Scale and Intensity in Classic Period Maya Agriculture: Terracing and Settlement at the "Garden City" of Caracol, Belize

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Substantial effort has been expended in search of the relationships between subsistence and settlement for the Classic Period (A.D. 250–900) Maya civilization. While this has resulted in the exploration and critique of a variety of different systems, the exact nature and variety of subsistence bases used remains incompletely defined. This paper seeks to document a specific Maya subsistence system—intensive agricultural terraces interwoven with a densely settled terrain—and to show how subsistence and settlement functioned together within the "garden city" of Caracol, Belize. The combination of a dense settlement embedded in a complex matrix of agricultural terraces formed a successful partnership at this site for at least four centuries. The on-the-ground visibility of the farming systems seen at Caracol may also have application relative to questions of sustainability at other Maya sites where the agricultural systems are largely invisible.

Considerations of Maya subsistence and settlement to some degree have been conditioned by historical and conceptual factors. For much of the twentieth century, "milpa," "swidden," "slash-burn," or "extensive" agricultural systems were thought to characterize Maya settlements (Harrison and Turner 1978; Morley 1946:141; Reina 1967; Steggerda 1941). Such an agricultural system meant that potential carrying capacity was limited, and it implied that Maya settlement was of fairly low density, helping foster notions of vacant ceremonial centers and a dichotomous society populated by priests and peasants (Thompson 1954; Vogt 1964; see Becker 1979 for historical perspective). This swidden or milpa perspective for Classic Maya agriculture implied relatively small population levels and allowed for a relatively uncentralized societal structure.

Settlement work in the 1950s and 1960s, specifically at Tikal, Guatemala, and in the Belize Valley, helped to change the swidden paradigm for Maya agriculture (Haviland 1970; Puleston 1983; Willey et al. 1965). The actual projected population densities for Tikal, based on mapped structures recorded in a large "block-mapped" area, were far greater than could be accommodated by a strictly swidden system (Coe and Haviland 1982; Culbert et al. 1990; Haviland 1970; Puleston 1983). Researchers began to investigate alternative subsistence strategies for the Maya, looking at root crops (Bronson 1966), ramon (Puleston 1968), aboriculture (Puleston 1978), kitchen gardens (Chase and Chase 1983; Puleston 1978) and intensive hydraulic systems that were both bajo-based (Harrison 1977, 1978) and riverine-based (Puleston 1977; Siemens and Puleston 1972). Terraces, first noted in the Maya literature of the 1920s and 1930s (Lundell 1940; Ower 1927; Thompson 1931), were also rejuvenated as a potentially intensive agricultural form (Donkin 1979; Turner 1974).

By the late 1970s most Maya researchers had rejected a solely swidden-based Classic-era Maya subsistence base (Hammond 1978; Harrison and Turner 1978). The continuing search for alternative subsistence strategies led to more detailed research on potential wetland systems (Flannery 1982; Pohl 1990; Turner and Harrison 1983), on terrace systems that were both large-scale (Chase and Chase 1987:53, 1990, 1994: 6–7; Healy et al. 1980, 1983; Laporte 1994:5; Lobato 1988:32; Turner 1978, 1979, 1983) and small-scale (Dunning and Beach 1994; Fedick 1994; Neff and Gifford n.d.), on hydrology (Healy 1983; Matheny 1982; Scarborough et al. 1995), and on intra-site agriculture or "gardens" (Killion et al. 1989). Most researchers now acknowledge that the Maya must have utilized multiple subsistence strategies to support their Late Classic population levels (cf. Fedick 1996). The extent of wet-land intensive agricultural systems was originally projected to be widespread, based upon aerial and satellite imaging (Adams 1980; Adams et al. 1981). Suggestions were made that settlements may have been intentionally located near bajos to exploit their agricultural potential (Adams 1980). Terracing was projected to cover some 10,000 km^2 in southern Mexico and at least 400 km^2 in the Vaca Plateau of Belize (Donkin 1979:82; Turner 1978:168–169).

However, intensive Maya agricultural systems have not been without critique. Mexicanists, such as Sanders (1979), were highly critical of the significance of the Rio Bec terrace systems reported by Turner (1978). More recently, the extent, importance, and dating of the Maya wetland systems for the Classic Period has been called into question (Pohl 1990; Pohl et al. 1996; Pope and Dahlin 1989; but see also Culbert 1997 and Harrison 1993).

Considerations of Maya subsistence and settlement have also been constrained by terminological distinctions made between "in-field" and "out-field" agricultural systems (cf. Sanders 1979:495, 1981; Vogt 1969). The use of these terms generally has been taken to mean that gardens ("intensive agriculture") were nurtured near residences while extensive swidden agriculture was practiced at some distance from any given settlement. Although these practices may have been in place in the Maya lowlands at certain times and places, they are likely not valid in densely populated landscapes, such as were present during the Late Classic era (Puleston 1982: 363–364). Killion (1992:6–8), following earlier suggestions made by Drennan (1988), has argued that, as population levels increased, in-field and out-field distinctions disappeared as subsistence pressures led to ever-increasing capital investments in agricultural systems. The investigations at Caracol demonstrate the coexistence of large-scale terracing, representing substantial planning and labor investment, with large-scale settlement, representing a carefully distributed urban population. Significantly, these in-field agricultural systems cover both urban Caracol and the surrounding Vaca Plateau and eastern foothills of the Maya Mountains.

Settlement and Agricultural Systems at Caracol

Although initial reconnaissance trips were made into Caracol in 1983 and 1984, the first full field season of the Caracol Archaeological Project was conducted in 1985 and fieldwork has continued since then on an annual basis.[1] During nearly a decade and a half of fieldwork, one of the underlying goals of the project has been the exploration of the relationship between settlement and agriculture (Figure 1). Critical to this enterprise have been both survey and excavation.

