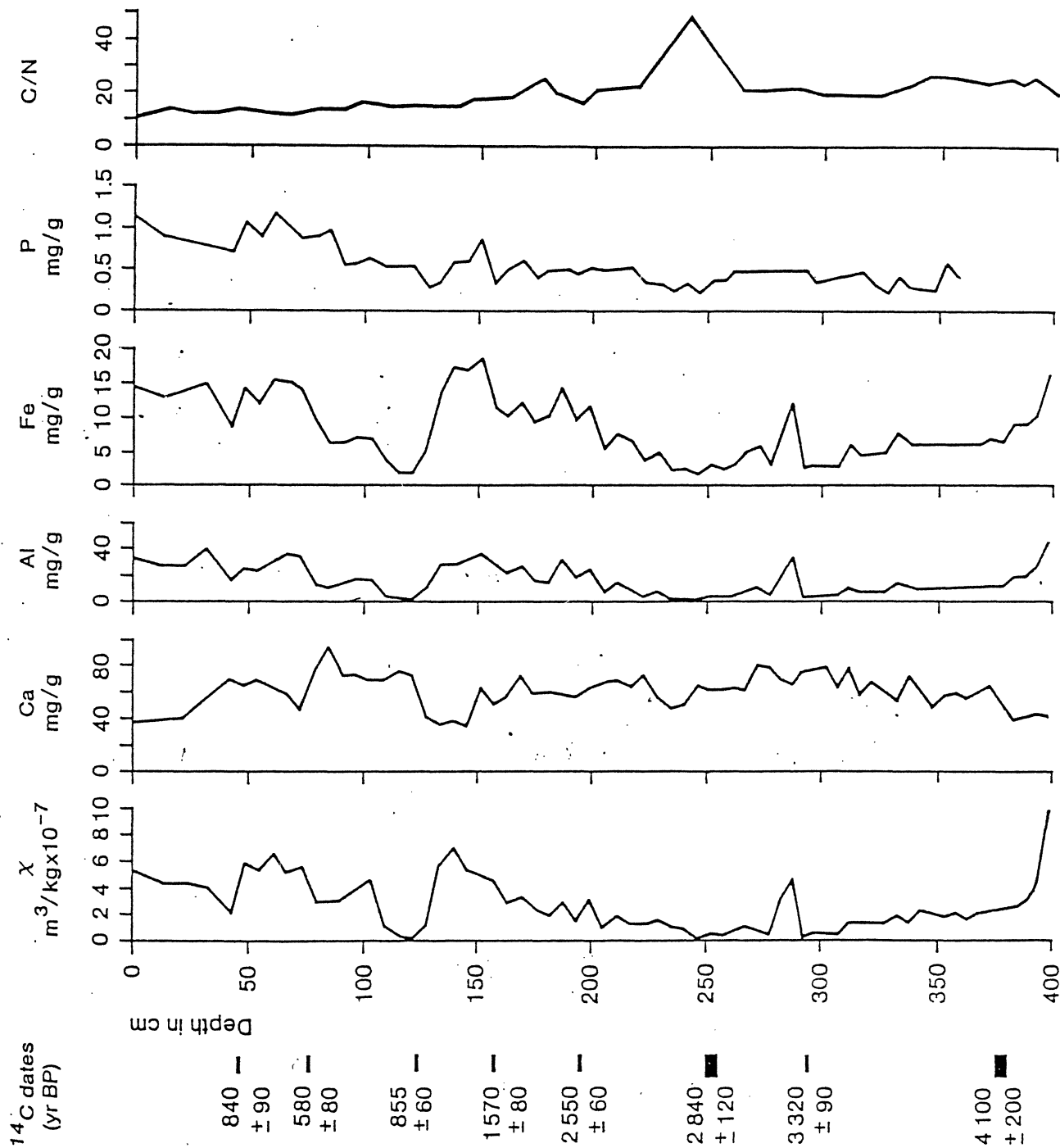


Figure 4.5 Palaeolimnological record of La Piscina de Yuriria

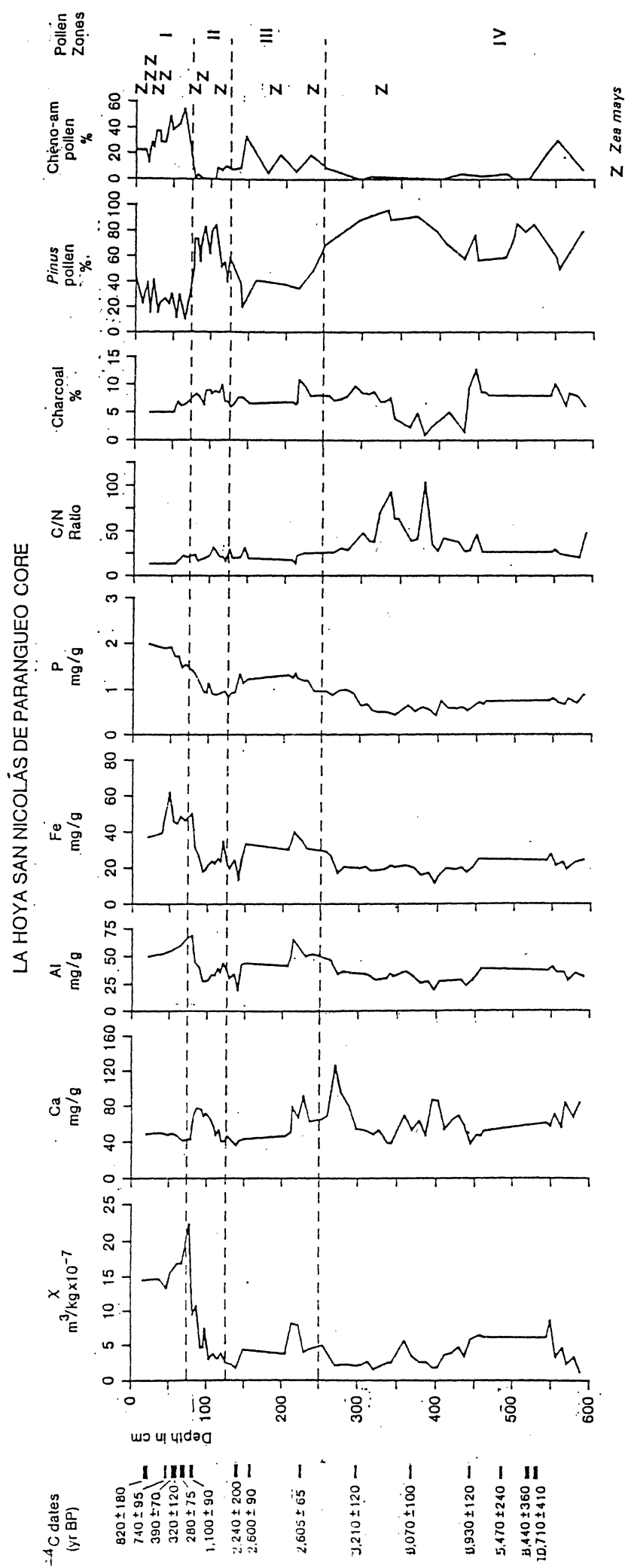


Figure 4.6 Palaeolimnological record of La Hoya San
Nicolas de Paranguo

between 4,600 and 4,200 before rising again. The subsequent transgression reached a peak by 1600 years B.P before the onset of a major phase of desiccation between 900 and 1,400 years ago. During this time, the lake is believed to have dried out completely. The recent past has been characterised by periodic flooding of the basin floor.

Lacustrine sequences from the Basin of Zacapu (Figs. 4.1 and 4.4) have been used to reconstruct the palaeoenvironmental history of this region. Metcalfe (1986) published the diatom record from a 14 m core collected from the small residual lake which still occupies the basin. This provides a 4,000 year record of change. The diatom assemblage from the base of the core suggests a more dilute lake than at present which Metcalfe (1986) believes to be indicative of greater precipitation or cooler temperatures resulting in a higher lake level. A possible low stand at approximately 3,250 years B.P. was followed by an abrupt change to higher lake levels by 2,820 years ago. A further brief fluctuation in the level of the lake resulted in a low stand by 2,590 years B.P. before cooler, deeper conditions returned around 2,240 years B.P. It is possible that the lake dried up entirely at about 1,100 years ago before a return to fresher conditions.

