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Richard Hansen

One of the primary interests that Ray Matheny instilled among his students working in the Maya area was the concept of a "collapse" that occurred at El Mirador and other Preclassic cities such as Edzna, Aguacatal, Tikal, Seibal, Becan, Komchen, and the interior of the Yucatan peninsula (W. Coe 1965b:13; Sabloff 1975:233; Ball, 1977:132; Ball 1978a, 1978b:213; Cowgill 1979:52; Matheny et al. 1980; Matheny et al. 1983:197; 1987b:337; Hansen 1984: 496–506, 1990:216 ff, 1994d, 1998, 2001:63–64, 2002; Hansen et al. 2008; Ringle and Andrews 1990). The opportunity to view this postulated observation, first hand, was one of the intellectual generators for additional research and work in the Maya Lowlands, particularly in the Mirador Basin, and suggests something of Matheny's impact and legacy in Maya studies.

Archaeological investigations in the Mirador Basin of northern Guatemala represent the collective repertoire and systematic collection of data from 51 sites to date in the geographically-defined area on the Guatemalan side of the border, some of which are among the largest and earliest major Maya sites in Mesoamerica (Figure 1). Ray Matheny and Bruce Dahlin directed the initial, systematic, archaeological excavations in this area through the formation of "Project El Mirador," which focused on El Mirador, and much credit should be delegated to them for the original success of the early investigations at this massive site. Subsequent research has shown that the extraordinary size and architectural complexity of sites such as El Mirador, Nakbe, Wakna, Tintal, La Ceibita, Tamazul, El Pesquero, and Xulnal during the Middle and Late Preclassic periods (1000 B.C.-A.D. 150) provide the backdrop for one of the most spectacular sagas of human history in the Americas. In view of the economic, political, and ideological panorama that must have provided the foundations for the extraordinary size and sophistication of these sites, the Mirador Basin sites suffered a dramatic demographic demise by about A.D. 150. Based on recent empirical data, this paper will examine several premises and resultant hypotheses relevant to the decline of the socio-political and economic systems at the end of the Late Preclassic period: (1) The Preclassic Maya sought and adapted to a specific environmental system in a variety of ways, most notably with the utilization of swamp muck for agricultural production systems; (2) by the terminal Late Preclassic period, the Preclassic Maya had engaged in excessive resource procurement to construct massive architectural complexes, causeways, platforms, and plazas, with corresponding increases in lime production, architectural mortars, and extensive uses of architectural stone throughout the Mirador Basin; (3) the excessive or conspicuous consumption of these resources had a negative environmental impact, primarily on the ancient agricultural systems existent in the Mirador Basin which contributed to a substantial and sustained loss of demographic density in the region by about A.D. 150.

SETTING

The region, now widely known as the "Mirador Basin" has been the object of systematic scientific exploration, mapping, and excavations since 1978 when Dahlin and Matheny began work at El Mirador. However, the formation of the subsequent Mirador Basin Project (previously known as the Regional Archaeological Investigation of the North Peten or RAINPEG Project), has been conducting a regional investigation in collaboration with the Ministry of Culture and Sports (MICUDE) and the Instituto de Antropologia e Historia de Guatemala (IDAEH) since 1987 and currently has explored, mapped, and excavated in 51 ancient cities and settlements in the Basin, with the support of the Global Heritage Fund, the Foundation for Maya Cultural and Natural Heritage (PACUNAM), Friends of the Natural and Cultural Heritage of Guatemala (APANAC), and the Foundation for Anthropological Research & Environmental Studies (FARES). These studies have identified early sites on or

Figure 11.1. Map of the Maya area (map by Joe Lebonnier, after Hansen 1991b)

near the surface dating to the Middle (ca. 1000 B.C.-400 B.C.) and Late Preclassic periods (300 B.C.-A.D. 150), with relatively little overburden from the large scale construction programs that characterize sites dating to the Early and Late Classic periods (A.D. 300–900) of Lowland Maya civilization.

In spite of an apparent large and complex socio-political system, a cessation of construction and major occupation of the area occurred near the end of the Late Preclassic period about A.D. 150–250, and extending until the Late Classic period, approximately A.D. 700, when a relatively modest population returned to the area. While both the speed and extent of this "collapse" are undergoing evaluations, it does appear that a major depopulation of unusual proportions occurred near the end of the Late Preclassic period throughout the Mirador Basin as well as a large portion of Lowland Mesoamerica (Hansen 1984: 496–506; 1990:216–221). The demise of complex societies is a complex and multi-causal issue and is a topic that has attracted great scholarly and public interest (e.g. Adams 1973; Culbert 1973a, 1973b, 1988, 1994; Shimkin 1973; Webb 1973, 1990; MacMullen 1976; Webster 1976, 1977; Dahlin 1983; Lowe 1985; Webster and Freter 1990; Tainter 1988; Graffam 1992; Marcus 1992; Cameron and Tomka 1993; Inomata and Webb 2003; Diamond 2005). One of the investigative strategies of the Mirador Basin project has been to understand the extent and nature of the Late Preclassic abandonment of the northern Peten area, and evaluate the factors that may have rendered the major Preclassic sites susceptible to social, political, and economic disintegration. The issue is even more complicated when factors such as climate and environmental impacts are necessarily involved (see Deevey et al. 1979; Folan et al. 1983; Dahlin et al. 1987; Dahlin 1994; Konrad 1984; Gunn 1991; Gunn et al. 1994, 1995). Such studies are especially poignant in the face of such early precocious architectural and economic development in the Mirador Basin, while other well known sites show relatively little occupation during these time periods (e.g. Haviland 1965; Fry 1969; Puleston 1974; Pendergast 1981; MacKinnon 1981). Excavations of the *bajos* (lowland areas of seasonal swamps and stunted vegetation), collection of pollen cores from shallow water lakes and wetland marshes known as *civales*, isotope analyses, and sedimentation profiles revealed evidence of an ecological degradation and environmental change in the Mirador Basin and revealed the need for additional archaeological attention to detailed environmental, ecological, ethnographical, and climatological data in the region.

GEOGRAPHICAL CONTEXT

The Mirador / Calakmul Basin is a geographically-defined, circumscribed region of the extreme north-central Peten and extreme southern Campeche (Figure 11.2, Figure 11.3). The area is bordered by rugged karstic formations on the northern, eastern, southern and, to a lesser degree, the western flanks, forming a rough triangle on the Guatemalan side of the international border between Mexico and Guatemala, covering approximately 810,000 acres (327,807 hectares) or 3278 square kilometers (Figure 2). The basin extends into southern Campeche, Mexico, with the site of Calakmul located on its northern edge (Figure 11.3). The majority of the enclosed area is dominated by bajos or seasonal, tree-covered swamps, leaving relatively little upland soils in comparison to the extensive lowlands. Bajos are low, seasonally inundated areas with stunted, hardwood vegetation (see Dahlin et al. 1980; Hansen et al. 2002; Dunning et al. 2002). Nearly 60 percent to 70 percent of the area has been estimated to be covered by bajos (see Jacob 1994:275 (Figure 3). Nevertheless, in spite of the abundance of bajo seasonal swamps with a dominance of arboreal species known as a tintal forest, the area is known to have five distinct types of tropical forests which can be found within the relatively small geographical confines of the Basin, a phenomena currently being investigated by means of a geological, botanical, and biological inventory of the region (Castañeda and Hansen 2007a, 2007b , 2008; Schuster et al. 2009; Budney et al. 2008; Force and Dohrenwend 2008; See Table 1). In addition, pollen cores from deeper water (8-15 m) lakes flanking the western edge of the basin have demonstrated the consistency and presence of tropical forest from at least about 6000 B.C., including the initial stages of human sedentary occupation, which, can be attributed to about 2600 BC according to the presence of dated corn pollen from the cores (Wahl 2000, 2005; Wahl et al. 2005; Wahl et al. 2006; Wahl et al 2007a; Wahl et al. 2007b; see Pohl et al. 1996 for similar dates). The basin appears to contain a unique soil chemistry, consisting primarily of Macanche, Uaxactun, and Yaloch soils while the remainder of the northern Peten consists primarily of Yaxá (Yx), Sacluc (Sc) or Sacpuy (Sp) soils of low to moderate fertility (Simmons et al. 1959) (Figure 11.4). Subsequent correlations to US soil taxonomies verify the presence of Cambisols unique to the area (Alvarado

Table 11.1 Vegetation Communities at Nakbe, Peten (Castañeda and Castañeda 1994; translate RD Hansen)

Vegetation Communitites and Descriptions
High Forest: Canopy forest 22-30 meters high found on all upland areas
Predominate Species: Ramón (*Brosimum* spp), zapotillo *(Pouteria durlandii),* chico zapote *(Manilkara achras),* yaxnic *(Vitex gaumeri),* pimienta (allspice) *(Pimienta dioica),* caoba (mohogany) *(Swietenia macrophylla),* sacuallón or valerio blanco *(Aspidosperma stegomeris),* valerio *(Aspidosperma magalocarpon),* saltemuch or puntero *(Sickingia salvadorensis),* chacah (gumbo limbo) *(Bursera simaruba),* copal *(Protium copal),* anonillo *(Malmea depressa)*
Shrubs: xup or mano de leon (*forchhammeria trifoloiata*), cordoncillo (*Piper sp*.)
Vines: cocolmeca (*Smilax munda*)
Herbaceous Plants: camotillo (*Zamia loddigesii*)
Epiphytes: 6 species of Bromeliaceae, 10 species of Orchidaceae
Pioneer Forest in Rocky Sites: Distinct vegetation communities found on the highest and driest areas, primarily on structure. Many of the high forest species found here, but are much smaller and lower.
Predominate Species: Candol (*Caesalpinia sp.*), chaltecoc (*Caesalpina velutina*), chanchunup or jubup (*Clusia flava*), chechén negro (*Metopium brownei*), Guarumo (*Cecropia peltata*), flor de chombo (*Plumeria acutifolia*), jesmo (*Lysiloma bahamensis*)
Shrubs: Pata de vaca (*Bahuinia divaricata*)
Herbaceous Plants: Maguey
Intermediate Low Forest: Transitory community between upland and bajo areas. Less dense and less height than High Forest.
Predominate Species: Sericote (*Cordia dodecandra*), Many of the same species as High Forest
Low Forest in the Bajos: Forest measuring approximately 6-8 meters high found in the seasonally inundated bajos
Predominate Species: Tinto (*Haematoxylon campechianum*), vaqueman or achiotillo (*Hampea trilobata*), chechén negro (*Metopium brownei*), chechén blanco (*Sebastiania longicuspis*), guayabillo (*Eugenia* spp), two species of papaturros (*Coccoloba* spp.)
Herbaceous Plants: Navajuela (*Cyperaceae*), Jícara (*Crescentia cujete*)
Julubal: Tangled shrub community that grows only in the most humid soils
Predomiante Species: julubo (*Bravaisia tubiflora*)
Small areas of Gramineas and Cyperaceas: This unusual vegetation community is defined by the great abundance of Cyperaceae, but is still under investigation
Aguadas in Shrub Stage:
Predominate Species: sericote (*Cordia dodecandra*), pucté (*Bucida buceras*), naranjillo (*Jacquinia paludicula*), zapotón or zapote bobo (*Pachira acuatica*)
Predominate Species at water level: zarza (*Mimosa pigra*), several other shrubs that are still undergoing investigation, The surface of the water is covered by xicinchah or lechuga chiclera (*Pistia stratiotes*)
Herbaceous Aguadas
Predominate Species: xichinchab (*Pistia stratiotes*), espina de agua (Hydrolea spinosa), cyperaceas of the genus *Cyperus, Eleocharis* and *Scleria*

