The Maya Collapses

Mysteries of lost cities ■ The Maya environment ■ Maya agriculture ■ Maya history ■ Copan * Complexities of collapses ■ Wars and droughts ■ Collapse in the southern lowlands ■ The Maya message ■

By now, millions of modern tourists have visited ruins of the ancient Maya civilization that collapsed over a thousand years ago in Mexico's Yucatan Peninsula and adjacent parts of Central America. All of us love a romantic mystery, and the Maya offer us one at our doorstep, almost as close for Americans as the Anasazi ruins. To visit a former Maya city, we need only board a direct flight from the U.S. to the modern Mexican state capital city of Merida, jump into a rental car or minibus, and drive an hour on a paved highway (map, p. 161).

Today, many Maya ruins, with their great temples and monuments, still lie surrounded by jungle, far from current human settlement (Plate 12). Yet they were once the sites of the New World's most advanced Native American civilization before European arrival, and the only one with extensive deciphered written texts. How could ancient peoples have supported urban societies in areas where few farmers eke out a living today? The Maya cities impress us not only with that mystery and with their beauty, but also because they are "pure" archaeological sites. That is, their locations became depopulated, so they were not covered up by later buildings as were so many other ancient cities, like the Aztec capital of Tenochtitlan (now buried under modern Mexico City) and Rome.

Maya cities remained deserted, hidden by trees, and virtually unknown to the outside world until rediscovered in 1839 by a rich American lawyer named John Stephens, together with the English draftsman Frederick Catherwood. Having heard rumors of ruins in the jungle, Stephens got President Martin Van Buren to appoint him ambassador to the Confederation of Central American Republics, an amorphous political entity then extending from modern Guatemala to Nicaragua, as a front for his archaeological explorations. Stephens and Catherwood ended up exploring 44 sites and cities. From the extraordinary quality of the buildings and the art, they

realized that these were not the work of savages (in their words) but of a vanished high civilization. They recognized that some of the carvings on the stone monuments constituted writing, and they correctly guessed that it related historical events and the names of people. On his return, Stephens wrote two travel books, illustrated by Catherwood and describing the ruins, that became best sellers.

A few quotes from Stephens's writings will give a sense of the romantic appeal of the Maya: "The city was desolate. No remnant of this race hangs round the ruins, with traditions handed down from father to son and from generation to generation. It lay before us like a shattered bark in the midst of the ocean, her mast gone, her name effaced, her crew perished, and none to tell whence she came, to whom she belonged, how long on her journey, or what caused her destruction.... Architecture, sculpture, and painting, all the arts which embellish life, had flourished in this overgrown forest; orators, warriors, and statesmen, beauty, ambition, and glory had lived and passed away, and none knew that such things had been, or could tell of their past existence.... Here were the remains of a cultivated, polished, and peculiar people, who had passed through all the stages incident to the rise and fall of nations; reached their golden age, and perished.... We went up to their desolate temples and fallen altars; and wherever we moved we saw the evidence of their taste, their skill in arts. ... We called back into life the strange people who gazed in sadness from the wall; pictured them, in fanciful costumes and adorned with plumes of feather, ascending the terraces of the palace and the steps leading to the temples.... In the romance of the world's history nothing ever impressed me more forcibly than the spectacle of this once great and lovely city, overturned, desolate, and lost,... overgrown with trees for miles around, and without even a name to distinguish it." Those sensations are what tourists drawn to Maya ruins still feel today, and why we find the Maya collapse so fascinating.

The Maya story has several advantages for all of us interested in prehistoric collapses. First, the Maya written records that have survived, although frustratingly incomplete, are still useful for reconstructing Maya history in much greater detail than we can reconstruct Easter Island, or even Anasazi history with its tree rings and packrat middens. The great art and architecture of Maya cities have resulted in far more archaeologists studying the Maya than would have been the case if they had just been illiterate hunter-gatherers living in archaeologically invisible hovels. Climatologists and paleoecologists have recently been able to recognize several signals of ancient climate and environmental changes that contributed to the Maya collapse.

Finally, today there are still Maya people living in their ancient homeland and speaking Maya languages. Because much ancient Maya culture survived the collapse, early European visitors to the homeland recorded information about contemporary Maya society that played a vital role in our understanding ancient Maya society. The first Maya contact with Europeans came already in 1502, just 10 years after Christopher Columbus's "discovery" of the New World, when Columbus on the last of his four voyages captured a trading canoe that may have been Maya. In 1527 the Spanish began in earnest to conquer the Maya, but it was not until 1697 that they subdued the last principality. Thus, the Spanish had opportunities to observe independent Maya societies for a period of nearly two centuries. Especially important, both for bad and for good, was the bishop Diego de Landa, who resided in the Yucatan Peninsula for most of the years from 1549 to 1578. On the one hand, in one of history's worst acts of cultural vandalism, he burned all Maya manuscripts that he could locate in his effort to eliminate "paganism," so that only four survive today. On the other hand, he wrote a detailed account of Maya society, and he obtained from an informant a garbled explanation of Maya writing that eventually, nearly four centuries later, turned out to offer clues to its decipherment.