Metcalfe is currently analysing the diatom record from two cores collected by CEMCA. Both cores cover the period between about 8,000 and 3,000 years B.P. The lower part of both sequences represent conditions in the basin varying between shallow, slightly acidic to circumneutral marsh and more open pools. Such conditions prevailed prior to 7,000 years B.P. The diatom record from the middle portions of both cores are discontinuous. A period of considerable catchment disturbance is recorded between about 6,900 and 5,800 years B.P., indicated by signs of reworking and inwash of diatoms. In the upper part of the profiles, the diatom assemblages indicate an alkaline marsh occupying the basin floor. Very shallow conditions from one of the cores records a decrease in *Alnus* at this time (S. Xelhuantzi, pers. comm. 1990), which may reflect a drying of the climate at this time.

A 4,100 year palaeoenvironmental record of la Piscina de Yuriria (Fig. 4.5) has been reconstructed by Metcalfe and Hales (in press). Using diatom and sediment-

chemistry data they concluded that the level of the lake fluctuated considerably over this period. The diatom assemblages indicate that the basal sediments were deposited in relatively shallow water. Between 3,320 and 2,840 years B.P. the lake deepened. It is possible that this reflects an increase in precipitation resulting in a relative freshening of the lake. This period of moister conditions was short-lived and an abrupt change in the diatom assemblage suggests the lake had shallowed by 2,540 $\pm$ 60 years B.P. A break in the diatom record between 1570 $\pm$ 80 years B.P and 900 $\pm$ 60 years B.P. is believed to be due to desiccation, and appears to represent the most arid period in the record; a peak of Juniper pollen in this segment (R.A Perrott pers. comm. 1990) supports this conclusion. A return to moister conditions after 900 years B.P is indicated by the diatom record. During the early 1980s La Piscina de Yuriria dried up, and today all that remains is a thick algal matt. This is probably in response to the slightly drier conditions experienced over this period together with increased use of groundwater for domestic and agricultural purposes. The record from this core is similar to that of Zacapu and clearly indicates that this region has experienced quite significant climatic fluctuations during the late Holocene.

Elsewhere in México, attempts to reconstruct Holocene climates based on palaeoecological and palaeolimnological evidence have not been as successful. Investigations in the Maya lowlands, for example, have been hindered by poor dating control. This region is underlain by limestone which causes a hard water effect. In addition, massive deposits of colluvium bring carbon of different ages and sources to the lakes. These problems are exacerbated by long term human disturbance and the pollen spectra reflect anthropogenic factors which mask any climatic signal ^{they} may contain. Leyden (1987), however, concluded that this area was marked by conditions of extreme aridity during the late Pleistocene with an increase in effective precipitation during the early Holocene. Because of the problems with dating in this region, the exact timing of these events cannot be determined.

Various other lines of evidence have been used to help reconstruct climatic

conditions in México. The glacial history of a number of the higher peaks in Central México provide useful climatic information and have the added benefit of being undisturbed by humans. Based on dated moraines and glacial tills Heine (1973, 1976, 1984) has reported three glacial and two neoglacial advances over the last 35,000 years (see also White and Valastro, 1984). These are:

- MI - 36,000-32,000 years B.P.
- MII - ca 12,000 years B.P.
- MIII - 10,000-8,500 years B.P.
- MIV - 3,000-2,000 years B.P.
- MV - Little Ice Age

and are believed to indicate periods of relatively moist, cool conditions.