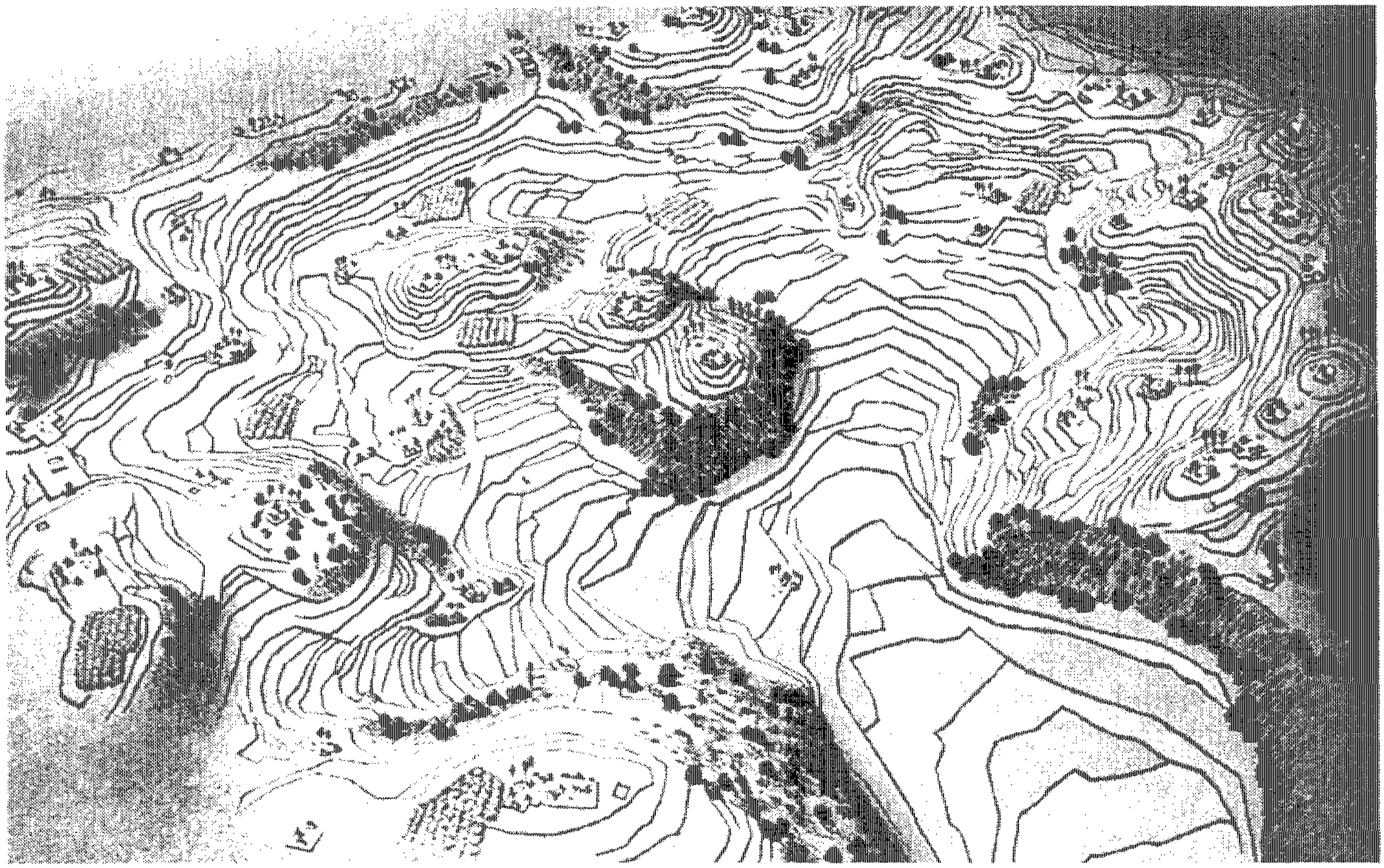
Techniques that were ultimately adopted for settlement (and terrace) survey differ from the ones initially used at the site, which employed causeways for base lines (Chase 1988). While causeways are still mapped and staked with transit points (so they can be used in triangulation), base lines running north-south and east-west are also established through the use of a transit; these cardinally oriented base lines have staked transit points every 50 meters. Brechas, or smaller lines-of-sight, are cut perpendicular to the base lines at the 50m intervals. Then, the areas on and in between these brechas are swept for evidence of settlement. The residential groups are transit mapped and permanent stakes are placed within each plazuela group (again for use in triangulation). Finally, if time permits, terraces are followed and mapped with compass and tape with all of these features being triangulated into known transit points on base-lines, on causeways, or in residential groups.

Excavations at Caracol have also provided substantial information that augments the data derived from the survey of the site's settlement and agricultural systems. Various research designs over the 15 years of the project have sampled groups in terms of proximity to causeways and in terms of proximity to fields. Excavations have also examined vacant terrain (sometimes finding buried groups), causeway and terrace junctions, and residential group and terraced-field junctions. Furthermore, terraces have been individually excavated to understand their construction and to obtain cultural debris from within them that can be used to aid in dating.

These investigations indicate that Caracol was an immense metropolis, a true "garden city" (Chase and Chase 1987: 53; Tourtellot 1993:222) whose agricultural terraces were a key feature in sustaining its huge population (Healy et al. 1983). The skeletal road system that integrates Caracol indicates that the city is spread over some 177 km^2 in the Vaca Plateau of western Belize at elevations ranging from 450 to 650 m above sea level in a karst area that receives between 1500 and 2500 mm of rainfall per year. As of 1997, some 17 km^2 of the site—about 10 percent of its total area—have been mapped; 16 km^2 of this settlement are shown in Figure 2. The mapped area of Caracol contains over 4,400 discrete structures. As determined by ground checks and LANDSAT work, some 90 km of intrasite causeways link the various parts of urban Caracol together, and three long-distance causeways to other sites add an additional 70 km to this system. Within the site, large architectural complexes and plazas—called "termini"— occupy the causeway ends. Even though located anywhere from three to almost ten km distant from the epicentral groups, these termini are directly linked to the epicenter and embedded in continuous settlement. Rather than concentrating all monumental architecture in one central location, the Caracol Maya appear to have distributed it over the landscape, presumably as an aid to site integration and control (A. Chase n.d.; Chase and Chase 1996a:807–808).

Over the course of 13 field seasons, 106 plaza or architectural groups have been investigated either by areal excavation or by a series of smaller excavations. Causeways and terraces have also been excavated. This work demonstrates that Caracol's history goes back at least to 600 B.C. and ends at approximately A.D. 1100. The site flourished around A.D. 650, when approximately 150,000 people occupied an estimated 36,000 structures (see Chase and Chase 1994:4–5 for detailed population estimation). By this time, the construction of these agricultural features peaked with terraces covering most of the landscape between residential groups. The density of occupation and the intensity of the terracing at the site is striking. Population figures corrected for contemporaneity and occupation suggest an estimated density of 847 people per km^2 over the 177 km^2 that make up the site of Caracol. For the 17 km^2 so far mapped, corrected population figures

Figure 1
Accurate, to-scale, reconstruction of Caracol's terraces and settlement in Area 4 in Figure 2; the archaeological map is shown in Figure 7. Painting by T. Rutledge and D. Morgan.



indicate an actual density of 1,036 people per km² (see below). And, agricultural fields—as seen in Figures 3 through 7—are fully integrated within this residential settlement.

The Caracol Terrace Sample

Investigations prior to the onset of the current Caracol Archaeological Project had suggested that terraces and terrace systems were widespread in the Caracol region (Lundell 1940; Healy et al. 1980, 1983). In particular, Healy and his colleagues (1983) recorded part of a terrace system (ca .05 km²) approximately 2 km away from Caracol's epicenter (Figure 3; see Figure 2 for the location of this terrace sample). These data effectively show the articulation of terraces with plaza groups. Healy's sample may have been small compared to the overall site of Caracol and the current map; however, the density of settlement relative to the area mapped foreshadowed later Caracol Archaeological Project population estimates. For the area mapped in Figure 3, Healy and his colleagues (1983:409) projected a population density ranging from 402 people per km² at 25 percent occupancy to 1610 people per km² at 100 percent occupancy for the Caracol area. Although they did not know just how large and broadly distributed the ancient agricultural and settlement system was at Caracol, the high end of their projections are verified in the 16 km² map shown in Figure 2. Uncorrected population figures (i.e., 100 percent occupancy) suggest approximately 1,295 people per km²; as previously noted, corrected figures would indicate an average population density on the order of 1,036 people per km² for the part of Caracol that is presently mapped.

Documentation of the size, scale, and intensity of Caracol's terrace systems has been a cumulative result of the current Caracol Archaeological Project. Over time—as structure and plaza group mapping progressed—the intensive nature of the settlement and agricultural terracing has emerged. One project goal has been to demonstrate the form

Figure 2
Mapped 16 km² of Caracol, showing locations of terraced-recorded areas shown in Figures 3 through 7. Magnetic north is to the top of the page; each square represents 500 m² of settlement; radial lines are causeways. Inset shows location of Caracol in Belize and Central America.