A further reason for our devoting a chapter to the Maya is to provide an antidote to our other chapters on past societies, which consist disproportionately of small societies in somewhat fragile and geographically isolated environments, and behind the cutting edge of contemporary technology and culture. The Maya were none of those things. Instead, they were culturally the most advanced society (or among the most advanced ones) in the pre-Columbian New World, the only one with extensive preserved writing, and located within one of the two heartlands of New World civilization (Mesoamerica). While their environment did present some problems associated with its karst terrain and unpredictably fluctuating rainfall, it does not rank as notably fragile by world standards, and it was certainly less fragile than the environments of ancient Easter Island, the Anasazi area, Greenland, or modern Australia. Lest one be misled into thinking that crashes are a risk only for small peripheral societies in fragile areas, the Maya warn us that crashes can also befall the most advanced and creative societies.

From the perspective of our five-point framework for understanding societal collapses, the Maya illustrate four of our points. They did damage their environment, especially by deforestation and erosion. Climate changes (droughts) did contribute to the Maya collapse, probably repeatedly. Hostilities among the Maya themselves did play a large role. Finally, political/

cultural factors, especially the competition among kings and nobles that led to a chronic emphasis on war and erecting monuments rather than on solving underlying problems, also contributed. The remaining item on our five-point list, trade or cessation of trade with external friendly societies, does not appear to have been essential in sustaining the Maya or in causing their downfall. While obsidian (their preferred raw material for making into stone tools), jade, gold, and shells were imported into the Maya area, the latter three items were non-essential luxuries. Obsidian tools remained widely distributed in the Maya area long after the political collapse, so obsidian was evidently never in short supply.

To understand the Maya, let's begin by considering their environment, which we think of as "jungle" or "tropical rainforest." That's not true, and the reason why not proves to be important. Properly speaking, tropical rainforests grow in high-rainfall equatorial areas that remain wet or humid all year round. But the Maya homeland lies more than a thousand miles from the equator, at latitudes 17° to 22° N, in a habitat termed a "seasonal tropical forest." That is, while there does tend to be a rainy season from May to October, there is also a dry season from January through April. If one focuses on the wet months, one calls the Maya homeland a "seasonal tropical forest"; if one focuses on the dry months, one could instead describe it as a "seasonal desert."

From north to south in the Yucatan Peninsula, rainfall increases from 18 to 100 inches per year, and the soils become thicker, so that the southern peninsula was agriculturally more productive and supported denser populations. But rainfall in the Maya homeland is unpredictably variable between years; some recent years have had three or four times more rain than other years. Also, the timing of rainfall within the year is somewhat unpredictable, so it can easily happen that farmers plant their crops in anticipation of rain and then the rains do not come when expected. As a result, modern farmers attempting to grow corn in the ancient Maya homelands have faced frequent crop failures, especially in the north. The ancient Maya were presumably more experienced and did better, but nevertheless they too must have faced risks of crop failures from droughts and hurricanes.

Although southern Maya areas received more rainfall than northern areas, problems of water were paradoxically more severe in the wet south. While that made things hard for ancient Maya living in the south, it has also made things hard for modern archaeologists who have difficulty under-

Gulf of Mexico

• Mérida

CHICHÉN ITZÁ ◆

COBA ◆

Puuc Region

20°

Bay of Campeche

MEXICO

CALAKMUL ◆

18°

PALENQUE ◆

EL MIRADOR ◆

BELIZE

Usumacinta River

Petén Area

TIKAL ◆

Lake Petén Itzá

BONAMPAK ◆

CARACOL ◆

16°

QUIRIGUA ◆

GUATEMALA

◆ COPÁN

HONDURAS

Pacific Ocean

14°

— UNITED STATES

Gulf of Mexico

Atlantic Ocean

Caribbean Sea

CENTRAL AMERICA

Pacific Ocean

| 0 | Miles | 50 | | 100 | | 150 |

| 0 | Kilometers | | 150 | |

92°

90°

88°   © 2004 Jeffrey L. Ward

standing why ancient droughts would have caused bigger problems in the wet south than in the dry north. The likely explanation is that a lens of freshwater underlies the Yucatan Peninsula, but surface elevation increases from north to south, so that as one moves south the land surface lies increasingly higher above the water table. In the northern peninsula the elevation is sufficiently low that the ancient Maya were able to reach the water table at deep sinkholes called cenotes, or at deep caves; all tourists who have visited the Maya city of Chichen Itza will remember the great cenotes there. In low-elevation north coastal areas without sinkholes, the Maya may have been able to get down to the water table by digging wells up to 75 feet deep. Water is readily available in many parts of Belize that have rivers, along the Usumacinta River in the west, and around a few lakes in the Peten area of the south. But much of the south lies too high above the water table for cenotes or wells to reach down to it. Making matters worse, most of the Yucatan Peninsula consists of karst, a porous sponge-like limestone terrain where rain runs straight into the ground and where little or no surface water remains available.

How did those dense southern Maya populations deal with their resulting water problem? It initially surprises us that many of their cities were not built next to the few rivers but instead on promontories in rolling uplands. The explanation is that the Maya excavated depressions, modified natural depressions, and then plugged up leaks in the karst by plastering the bottoms of the depressions in order to create cisterns and reservoirs, which collected rain from large plastered catchment basins and stored it for use in the dry season. For example, reservoirs at the Maya city of Tikal held enough water to meet the drinking water needs of about 10,000 people for a period of 18 months. At the city of Coba the Maya built dikes around a lake in order to raise its level and make their water supply more reliable. But the inhabitants of Tikal and other cities dependent on reservoirs for drinking water would still have been in deep trouble if 18 months passed without rain in a prolonged drought. A shorter drought in which they exhausted their stored food supplies might already have gotten them in deep trouble through starvation, because growing crops required rain rather than reservoirs.