The potential of archaeological records as a source of palaeoclimatic information is considerable and can often provide additional information when other lines of evidence are not available. Various researchers, however, have drawn different conclusions as to the prevailing climate conditions during the rise of different Mesoamerican cultures. As already discussed, Sears (1951b) considered the climate to be of fundamental importance in the rise of cultural groups in the Basin of México. His conclusion that the rise of Teotihuacán coincided with a period of aridity has been disputed by Saunders (1976) who believed that when Teotihuacán was founded the climate was relatively wet, but Lake levels and precipitation began to decline at approximately 1,700 years B.P. This conclusion is supported in part by the findings of García (1974) who attempted to reconstruct the climate during the rise and fall of Teotihuacán. She concluded that at the peak of its importance the climate in the Basin of México was as wet as during the wettest period in the meteorological record. However, the decline of the city coincided with a period of increased aridity which could have played a significant role in the ultimate collapse of this city at approximately 1,300-1,250 years B.P.

Armillas (1969) concluded that the northward expansion of the Mesoamerican frontier between 1,400 and 1,100 years B.P. was the result of wetter climatic conditions and that the subsequent contraction about 800 years B.P. was due to a period of intense drought. Evidence from the American Southwest lends support to the idea that drought

conditions occurred at this time followed by a shift to more humid conditions between 1,000 and 600 years B.P. (Schoenwetter and Eddy, 1964). O'Shae (1980) concluded that the fall of Tollan (Tula) was a result of intense drought conditions. It was during this period of drought that the Chichimeca moved into the lake district of Central México. The rise of the Aztec civilization in the Basin of México is believed to have coincided with this period of increased moisture conditions (Metcalf, 1987).

Based on his investigation of archaeological sites in the Maya lowlands, Dahlin (1983), has challenged the work of those researchers that have suggested that the climate in the Maya lowlands has remained stable over the past 3,000-4,000 years (eg. Cowgill and Hutchinson, 1966). He concluded that this region experienced a severe and prolonged drought between 2,050 and 1,500 years B.P. The drought led to repeated crop failure and a reduction in the availability of portable drinking water and caused a collapse in the Maya population of the northern Yucatán during the late Preclassic. The rise of the Maya during the Classic period was confined to the better watered areas in the extreme northern part of Guatemala, northern Belize and Quintana Roo.

4.3 SUMMARY OF LATE PLEISTOCENE/HOLOCENE CLIMATIC CHANGE

There is an increasing amount of evidence which suggests that Central México has experienced quite significant changes in the climate over the Holocene. A number of studies have concluded that the late Holocene was characterised by stable conditions (Cowgill and Hutchinson, 1966; Watts and Bradbury, 1983; Bradbury, 1989). However, many of these studies lack detailed chronologies which makes attempts to elucidate such changes difficult. Many of the recent investigations that have been carried out in the highlands of Central México have benefited from well dated chronologies and from adopting a multidisciplinary approach to the investigation (eg. Metcalf *et al.*, 1989, 1991). These studies have shown that quite abrupt climatic changes characterise the late Holocene and a number of relatively moist and dry episodes can be identified.

Following a period of relatively wet conditions between 8,200 and 4,500 years

B.P. an abrupt dry phase is recorded between 4,500 and 4,200 years B.P. Arid conditions also prevailed between 3,300 and 2,800 years B.P. Following this, there was a rise in the level of many lakes, and is used to infer wetter conditions. The most arid period over the late Holocene occurred approximately 1,200 years ago at which time a number of lakes in the highlands appear to have dried out (Metcalf *et al.*, 1989, 1991). The record after this time indicates that generally wetter conditions have prevailed.

4.1.4 LATE HOLOCENE ENVIRONMENTAL DEGRADATION IN MESOAMERICA

The devastating effects of accelerated erosion are a common feature of the Mexican landscape. The loss of valuable agricultural land and the development of extensive badlands have often been attributed to increased land-use pressure and the introduction of European farming techniques after the arrival of the Spanish. (Helms, 1975; Eckholm, 1976). It has been suggested, however, that this is not a recent phenomenon and that episodes of accelerated erosion can be associated with the rise of various Mesoamerican cultures.