1994: 118–119), but with relatively rare minerals such as Todorokite (Dixon et al. 1994) which is a manganese oxide derivative. In addition, recent geological studies indicate that the Mirador region consists of the Buena Vista Formation, a calcareous unit of early Eocene age (50–60 million years old), which, due to its gypsiferous formation, is a "structural and depositional basin in its Tertiary geology" (Force and Dohrenwend 2008:2). The multidisciplinary studies conducted to date suggest that the region appears to be botanically, culturally, geologically, and geographically distinct from other areas in the Peten, representing an unusual natural and cultural "circumscription" in the Maya Lowlands (Hansen 2001; Hansen et al 2002; Jacob 1994; Alvarado

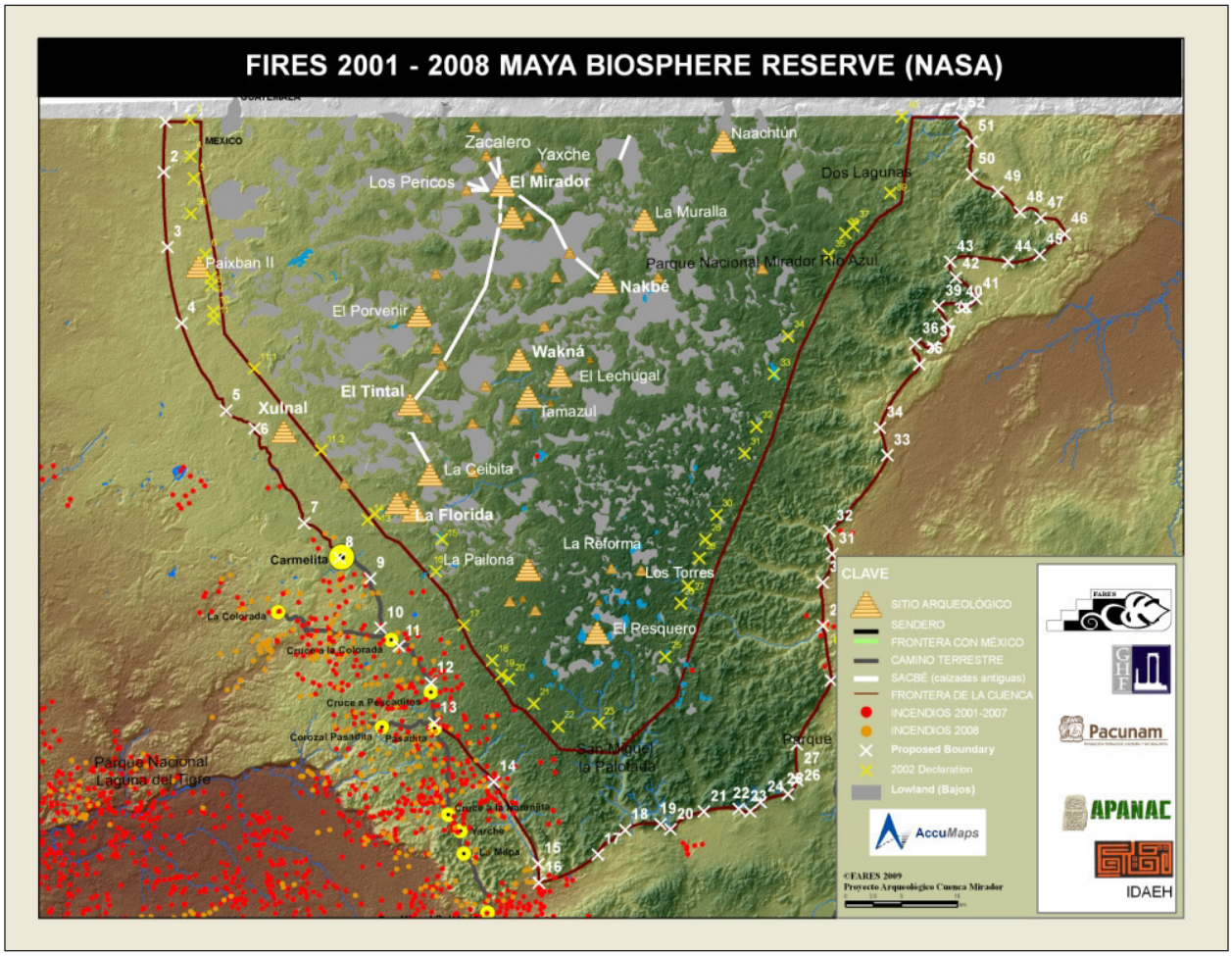

Figure 11.2. Map of Northern Guatemala showing principal sites in the Mirador Basin under research by the Mirador Basin Project. Dots represent sites undergoing exploration and mapping for the first time. (map: Josie Thompson, FARES).

1994; Dixon et al. 1994; Castañeda and Castañeda 1994; Castañeda 1995; Castañeda and Hansen 2007b; Force and Dohrenwend 2008). Hence, the area has been geographically dubbed throughout the scientific and popular literature, as the "Mirador Basin" or "Cuenca Mirador" (Spanish), although it is a very ancient system that currently is formed as a shallow hydrologic depression with gradual water release to the Candelaria system to the northwest, and the San Pedro system to the west.

CULTURAL CONTEXT

The Maya occupation of this region during the Middle and Late Preclassic periods is marked by an unusual abundance of major sites which are early and large (Dahlin 1984; Matheny 1986, 1987a, 1987b; Hansen 1990, 1991b, 1991c, 1992a, 1992b, 1992c, 1993a, 1993b, 1994a; 1994e, 1998, 2000, 2001, 2005, 2006; Hansen et al. 2008). The size and antiquity of the sites are further enhanced by the presence of the extremely large architectural constructions (Matheny et al. 1980; Dahlin 1984; Matheny 1980, 1986, 1987a, 1987b; Howell and Copeland 1989; Nielsen 1990; Hansen 1984, 1990, 1998, 2000, 2005). The monumental architectural constructions in the Mirador Basin are accompanied by numerous small residential constructions scattered throughout the site centers and peripheral regions, indicating an urban character of the sites (Demarest et al. 1984; Velasquez 1992a, 1992b, 1993a, 1993b, Balcárcel 1999; Biascoechea 2008; Mauricio-Martinez

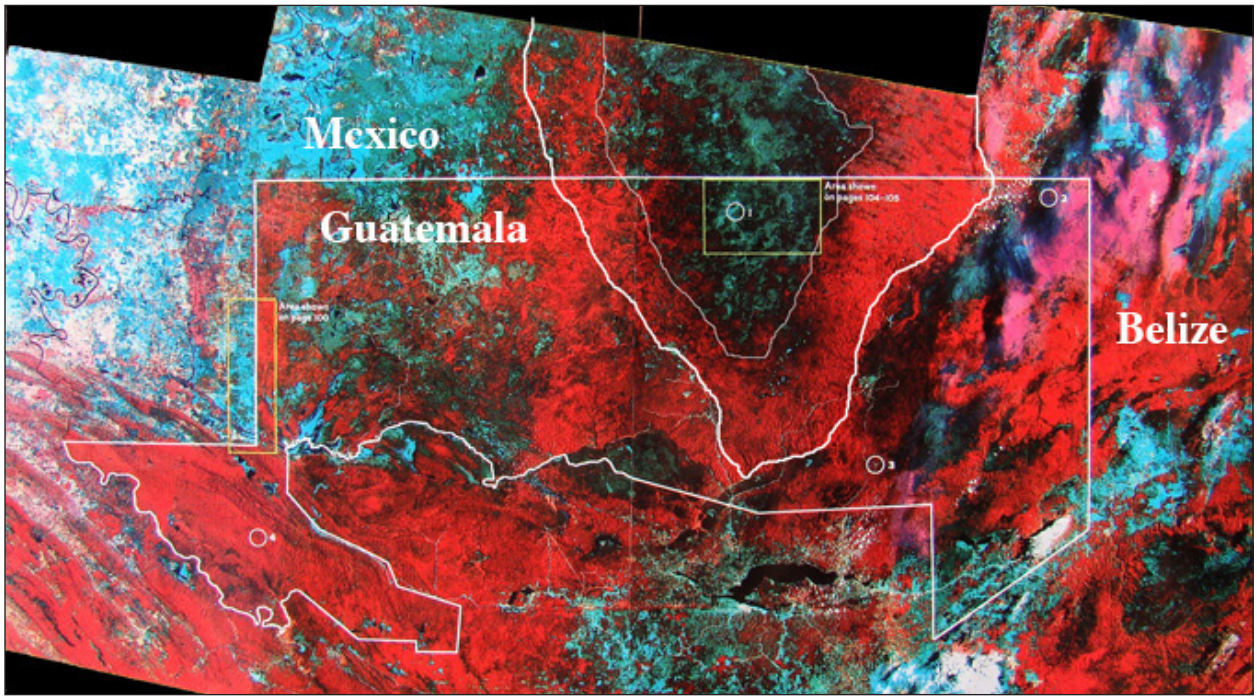

Figure 11.3. Satellite photograph of the northern Peten and southern Campeche, showing the area of the Mirador Basin. The red areas of the photograph consist of predominantly upland forest, while the blue area in the center of the northern Peten consists primarily of bajo (seasonal swamp) vegetation (Photo: NASA, National Geographic, Nov. 1992, pp. 98-99).

2008; Morales-Aguilar 2008). The urban nature of early Maya sites in the northern Peten appears to be compatible with studies of subsequent Maya settlement and demographic distributions (e.g., Fash 1983; Smyth and Dore 1994).

The Preclassic Occupation.