Of particular importance for our purposes are the details of Maya agriculture, which was based on crops domesticated in Mexico—especially corn, with beans being second in importance. For the elite as well as commoners,

corn constituted at least 70% of the Maya diet, as deduced from isotope analyses of ancient Maya skeletons. Their sole domestic animals were the dog, turkey, Muscovy duck, and a stingless bee yielding honey, while their most important wild meat source was deer that they hunted, plus fish at some sites. However, the few animal bones at Maya archaeological sites suggest that the quantity of meat available to the Maya was low. Venison was mainly a luxury food for the elite.

It was formerly believed that Maya farming was based on slash-and-burn agriculture (so-called swidden agriculture) in which forest is cleared and burned, crops are grown in the resulting field for a year or a few years until the soil is exhausted, and then the field is abandoned for a long fallow period of 15 or 20 years until regrowth of wild vegetation restores fertility to the soil. Because most of the landscape under a swidden agricultural system is fallow at any given time, it can support only modest population densities. Thus, it was a surprise for archaeologists to discover that ancient Maya population densities, estimated from numbers of stone foundations of farmhouses, were often far higher than what swidden agriculture could support. The actual values are the subject of much dispute and evidently varied among areas, but frequently cited estimates reach 250 to 750, possibly even 1,500, people per square mile. (For comparison, even today the two most densely populated countries in Africa, Rwanda and Burundi, have population densities of only about 750 and 540 people per square mile, respectively.) Hence the ancient Maya must have had some means of increasing agricultural production beyond what was possible through swidden alone.

Many Maya areas do show remains of agricultural structures designed to increase production, such as terracing of hill slopes to retain soil and moisture, irrigation systems, and arrays of canals and drained or raised fields. The latter systems, which are well attested elsewhere in the world and which require a lot of labor to construct, but which reward the labor with increased food production, involve digging canals to drain a waterlogged area, fertilizing and raising the level of the fields between the canals by dumping muck and water hyacinths dredged out of canals onto the fields, and thereby keeping the fields themselves from being inundated. Besides harvesting crops grown over the fields, farmers with raised fields also "grow" wild fish and turtles in the canals (actually, let them grow themselves) as an additional food source. However, other Maya areas, such as the well-studied cities of Copan and Tikal, show little archaeological evidence of terracing, irrigation, or raised- or drained-field systems. Instead, their inhabitants

must have used archaeologically invisible means to increase food production, by mulching, floodwater farming, shortening the time that a field is left fallow, and tilling the soil to restore soil fertility, or in the extreme omitting the fallow period entirely and growing crops every year, or in especially moist areas growing two crops per year.

Socially stratified societies, including modern American and European society, consist of farmers who produce food, plus non-farmers such as bureaucrats and soldiers who do not produce food but merely consume the food grown by the farmers and are in effect parasites on farmers. Hence in any stratified society the farmers must grow enough surplus food to meet not only their own needs but also those of the other consumers. The number of non-producing consumers that can be supported depends on the society's agricultural productivity. In the United States today, with its highly efficient agriculture, farmers make up only 2% of our population, and each farmer can feed on the average 125 other people (American non-farmers plus people in export markets overseas). Ancient Egyptian agriculture, although much less efficient than modern mechanized agriculture, was still efficient enough for an Egyptian peasant to produce five times the food required for himself and his family. But a Maya peasant could produce only twice the needs of himself and his family. At least 70% of Maya society consisted of peasants. That's because Maya agriculture suffered from several limitations.

First, it yielded little protein. Corn, by far the dominant crop, has a lower protein content than the Old World staples of wheat and barley. The few edible domestic animals already mentioned included no large ones and yielded much less meat than did Old World cows, sheep, pigs, and goats. The Maya depended on a narrower range of crops than did Andean farmers (who in addition to corn also had potatoes, high-protein quinoa, and many other plants, plus llamas for meat), and much narrower again than the variety of crops in China and in western Eurasia.

Another limitation was that Maya corn agriculture was less intensive and productive than the Aztecs' *chinampas* (a very productive type of raised-field agriculture), the raised fields of the Tiwanaku civilization of the Andes, Moche irrigation on the coast of Peru, or fields tilled by animal-drawn plows over much of Eurasia.

Still a further limitation arose from the humid climate of the Maya area, which made it difficult to store corn beyond a year, whereas the Anasazi living in the dry climate of the U.S. Southwest could store it for three years.

Finally, unlike Andean Indians with their llamas, and unlike Old World

peoples with their horses, oxen, donkeys, and camels, the Maya had no animal-powered transport or plows. All overland transport for the Maya went on the backs of human porters. But if you send out a porter carrying a load of corn to accompany an army into the field, some of that load of corn is required to feed the porter himself on the trip out, and some more to feed him on the trip back, leaving only a fraction of the load available to feed the army. The longer the trip, the less of the load is left over from the porter's own requirements. Beyond a march of a few days to a week, it becomes uneconomical to send porters carrying corn to provision armies or markets. Thus, the modest productivity of Maya agriculture, and their lack of draft animals, severely limited the duration and distance possible for their military campaigns.