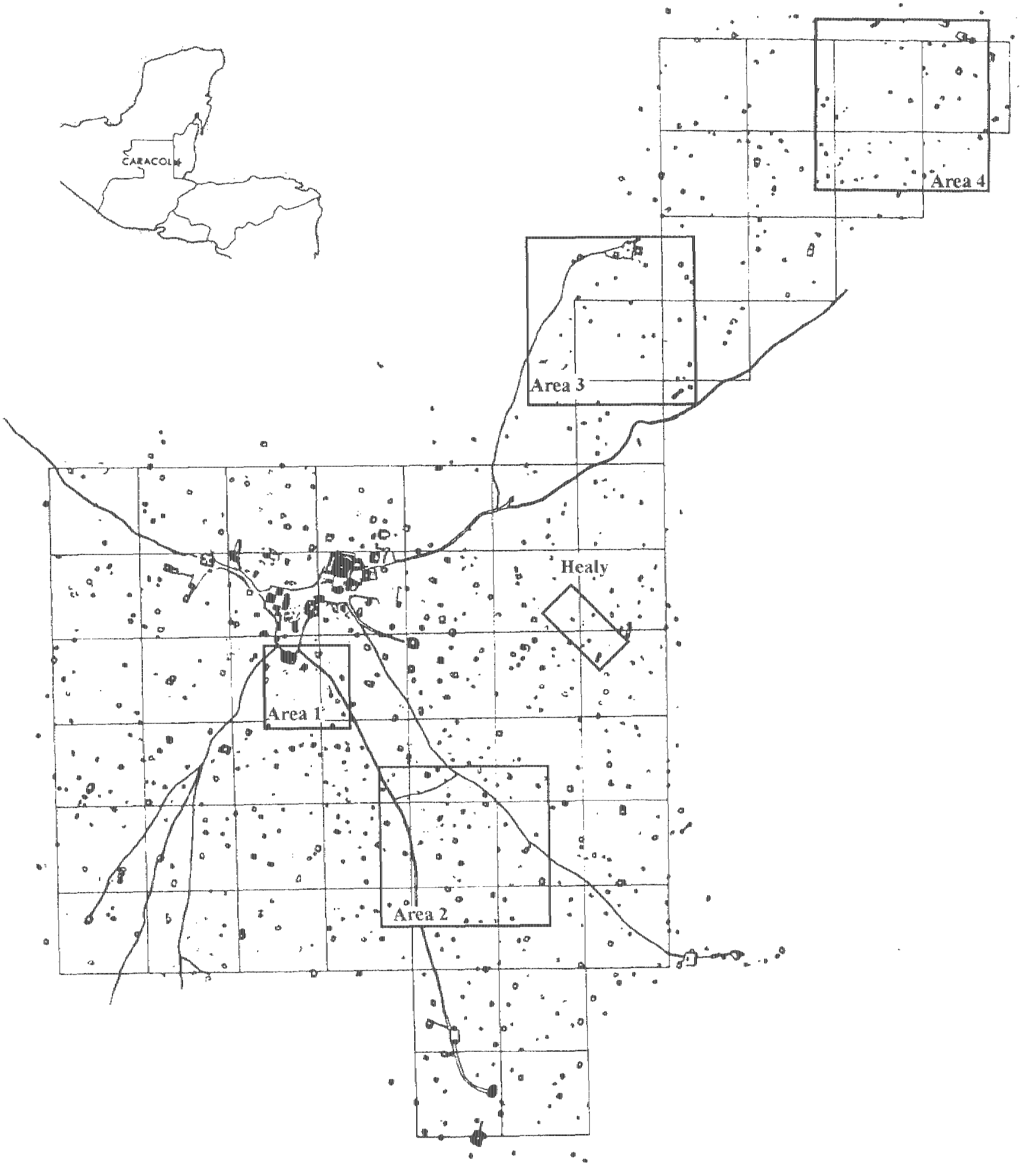
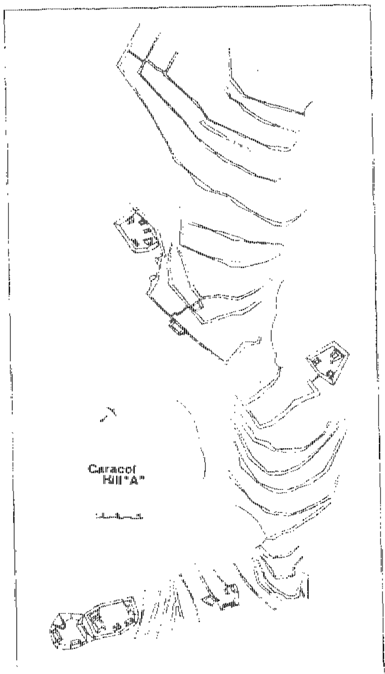


Figure 3
Area mapped by Paul Healy and his colleagues in eastern part of Caracol (after Healy et al. 1983:figure 3); Figures 3 through 7 are presented at the same scale.



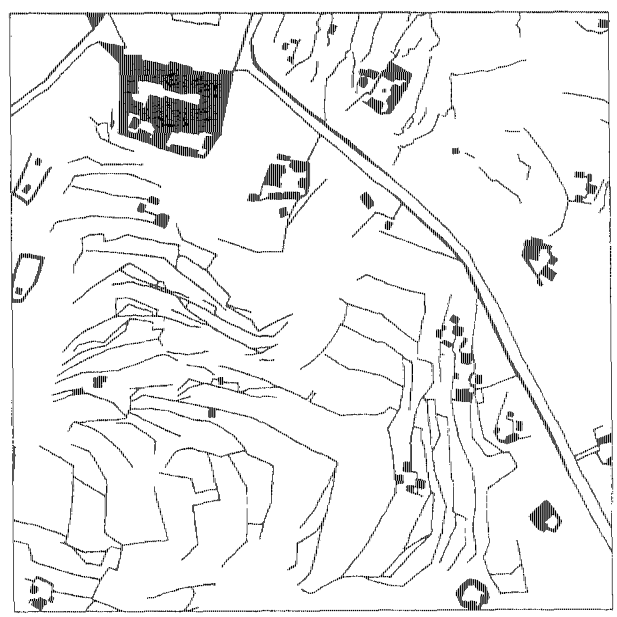
of the ancient agricultural system at the site through the complete mapping of all features in large sample areas of the site. The difficulty involved in this exercise was recognized almost from the start of the field project. Initial mapping undertaken in 1985 and 1986 had recorded several terraces in association with the Northwest Acropolis (Chase and Chase 1987:64-65) and had effectively demonstrated how time consuming this process was. Complete terrace mapping between the Conchita and Pajaro-Ramonal Causeways—a pie-shaped settlement wedge extending 3.5 km into the site's core—was attempted; this activity spanned 1988 through 1991 (four field seasons) and, although fairly comprehensive, even in this section of the site terrace mapping is not complete. In 1994 and 1995 "block mapping" of all of the terrace systems in the northeast sector of Caracol was also attempted, but the density of the terraces in this part of the site prevented total coverage; instead, large sample areas were intensively surveyed (Chase and Chase in press).

Terrace mapping is approximately ten times more time consuming than solely undertaking a transit map of plazuela groups and structures. The terraces are irregular and difficult to follow because of tropical lowland growth; they require additional cutting to clear areas. Daily plots of surveyed areas are also a necessity as even one wrong angle or mistaken measurement has the potential to misalign an entire system. On the positive side, however, the intensive terrace survey operation not only provides a better idea of the conjunction between ancient occupation and agricultural systems, but it also has led to more accurate mapping of the settlement itself. Areas that were first transit mapped and, then, subsequently block-mapped for terraces generally had their group counts increased by 10 percent as smaller plazas located among the terraces were recorded (Chase and Chase in press).

As a result of purposeful attempts to block-map terrace systems at the site, three separate 1-km^2 areas have been selected to provide a fairly detailed idea of the nature of Caracol's terrace systems; they are located at distances ranging from 1 to 5 km from the site epicenter. An additional area of .25 km^2 is also provided to illustrate how the site's terrace systems abut the monumental architecture in Caracol's epicenter. These four areas are located relative to the overall site in Figure 2.

Area 1 (Figure 4) shows settlement and terraces systems immediately adjacent to epicentral Caracol. On the north side

Figure 4
Caracol Terrace Area 1, a 500-m^2 mapped section adjacent to the site epicenter. Settlement and terraces mapped by A. Chase, S. Connell, and S. Jaeger. North is to the top of the page. See Figure 2 for location.