In the latter part of the 20th century, a major focus on the origins of lowland Maya civilization created a series of new paradigms for understanding the rise of social, economic, and political complexity (Adams and Culbert 1977; Fash 1983; Hammond 1991). A major Late Preclassic occupation at El Mirador was first identified between 1978 and 1983 during the Mirador Project, (Matheny et al. 1980; Forsyth 1980; Dahlin 1984; Hansen 1984; Matheny 1986, 1987a, 1987b) When the Mirador Project concluded in 1983, Hansen continued the survey and systematic investigation within the Basin by organizing an exploratory expedition to Nakbe in 1987 (Hansen 1987a, 1987b, 1989), and at the request of the Guatemalan government, organized a regional study of the area starting in 1989. Part of the enigma of the area was due to an apparent inadequacy of the prevailing models of incipient Maya cultural development (Adams 1977; Adams and Culbert 1977; Hansen 1984:12–30) which prompted an initial concern with settlement hierarchy of the sites in this region, the sequence of architectural development, and socio-political relationship of the "satellite" sites of such as Nakbe, Tintal, Xulnal, Povenir, La Ceibita, Tamazul, and Wakna to each other and to El Mirador. The sites were joined by major causeways 30 to 40 m wide, 2 to 6 m high, and between 13 and 25 km in length. Recent improved satellite technology has indicated a remnant of a major causeway that extended from the southern side of the site of Calakmul to the south in a portion of the Laberinto bajo suggesting a probable link between Mirador and early Calakmul. The initial phases of causeway construction, particularly the Nakbe-Mirador-Tintal and Sacalero-Cascabel causeways, date at least to the late Middle Preclassic period between 600 and 400 B.C. according to ceramics recovered from the early causeway levels (Suasnavar 1994a, 1994b). The presence of the web of causeways indicates that

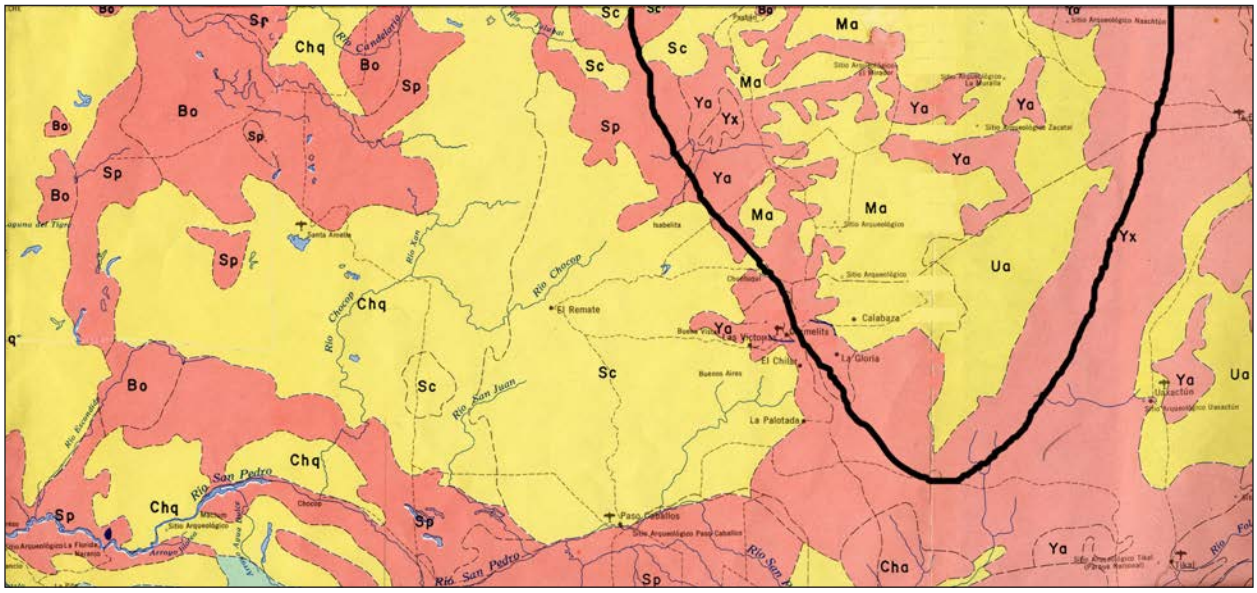

Figure 11.4. Map of the soils of Peten, created from surface surveys in the 1950's (Simmons et al. 1959). Note the triangular formation of distinct soils in the center of the map, representing the area of the Mirador Basin.

a federation of some sort had occurred between the dominant sites, and suggests an extraordinary control and expenditure of labor on an intersite basis.

Middle Preclassic Period

The antiquity of the social, political, and economic confederation evident in the Mirador Basin has redefined our perceptions of the sophistication of Preclassic societies and has formed a perspective more in line with the architectural development. Investigations at Nakbe, La Florida, Wakna, Xulnal, El Pesquero, and El Mirador have revealed extensive Middle Preclassic occupations with finely stratified primary deposits associated with major platforms and pyramidal architecture dating from ca. 1000 B.C. to 400 B.C. (see Hansen 2005). These deposits are associated with evidence of complex social and economic interactions such as importation and distribution of oceanic shells, basalt, granite, jade, and obsidian as well as exotic stone such as sandstone and crystalline limestone. In addition, the development of a tiered social hierarchy is indicated by complex settlement organizations, stratified architectural constructions of varying size and height, and identifications of elite status such as dental and cranial deformation, dental inlays, greenstone and obsidian importations and artifact associations (Hansen 1984, 1990, 1991b, 1991c, 1992b, 1992c, 1993a, 1993b, 1994a, 1994b 1998, 2001, 2005; Hansen and Guenter 2005; Forsyth 1992, 1993a, 1993b; 1993c; Mata A. and Hansen 1992). Stone sculptures, stelae, and large stone altars were also carved and utilized during this time (Hansen 1992c, 1994c, 2007; Hansen and Guenter 2005), as were specialized blocks for architectural constructions (Woods and Titmus 1994, 1996; Hansen 1992c; Forsyth 1993b). Some of the defining characteristics of Middle Preclassic architecture include lime plaster floors with an average thickness of 2 to 4 cm, wattle-and-daub residences, vertical-walled platforms of both residential and public nature with heights of up to 8 meters, formal ritual architecture formats such as E-Groups, and pyramidal structures from 13 to 24 meters high (Hansen 1998, 2001, 2005). Small, roughly hewn stones from quarries predominate early wall constructions between 1000 and 600 B.C., but these were replaced by massive stone blocks measuring up to 1.4 m long, 50 cm high, and 50 cm thick (see Hansen 1998:97; L. Hansen and Hansen 2009). The advent of the use of these blocks around 600 B.C. suggests the formation of a group or class of lithic specialists practicing a craft specialization, as determined by extensive experimental work by the Mirador Basin project involving the excavation of quarries, replication of stone tools, quarrying and

extraction of stones via ancient technology. In addition, the project conducted the literal transportation of blocks, and detailed microscopic and use-wear analyses which have confirmed the accuracy and consistency of the resultant observations (Woods and Titmus 1994, 1996; Hansen et al. 1997; Hansen et al. n.d.).

The Middle Preclassic period also witnessed the use of architecture as an artistic canvas, with finely painted deity masks and carefully sculpted panels carved from megalithic blocks, noted above, and covered with stucco flanking stairways of terraced structures. The stucco, however, on this art measured only 1 to 2 cm thick with the primary emphasis being on the finely carved stone armatures on the face of the blocks. Middle Preclassic architectural art consisted of sculpted stone masonry on the facades of structures covered with painted stucco often incised with geometric lines, and frequently associated with the ubiquitous "J-scroll-and-bracket" motifs, as first noted in the site of Rio Azul where a Middle Preclassic façade was exposed (Valdez 1995). Excavations on Middle Preclassic architecture at El Mirador, particularly Str.34 Sub1, indicate the "J-scroll-and bracket" is equally pervasive in the architectural art.

The Late Preclassic Period

During the Late Preclassic period (ca. 300 B.C.-A.D. 150) the architecture at Nakbe, El Mirador, Wakná, La Ceibita, Tamazul, and Tintal as well as numerous other sites in the Basin, including those on the Mexican side such as Yaxnohcah, Balakbal, and Calakmul, became much more massive. The largest constructions at these sites were built during this period, commensurate with other sites in the Lowlands such as Edzna and San Bartolo (Matheny 1987a; Howell and Copeland 1989; Hansen 1990, 1992c, 1998, 2001; Martinez and Hansen 1993; Forsyth and Acevedo 1994). By this time, the degree of political centralization in the Mirador Basin was at a climax with the size and scale of architecture unmatched at any period of Maya history. Large scale architectural art depicting deity figures continued to be constructed adjacent to central stairways on the facades of pyramids. A consistent architectural form with three primary structures on a large platform in a triadic pattern (Figure 5), corresponding to important elements of Maya ideology and cosmology, was developed and constructed over a wide geographical area in the Lowlands during the early Late Preclassic period (see Freidel 1985; Hansen 1990, 1991b, 1992a, 1992b, 1992c, 1993b, 1994a, 1998, 2000, 2001, 2005; Hansen and Balcárcel 2008; Martinez and Hansen 1992; Forsyth and Acevedo 1994). The architectural innovations of the triadic architectural format and the proliferation of architectural masks and panels which began in the Middle Preclassic period appear relatively quickly in the archaeological and architectural sequence throughout the Mirador Basin and the surrounding Maya Lowlands, suggesting an institutionalization of a widely adopted religious and/or political ideology. These radical architectural formats imply major ideological catalysts (particularly political, religious, and economic) as primary movers in the stimulation of architectural development as well as a corresponding control of vast amounts of labor. Specialized stucco manufacture was introduced during this time (E. Hansen 1994; E. Hansen et al. 1995; E. Hansen et al. 1997a; E. Hansen et al. 1997b; Schreiner 2000a, 2000b, 2001, 2002a, 2002b, 2003, 2004). It was also during this time that writing began to appear in sophisticated formats, occasionally found on carved stone monuments, stelae, or murals (Hansen 1991a, 1992a, 2001; Saturno 2006; Saturno et al 2006). Late Preclassic formal tombs are known to have been constructed in the Lowlands (Coe and McGinn 1963; Coe 1965a), but the large size and elaborate form of royal tombs from this period are especially evident in the Mirador Basin, where looted Preclassic royal tombs have been discovered at the site of Wakná (Hansen 1991b, 1992b, 1992c, 1998). An intact royal tomb was discovered in a residential area of San Bartolo (Saturno et al. 2006).

Ecological Context

One of the most distinguishing characteristics of the Mirador Basin is the quantity and density of bajos, which suggests that the concentration of Preclassic and Classic sites in the area may have a direct correlation to these features. It is significant to note, however, that where extensive marshlands are noted today, such as in the Laguna de Tigre area, there are very few sites of even modest size, The nature and formation of bajos have attracted the attention of several scholars (Cowgill and Hutchinson 1963; Turner 1974; Harrison 1978; Dahlin et al. 1980; Brenner et al. 1990; Miller et al. 1991; Pope and Dahlin 1989; Dominguez Carrasco 1992, 1993; Pohl et al. 1996; Jimenez-Osorio and Rorive 1999; Dunning et al. 2002; Baker 2003; Schreiner et al. 2008) with widely varying results (i.e. Harrison 1977, 1978; Pope and Dahlin 1989; Miller et al 1991; Jacob 1993). As noted above, soil descriptions from the Peten