We are accustomed to thinking of military success as determined by quality of weaponry, rather than by food supply. But a clear example of how improvements in food supply may decisively increase military success comes from the history of Maori New Zealand. The Maori are the Polynesian people who were the first to settle New Zealand. Traditionally, they fought frequent fierce wars against each other, but only against closely neighboring tribes. Those wars were limited by the modest productivity of their agriculture, whose staple crop was sweet potatoes. It was not possible to grow enough sweet potatoes to feed an army in the field for a long time or on distant marches. When Europeans arrived in New Zealand, they brought potatoes, which beginning around 1815 considerably increased Maori crop yields. Maori could now grow enough food to supply armies in the field for many weeks. The result was a 15-year period in Maori history, from 1818 until 1833, when Maori tribes that had acquired potatoes and guns from the English sent armies out on raids to attack tribes hundreds of miles away that had not yet acquired potatoes and guns. Thus, the potato's productivity relieved previous limitations on Maori warfare, similar to the limitations that low-productivity corn agriculture imposed on Maya warfare.

Those food supply considerations may contribute to explaining why Maya society remained politically divided among small kingdoms that were perpetually at war with each other, and that never became unified into large empires like the Aztec Empire of the Valley of Mexico (fed with the help of their *chinampa* agriculture and other forms of intensification) or the Inca Empire of the Andes (fed by more diverse crops carried by llamas over well-built roads). Maya armies and bureaucracies remained small and unable to mount lengthy campaigns over long distances. (Even much later, in 1848,

when the Maya revolted against their Mexican overlords and a Maya army seemed to be on the verge of victory, the army had to break off fighting and go home to harvest another crop of corn.) Many Maya kingdoms held populations of only up to 25,000 to 50,000 people, none over half a million, within a radius of two or three days' walk from the king's palace. (The actual numbers are again highly controversial among archaeologists.) From the tops of the temples of some Maya kingdoms, it was possible to see the temples of the nearest kingdom. Maya cities remained small (mostly less than one square mile in area), without the large populations and big markets of Teotihuacan and Tenochtitlan in the Valley of Mexico, or of Chan-Chan and Cuzco in Peru, and without archaeological evidence of the royally managed food storage and trade that characterized ancient Greece and Mesopotamia.

Now for a quick crash-course in Maya history. The Maya area is part of the larger ancient Native American cultural region known as Mesoamerica, which extended approximately from Central Mexico to Honduras and constituted (along with the Andes of South America) one of the two New World centers of innovation before European arrival. The Maya shared much in common with other Mesoamerican societies not only in what they possessed, but also in what they lacked. For example, surprisingly to modern Westerners with expectations based on Old World civilizations, Mesoamerican societies lacked metal tools, pulleys and other machines, wheels (except locally as toys), boats with sails, and domestic animals large enough to carry loads or pull a plow. All of those great Maya temples were constructed by stone and wooden tools and by human muscle power alone.

Of the ingredients of Maya civilization, many were acquired by the Maya from elsewhere in Mesoamerica. For instance, Mesoamerican agriculture, cities, and writing first arose outside the Maya area itself, in valleys and coastal lowlands to the west and southwest, where corn and beans and squash were domesticated and became important dietary components by 3000 B.C., pottery arose around 2500 B.C., villages by 1500 B.C., cities among the Olmecs by 1200 B.C., writing appeared among the Zapotecs in Oaxaca around or after 600 B.C., and the first states arose around 300 B.C. Two complementary calendars, a solar calendar of 365 days and a ritual calendar of 260 days, also arose outside the Maya area. Other elements of Maya civilization were either invented, perfected, or modified by the Maya themselves.

Within the Maya area, villages and pottery appeared around or after 1000 B.C., substantial buildings around 500 B.C., and writing around

400 B.C. All preserved ancient Maya writing, constituting a total of about 15,000 inscriptions, is on stone and pottery and deals only with kings, nobles, and their conquests (Plate 13). There is not a single mention of commoners. When Spaniards arrived, the Maya were still using bark paper coated with plaster to write books, of which the sole four that escaped Bishop Landa's fires turned out to be treatises on astronomy and the calendar. The ancient Maya also had had such bark-paper books, often depicted on their pottery, but only decayed remains of them have survived in tombs.

The famous Maya Long Count calendar begins on August 11,3114 B.C.— just as our own calendar begins on January 1 of the first year of the Christian era. We know the significance to us of that day-zero of our calendar: it's the supposed beginning of the year in which Christ was born. Presumably the Maya also attached some significance to their own day zero, but we don't know what it was. The first preserved Long Count date is only A.D. 197 for a monument in the Maya area and 36 B.C. outside the Maya area, indicating that the Long Count calendar's day-zero was backdated to August 11, 3114 B.C. long after the facts; there was no writing anywhere in the New World then, nor would there be for 2,500 years after that date.

Our calendar is divided into units of days, weeks, months, years, decades, centuries, and millennia: for example, the date of February 19, 2003, on which I wrote the first draft of this paragraph, means the 19th day of the second month in the third year of the first decade of the first century of the third millennium beginning with the birth of Christ. Similarly, the Maya Long Count calendar named dates in units of days *(kin)*, 20 days *(uinal)*, 360 days *(tun)*, 7,200 days or approximately 20 years *(katunn)*, and 144,000 days or approximately 400 years *(baktun)*. All of Maya history falls into baktuns 8,9, and 10.