Early proponents of this idea based their conclusions on geomorphological (Cook, 1949) and archaeological (Vaillant, 1944) evidence. Deevey (1944) commented that the record from Lake Pátzcuaro indicated that human disturbance had altered the pollen spectra and that ^{the} lake sediment record often provide a method of assessing environmental degradation within a given region. Palaeolimnological investigations which have attempted to assess long term human disturbance on the Mesoamerican environment have focused on two main areas: the highlands of Central México and the Maya lowlands.

A number of palaeolimnological investigations in Mexico suggested that episodes of accelerated erosion, as inferred from lake sediment records, have occurred over the last 3,000-4,000 years ago. Bradbury (1971) reported that two phases of accelerated erosion could be identified from the lake sediment record at Chalco in the Basin of Mexico. It was not until the 1980s that investigators have attempted to assess the extent

of human impact in this area. Much of this work has been carried out by the former members and members of the TPRG in the highlands of Mexico and by the late Edward Deevey and his associates in the Maya lowlands. The results of these investigations have been summarized in a number of recent publications (Metcalf *et al.* 1989). The following discussion draws on this work and others publications by members of these research groups.

Evidence from the Upper Lerma, or Toluca, Basin situated to the west of the Basin of Mexico (Fig. 4.3). clearly indicates that this area has experienced periods of disturbance over the last 3,000 years. Accelerated erosion in this region is inferred by an increase in the influx of clastic material approximately 3,000 years ago.

A dramatic increase in the level of disturbance within the basin occurred between 1,400 and 900 years ago. This episode was probably a result of a period of temple building by the Matlatzinca who inhabited the basin prior to the Spanish Conquest. This group, who stemmed from the Otomí, entered the area approximately 1350-1250 years B.P. and over the next 400 years built numerous ceremonial centres, the largest at Teotenango in the southern part of the basin. Although there is evidence of disturbance within this area in the Preclassic and Classic periods this did not continue into the Postclassic and Hispanic period (Metcalf *et al.*, 1989).

The Zacapu Basin is situated to the north west of the Basin of Pátzcuaro. Three periods of disturbance are recorded in this basin, although the earliest two indicate only minor disturbance at this site. The timing of these events has been problematic and is discussed in full by Metcalf (1985). However, a major phase of disturbance is believed to have occurred in this basin approximately 1,200 years B.P. and coincides with the arrival of the Purepecha in this region. Increased disturbance is suggested by a large increase in magnetic susceptibility (X), calcium (Ca), Aluminium (Al), iron (Fe), and phosphorus (P) indicating an influx of weathered volcanic material (Fig. 4.4). A sharp increase in the diatom species *Stephanodiscus* at this time is believed to indicate cultural eutrophication (Metcalf, 1985; Metcalf *et al.*, 1989). The lacustrine record is

supported by geomorphological evidence which indicates that accelerated erosion prompted the abandonment of several Purepechan villages in this basin during the thirteenth century (Tricart, pers. comm., 1986, cited in Metcalfe *et al.*, 1989).

The crater lake of La Piscina de Yuriria (Fig. 4.5), provides an excellent record of disturbance within this region and four periods of disturbance can be inferred from the record (Metcalfe *et al.*, 1989; Metcalfe and Hales, in press). The earliest of these events dates prior to 4,000 years B.P. Other episodes of disturbance within the catchment occurred between 3,300 and 2,850 years B.P., 1,600 and 900 years B.P. and <900 years B.P. Unfortunately, it is not possible to determine whether these erosional episodes are a result of climatic or human factors, however, analysis of the pollen record which is currently in progress (R.A. Perrott) should help clarify the record.

Using a variety of techniques including X , X_{fd} , sediment chemistry, and C/N analysis Steininger (1988) concluded that two periods of disturbance had taken place at La Hoya San Nicolás de Parangueo (SNP; Fig. 4.6). The record from SNP is similar to that described for La Piscina de Yuriria, and several phases of disturbance within the catchment have been attributed to human activity. The first episode began about 3,000 years ago and coincided with the introduction of maize agriculture in the region. The most recent episode of disturbance within the basin is more difficult to date as there is an inversion of the dates in the upper part of the core from this lake. This inversion is believed to be a result of the introduction of old carbon with the input of sediment into the lake. A date of 1,100 immediately below the inverted dates indicates that erosion began sometime 1,100 years ago.