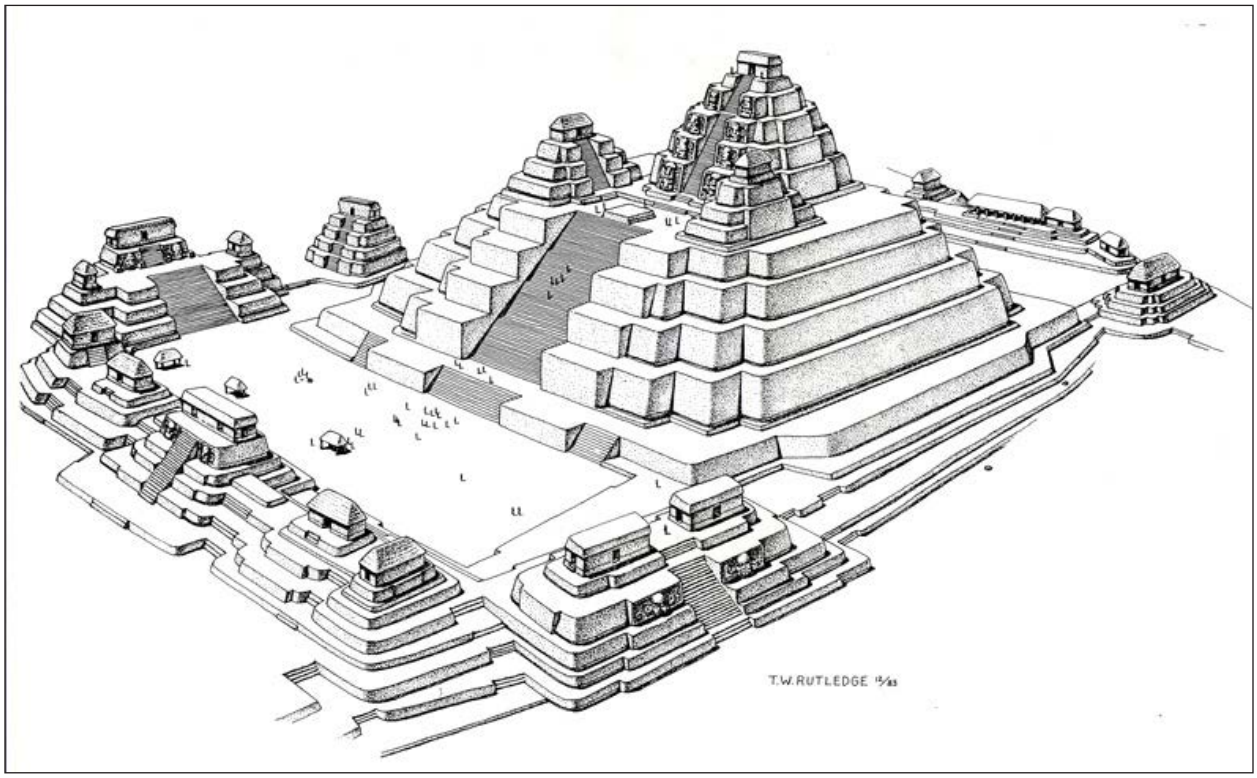

Figure 11.5. Drawing by T.W. Rutledge of the Tigre Complex at El Mirador during the Late Preclassic period (after Hansen 1984, 1990: ii).

(Simmons et al. 1959; FYDEP 1968; Stevens 1964) identified a high percentage of Macanche (Ma), Yaloch (Ya), and Uaxactun (Ua) soils in the area of the Mirador Basin (Fig 4). The presence of these soils (Ma, Ya, Ua) differentiates the Mirador Basin from the surrounding areas of the northern Peten, which have soils that are predominately Yaxá (Yx), Sacluc (Sc), or Sacpuy (Sp) soils of low to moderate quality. Varying perspectives of these soils have ranged from low to moderate fertility (FYDEP 1968) to "potentially the most productive soils of El Peten" (Stevens 1964:300; see also Olson 1969-cited in Dahlin et al. 1980). These variations suggested either that previous studies were incomplete, or that the bajos were much more heterogeneous than had been previously thought. The heterogeneity of the bajos is suggested by the fact that Dahlin (Dahlin et al. 1980) found that bajos surrounding El Mirador were extremely acidic (pH 3.3) while Mirador Basin Project/ RAINPEG samples from bajos near Nakbe indicated a consistently neutral pH between 6.5 and 7.5.

The idea that the bajos were lakes at one time was once thought viable (Cooke 1931; see also Harrison 1977; Miller et al. 1991:135). Yet, more recent studies have demonstrated that the bajos were not lakes, at least not during the periods of Maya occupation, since soil formations do not suggest lakebed environments and evidence of Preclassic residences has been recovered in the bajos themselves (Dahlin et al. 1980; Pope and Dahlin 1989; Dominguez-Carrasco 1992). This corroborates studies by Cowgill and Hutchinson (1963:39) which concluded that the bajo near Tikal (Santa Fe) had not had standing water in the area of the excavation since at least the late Pleistocene period.

In order to understand the geological history and utilization of the *bajos*, as well as the role of the *bajos* in the rise and demise of the Preclassic Maya in the area, the Mirador Basin project has been conducting a series of excavations and investigations of the *bajo* formations near Naranjita, Nakbe, and El Mirador (Jones 1991, Jacob 1993, 1994, Wahl 2000, 2005; Wahl et al. 2005, 2006, 2007a, 2007b; Schreiner et al. 2008; Nickels 2009. Test excavations in transects in several directions extending from the upland areas to the lowest point of the *bajos* as well as strategic placement of excavations

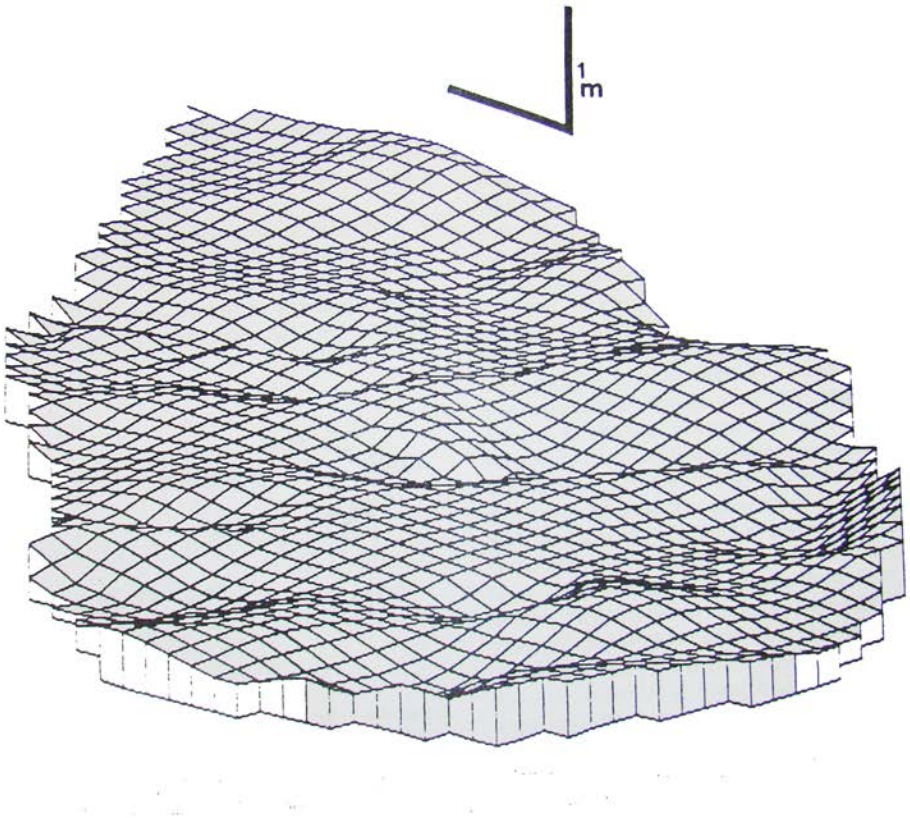

Figure 11.6. Micro mapping of the bajo surface with a Total Station system, showing the distortions created by the expansion and contraction of clays in seasonal wet and dry periods (after Jacob 1994.

in *bajos*, *civales*, and along causeways have allowed a view of the soil profiles and chemical composition from a variety of environmental niches in the area. Previous studies in *bajos* have involved very few excavations and have consisted of a limited exposure of horizontal and vertical profiles of the deposits. Our initial studies included mapping and excavation transects across the *bajos* to the north, east, and south of the civic center of Nakbe, and subsequently in the Bajo La Jarrilla to the west of the civic center of El Mirador and in the Isla Gavilán area to the southwest of El Mirador (Bajo Pedernal, Bajo Carrizal). More than 32 excavations were placed in selected areas of varying topographic levels in the transects within the *bajos* themselves and along the perimeter of the *bajos* (Nak Op. 400 A-J, 400 C-1, 400 C-2, 400 H-1, 400 H-2, 400 J-1, Op. 401 A-B; ElM Op. 500 109-I, 109M, 109T, 109U, 109V, 109Y, 109Z, 109BB) ranging in size from 1.5 x 1.0 x 2.65 m to 5 x 1.5 x 2.8 m for trenches, and up to 9 m x 8 m x 2.0 m for horizontal exposures (Op. 109M). The deposits revealed by excavations were analyzed according to stratigraphic position, composition, texture, color, soil pH, and the comparative relationship with other trenches. Soil samples from pit and trench profiles were collected for additional laboratory chemical and pollen analyses.

One of the diagnostic characteristics of bajos composed of montmorillonitic clays is the formation of gilgai, which occur in clay soils that swell and contract with the seasonal wet and dry conditions (Hallsworth et al. 1955; see Puleston 1978). The expansion and contraction of clay soils (called Vertisols) can form rectangular, circular, and linear features naturally (Puleston 1978:234– 235). The undeniable presence of gilgai throughout the bajos surrounding Nakbe was verified both on the surface and in the excavations

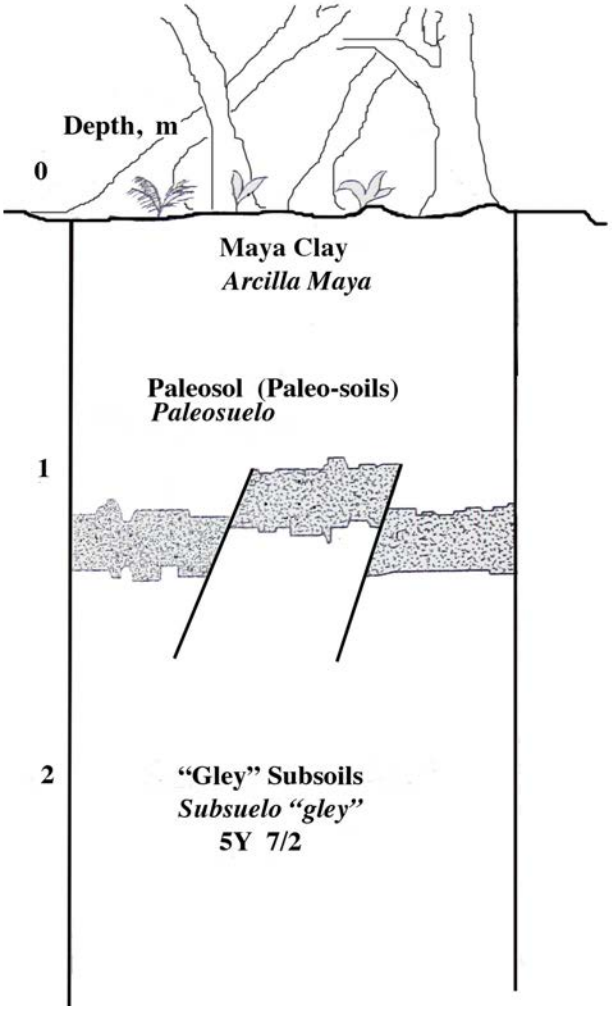

Figure 11.7. Schematic drawing of the natural movement of soils along "slickensides" which are a form of "fault lines" created as clays become seasonally inundated and expand. During the dry season, the clays contract to a dry and hardened state (after Jacob 1994:279).

(Jacob 1994; Hansen et al 2002; Schreiner et al 2008). The application of Total Station mapping technology in the bajos on a micro-scale at Nakbe showed the surface fluctuations that result from the subsurface movements of soils in a process called "argilloturbation" (Figure 6). The extrusion of subsoil materials, called "chimneys" is responsible for the marked soil level fluctuation on the surface. The vertical movement of soil strata through the argilloturbation process formed natural, vertical, "fault lines" of smoothed clay (Figure 7). These diagnostic features, which facilitate the expansion/ contraction movements of saturated soils, are called "slickensides," and were present in all bajo excavations at Nakbe and El Mirador.