The so-called Classic period of Maya civilization begins in baktun 8, around A.D. 250, when evidence for the first kings and dynasties appears. Among the glyphs (written signs) on Maya monuments, students of Maya writing recognized a few dozen, each of which was concentrated in its own geographic area, and which are now considered to have had the approximate meaning of dynasties or kingdoms. In addition to Maya kings having their own name glyphs and palaces, many nobles also had their own inscriptions and palaces. In Maya society the king also functioned as high priest carrying the responsibility to attend to astronomical and calendrical rituals, and thereby to bring rain and prosperity, which the king claimed to have the supernatural power to deliver because of his asserted family relationship to the gods. That is, there was a tacitly understood quid pro quo:

the reason why the peasants supported the luxurious lifestyle of the king and his court, fed him corn and venison, and built his palaces was because he had made implicit big promises to the peasants. As we shall see, kings got into trouble with their peasants if a drought came, because that was tantamount to the breaking of a royal promise.

From A.D. 250 onwards, the Maya population (as judged from the number of archaeologically attested house sites), the number of monuments and buildings, and the number of Long Count dates on monuments and pottery increased almost exponentially, to reach peak numbers in the 8th century A.D. The largest monuments were erected towards the end of that Classic period. Numbers of all three of those indicators of a complex society declined throughout the 9th century, until the last known Long Count date on any monument fell in baktun 10, in the year A.D. 909. That decline of Maya population, architecture, and the Long Count calendar constitutes what is known as the Classic Maya collapse.

As an example of the collapse, let's consider in more detail a small but densely built city whose ruins now lie in western Honduras at a site known as Copan, and described in two recent books by archaeologist David Webster. For agricultural purposes the best land in the Copan area consists of five pockets of flat land with fertile alluvial soil along a river valley, with a tiny total area of only 10 square miles; the largest of those five pockets, known as the Copan pocket, has an area of only 5 square miles. Much of the land around Copan consists of steep hills, and nearly half of the hill area has a slope above 16% (approximately double the slope of the steepest grade that you are likely to encounter on an American highway). Soil in the hills is less fertile, more acidic, and poorer in phosphate than valley soil. Today, corn yields from valley-bottom fields are two or three times those of fields on hill slopes, which suffer rapid erosion and lose three-quarters of their productivity within a decade of farming.

As judged by numbers of house sites, population growth in the Copan Valley rose steeply from the 5th century up to a peak estimated at around 27,000 people at A.D. 750-900. Maya written history at Copan begins in the year with a Long Count date corresponding to A.D. 426, when later monuments record retrospectively that some person related to nobles at Tikal and Teotihuacan arrived. Construction of royal monuments glorifying kings was especially massive between A.D. 650 and 750. After A.D. 700, nobles other than kings also got into the act and began erecting their own palaces,

of which there were about twenty by the year A.D. 800, when one of those palaces is known to have consisted of 50 buildings with room for about 250 people. All of those nobles and their courts would have increased the burden that the king and his own court imposed on the peasants. The last big buildings at Copan were put up around A.D. 800, and the last Long Count date on an incomplete altar possibly bearing a king's name has the date of A.D. 822.

Archaeological surveys of different types of habitats in the Copan Valley show that they were occupied in a regular sequence. The first area farmed was the large Copan pocket of valley bottomland, followed by occupation of the other four bottomland pockets. During that time the human population was growing, but there was not yet occupation of the hills. Hence that increased population must have been accommodated by intensifying production in the bottomland pockets by some combination of shorter fallow periods, double-cropping, and possibly some irrigation.

By the year A.D. 650, people started to occupy the hill slopes, but those hill sites were cultivated only for about a century. The percentage of Copan's total population that was in the hills, rather than in the valleys, reached a maximum of 41%, then declined until the population again became concentrated in the valley pockets. What caused that pullback of population from the hills? Excavation of the foundations of buildings in the valley floor showed that they became covered with sediment during the 8th century, meaning that the hill slopes were getting eroded and probably also leached of nutrients. Those acidic infertile hill soils were being carried down into the valley and blanketing the more fertile valley soils, where they would have reduced agricultural yields. This ancient quick abandonment of hillsides coincides with modern Maya experience that fields in the hills have low fertility and that their soils become rapidly exhausted.

The reason for that erosion of the hillsides is clear: the forests that formerly covered them and protected their soils were being cut down. Dated pollen samples show that the pine forests originally covering the upper elevations of the hill slopes were eventually all cleared. Calculation suggests that most of those felled pine trees were being burned for fuel, while the rest were used for construction or for making plaster. At other Maya sites from the pre-Classic era, where the Maya went overboard in lavish use of thick plaster on buildings, plaster production may have been a major cause of deforestation. Besides causing sediment accumulation in the valleys and depriving valley inhabitants of wood supplies, that deforestation may have begun to cause a "man-made drought" in the valley bottom, because forests

play a major role in water cycling, such that massive deforestation tends to result in lowered rainfall.

Hundreds of skeletons recovered from Copan archaeological sites have been studied for signs of disease and malnutrition, such as porous bones and stress lines in the teeth. These skeletal signs show that the health of Copan's inhabitants deteriorated from A.D. 650 to 850, both among the elite and among the commoners, although the health of commoners was worse.