The Maya lowlands encompassing Mexican Yucatán, Guatemala and Belize was once densely populated with a number of important centres situated by the major lakes in the region. Of particular importance are the lake basins situated in the Petén Lake district which were occupied by the Maya at various times during the Preclassic and Classic (Brenner, 1978).

As discussed above, early investigations attempted to use the lake sediment

records from many of these lakes to reconstruct past climates, but found that the widespread impact of deforestation in this area had severely effected the climatic signal (Leyden, 1987). In recent years a number of multidisciplinary investigations have been undertaken using such techniques as palynology, geochemistry, grain size and microfossil analysis (Brenner, 1978; Deevey et al., 1979; Binford, 1983; Deevey et al., 1983; Leyden, 1987); the object being to assess the effects of the Maya population on the lake-catchment ecosystem.

Lakes Yaxhá, Sacnab and Quéxil in the Petén were the focus of this investigation. In most of these lakes the accumulation of a thick clay, referred to as the 'Maya Clay', is associated with disturbance in the catchment probably due to permanent settlement (Deevey et al., 1979). As discussed these studies have been hindered by the lack of an independent dating framework. The chronology has been based on correlation of pollen sequences and known archaeological phases based on the Maya Stelae calendar (Vaughan et al., 1985). The longest record was provided by a core recovered from Lake Quéxil which unlike Lake Yaxhá and Sacnab provided evidence of pre-disturbance conditions in this region. It is clear from this study that the Maya had a considerable impact on their environment and that at the time of their peak there was a decline in arboreal pollen, associated with an increase in *gramineae* and inorganic sedimentation. Influxes of total phosphorus (P), carbonates and silicates increased when the population appears to have increased in these catchments. During the late Preclassic all these lakes display an increase in microfossils, which in the case of Quéxil and Sacnab appears to be associated with increased nutrient enrichment. However, during the Classic period there is a marked decline in microfossils. It is possible that this decline was due to increased sediment input into the lakes, resulting in increased turbidity and reduced sunlight penetration. The introduction of these clays may also have resulted in the clogging of feeding apparatus.

The cessation of agriculture after the fall of the Classic Maya resulted in increased erosion, and therefore, siltation of the lakes. After the collapse of the Maya the

forests began to recover, this recovery was identified by the decline in grass pollen and an increase in arboreal pollen in the core. The modern species composition, however, differs considerably from the pre-disturbance record. In addition, present day levels of inorganic sediment and P remain higher than they were prior to disturbance, suggesting that the effects of Maya urbanization are still having delayed effects on the Petén lakes more than a thousand years after the collapse of this civilization.

Rue (1987) analysed the pollen of two cores collected from Lake Yojoa and Petaspilla Swamp in Western Honduras. His results imply that deforestation began in this region approximately 4,000 years ago. As there is no evidence of permanent settlement at this time he suggested that early disturbance may have been the result of slash and burn. He concluded that there was an intensification in agriculture after 3,000 years B.P., although after this period there is little change in the pollen record. Maya disturbance is seen in the basal part of the core from Petaspilla Swamp and possibly coincides with the terminal Classic-early Postclassic period.

Byrne and Horn (in press) collected a 9.2 m long core from Lake Catemaco in the State of Veracruz, México. Although the core is dated by five ^{14}C dates they believe that these dates are too old and that contamination has occurred. Instead they have used an even more debatable tephra chronology which gives the core a basal date of 3,000 years B.P. rather than ca. 7,000 years B.P. as given by the ^{14}C date.

They identified four main pollen zones. Maize is present throughout the core, but increases significantly in the upper part of the core. This rise coincides with a decrease in the percentage of arboreal taxa and an increase in the number of composites. This period of intense agricultural activity had diminished significantly in the post-Hispanic. If the radiocarbon dates obtained for this core were accepted this would represent one of the earliest agricultural sites found to date in México. However, even in the earliest Mesoamerican records, maize does not appear continuously until approximately 5,000 years B.P.