Table 11.2 Provenience/depth of Pollen Samples (John Jacob, TexasA&M)

TAMU #	Sample Source	Sample Depth
1	Cival Madre #1	120–130 cm
2	Cival Madre #1	250–270 cm
3	Cival Madre #1	340–360 cm
4	Zacatal #1	170–185 cm
5	Zacatal #1	230–240 cm
6	Zacatal #1	270–275 cm
7	Zacatal#1	320–330 cm
8	Zacatal #1	380–385 cm
9	Zacatal #1	460–470 cm
10	Zacatal #1	550–560 cm

Another series of important discoveries in the bajos at Nakbe and subsequently in the bajos near El Mirador, consist of the identification of a dark brown layer beneath a sedimentary clay deposit at a depth from about 1 m to as much as 2.4 m below the surface (Jacob 1994, 1995; Schreiner and Hernandez 2008; Schreiner et al. 2008; Nickels 2009) (Figure 7, Figure 8, Figure 9) The nature and composition of this layer is tentatively interpreted as a previously exposed, original surface, or a buried "A-horizon." Excavations in 32 separate areas of bajos at El Mirador and Nakbe consisting of more than 100 excavation operations have revealed this deposit of clay sediments which invariably have buried what appear to be a histosol layer (histosols are soils derived from organic composition, particularly peats).

The subsequent analyses of the pollen percentages and pollen classification of five samples from the Mirador Basin by the late Dr. Barbara Leyden of the University of South Florida indicated that all five samples were consistent with a wetland marsh environment (see Hansen et al. 2002:284, Fig. 11.13, Fig. 11.16; See Table 11.2, Table 11.3, Table 11.4). The samples, taken from depths of 1.20–1.30 m and 3.40–3.60 m at Cival Madre (located in the large bajo to the east of Nakbe) and at 1.70–1.85 m, 2.30–2.40 m, and 3.80–3.85 m at Zacatal showed only minor fluctuations in the marsh environment during the centuries of its existence. The consistency of the pollen between samples from the Cival Madre, a major cival swamp, and Zacatal (an

Figure 11.8. Dark buried A-horizon layer buried beneath several meters of sterile clay, located in Bajo Carrizal, El Mirador. (Photo: R.D. Hansen).

Table 11.3 Pollen Concentration and Preservation per Sample, Cival Madre #1 and Zacatal Aguada, Nakbe (Analyst: Weinstein 1994)

Sample	Pollen Concentration	Pollen Preservation
1	High	Good. Variety of taxa
2	Med/High	Good. Variety of taxa
3	Med/High	Fair/Good. Variety of taxa, crumpled grains
4	High	Good. Variety of taxa
5	High	Good. Variety of taxa
6	High	Good. Variety of taxa Torn Grains
7	High	Fair. Variety of taxa. Torn Grains
8	Low	Fair. Limited variety of taxa. Crumpled grains
9	Low/Med	Fair. Limited variety of taxa. Torn & crumpled grains
10	Low/Med	Fair. Limited variety of taxa. Torn & crumpled grains

Figure 11.9. Graduate Student Kara Nickels pointing to a dark, buried, A-Horizon layer buried beneath several meters of sterile clay, located in Bajo Jarrilla, El Mirador. The depth of the sedimentation is attributed to the influx of a major drainage system into the bajo from the eastern side of El Mirador (Photo: R.D. Hansen).

arteficial reservoir which has converted into a cival to the west of Nakbe, is demonstrated by the presence of grasses, sedges, and composite species (Eichhornia, Monolete, Cladium jamaicense) and lends support to the hypothesis that the bajos were originally wetland marsh environments. This data also corresponds well with the stratigraphic data obtained in the bajos of the Mirador Basin. Varied laboratory analyses of some of the same samples demonstrate the inadvertent loss of some of the pollen between Weinstein's presence/absence analysis (Weinstein 1994) and the later pollen counts and classification analyses that were realized by Leyden (see also Leyden 2002). This degradation is probably due to the abundance of thinner or less readily preserved pollen grains observed by Weinstein which decomposed at some point during extraction and cleaning process- a common occurrence in pollen analyses (Covich 1978:149). However, the results obtained in the initial studies from carefully controlled contexts in the northern Peten, in addition to the cores extracted by Wahl et al. have provided an expanded statistical representation of the ancient pollens existent

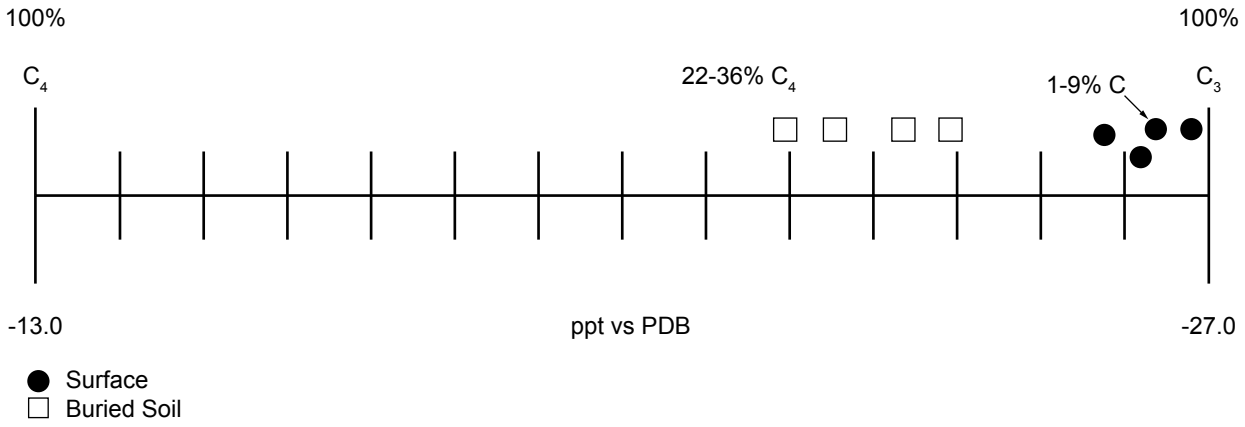

Figure 11.11. Delta C-13 isotope analyses of sediments at Nakbe. Buried A-Horizon levels show a consistent C-4 isotopic signature (grasses, corn), while the sedimentation layer shows a consistent C-3 isotopic signature (contemporary tropical forest), suggesting a major change in the composition and form of the original swamp (after Hansen et al. 2002:283).

Figure 11.10. Aerial photograph of Bajo Carrizal, located to the southwest of El Mirador, depicting the pervasive rectangular/linear features in the bajo. Excavations demonstrate definite surface manipulation by the original inhabitants. (Photo: Enrique Hernandez).

Figure 11.12. Portion of the Bajo Carrizal with the remnants of the ancient cival system, in an evolutionary phase *(Photo: Enrique Hernandez).

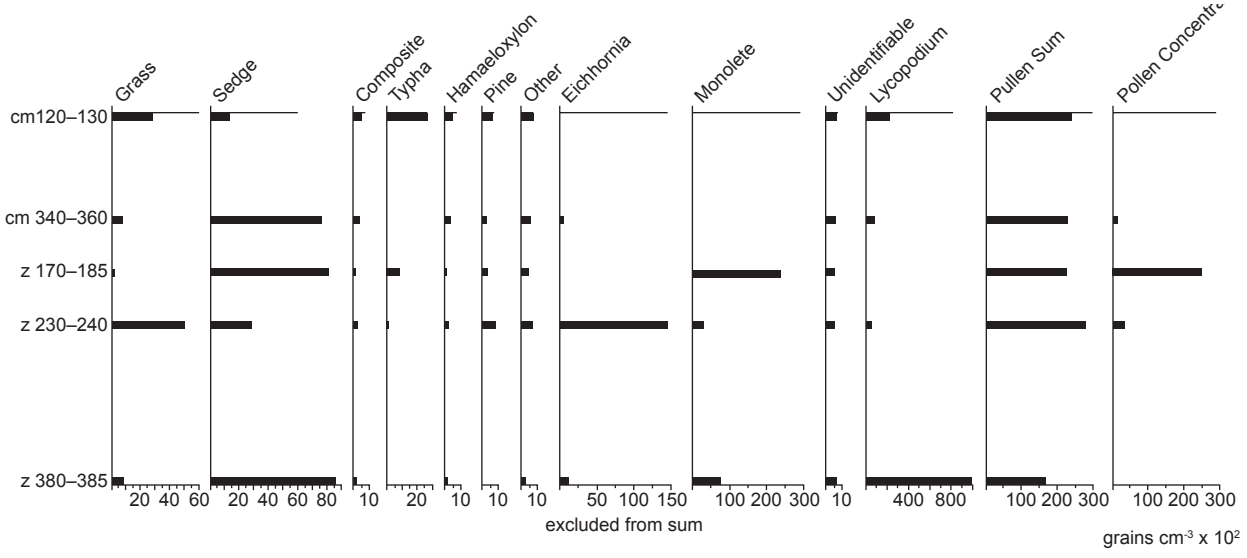

Figure 11.13. Cival Madre #1 and Zacatal Pollen Percentage Charts, indicating pollen recovered from cores (Analyst: B. Leyden).

Table 11.4 Relative Percentages of Pollen from Cival Madre #1 and Zacatal, Nakbe

Pollen Type	#1	#3	#4	#5	#8
Grasses	26	8	2	51	8
Sedges	14	78	82	29	86
Composites	6	5	+	3	+
Chenopodiaceae- Amaranthaceae	+	-	-	-	-
Combretaceae	+	6	+	+	+
Haematoxylon	5	-	+	+	+
Bursera	-	-	+	+	+
Palm	+	-	-	+	-
Pine	7	3	4	9	+
Oak	+	-	-	+	-
Alder	-	-	-	+	-
Sweet gum	-	-	-	+	+
elm	-	-	-	+	-
Sapotaceae type	+	-	+	-	-
other/unknown	5	+	3	2	-
Cattail	29	+	5	+	-
Potamogeton	+	-	-	-	-
Excluded from sum					
Water Hyacinth type	+	5	+	145	11
unidentifiable	7	6	5	5	7
Fern spores					
Trilete	4	2	3	+	5
monolete					
psilate	+	-	239	27	74
other	-	-	42		25
Lycopodium spike	215	74	4	35	987
Pollen sum	240	228	225	278	170
Pollen Concentraion					
grains m^{-3}	525	1525	25425	3272	114

in the bajos and associated areas (see Wahl 2000, 2005; Wahl et al. 2005, 2006, 2007a, 2007b; See Table 11.5). The values of such testing demonstrate the variations and similarities of the ancient vegetative types at a specific point in time (synchronic) as well as the vegetative changes through time (diachronic).