Recall that Copan's population was increasing steeply while the hills were being occupied. The subsequent abandonment of all of those fields in the hills meant that the burden of feeding the extra population formerly dependent on the hills now fell increasingly on the valley floor, and that more and more people were competing for the food grown on those 10 square miles of valley bottomland. That would have led to fighting among the farmers themselves for the best land, or for any land, just as in modern Rwanda (Chapter 10). Because Copan's king was failing to deliver on his promises of rain and prosperity in return for the power and luxuries that he claimed, he would have been the scapegoat for this agricultural failure. That may explain why the last that we hear from any Copan king is A.D. 822 (that last Long Count date at Copan), and why the royal palace was burned around A.D. 850. However, the continued production of some luxury goods suggest that some nobles managed to carry on with their lifestyle after the king's downfall, until around A.D. 975.

To judge from datable pieces of obsidian, Copan's total population decreased more gradually than did its signs of kings and nobles. The estimated population in the year A.D. 950 was still around 15,000, or 54% of the peak population of 27,000. That population continued to dwindle, until there are no more signs of anyone in the Copan Valley by around A.D. 1250. The reappearance of pollen from forest trees thereafter provides independent evidence that the valley became virtually empty of people, and that the forests could at last begin to recover.

The general outline of Maya history that I have just related, and the example of Copan's history in particular, illustrates why we talk about "the Maya collapse." But the story grows more complicated, for at least five reasons.

First, there was not only that enormous Classic collapse, but at least two previous smaller collapses at some sites, one around the year A.D. 150 when El Mirador and some other Maya cities collapsed (the so-called pre-Classic

collapse), the other (the so-called Maya hiatus) in the late 6th century and early 7th century, a period when no monuments were erected at the well-studied site of Tikal. There were also some post-Classic collapses in areas whose populations survived the Classic collapse or increased after it—such as the fall of Chichen Itza around 1250 and of Mayapan around 1450.

Second, the Classic collapse was obviously not complete, because there were hundreds of thousands of Maya who met and fought the Spaniards—far fewer Maya than during the Classic peak, but still far more people than in the other ancient societies discussed in detail in this book. Those survivors were concentrated in areas with stable water supplies, especially in the north with its cenotes, the coastal lowlands with their wells, near a southern lake, and along rivers and lagoons at lower elevations. However, population otherwise disappeared almost completely in what previously had been the Maya heartland in the south.

Third, the collapse of population (as gauged by numbers of house sites and of obsidian tools) was in some cases much slower than the decline in numbers of Long Count dates, as I already mentioned for Copan. What collapsed quickly during the Classic collapse was the institution of kingship and the Long Count calendar.

Fourth, many apparent collapses of cities were really nothing more than "power cycling": i.e., particular cities becoming more powerful, then declining or getting conquered, and then rising again and conquering their neighbors, without changes in the whole population. For example, in the year 562 Tikal was defeated by its rivals Caracol and Calakmul, and its king was captured and killed. However, Tikal then gradually gained strength again and finally conquered its rivals in 695, long before Tikal joined many other Maya cities in the Classic collapse (last dated Tikal monuments A.D. 869). Similarly, Copan grew in power until the year 738, when its king Waxak-lahuun Ub'aah K'awil (a name better known to Maya enthusiasts today by its unforgettable translation of "18 Rabbit") was captured and put to death by the rival city of Quirigua, but then Copan thrived during the following half-century under more fortunate kings.

Finally, cities in different parts of the Maya area rose and fell on different trajectories. For example, the Puuc region in the northwest Yucatan Peninsula, after being almost empty of people in the year 700, exploded in population after 750 while the southern cities were collapsing, peaked in population between 900 and 925, and then collapsed in turn between 950 and 1000. El Mirador, a huge site in the center of the Maya area with one of the world's

largest pyramids, was settled in 200 B.C. and abandoned around A.D. 150, long before the rise of Copan. Chichen Itza in the northern peninsula grew after A.D. 850 and was the main northern center around 1000, only to be destroyed in a civil war around 1250.

Some archaeologists focus on these five types of complications and don't want to recognize a Classic Maya collapse at all. But this overlooks the obvious facts that cry out for explanation: the disappearance of between 90 and 99% of the Maya population after A.D. 800, especially in the formerly most densely populated area of the southern lowlands, and the disappearance of kings, Long Count calendars, and other complex political and cultural institutions. That's why we talk about a Classic Maya collapse, a collapse both of population and of culture that needs explaining.

Two other phenomena that I have mentioned briefly as contributing to Maya collapses require more discussion: the roles of warfare and of drought.

Archaeologists for a long time believed the ancient Maya to be gentle and peaceful people. We now know that Maya warfare was intense, chronic, and unresolvable, because limitations of food supply and transportation made it impossible for any Maya principality to unite the whole region in an empire, in the way that the Aztecs and Incas united Central Mexico and the Andes, respectively. The archaeological record shows that wars became more intense and frequent towards the time of the Classic collapse. That evidence comes from discoveries of several types over the last 55 years: archaeological excavations of massive fortifications surrounding many Maya sites; vivid depictions of warfare and captives on stone monuments, vases (Plate 14), and on the famous painted murals discovered in 1946 at Bonampak; and the decipherment of Maya writing, much of which proved to consist of royal inscriptions boasting of conquests. Maya kings fought to take one another captive, one of the unfortunate losers being Copan's King 18 Rabbit. Captives were tortured in unpleasant ways depicted clearly on the monuments and murals (such as yanking fingers out of sockets, pulling out teeth, cutting off the lower jaw, trimming off the lips and fingertips, pulling out the fingernails, and driving a pin through the lips), culminating (sometimes several years later) in the sacrifice of the captive in other equally unpleasant ways (such as tying the captive up into a ball by binding the arms and legs together, then rolling the balled-up captive down the steep stone staircase of a temple).