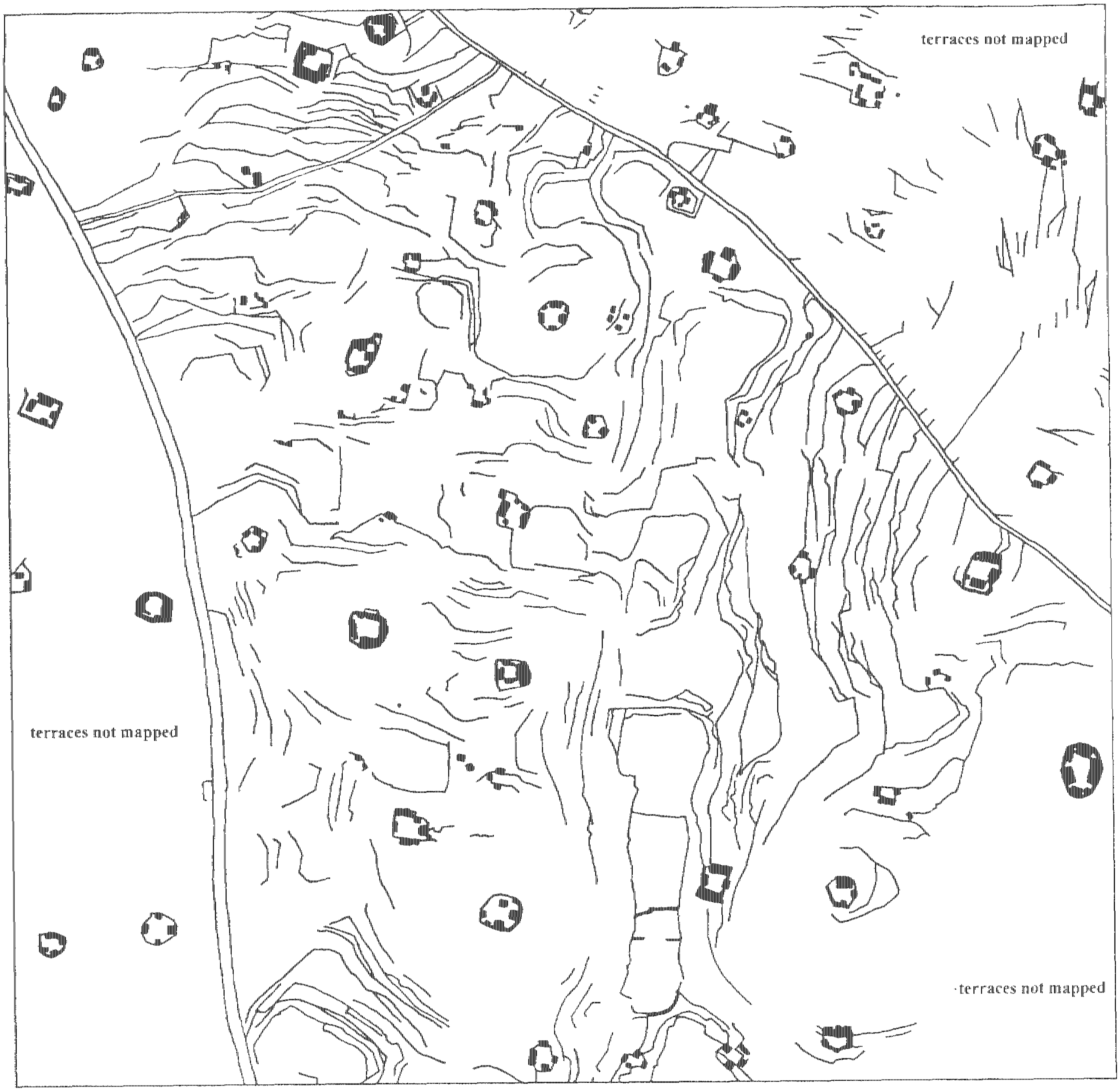
of this area is the South Acropolis, located on a prominent hilltop that overlooks a deep valley to its south. A key feature in this area is the Pajaro-Ramonal Causeway, which runs diagonally across the block, ultimately climbing to enter the plaza area just north of the South Acropolis. The South Causeway climbs into this same plaza from the southwest. There are approximately 60 m of elevation differential in this sampled area, with the highest elevations located to the north and southeast. Non-epicentral settlement is located above the agricultural fields on discrete hills or ridges in the southeast and western areas of this sector, as well as within the fields themselves. Residential groups located within the fields include both large and small constructions. Excavation of the South Acropolis recovered substantial Early Classic (A.D. 250–550) and Late Classic (A.D. 550–900) remains, including three tombs and one cremation. Excavations in three residential groups in Area 1 produced Late Classic artifactual material associated with three other tombs and one simple burial. Terraces within this mapped area consist of both weir terraces and linear dry-field terraces.[2] The broad valley below the South Acropolis, which is of a fairly gradual slope, is completely dominated by concave-shaped weir terraces; convex-shaped dry-field terraces are in evidence on the steeper ridge below the South Acropolis and in the more elevated southeastern part of this area.

Area 2 (Figure 5) is located from 1 to 2 km distant from the site epicenter between the Conchita and Pajaro-Ramonal causeways. This sample block is a low, relatively flat area that contains a series of isolated rounded hills. The greatest elevations in this area are located in the extreme northwest and southeast; the elevation differential in this block is approximately 40 m. Some 27 percent of the plazuela groups are located on hilltops; residential groups located amid the terraces include both large and small constructions. Ten residential groups were tested in Area 2, resulting in the recovery of nine tombs, nine other interments, twenty-one caches, and one shell-production locus. Except for Early Classic fill material, all remains dated to the Late Classic era. Terraces were completely mapped only in the area between the two causeways. Both weir and dry-field terraces occur. The weir terraces ring several distinct bajo areas south of a "cross-causeway," which links the Conchita and Pajaro-Ramonal Causeways to each other 1.5 km away from the site epicenter. An elongated north-south bajo-valley system occupies the southern part of this area. Two low walls—one complete and one partial—bisect the valley, connecting to terraces on either side. These probably functioned as more elaborate silt traps or, possibly, even dams (cf. Healy 1983; Turner and Johnson 1979). A third wall, semi-circular in form, certainly served as a sort of dam or break-water; the valley drops to its south into a series of very broad weir terraces (Chase and Chase 1989:fig. 5).

Area 3 (Figure 6) is located between 1.5 and 2.8 km northeast of the epicenter in an area of extremely rugged terrain. Approximately 130 m of elevation differential exist within this sample area. The northern part of Area 3 is dominated by the Puchituk terminus, which was constructed on an extremely high hill. The Puchituk Causeway runs down the spine of a ridge, along the eastern side of a broad unmapped hill, and eventually drops into and crosses a very broad and generally flat valley. High hills and a broad plateau characterize the eastern part of this area. Settlement and terraces were completely mapped immediately east and south of the Puchituk causeway and terminus. Approximately 42 percent of the plazuela groups mapped within this area were located on hills. Eight groups were excavated in this area, yielding three tombs, seven other burials, and seven caches; invisible structures were found deeply buried in vacant terrain on the saddle of one ridge. Artifactual remains from this area range in date from the very beginning of the Early Classic Period through the end of the Late Classic. Again, weir and linear dry-field terraces occur. One of the terraces here is approximately 600 m in length. Some residential groups on hills are completely ringed by dry-field terraces. Water-control walls occur on an adjacent hillside as well as in the valley bottom. Just south of the Puchituk terminus, two walls diverted water, presumably run-off from the architectural complexes, away from the nearest terraced gully. In the valley itself, two different sets of walls, one set for a gully running parallel to the causeway and the other set for run-off in the broad east-west valley, must have served breakwater functions.