Detailed pollen and isotope data from excavations, deep lake cores, and profiles of existent aguadas in the area, suggest that the bajos were originally civales, wet

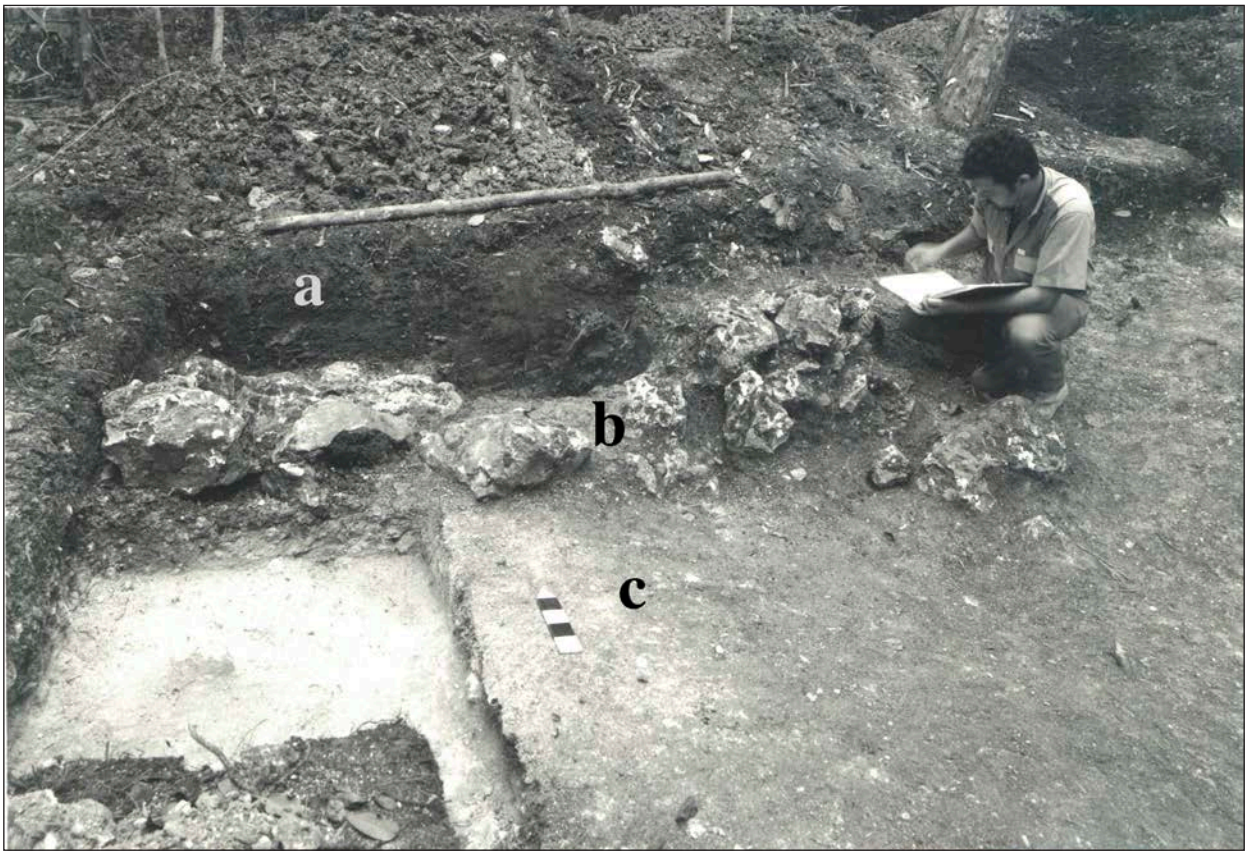

Figure 11.14. Terrace dams showing imported soils from the bajos (a), the terrace dams (b), and the radically different soils outside of the terraces (Photo: R.D. Hansen).

marshland areas of which fossil remnants of the ancient systems can be observed, particularly in the bajo to the east of Nakbe, near the western edge, and in the extreme southern portion of the Mirador Basin. Stable isotope data of these soils have identified the C-4 (grasses, corn) nature of this consistently identifiable layer, while the subsequent deposits over the layers consistently display the vast majority of C-3 plants consistent with modern vegetation signatures (Figure 10) (see Jacob 1994, 1995: Fig. 4–16). A similar isotopic signature was found in the Usumacinta Basin, with the significant difference that the C-3 isotopes were also found below the C-4 deposits, indicating that the original forest preceded the agricultural development, and then returned post abandonment (Johnson et al 2007:1127).

The significance of argilloturbation and slickensides of Vertisols is that they have disguised and distorted much of the original A- horizon of the bajo floor (see Figure 11.7; see also Hansen et al. 2002: 283, Fig. 12. Nearly all bajo excavations near Nakbe and at El Mirador revealed this buried soil horizon below a sedimentary surface layer, but it was often not stratigraphically intact because of the severe soil movements and displacements (Jacob 1994, 1995). The buried soil horizon consisted of colors in the Munsell Soil Color charts ranging from dark gray (10YR4/1), gray (10YR 5/1), very dark grayish brown (10YR 3/2), to a light olive gray (5Y 6/2), colors that are distinctly similar to or darker than the surface horizon. In several instances, the paleo soil was observed to have root traces of fossilized iron, suggestive of reduction and oxidation cycles. In many cases, (e.g. Nak Op. 400 A, ELM Op. 500), the buried soil is similar to the surface levels of the present-day perennial marshland

Table 11.5 Provenience/Identification of Nakbe Pollen and Phytolith Samples (Analyst: John Jones 1991)

Sample	Provenience	Results
A.	Vessel fill, Cache 1, Nakbe Op. 52 B. (Late Classic)	No pollen observed.
B.	General soil sample, Nakbe 51 C.09.16. Surface depth: 2.0 m E, 1.8 m W. Datum depth: 2.75 m. Middle Preclassic (790 BC uncorrected)	No pollen observed
C.	Bajo soil, Nakbe Op. 18A, DP 18. Middle Preclassic (800-600 BC)	No pollen observed
D.*	Buried soil horizon, Nakbe Op. 32 F.16.42. Datum depth: 3.25 m. Middle Preclassic (650 BC uncorrected; 450 BC uncorrected)	Fair preservation, at least 9 taxa observed, including corn (*Zea mays*.)
E. *	Buried deposit in MPC structure. Nakbe Op. 53 E.11.25. In 1.74-2.15 m from E-W wall. Red/gold color earth. Middle Preclassic (ca. 600-500 B.C.)	Good preservation; at least 18 taxa** observed, including corn (*Zea mays*) and squash (*Cucurbita sp*.)
F.	Soil from within MPC figurine head. Nakbe Op. 51 C.09.20. Surface depth 2.0 m E. Datum Depth 2.75 m. Middle Preclassic (1235 BC uncorrected; 790 BC uncorrected	No pollen observed
G.	Soil from within intact MPC jar rim. Nakbe Op. 51C.09.15. Surface depth: 2.0 m E., 1.82 m W. (1235 BC Uncorrected; 790 B.C. uncorrected)	Few grains observed, poor preservation
H.	Pollen wash of jar rim, sample G.	No pollen observed.

* An abundance of well-preserved Cretaceous-Paleocen spores and pollen grains in observed in these samples, including Appendicisporites spp.

** Corn (*Zea mays*), squash (*Cucurbita sp.*), Chico zapote (*Achras zapota*), pine, fern spores, copo (*Ficus*), palms (escoba), chichém, ceiba, chacah (*Bursera simaruba*), grasses, possible cacao pollen.

environments (see below). The surface depth of the buried layer varied slightly according to proximity to the upland elevations and water discharge locations, as well as the vertical movement of soils due to the repeated dry/wet cycles of the clay. However, on the average, this layer was located from 1.0 m to 1.60 m below the surface and occasionally deeper where sedimentation appears to have been greater (ie. Nickels 2009) (Figure 11.8, Figure 11.9). Detailed analyses of the soils, both at the sites and in the laboratories suggest that the environment may have been wetter when the buried soil was at the surface (Jacob n.d.: 28), and most likely that of a perennially wet marshland /cival.

AGRICULTURAL UTILIZATION AND ECOLOGY OF THE BAJOS

Previous studies of radar surveys and remote sensing data over the Maya Lowlands (Siemens and Puleston 1972; Adams et al. 1981; Adams, et al. 1990) suggested evidence for networks of canals throughout many swamps and *bajo* regions, as well as implications for a "wetland garden" system of agricultural production (ibid; Puleston 1977, 1978; MacKinnon 1981; Flannery 1982; Turner and Harrison 1983; Harrison 1996; Fedick 1988, 1996a, 1996b, 1996c). In their initial studies of the northern Peten, Pope and Dahlin (1989) failed to find raised fields or artificial canals in radar and aerial photographs and suggested that many wetland habitats were unsuitable for productive and predictable sustained agriculture (Pope and Dahlin 1989: 94, 98). Furthermore, Pope and Dahlin suggested that the Mirador *bajos* were never perennially moist, based on Dahlin's explorations in the *bajo* adjacent to El Mirador (Bajo Jarrilla) (ibid.). Recent aerial and satellite photos of Bajo Carrizal, to the south of La Muerta and the Gavilan island, show distinct horizontal and parallel features within the bajo, suggesting a artificial manipulation of the surface, although it is heavily sedimented (Figure 11.11). Similar features have been found in numerous areas of the Lowlands, suggesting an intensive use of the bajos and their peripheral areas as agricultural engines for ancient Lowland economies (e.g. Armillas 1971; Turner and Harrison ibid, Fedick ibid; Dunning

and Beach 1994; Dunning 1996; Dunning et al. 2002; Baker 2003).

In the Bajo Carrizal case, the large parallel features were first noted by George Stuart (1975:785), where consistent patterns of light green and dark green bands were observed traversing the entire bajo (Figure 11.11). The inhospitable environment impeded surface exploration of these features until Schreiner, Wahl, and Hernandez managed to locate them with GPS and conduct a series of excavations (Schreiner et al. 2008). Each parallel band measures approximately 85 m wide and 300 to 500 m long, with the dark green bands consisting of higher elevations dominated by larger and thicker trees, including the Inkwood ("Logwood") or *palo tinto* tree (*Haematoxylum campchianum*). The inkwood tree was notably absent in the lighter color bands, where the surface is topographically more depressed with a longer period of inundation. The standing water created more of a stunted forest, ranging only from 5 to 7 m in height, and a common sedge (*Cyperaceae*) known locally as *navajuela* (*Scleria sp*.) is characteristic of the feature, a fossil remnant of the ancient system in an evolutionary phase (Figure 11.12). Three excavation operations, Op. 501A (2 m x1 m), Op. 501B (3 m x 1 m) and Op. 501C (6.4 x 1 m), were placed in the light banded (low) area (501A, 501B), and on the dark banded (upper) area (501C). Stratified layers of organic surface soils, followed by clay sedimentations, and subsequently by a sharp distinct black layer paleosol were detected in all excavations, indicating a stratigraphic continuity throughout the bajo (Figure 11.8). A similar feature was located by Dunning et al. in a bajos at Yaxha and at La Milpa (Dunning et al. 2002:277), with a calibrated carbon date of AD 75 (Beta-134143).

As noted above, the Mirador Basin data of isotopes, phytoliths, pollen extractions, cores, studies of contemporary civales, updated aerial imagery, and stratigraphic excavations, suggest that the bajos at El Mirador and Nakbe were a perennially-moist marshland environment, although it appears that the extensive sedimentation may have buried evidence for artificial manipulations of the original surface levels. Perhaps even more disfiguring was the "argilloturbation" (see above) which caused vertical movements of clays and sediments throughout the bajos (Jacob 1994; Dunning et al. 2002:275–278; Hansen et al 2002). Such disfigurements appear to have altered artificial manipulations of the surfaces and would not be visible by small test pits or narrow trenches, methods utilized frequently in previous excavations in the bajos (e.g.Cowgill and Hutchinson 1963; Miller et al. 1991). As Adams et al. (1990) noted, increased bajo investigations can facilitate understanding of the artificial manipulations in the marshes, and underscores the need for sensitive mapping technology in the bajos which could detect subtle topographical variations that might represent surviving vestiges of ancient subsistence systems (see also Puleston 1977, 1978). It is also probable that large scale horizontal exposures (10 by 10 m, 20 x 10 m) of the original A-Horizon layer in the bajos would facilitate detection of evidence of ancient subsistence or land use systems that were buried by occupation and post-occupation deposition and sedimentation.