Maya warfare involved several well-documented types of violence: wars

between separate kingdoms; attempts of cities within a kingdom to secede by revolting against the capital; and civil wars resulting from frequent violent attempts by would-be kings to usurp the throne. All of these types were described or depicted on monuments, because they involved kings and nobles. Not considered worthy of description, but probably even more frequent, were fights between commoners over land, as overpopulation became excessive and as land became scarce.

The other phenomenon important to understanding Maya collapses is the repeated occurrence of droughts, studied especially by Mark Brenner, David Hodell, the late Edward Deevey, and their colleagues at the University of Florida, and discussed in a recent book by Richardson Gill. Cores bored into layers of sediments at the bottoms of Maya lakes yield many measurements that let us infer droughts and environmental changes. For example, gypsum (a.k.a. calcium sulfate) precipitates out of solution in a lake into sediments when lake water becomes concentrated by evaporation during a drought. Water containing the heavy form of oxygen known as the isotope oxygen-18 also becomes concentrated during droughts, while water containing the lighter isotope oxygen-16 evaporates away. Molluscs and Crustacea living in the lake take up oxygen to lay down in their shells, which remain preserved in the lake sediments, waiting for climatologists to analyze for those oxygen isotopes long after the little animals have died. Radiocarbon dating of a sediment layer identifies the approximate year when the drought or rainfall conditions inferred from those gypsum and oxygen isotope measurements were prevailing. The same lake sediment cores provide palynologists with information about deforestation (which shows up as a decrease in pollen from forest trees at the expense of an increase in grass pollen), and also soil erosion (which shows up as a thick clay deposit and minerals from the washed-down soil).

Based on these studies of radiocarbon-dated layers from lake sediment cores, climatologists and paleoecologists conclude that the Maya area was relatively wet from about 5500 B.C. until 500 B.C. The following period from 475 to 250 B.C., just before the rise of pre-Classic Maya civilization, was dry. The pre-Classic rise may have been facilitated by the return of wetter conditions after 250 B.C., but then a drought from A.D. 125 until A.D. 250 was associated with the pre-Classic collapse at El Mirador and other sites. That collapse was followed by the resumption of wetter conditions and of the buildup of Classic Maya cities, temporarily interrupted by a drought around A.D. 600 corresponding to a decline at Tikal and some other sites. Finally, around A.D. 760 there began the worst drought in the last 7,000

years, peaking around the year A.D. 800, and suspiciously associated with the Classic collapse.

Careful analysis of the frequency of droughts in the Maya area shows a tendency for them to recur at intervals of about 208 years. Those drought cycles may result from small variations in the sun's radiation, possibly made more severe in the Maya area as a result of the rainfall gradient in the Yucatan (drier in the north, wetter in the south) shifting southwards. One might expect those changes in the sun's radiation to affect not just the Maya region but, to varying degrees, the whole world. In fact, climatologists have noted that some other famous collapses of prehistoric civilizations far from the Maya realm appear to coincide with the peaks of those drought cycles, such as the collapse of the world's first empire (the Akkadian Empire of Mesopotamia) around 2170 B.C., the collapse of Moche IV civilization on the Peruvian coast around A.D. 600, and the collapse of Tiwanaku civilization in the Andes around A.D. 1100.

In the most naive form of the hypothesis that drought contributed to causing the Classic collapse, one could imagine a single drought around A.D. 800 uniformly affecting the whole realm and triggering the fall of all Maya centers simultaneously. Actually, as we have seen, the Classic collapse hit different centers at slightly different times in the period A.D. 760-910, while sparing other centers. That fact makes many Maya specialists skeptical of a role of drought.

But a properly cautious climatologist would not state the drought hypothesis in that implausibly oversimplied form. Finer-resolution variation in rainfall from one year to the next can be calculated from annually banded sediments that rivers wash into ocean basins near the coast. These yield the conclusion that "The Drought" around A.D. 800 actually had four peaks, the first of them less severe: two dry years around A.D. 760, then an even drier decade around A.D. 810-820, three drier years around A.D. 860, and six drier years around A.D. 910. Interestingly, Richardson Gill concluded, from the latest dates on stone monuments at various large Maya centers, that collapse dates vary among sites and fall into three clusters: around A.D. 810, 860, and 910, in agreement with the dates for the three most severe droughts. It would not be at all surprising if a drought in any given year varied locally in its severity, hence if a series of droughts caused different Maya centers to collapse in different years, while sparing centers with reliable water supplies such as cenotes, wells, and lakes.

The area most affected by the Classic collapse was the southern lowlands, probably for the two reasons already mentioned: it was the area with the densest population, and it may also have had the most severe water problems because it lay too high above the water table for water to be obtained from cenotes or wells when the rains failed. The southern lowlands lost more than 99% of their population in the course of the Classic collapse. For example, the population of the Central Peten at the peak of the Classic Maya period is variously estimated at between 3,000,000 and 14,000,000 people, but there were only about 30,000 people there at the time that the Spanish arrived. When Cortes and his Spanish army passed through the Central Peten in 1524 and 1525, they nearly starved because they encountered so few villages from which to acquire corn. Cortes passed within a few miles of the ruins of the great Classic cities of Tikal and Palenque, but he heard or saw nothing of them because they were covered by jungle and almost nobody was living in the vicinity.