Area 4 (Figure 7) is located from 3.7 to 5 km northeast of the epicenter. Like Area 3, it is characterized by a great deal of elevation differential. The broad valley in the northwest corner of this area is some 120 m below the hills that line the southern and eastern parts of this area. Terraces and settlement were completely mapped in all but the southeast corner of this block, an area disturbed by modern road construction. Groups on the tops of hills comprise 35 percent of the mapped sample in this area; many smaller groups are located within the agricultural terraces. Excavations were undertaken in six groups in this area. No tombs were excavated, but eight burials and eleven caches were recovered. Intensive excavations were made in two groups and resulted in the recovery of material with dates as early as 600 B.C. (Middle Preclassic Period) through approximately A.D. 1000 (Terminal Classic). The archaeological map of this area was used to create a reconstruction (Figure 1) that more clearly illustrates the relationship between contours and terracing. On the map, the valleys are clearly demarcated by weir terraces and the arable land between residential areas is covered by dry-field terraces.

Figure 5
Caracol Terrace Area 2, a 1-km² mapped portion of the site between the Pajaro-Ramonal and Conchita Causeways. Settlement and terraces mapped by A. Chase, G. Fuller, S. Jaeger, T. Murtha, and D. Troutman. North is to the top of the page. See Figure 2 for location.

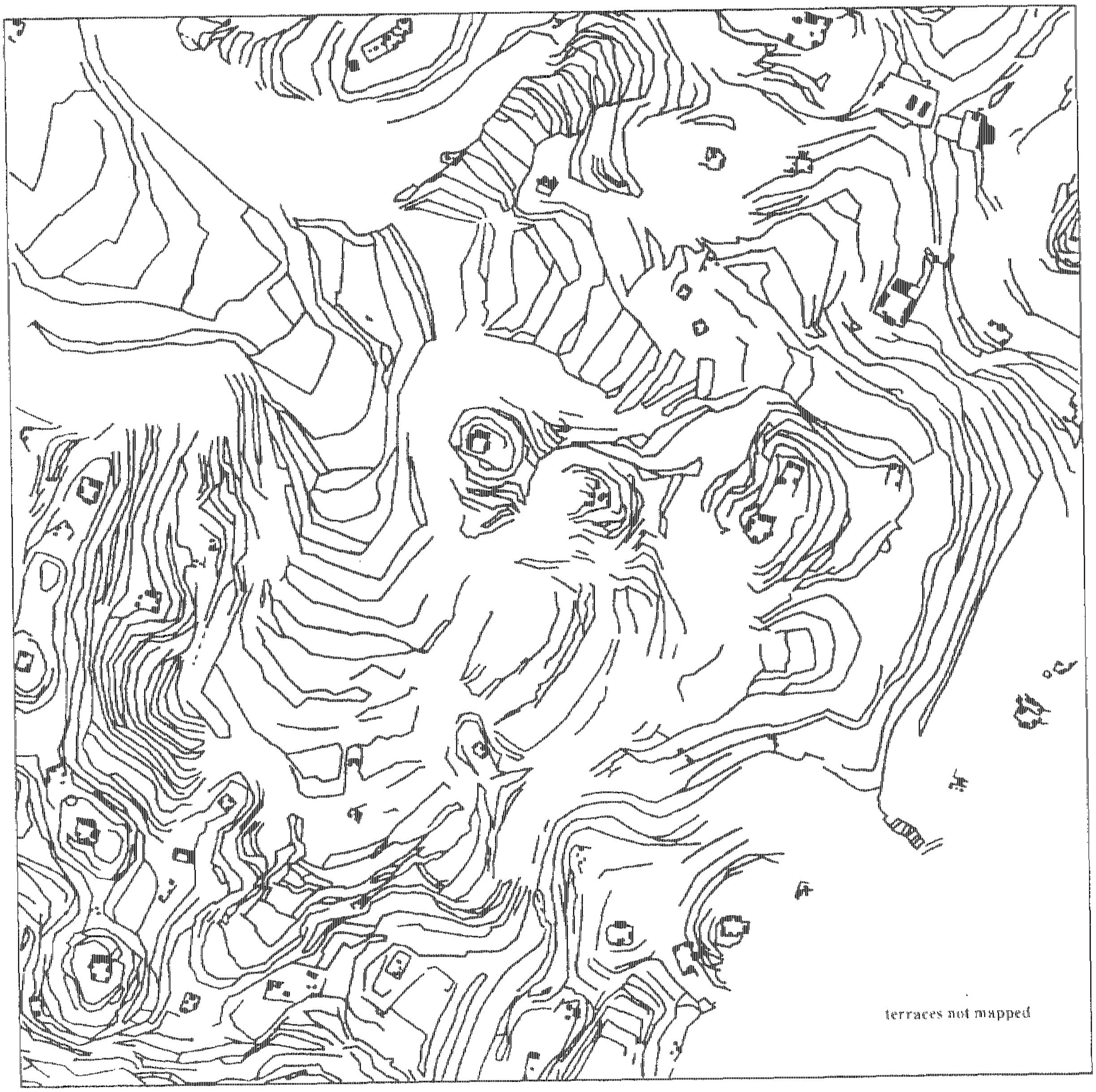


Formal Variation in the Caracol Terraces

The Caracol terraces represent a substantial "capital" investment in terms of time, labor, and planning. Terrace systems, mimicking those illustrated in Figures 4 through 7, are found throughout Caracol. There are *no* surveyed parts of Caracol where large areas of land exist without terraces.

Figure 6
Caracol Terrace Area 3, a 1-km² mapped portion of the site adjacent to the Puchituk terminus. Settlement and terraces mapped by B. Adams, D. Bidstrup, A. Chase, C. Lee, W. McFarlane, S. Mattingly, A. Morris, T. Murtha, and K. Straight. North is to the top of the page. See Figure 2 for location.

Figure 7
Caracol Terrace Area 4, a 1-km^2 mapped northeastern portion of the site. Settlement and terraces mapped by D. Bidstrup, C. Campaign, A. Chase, W. McFarlane, A. Matusik, T. Murtha, and K. Straight. North is to the top of the page. See Figure 2 for location.



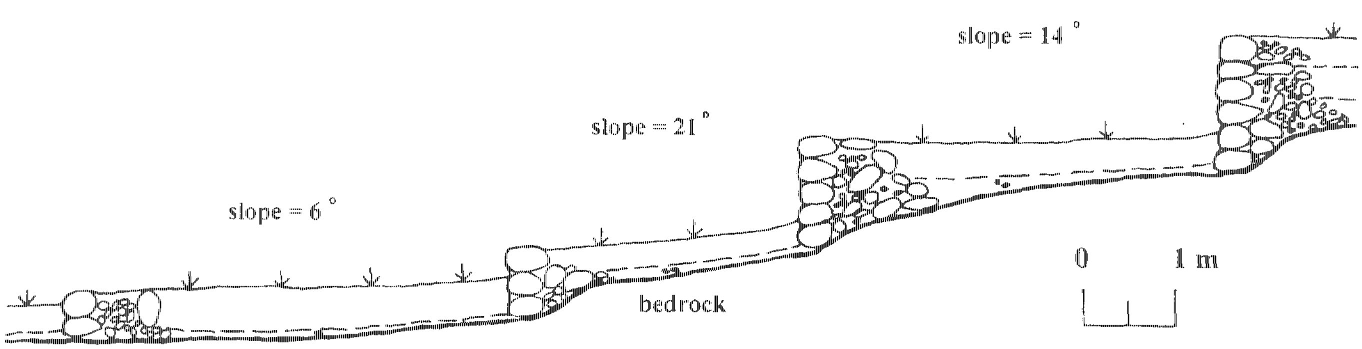
The construction and organization of the Caracol terraces indicate that most were not the result of simple bedding activity to catch silt and free-wash, as some have argued for these features elsewhere in the Maya area (Sanders 1979). The Caracol terraces contain facings of large, rough stones that are often several "courses" high (Coultas et al. 1993; Healy et al. 1980, 1983:404). They range in height from 20 cm to almost 3 m; all are anchored on bedrock (Figure 8). In general, the highest terraces are placed across rapidly descending valley gradients, while the lowest terraces occur in valley areas having very little gradient. Occasionally, some terraces are faced with formally cut stone.