SOIL CORES, POLLEN, AND AGRICULTURAL TERRACES

To corroborate the data obtained from excavations in the bajos, a series of auger samples were collected from various topographic levels throughout the site area of Nakbe and core samples obtained from three lakes with depths from 8 meters to 17 meters along the western edge of the Mirador Basin (Wahl 2000, 2005; Wahl et al. 2005, 2006, 2007a, 2007b). Pollen samples from primary midden deposits in the site center of Nakbe (Jones 1991) (Table 5), had indicated that many of the contemporary forest pollens at Nakbe were also found in the early phases of the Middle Preclassic period (1000–600 B.C.), which is corroborated by subsequent data from cores in the lake of Puerto Arturo, a cival-lake located on the western edge of the Mirador Basin.. The discovery of agricultural pollen in sealed Middle Preclassic contexts (Jones, ibid) and in consistent pollen cores from the lakes (Wahl, ibid) indicates that agricultural exploitation of the forest was thriving and functioning in the Mirador Basin during this time. The presence of Zea pollen in the Puerto Arturo cores however suggests that corn was present in the Basin by about 2600 B.C. (Wahl et al. 2006:384–385), a date that is consistent with other samples from the Maya Lowlands (see Leyden 2002). The "milpa" system, as it currently exists among contemporary populations in the northern Peten, seems to have been less significant, or perhaps even non-existant during the Preclassic periods due to the fact that the rich, organic marsh muck from the bajos was transported into the civic centers and placed in extensive terrace systems (Puleston 1973, 1977, 1978). Extensive terrace constructions, dams, dikes,

and evidences of hydraulic control have been located throughout Nakbe, and the sites of La Florida, Naba, Wakna, and El Mirador (Martinez and Hansen 1993; Martinez et al. 1999; Bozarth and Hansen 2001; Hansen et al. 2002. The terraces and dams were constructed of stone walls to contain the imported histosol or organic muck layers from the wetland marshes that surrounded the major sites of the Mirador Basin (Figure 11.14; see Hansen et al 2002: 289 Fig. 20). Phytoliths, which are silicate fingerprints of individual types of plants, were obtained by Dr. Steven Bozarth of the University of Kansas and have revealed that agricultural production on the terraces and muck soils consisted of corn, squash, gourds, cotton, and palms (Bozarth and Hansen 2001; Bozarth 2007). In several cases, the marsh muck accumulated to up to deposits 3 meters thick, since the simplest procedure for renovating a field was simply to apply another thin layer of muck (Hansen et al. 2002). In other cases, such as the terraces next to what is believed to be the royal residence compound at Nakbe (Group 18), muck had been transported, deposited, and formed into "cuyitos," or small hillocks or undulating surfaces which accommodated corn and bean plantings. This agricultural strategy, still utilized today in Campeche near the village of Conhuas on the Escarcega-Chetumal highway (William Folan, personal communication 1994, 1998) demonstrates the continuity of agricultural behavior over thousands of years of time. In an example from Nakbe near Group 18, a layer of lime had been placed over the field surface which would alter the pH to a more neutral acidity as well as serve as a deterrent to insects.

DEMOGRAPHIC DEGRADATION.

It was in the midst of a vibrant and seemingly prodigious Late Preclassic growth and development that construction ceased, monuments ceased to be erected, causeways became overgrown, monumental buildings were left with Preclassic ceramics and stone tools left directly on the floors, and the area largely abandoned, beginning by about A.D. 150 to A.D. 250 (see Table 11.6). By every indication, a major demographic demise of monumental proportions had occurred in the Mirador Basin. Excavations of the large public architecture in major sites, smaller settlements scattered throughout the area, as well as small residential structures away from the civic centers of the sites revealed Preclassic artifacts in situ on floors, suggesting that a major abandonment had occurred not only within the major centers of the basin but also among rural residences and isolated small settlements located as much as 40 km from the major sites.

The nature of this collapse and its extent throughout Mesoamerica has been described elsewhere (e.g. Hansen 1990: 216ff, 2001; Hansen et al. 2008), but the challenge has been to identify the components which interrupted nearly a thousand years of fairly consistent and vibrant occupation. The issues of "collapse" and "abandonment" are complex, and terms are not synonymous (see Winter 2003: 104). In the cases where a "collapse," defined as a long term, permanent abandonment and cessation of complex societal behaviors, have been amply documented, such as the Akkadian empire of southern Mesopotamia or the African culture at Zimbabwe, studies indicate that the catalysts were invariably climatic, environmental, or ecological (Huffman 1972; Garlake 1973; Connah 1987; Gibbons 1993; Weiss et al. 1993). In Mesopotamia, this involved an increase in aridity, changes in wind circulation, and particularly the salinity of soils (Jacobson and McC.Adams 1958; Walters 1970:160–161; Gibson 1974; McC. Adams 1978:330; Turner et al. 1993; Ponting 1993; Johnson and Lewis 2007). In Zimbabwe, the surrounding rural areas, which supported the cultural systems, were "over-cropped, over-grazed, over-hunted, and over-exploited every essential aspect of subsistence agriculture" (Connah 1987:213). In Mesoamerica however, some abandonments appear to have had causes related to warfare or specific geological events such as volcanism (see Webster 1976, 1977; Demarest and Valdes 1994; Inomata and Webb 2003; Sheets 1983; McKee and Sheets 2003). Excavations in specified areas at sites such as Aguateca have revealed that abandonment of the site was probably due to "an attack by enemies" (Inomata 2003:59), but it remains to be explained as to why the site was not subsequently re-occupied. Warfare has invariably created "abandonment" scenarios, but rarely a "collapse" scenario because surrounding populations gradually return to the primary site (e.g. Dresden, Germany; Hiroshima, Japan). The long term "collapse" at sites like Aguateca suggests that the warfare may have been the "symptom" of the cause, and not necessarily the cause for the permanent abandonment. Occupation at Ceren, El Salvador was terminated by a volcanic eruption by about A.D. 470 (Sheets 1983; McKee and Sheets 2003), but societies continued to reside in the area until the Spanish conquest and beyond. Rather, long term demographic depopulations are almost invariably linked to environmental degradation

Table 11.6 Radiocarbon Dates for Terminal Occupation

Site	Reference no.	Operation	Location	C14 Age	Uncorrected C14 Date	Source
El Mirador	Beta 5553	47C	Carbon sample directly off floor of Str. 313	1990±70 B.P.	40 B.C. ± 70	Struz-Ladeen 1986:116
El Mirador	Beta 5554	47D	Ash sample at the base of steps, Str. 313	1950± 80 B.P.	A.D. 0 ± 80	Struz-Ladeen 1986:116
El Mirador	Beta 5556	48E	Midden on floor on east side of stairs, Str. 314	2050 ± 60 B.P.	100 B.C. ± 60	Struz-Ladeen 1986:116
El Mirador	Beta 5549	60C	Sample from surface of lower step, Str. 2A6-3	1780 ± 60 B.P.	A.D. 170 ± 60	Howell 1989:36
El Mirador	TEM 13	2	Sample from level 2 of Aguada	1450 ± 125 B.P.	A.D. 500 ± 125	Dahlin et al. 1980:47
El Mirador	Beta 1965	26G	Sample from intrusive pit chopped in floor/step	2065 ± 90 B.P.	115 B.C. ± 90	Hansen 1990:208
Nakbe	Beta 31752	51 B	Sample from fine ash deposit above floor, associated with Protoclassic sherd	1580 ± 70 B.P.	A.D. 370 ± 70	Unpublished
Nakbe	UCLA 2849A	59C	Sample from stucco floor, associated with Late Preclasssic sherds	1805 ± 80 B.P.	A.D. 145 ± 80	Unpublished
Nakbe	UCLA 2849C	51B	Sample from ash on stucco floor	1700 ± 90 B.P.	A.D. 250 ± 90	Unpublished

(see below). And, the first and most logical manner to determine the complex multi-causes of a collapse are to look at the systems that gave rise to the social, political, and economic complexity and their subsequent degeneration. If the collapse of socio-political and economic complexity in the Maya area in the Late Preclassic period was associated with climatological, environmental, and ecological factors, as suggested by comparative data from the other areas of the world, the evidence would have to be wrested archaeologically from those areas where such information might be available. As a result, the Mirador Basin Project conducted extensive excavations, coring, sampling, and surveys in areas mostly likely to yield environmental and ecological data. This led to stratigraphic excavations in 32 separate areas of the *bajos* near El Mirador and Nakbe, more than 130 excavations in terraces, dams, and platforms in the civic centers, the coring of lakes, *aguadas*, followed by pollen analyses, phytolith studies, detailed soils analyses, fertility studies of Peten soils, water quality research, hydrologic collection systems, stable isotope analyses, and exhaustive replication and quantification experiments, including the experimental replication of ancient terraces and fields using *bajo* mucks in the village of Carmelita.

These data have allowed the formation of three testable hypotheses: (1) *the Preclassic Maya sought and adapted to a specific environmental system it in a variety of ways, most notably with the utilization of swamp muck for agricultural production systems*; (2) *by the terminal Late Preclassic period, Preclassic Maya engaged in excessive resource procurement for use in the form of massive architectural complexes, platforms, and plazas, with corresponding increases in lime production, architectural mortars, and exorbitant uses of architectural stone*; (3*) the conspicuous consumption of these resources had a negative environmental impact consisting of the erosion of upland soils and the degradation of ancient agricultural systems existent in the Mirador Basin, which contributed to a substantial loss of demographic density in the region*. Note that this does not imply that these were the only factors associated with a demographic demise, but they were prime catalysts in an arena of multi-causal factors for a dramatic demographic decline, near complete cessation of major architectural constructions, the disintegration of vibrant trade and exchange networks, and the return of tropical forest species.