How did such a huge population of millions of people disappear? We asked ourselves that same question about the disappearance of Chaco Canyon's (admittedly smaller) Anasazi population in Chapter 4. By analogy with the cases of the Anasazi and of subsequent Pueblo Indian societies during droughts in the U.S. Southwest, we infer that some people from the southern Maya lowlands survived by fleeing to areas of the northern Yucatan endowed with cenotes or wells, where a rapid population increase took place around the time of the Maya collapse. But there is no sign of all those millions of southern lowland inhabitants surviving to be accommodated as immigrants in the north, just as there is no sign of thousands of Anasazi refugees being received as immigrants into surviving pueblos. As in the U.S. Southwest during droughts, some of that Maya population decrease surely involved people dying of starvation or thirst, or killing each other in struggles over increasingly scarce resources. The other part of the decrease may reflect a slower decrease in the birthrate or child survival rate over the course of many decades. That is, depopulation probably involved both a higher death rate and a lower birth rate.

In the Maya area as elsewhere, the past is a lesson for the present. From the time of Spanish arrival, the Central Peten's population declined further to about 3,000 in A.D. 1714, as a result of deaths from diseases and other causes associated with Spanish occupation. By the 1960s, the Central Peten's population had risen back only to 25,000, still less than 1% of what it had been at the Classic Maya peak. Thereafter, however, immigrants flooded

into the Central Peten, building up its population to about 300,000 in the 1980s, and ushering in a new era of deforestation and erosion. Today, half of the Peten is once again deforested and ecologically degraded. One-quarter of all the forests of Honduras were destroyed between 1964 and 1989.

To summarize the Classic Maya collapse, we can tentatively identify five strands. I acknowledge, however, that Maya archaeologists still disagree vigorously among themselves—in part, because the different strands evidently varied in importance among different parts of the Maya realm; because detailed archaeological studies are available for only some Maya sites; and because it remains puzzling why most of the Maya heartland remained nearly empty of population and failed to recover after the collapse and after regrowth of forests.

With those caveats, it appears to me that one strand consisted of population growth outstripping available resources: a dilemma similar to the one foreseen by Thomas Malthus in 1798 and being played out today in Rwanda (Chapter 10), Haiti (Chapter 11), and elsewhere. As the archaeologist David Webster succinctly puts it, "Too many farmers grew too many crops on too much of the landscape." Compounding that mismatch between population and resources was the second strand: the effects of deforestation and hillside erosion, which caused a decrease in the amount of useable farmland at a time when more rather than less farmland was needed, and possibly exacerbated by an anthropogenic drought resulting from deforestation, by soil nutrient depletion and other soil problems, and by the struggle to prevent bracken ferns from overrunning the fields.

The third strand consisted of increased fighting, as more and more people fought over fewer resources. Maya warfare, already endemic, peaked just before the collapse. That is not surprising when one reflects that at least 5,000,000 people, perhaps many more, were crammed into an area smaller than the state of Colorado (104,000 square miles). That warfare would have decreased further the amount of land available for agriculture, by creating no-man's lands between principalities where it was now unsafe to farm. Bringing matters to a head was the strand of climate change. The drought at the time of the Classic collapse was not the first drought that the Maya had lived through, but it was the most severe. At the time of previous droughts, there were still uninhabited parts of the Maya landscape, and people at a site affected by drought could save themselves by moving to another site. However, by the time of the Classic collapse the landscape was now full, there

was no useful unoccupied land in the vicinity on which to begin anew, and the whole population could not be accommodated in the few areas that continued to have reliable water supplies.

As our fifth strand, we have to wonder why the kings and nobles failed to recognize and solve these seemingly obvious problems undermining their society. Their attention was evidently focused on their short-term concerns of enriching themselves, waging wars, erecting monuments, competing with each other, and extracting enough food from the peasants to support all those activities. Like most leaders throughout human history, the Maya kings and nobles did not heed long-term problems, insofar as they perceived them. We shall return to this theme in Chapter 14.

Finally, while we still have some other past societies to consider in this book before we switch our attention to the modern world, we must already be struck by some parallels between the Maya and the past societies discussed in Chapters 2-4. As on Easter Island, Mangareva, and among the Anasazi, Maya environmental and population problems led to increasing warfare and civil strife. As on Easter Island and at Chaco Canyon, Maya peak population numbers were followed swiftly by political and social collapse. Paralleling the eventual extension of agriculture from Easter Island's coastal lowlands to its uplands, and from the Mimbres floodplain to the hills, Copan's inhabitants also expanded from the floodplain to the more fragile hill slopes, leaving them with a larger population to feed when the agricultural boom in the hills went bust. Like Easter Island chiefs erecting ever larger statues, eventually crowned by pukao, and like Anasazi elite treating themselves to necklaces of 2,000 turquoise beads, Maya kings sought to outdo each other with more and more impressive temples, covered with thicker and thicker plaster—reminiscent in turn of the extravagant conspicuous consumption by modern American CEOs. The passivity of Easter chiefs and Maya kings in the face of the real big threats to their societies completes our list of disquieting parallels.