Although Healy and his colleagues (1983:404) defined three different kinds of terrace wall construction for Caracol, all are variants of the same type and, realistically, the same terrace can produce differing construction techniques depending on where it is sampled. The more recent terrace work at Caracol has revealed only two general terrace types: piled-stone terraces of varying widths and heights that occur throughout the site on hillsides and in valleys; and double-lined stone terraces of limited height that are located in valley bottoms or in flattish areas. Excavated examples of Caracol's piled-stone terraces are situated on bedrock and have up to a meter of rock fill piled behind the visible facing (cf. Healy et al. 1983). The double-lined stone terraces are also set on bedrock. They are characterized by a visible outer stone facing that usually represents only a slight elevational difference (up to half a meter); behind this facing is stone and/or dirt fill, which in turn is bounded by a buried line of larger stones placed up to a meter behind the visible facing. If any of Caracol's terraces were originally designed to catch silt and free-wash, it is the double-stone terrace type. All known examples of this kind of terrace occur in very low slope areas, sometimes ringing bajos.

Both within valleys and on hillsides terrace facings occasionally project above the ground surface, forming a narrow wall similar to a small causeway balustrade. However, these features are not broad enough to have served as walkways and their spatial locations usually preclude the possiblity that they could have performed any function related to soil retention. Terrace connecting walls or "walkways," reported by Turner (1974:120) for the Rio Bec region and noted by Healy et al. (1983:402) as occurring at Caracol are not present in any of the mapped samples.

Missing natural soil horizons and other features recovered archaeologically suggest that the soil behind these terrace facings has been substantially manipulated (Coultas et al. 1993, 1994; Healy et al. 1983:406). Smaller stones appear to have been systematically culled from the earth and placed behind the formal terraces (Healy et al. 1983:406 and Caracol Project excavations), presumably for construction purposes. Some soils, particularly those located above bedrock, which are generally useful for construction fills and mortar mixes, also appear to have been systematically removed from the field areas. Rich agricultural soils were sometimes moved into the terraced fields in place of the removed horizons; some of the introduced soils may have been transported some distance, as suggested by the occurrence of alluvial snail shells in hillside terrace soils (Turner 1978:170, following the work of Saxe and Wright n.d.; see also Hansen et al. 1997 for extensive movement of bajo soils at Nakbe). Artifactual material also appears to have been intentionally mulched into the lower

Figure 8
Schematic drawing showing idealized Caracol terrace construction, cross-sections and relationships.



soil levels of many terraces. Soil refurbishment and the further elevation of terraces, after their initial construction, are also indicated in the excavated data.

Survey southwest of Caracol's South Acropolis found the remains of a field system that was under construction. An area measuring about 200 m long by 40 m wide on the edge of a ridge had been dug down to bedrock with the black upper soil piled on one side of this excavation. Rather than simply digging a ditch to anchor a terrace wall as a silt-trap, which is commonly done for "sloping terraces" (Wilken 1987:105), the Caracol Maya appear to have systematically modified the entire landscape and associated soils to create more complex "flat terraces," "check dams," and various combinations of these two forms (cf. Wilken 1987:99–104; 113–120). The general lack of quarries at Caracol, a feature common at Tikal (Carr and Hazard 1961:12), suggests that such pits and stripped areas (which must have existed in great numbers over the course of Caracol's history) may have been intentionally covered over by terrace systems.

The complex nature of the Caracol terrace systems is also evident in the fact that single terraces cross-cut descriptive categories used at other sites, including "check dams," "weir" or "channel-bottom terraces," and "box terraces." While "linear dry-field terraces" occur in the Caracol region, they are generally the more labor intensive "flat terraces" and not the more easily formed "slope terraces" described by Wilken (1987:104–113). Single continuous terraces can run for up to 1 km in length, incorporating several different terrace "types" depending on the terrain that is crossed. Linear dry-field and weir terraces differ in their relationships to the terrain. Weir terraces are generally perpendicular to the slope of the drainage channel. At Caracol, weir terraces are almost always combined with shorter dry-field terraces in such a way as to produce a concave pattern when seen in plan. Linear dry-field terraces usually run parallel to a given elevation. As they generally follow the curvature of hills, linear dry-field terraces often produce a convex pattern when seen in plan.

Terraces are located in virtually every conceivable location at Caracol. They are placed immediately adjacent to the epicenter (Figure 4) as well as distributed throughout the surrounding core (Figures 5, 6, and 7) and mantle (terms defined in Chase and Chase 1987:51–54). Terraces are found on slopes with variation much greater than that found in the Belize Valley, where Fedick (1994:figure 14) reports average slopes of between 3 to 6 degrees. While the terrace beds themselves are generally flat, the slope from the top of one stone-raised terrace to the top of the next in Area 4 ranges from 2 to 27 degrees, with the average slopes of terrace series in this part of the site ranging from 2.57 to 17.38 degrees (Table 1). The increased scale of these slopes, compared to the Belize Valley, is likely due to the greater population scale and density at Caracol, which has led to use of all available land resources. Like the Rio Bec area, where Turner (1974:125–126) reports slopes ranging from 4 to 47 degrees, the use of even steeper slopes for terracing is in evidence elsewhere at Caracol.

Drainage control is also evident in the Caracol systems. Although they are rare, formally constructed guide walls exist. These run perpendicular or diagonal to a given slope and serve either to divert the water flow or to cause it to slow (examples of these features exist in Area 3 on the hillside immediately south of the terminus plaza and in the broad southern valley). Many of Caracol's flat terraces are sloped along their length, which would cause water to seep laterally. Finally, what may be seepage outlets occur within some of the site's terrace systems, visible as seemingly purposefully constructed breaks within an otherwise continuous terrace face.

The fact that the Maya of Caracol were very concerned with water and water flow may also be seen in the site's reservoir locations. Reservoirs are consistently located within the residential core area (all but the epicentral reservoir are suppressed in the terrace maps that accompany this paper). There are an average of five reservoirs in any mapped km^2 of settlement at Caracol. Reservoirs are generally located in

Table 1
Caracol Terrace Slopes: Area 4

Series/ Kind		Number of Terraces in Series	Range of Slope/ Perpendicular Distance		Average Slope
1	weir	7	2°-3°	75 m	2.57°
2	linear	2	5°-6°	12 m	5.50°
3	weir	14	3°-11°	245 m	6.39°
4a	linear	3	5°-7°	15 m	6.00°
4b	weir	6	5°-9°	59 m	6.67°
5	weir	15	5°-8°	160 m	6.73°
6	linear	2	6°-9°	19 m	7.50°
7a	linear	6	8°	90 m	8.00°
7b	weir	5	7°-12°	70 m	8.20°
8	linear	7	5°-13°	72 m	8.29°
9	weir	7	4°-14°	154 m	9.43°
10	linear	9	6°-14.5°	89 m	10.78°
11	weir	11	8°-14°	164 m	10.91°
12	linear	3	11°	14 m	11.00°
13	linear	8	9°-15°	131 m	11.94°
14	linear	5	11°-13°	35 m	12.20°
15	weir	5	10°-14°	91 m	12.40°
16	linear	6	9°-18°	39 m	12.67°
17	linear	10	8°-18°	90 m	13.35°
18	linear	8	7°-18°	41 m	13.75°
19	weir	18	6°-27°	146 m	15.64°
20	linear	18	12°-22.5°	146 m	16.14°
21	linear	7	13°-18°	53 m	16.79°
22	linear	10	10°-22°	73 m	17.35°
23	linear	4	16°-18.5°	22 m	17.38°

terrain above the fields, often near hilltop residential groups, possibly suggesting knowledge of the health hazards of water contamination that would have resulted from the application of human nightsoil or other fertilizers to the fields. However, a half dozen mapped reservoirs are placed within the field systems and not in proximity to residential groups, their locations suggesting that these features may also have been used to carry out something analogous to "pot irrigation" (cf. Kirkby 1973 in the Valley of Oaxaca). In contrast to other Mesoamerican urban situations, such as at Teotihuacan where population density, as seen in the close spacing of households, was clearly detrimental to long-term health (cf. Storey 1985), there does not appear to be a decrease in health standards correlated with Caracol's dramatic population growth (Chase 1994; Chase et al. n.d.). Reservoir locations and the spatial distances between residential groups undoubtedly aided in the creation of this health profile.