The extent and relative speed of the clay deposition over the buried, rich, organic layers suggest a dichotomy

in issues: if the Maya were responsibly renovating agricultural terrace systems and farming the same plots over extended periods of time, how and why did such extensive siltation occur over the organic surfaces of the cival marshlands? What were the mechanisms that allowed extensive clay deposition to bury the economic engines of Middle and Late Preclassic societies in the Basin? One of the more obvious explanations would have to involve deforestation strategies so extensive that uncontrolled sedimentation would be a viable mechanism for the burial of the rich organic layers of the cival marshlands. Since the Preclassic Maya do not appear to have employed slash and burn agricultural strategies but rather, an intensive agricultural system (see Harrison and Turner 1978; Flannery 1982; Healy et al. 1983 for intensification in Belize), I have suggested that the mechanism for mass deforestation was the production of lime stucco, an intensive process of burning green wood and limestone to create quicklime for massive architectural constructions (Honan 1995; Hansen 1994a, 2002, 2006). This factor has been suggested to have had a primary impact in other areas of the world (e.g. Gourdin and Kingery 1975; Blackman 1982; Wertime 1983; Kohler-Rollefson and Rollefson 1990; Rollefson 1990; Rollefson and Kohler-Rollefson 1989; Rollefson et al. 1992; Weiss et al. 1993). The Mirador Basin project organized and participated in six years of research into the study of Mesoamerican lime production and utilization, conducted primarily by Thomas Schreiner and Eric Hansen, to determine the relevant costs in wood and stone consumption (E. Hansen 1994, 2000a, 2000b, 2007; E. Hansen et al. 1995; E Hansen et al. 1997a, 1997b); Schreiner 1998, 2001, 2002a). This work resulted in two outstanding Ph.D. dissertations (E.Hansen 2000b; Schreiner 2002a) The geology of the Yucatan and particularly the northern Peten essentially consists of tiers of limestone that have arisen in succession by uplift. The oldest tier is located in the Mirador Basin, and consists of crystalline limestones mixed with extensive layers of a type of limestone known to the Maya as Tzaal, a soft porous limestone that occurs as a surface strata consisting of almost pure calcium carbonate with approximately two percent of montmorillonite clay which was created by an ancient process of dissolution and re-precipitation of calcium carbonate. Because of the abundance of Tzaal, the Maya apparently were overzealous in the use of lime. For example, recent excavations on the 25 km long Tintal-El Mirador causeway by Enrique Hernandez (San Carlos University) and Tom Schreiner (U Cal Berkeley) determined that the Maya used a minimum 10,000 cubic meters of lime plaster (35cm x 35 m x 1000m) and up to 40,000 cubic meters (1.2 m x 35 m x 1000m) of tzaal stone per kilometer of its length during any one construction phase of the four identified phases (Schreiner, personal communication 2006; see Schreiner and Hernandez 2008; Schreiner et al 2009). Extensive replications of lime production systems have demonstrated a consistent ratio of 5:1, meaning 5 units of wood, 5 units of stone for every 1 unit of lime produced (Schreiner 2002b). Under this scenario, Schreiner determined that the final lime plaster coating on the single pyramid of Tigre, the second largest structure at the site of El Mirador, required 2200 cubic meters of lime plaster (with calculations for impurities and the fractional component of unburned limestone), or, in other terms, the complete deforestation of 163 hectares of every single tree (Schreiner 2002b:87).

Diachronic evaluations of nearly 140 stucco floors from the Middle Preclassic through the terminal Preclassic periods further demonstrate the remarkable expansion of the lime production industry. This was done through a detailed association of ceramics which can be seriated fairly reliably because of the extensive size and sealed contexts of samples, plus absolute dating mechanisms where possible.

The data are particularly insightful because many of the floors were observed in constructional succession, meaning that pre-existing floors were in place when the next floor was constructed (see Table 11.7). During the early Middle Preclassic period (ca. 1000–600 B.C.), some floors averaged 2 to 2.4 cm thick, but the majority constituted a stucco layer of 4.68 cm thick (n=16), by the late Middle Preclassic period (600-400 B.C), floors averaged nearly 5.06 cm thick (n=16), by the early Late Preclassic (ca. 300–200 B.C.), floors averaged 8.60 cm thick (n=28), and yet by the middle Late Preclassic period (ca. 100 BC-AD 1), plaster floors averaged an astounding 12.93 cm thick (n=46), a phenomena yet unparalleled in any of the subsequent occupations of the basin. By the terminal Late Preclassic and Protoclassic periods, floor thicknesses were down slightly to 11.79 cm (n=27). After this period of time, the near total abandonment of the region suggests only minimal constructions, particularly as funerary or isolated residence structures.

The frequent placement of floors over previous floors during the Late Preclassic period does not seem to have contributed to constructional strengths of the floors and most likely represents a procedure of conspicuous

consumption. This is particularly evident where high traffic floors in earlier periods were substantially thinner and yet structurally sound. The excessive use of lime plaster is found not only in the plazas and causeways, but was found in the massive constructions of the buildings and correlates with distinctive stone patterns associated with the construction of the architectural complexes.

A similar abuse of resources is evident in the use of stone. The general characteristics and lithic modes of stone architecture have chronological value that can be perceived through time (Hansen 1998:96ff). In the Middle Preclassic period between 1000 and 600 BC, architectural constructions consisted of vertical walled platforms, roughly hewn stones 25 cm by 28 cm by 8 cm (Hansen ibid:96–99). Between 600 and 400 BC however, stone work changed radically to blocks averaging from 1.0 to 1.4 m in length, 40–50 cm high, and 40 to 50 cm thick, indicating a specialized and systematic production (Hansen ibid, Woods and Titmus 1994, 1996). These blocks were placed in walls with the long axis exposed so that a 50 square meter section of wall would have required 19 cubic meters of stone. By the Late Preclassic period (ca. 200 B.C.), however, the Maya were placing the same blocks with the long axis into the building and exposing only the smaller face of the stone, requiring at least 40 cubic meters of stone to construct the same section of wall (Hansen 1998:97). Therefore, the surface area of wall covered by a single stone during the late Middle Preclassic period now required approximately three to four stones to cover the same section of wall, an extreme jump in the labor, resources used, and distances required to haul the massive blocks from their quarries. The fact that such strategies did not enhance the architectural stability of architecture is evident in understanding the construction techniques of early Maya architecture. This process, involving construction pens or construction cells, would have contained weight and pressure volumes to a minimum because of the containment of the fill by rectangular, box-like crude cell wall constructions, allowing minimal or non-existant pressures on the external surfaces of structures. This amounts to what can be determined as conspicuous consumption of stone, paralleling the use of lime stucco, and creating huge deficits in the costs of available agricultural spaces, soils, water, labor, diversion of logistical resources, and time resources which may have had a more productive venue in the economic fabric of the society.

The third display of the conspicuous consumption of resources is evident in the massive construction programs throughout the entirety of the Mirador Basin during the Late Preclassic period. The large constructions at El Mirador, Nakbe, Tintal, Wakna, Xulnal, Paixban I, Paixban II, and La Ceibita are characteristic of the investment of labor incorporated in the transport of fill, quarrying of rough stones, and preparation of platforms, plazas, acropolis constructions, causeways, and pyramidal constructions. Based on experimental transport of fill and quarrying methods, it is calculated that the Tigre complex at El Mirador involved at least 5 million man days of labor to construct the basic constructional frame of the platforms of the building (Hansen 1990). The single construction of Danta, with a basal platform of nearly 600 m by 320 m and a height of 72 m has a tentative estimate of 2.8 million cubic meters of fill, providing that there is no natural feature in the interior of the construction.

The exorbitant size of the monumental constructions, requiring not only massive quantities of fill but also increasingly expensive uses of stone and stucco resources, provided a consumption that may have doomed the expanding populations, especially if other, unplanned challenges were to confront the societies such as corn viruses, threats of warfare, or drought. But it was the disablement of the agricultural system that had the greatest impact. This was realized through major erosion of upland surfaces which were deforested to feed a burgeoning lime production industry and allowed natural clay sediments to extend to the bajos, burying the organic histosols under a meter to three meters of sterile clay. Deforestation has been credited for catastrophic consequences elsewhere in the Maya Lowlands (see Abrams and Rue 1988). The deforestation for lime consumption has also been reported for the Highlands of Mexico (Vaillant 1935, 1937, 1938; Millon 1967: 48; O'Hara et al. 1993; Barba 1995). The consistent location of buried histosols in the bajos is indicative of the radical change from a *cival* structure of the low lying areas surrounding the major sites to a *bajo* structure of the area, which had negative agricultural capabilities. During the wet season, the bajos were seasonally inundated. During the dry season, the bajos became cement-like in durability and low productivity because of the clay content (Secaira 1992). Evidence for advanced erosion is consistent for the Preclassic periods in several locations outside of the Mirador Basin. In a landmark study of the sedimentation rates of Lake Salpeten, Anselmetti et al (2007) noted

that the maximum period of erosion and soil lost occurred during the Middle and Late Preclassic periods (Anselmetti et al. 2007:915), periods that he assumed to be associated with "relatively low Maya population densities" (ibid; but see also Rice 1976a, 1976b). Population densities in the Mirador Basin indicate a demographic apogee during the Preclassic periods, and the increased erosion during the Middle and Late Preclassic periods may reflect a higher population in the Salpeten region than previously detected (see Rice 1976a, Rice and Rice 1990; Rice and Culbert 1990). Recent studies by the Mirador Basin Project under the supervision of Kara Nickels (University of California-San Diego) and Thomas Schreiner (University of California, Berkeley) have demonstrated sedimentation in high discharge areas of the bajos adjacent to El Mirador of up to 3 vertical meters over what appears to be the dark, original organic surface (see Figure 11.8, Figure 11.9).

Because of the extensive sedimentation visible in all bajo excavations, the inability to extract the rich agricultural mucks from the surrounding swamps is what may have contributed, at least in part, to a demographic demise of the terminal Late Preclassic populations in the Mirador Basin and furthermore, may have rendered the area undesirable for subsequent re-occupation of the area for hundreds of years.

By the Late Classic period, small groups of Late Classic artisans were residing within the ruins of the Mirador Basin, perhaps contributing to pilgrimage agendas and painting Codex-style pottery depicting complex mythological scenes (Lopez 1992a, 1992b; Lopez and Ortiz 1994; Reents-Budet 1994; Hansen 1996;; Hansen et al. 2008). These architectural groups were restricted primarily to structures no more than 5 m in height and involved limited populations which faced, as do the modern populations of the northern Peten, the bleak prospects of farming clay covered *bajos*. By about A.D. 900, these populations were again obliged to abandon the area, and, according to detailed pollen data (Wahl et al. 2006, 2007a), the area has remained unpopulated until the present day.

EPILOGUE

Today the Mirador Basin remains isolated and uninhabited, although increasing numbers of cattle ranchers, invasive settlers, loggers, and displaced Kekchi and Quiche Maya settlers from the Guatemalan Highlands are rapidly settling and expanding populations in the Peten area. The original forest environment of the western Peten has been devastatingly altered as vast tracts of rainforest in the Laguna de Tigre area are currently being cut by slash-and- burn agriculture and cattle interests, facilitated by logging and oil roads. A high demand for ancient Maya art and artifacts by collectors is continuing to fuel large-scale looting in the isolated sites in the Peten. In the face of rapidly expanding deforestation and looting pressures in the northern Peten, the best models for site and rainforest preservation are archaeological parks because they offer potent, sustainable, economic alternatives to exploitive models that create less revenue and create threatening situations. Archaeology in the Maya Lowlands today must apply rigorous scientific methodologies to the extraction and preservation of data, incorporate a multidisciplinary approach to understanding the cultural and natural systems of ancient societies, develop conservation programs of both cultural and environmental systems, and become actively involved in the contemporary economic and social climate of communities so that they, the communities, also are involved in the conservation stewardship of the regions. By these means, the scholar has the tools to protect and conserve the scientific record for generations of future scholars in a myriad of disciplines.

The ancient Maya wanted to preserve, in a near permanent format of stone, stucco, and ceramic, a record of their historical protagonists, their history, and their ideologies. It was a method of communication to us through time, and archaeological research has been the vehicle of liberating that record. Nevertheless, as the body of multidisciplinary data from the Mirador Basin and other areas in the Maya Lowlands accumulate, perhaps we can hear their voices again, over the din of distant chainsaws, as a cautionary reminder to not repeat the mistakes of the past.

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