The Caracol terrace systems further illustrate the difficulty of viewing lowland Maya agriculture as simply maintaining intensive in-field gardens and extensive out-field plots. "Intensive in-field systems" are in evidence throughout the Caracol core area (a 10-km radius from the central architecture) and similar terracing has been noted throughout the surrounding (and outlying) region, suggesting that true swidden or milpa agriculture, if practiced, likely would have been conducted at substantial distances from the site epicenter, on the order of minimally 12, and more likely 30, km. In essence, the Caracol data accords well with Killion's (1992) observations that distinctions in the amount of capital investment and intensive labor put into in-field and out-field agricultural production disappear as population increases.

Temporal Considerations

Terraces can be directly and indirectly dated. While some of Caracol's terraces are largely devoid of trash, others contain some human refuse as part of their fill. Such trash, and particularly the ceramics within this fill, can be used to date terraces, acting as a form of *terminus post quem*. The earliest materials that Healy et al. (1983:408) found within the terraces he excavated dated to the Early Classic Period, meaning that the terraces could have been constructed either at or after this time. However, the majority of excavated terraces contain only Late Classic ceramics (Healy 1983:407–408 and Caracol Project excavations), suggesting that the majority of the terrace construction was during the Late Classic Period. Additional dating information can also be derived from reviewing associated architectural features and their stratigraphic relationships to terraces. For instance, excavations of both the Conchita and Pajaro-Ramonal termini indicate that these plaza areas were constructed in the early part of the Late Classic Period (Chase and Chase 1989:10–15). Causeways connect these plazas to the epicenter and can be assumed to have been coeval constructions; excavations within these two causeways support this early Late Classic dating. Both the Conchita and Pajaro-Ramonal Causeways articulate with a variety of terraces. For the most part, terraces abut these causeways, indicating that they were constructed after the causeways were built. The fact that the terrace abutments are not in alignment on either side of a given causeway, even if the terrain would permit it, also supports their being later constructions than the causeways, meaning that they were constructed at some point during the Late Classic Period. Residential groups, located among terraces, also provide patterns of articulation that can be similarly interpreted, both visually and through excavation. When found in association, earlier residential groups are abutted by terraces; their platforms do not cover any evidence of terracing. But, excavation has also shown that some late Late Classic residential groups were placed atop, or minimally expanded over, some preexisting terraces.

The overall combination of spatial patterns and excavation data thus suggest that the majority of Caracol's terraces and terrace systems were initially constructed in the early part of the Late Classic Period. Given the placement of small groups in the fields during the later part of the Classic Period, it is likely that these terrace systems were added to and modified through the end of the Late Classic, but used through the Terminal Classic Period. Initial work on the terraces suggested that there was a widespread depletion of the Caracol terrace soils by the Terminal Classic Period and that this may have even been the cause of the site's abandonment (Healy et al. 1983:406, 409). However, additional work has instead suggested that the soils maintained their fertility during this time and that outlying settlement, albeit on a lessened scale and probably without further terrace construction, continued for almost two centuries beyond the epicentral abandonment (Chase and Chase 1996b). Thus, the fertility of Caracol's soils were likely not a primary factor in its "collapse" (Coultas et al. 1994:28).

Functional Considerations of the Caracol Terraces

Terraces in Mesoamerica are generally ascribed as either "agricultural" or "residential" in function. Residential terraces are noted predominantly in central and northern Mexico (Blanton 1978; Sanders and Nichols 1988:44–45), although agricultural terraces also occur (Evans 1990). Excavations into these Mexican residential terraces often find the remains of foundation walls which once supported buildings. At Monte Alban terraces are factored into the population estimate for the site; 1 km^2 of these terraces is estimated as having supported in the neighborhood of 15,000 inhabitants (Sanders and Nichols 1988:45, 70). Without considering the Monte

Alban terraces as residential, the overall population estimate for the site would be substantially lower.

Unlike central Mexico, there is no reason to consider Caracol's terraces to be anything other than "agricultural" in nature. First, Caracol terrace excavations do not recover foundation walls in the upper levels; instead, all excavated Caracol terraces exhibit particular soil horizons behind them that are not indicative of human residential patterns (cf. Healy et al. 1983). Second, residential "terraces" or vacant terrain housing pads are noted elsewhere in the central Peten, especially during the Postclassic era (cf. Chase 1985); the Caracol terraces do not resemble these residential vacant terrain features. Finally, Caracol's estimated population of between 115,000 to 150,000 people based on structure counts is exceedingly elevated for a Classic Maya site (Rice and Culbert 1990:20–22); if even a small proportion of the site's terraces (say 10 percent) were residential, the site's population would have to be estimated as being over 400,000 inhabitants, something we think unlikely. We also doubt that the site's terraces were differentially utilized depending on distance from the epicenter, as the terraces abutting the epicenter exhibit the same properties as those 5 kilometers distant. While not completely ruling out any other alternative functions, the extant data indicate that the vast majority of Caracol's terraces must have been agricultural in nature, if only to feed the site's already large Late Classic population.

In considering the Caracol terraces to be agricultural, it must be noted that there is little in the way of direct functional evidence in support of this assertion. The soils in the Caracol area preserve neither pollen nor phytoliths (Jones 1994). This means that the crops that were planted in Caracol's fields are currently unknown to us. Healy and his colleagues (1983:407), however, noted that "corn (*Zea mays*), ragweed (*Ambrosia*), and other Compositae, weeds usually associated with cultivated fields and vegetational disturbance," came from a coring of the site's main reservoir. The skeletal population of Caracol exhibits good health (D. Chase 1994, 1997), indicating that the site's inhabitants did not lack food resources and that agricultural products were an important part of the ancient Caracol diet. In combination with the density of population, the health of the inhabitants strongly argues that the people of Caracol must have had most of the available land under cultivation in order to maintain a successful dietary regimen. In this light, the patterning of formal and spatial variation of the terraces provides indirect evidence in support of their agricultural use.

While relevant ethnographic analogies are absent in the Maya area, comparative agricultural studies from both ethnology and geography may help interpret how the Caracol terraces were utilized. Generally, modern peoples in the Southern Maya lowlands do not practice terracing. And, the population diaspora between the Maya Terminal Classic and Historic Periods means that, even if modern ethnographic analogies were present, they would probably not be of relevance. However, looking at comparable population densities and situations of self-sufficiency elsewhere, several observations can be made regarding the agricultural nature of Caracol's terraces. First, these fields would have been under continuous cultivation involving inter-cropping and multi-cropping, if analogous African data can be used (cf. Netting 1993:269, table 9.1). Second, based on what is known of Maya agriculture, a wide variety of cultigens would have been grown on these terraces (cf. Dunning 1996; Rice 1993). Third, based on the need to keep the soils fertile, it is likely that there was widespread use of plant and animal wastes (Coultas et al. 1994:28). The location of terraces in and around housing likely fostered the use of nightsoil. Fourth, based on a consideration of agriculture and population density factors (cf. Turner and Brush 1987:191–193), there may have been commodity production in addition to basic subsistence activities in some fields. Cotton may have been one of these crops under commodity production based on the recovery of spindle whorls and other artifacts associated with the production of cloth from Caracol's archaeological record (D. Chase n.d.). Palm fronds, useful as roofing material, may well have been another commodity crop given the large numbers of perishable residences at Caracol.

Discussion

Based on present archaeological data, the majority of Caracol's terrace systems appear to have been constructed after A.D. 550, being added to and modified through no later than A.D. 800. Thus, approximately 250 years can be allocated to the production of the terrace systems that are seen in the landscape at Caracol. Given Caracol's rapid population expansion between A.D. 562 and A.D. 650 (Chase and Chase 1989), it is further likely that most of the site's terrace systems were established within this initial timespan, but that for the remainder of the Late Classic Period these systems were carefully maintained. Accretive growth surely also occurred within the initial systems, with terraces being lengthened and systems being extended into higher grade hill-slopes over time. New terrace systems likely were established farther and farther away from the site epicenter as Caracol's residential population expanded into these areas. But, how and why did these terrace systems come into being? From our standpoint these terrace systems must have been adopted as a means of attaining agricultural self-sufficiency in an era of population growth, in accord with patterns seen at other early empires (Chase and Chase 1996b; Sinopoli 1994).

The large-scale organized, as opposed to discrete "hodgepodge," nature of the terrace systems indicates to us that they were likely not merely the accreditive result of individual family efforts (cf. Demarest 1992:145–147; Netting 1993). Rather, the magnitude and formality of the landscape modification involved in Caracol's large-scale terracing indicates planning and implementation of the fields by something larger than the family unit. How centralized this planning and implementation may have been is only conjectural. Healy and his colleagues (1983:402) felt that the orderly layout of Caracol's terraces gave "the appearance of being well coordinated and planned" and that they "were built at roughly the same time, and under well-organized, centralized direction. They do not appear to have been carried out haphazardly, or on an individual family level of organization." Wilken (1987: 98, 117–120) notes that in large-scale terrace systems, especially those involving "flat terraces" with level surfaces (like those at Caracol), some central control of labor to both construct such systems and ensure their upkeep is necessary. Like Healy and his colleagues (1983) and in agreement with Wilken (1987), we feel strongly that Caracol's Late Classic terraces must have operated under some form of centralized control.

Based upon excavation data, it would appear that Classic Period residential construction and terrace construction went hand-in-hand. The distribution of settlement, terracing, causeways, and termini on the Caracol landscape is extremely organized and likely planned. Causeways radiate from the epicenter and termini are located at set distances, providing a spatial skeleton for a highly integrated administered economy (A. Chase n.d.). Of even more interest, however, are the relative locations of household units within the Caracol core. Plazuela groups are intermixed among the fields, but are regularly spaced, with distances between 50 and 150 m depending upon terrain and the nature of terracing in the area. Attached "side-by-side" plaza units are extremely rare (Chase et al. 1990; Chase and Chase 1996b:71). This is in contrast to the situation at other Maya sites where extended kinship groups appear to have chosen to live in attached residential clusters whenever possible; this can be seen clearly in settlement at sites such as Copan (cf. Webster 1989) and Tikal (Haviland et al. 1985:184–185). The absence of such kin-based clustering of residential groups in the Caracol landscape is striking.

We believe that the natural tendency to agglutinate households was checked by both economic and social factors at Caracol. Even terraced fields have productivity thresholds, which would have limited the number of people that could be effectively fed. And, there must have been administrative adjudication of disputes over the locations of new residential groups, probably leading to increased population in outlying areas. The frequency of small and potentially lower-status residential groups located within the fields appears to increase at 3.7 to 5 km from the epicenter in the northeastern sector of the site in Area 4 (Figure 7). This settlement observation may accord with long-term problems involved in inheritance rights over working specific fields. Netting (1993: 167–171) noted that, over time and with increased family numbers, surrounding fields would not have provided sufficient resources for an expanding household and that inheritance rights would further diminish the size of fields available to a given family unit. This would eventually lead to exterior mediation to solve conflicts over field rights as well as out-migration. Thus, over time related family units would have presumably become widely scattered over the broader Caracol landscape, presumably creating the observed pattern of smaller residential groups associated with fields further from the epicenter.

Given the fact that other economic industries are undertaken on a household basis (Chase and Chase 1994), it is assumed that households also worked specific portions of the Caracol terrace systems. But, there are neither clear spatial relationships between specific fields and specific households nor clear divisions of the fields into potential household-related lots. Precisely who is working the fields is also difficult to determine. Residences found within the fields include groups with smaller plazas and structures as well as those with larger plazas and bigger structures. Combined with artifactual remains and interments, this suggests that a residential location within the fields was not limited to lower-status individuals.

Conclusions

The Caracol terrace systems represent massive landscape modifications and required substantial investments of time, labor, and upkeep. The terraces cover much of the available land within the Caracol core area and are well integrated with both settlement and causeways. There is archaeological evidence to suggest that the terrace construction went hand-in-hand with settlement. While some terraces were present prior to the construction of residential groups, the majority were built following or coeval with the initial Late Classic settlement growth. The scale and organization of these terraces systems, especially when placed within Caracol's dated settlement history, suggests that some level of administrative control or, minimally, intervention existed with regard to the creation and management of the combined settlement and agricultural systems. The Caracol terrace systems were key elements in the subsistence support of a large and dense population of between 115,000 to 150,000 people. We believe the occurrence of these features at Caracol was fostered by the site's attempts at self-sustainability as an imperial capital (Chase and Chase 1996a, 1996b; cf. Sinopoli 1994).

The Caracol field systems provide but one example of the Lowland Classic Maya use of terraces as a key means to sustain intensive agriculture for a large and densely occupied Late Classic population. Although the stone terrace systems are in clear evidence at Caracol and are thus easier to interpret, we suspect that similarly intensive systems of agriculture were in use at other sites in the Southern lowland Maya area, in spite of a general lack of such easily recognizable construction features. Once conceptually separated in lieu of preconceived Western "urban" and "rural" dichotomies, we are now coming to recognize that Maya "sustaining" and "urban" areas can completely overlap, as they appear to do for the Late Classic "garden city" of Caracol, Belize.

Notes

1. The University of Central Florida Caracol Project has been assisted by many individuals, institutions, and foundations during its existence. The University of Central Florida and the government of Belize have been particularly instrumental in ensuring the success of the project. Major funding has been obtained from numerous sources: private donations annually to the University of Central Florida; the Harry Frank Guggenheim Foundation (1988, 1989); U.S.A.I.D. and the government of Belize (1989–1992); the government of Belize (1993); the National Science Foundation (1988 [BNS-8619996], 1994–1996 [SBR-9311773], 1997 [SBR-9708637]); the Dart Foundation (1996); the Foundation for the Advancement of Mesoamerican Studies, Inc. (1997); the Stans Foundation (1997, 1998); and the Ahau Foundation (1998). The authors would like to thank Pat Culbert, Paul Healy, Laura Levi, Tim Murtha and two anonymous reviewers for editorial comments on an earlier version of this manuscript.

2. Confusion exists over both the form and designation of Maya terraces. Although traditionally referred to as "linear sloping dry field terraces," following the designation made by Spencer and Hale (1961), Maya terraces are not "sloping." Wilken (1987:104) notes that "slope terraces" change the original gradients "only slightly or not at all." The Maya terraces reported on here are instead "flat, or bench, terraces," characterized as "the ultimate in slope management" (Wilken 1987:113). So that the Caracol terraces are not confused with "slope terraces," they are referred to in this paper as simply and, more correctly, "dry-field terraces." Similarly, the "weir terraces" or "check dams" at Caracol are also "flat" terraces.

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