The Map of Chunchucmil

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The map of Chunchucmil can be found as a series of 10 blocks, each containing approximately 1 km^2 (see below), accessible as supplementary electronic files (http://upcolorado.com/university-press-of-colorado/item/3076-ancient-maya-commerce). The features on the map and the methods used to create it are presented below. We begin this chapter by putting the Chunchucmil map in context with other large mapping projects. For information on Chunchucmil's broader geographic, ecological, hydrological, and pedological contexts, see chapters 6, 7, and 9.

The number of large Maya sites that have been systematically mapped and published can be counted on two hands: Tikal, Mayapán, Dzibilchaltún, Copán, Calakmul, Cobá, and a couple others depending on how one defines terms like "large" and "systematic." The list remains small because overgrown vegetation in the Maya area makes it extremely expensive and time-consuming to map more than a few square kilometers. This list will grow quickly, however, due to LiDAR, a relatively new remote-sensing technique that sees through the vegetation and quickly produces digital elevation models that sometimes show many prehispanic features (Chase et al. 2011; cf. Prufer et al. 2015). Prior to LiDAR, mapping a big site required chopping hundreds of kilometers of paths and walking nearly every square meter. Using these methods, Folan, Fletcher, et al. 2001 map of 30-km^2 Calakmul took 87 months to compile. Since basic analyses (estimating population and establishing settlement hierarchies) can be done through sampling, research designs involving full-coverage mapping require additional justification.

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In the late 1970s, Ed Kurjack, Silvia Garza, and Dave Vlcek provided two justifications for the kind of irregularly intensive mapping project that we undertook at Chunchucmil. First, by ground-truthing aerial photos north of the Chunchucmil site center, they showed that Chunchucmil's settlement density seemed too high to be supported by swidden farming (Kurjack and Garza Tarazona de González 1981; Vlcek et al. 1978; see also chapter 8, this volume). Yet no conclusions could be made about Chunchucmil's economy without excavations in a representative sample of residential compounds. Selecting a representative sample of residential compounds for excavation (see chapter 3) required baseline knowledge of the quantity, location, and configuration of the compounds available to sample: the sampling universe. Getting this knowledge required a map that covered most of the site. Second, Kurjack and colleagues noticed that boundary walls—*albarradas* (described in depth later in this chapter)—delimit residential compounds, that adjacent compounds share *albarradas*, and that narrow alleys snaked between the compounds. Few Classic-period sites have large numbers of boundary walls delimiting residential groups (Cobá [Folan et al. 1983] and Becán [Thomas 1981] are the best examples) and fewer have shared *albarradas* (see Magnoni et al. 2012:316). Alleyways are found only in the Postclassic (e.g., Mayapán; Pollock et al. 1962). Chunchucmil has very little Postclassic occupation (see chapter 4). Documenting and analyzing the variation in residential compounds and how the alleys connected them with other parts of the site would tell precisely how people moved through the heterogeneous spaces of the city and therefore provide a fine-grained understanding of the urban experience (Hutson 2010, 2016; Hutson and Magnoni 2011; Magnoni et al. 2012). Such analyses require a contiguous map of a very large chunk of the site. Settlement transects alone would not be enough.

Dahlin set a goal of mapping a 4-by-4-km square at Chunchucmil. Based on earlier aerial-photo analyses (Vlcek et al. 1978), the 16-km^2 goal promised to capture the majority of the site and most, if not all, of the variation within its settlement.

A mapping trial run in 1993, the first field season of PREP, led to the formalization of mapping methods (see below), which were first deployed in earnest in the 1996 field season. Mapping continued in each of the nine subsequent field seasons. By 2006, when the tenth and final season of mapping was complete, we had mapped 11.67 km^2 (figure 2.1). In comparison, Stuart et al. (1979) mapped 19 km^2 at Dzibilchaltún, Folan, Fletcher, et al. 2001 mapped 30 km^2 at Calakmul, Carr and Hazard (1961) mapped 9 km^2 at Tikal (Puleston [1983] later added to the map), and Chase and others (2011) mapped 23 km^2 at Caracol. In contrast to these sites, the density of archaeological features at Chunchucmil is much higher (see chapter 5). We return to sampling issues shortly. We mapped with a high level of detail. Though no map can be a mirror image of the terrain (Monmonier 1991), some maps include more details than others. The amount of detail one strives to include presents a tradeoff. Given a finite set of resources, one can include more detail at the expense of covering less ground, or one can cover more ground at the expense of including less detail. Having chosen to include more detail, we moved slowly and were not able to cover as much ground as we originally intended. For example, in each of the 1,167 ha of our map, we documented all visible examples of *albarradas*, a rather ubiquitous feature at Chunchucmil. In comparison, at Dzibilchaltún (Stuart et al. 1979), *albarradas* were not mapped and other details (such as platform height) were not noted, allowing a faster pace and coverage of more ground.

The area that we mapped does not encompass the entire site. In fact, our 11.67 km^2 cover only 60 percent of what we consider to be the site. Nevertheless, the mapping strategy we deployed gives us confidence that our 11.67-km^2 sample succeeded in capturing most of the variation in settlement at the site. The strategy combined two forms of coverage: a 9.3-km^2 polygon of terrain anchored in the center of the site, and five sampling transects that extended up to 2 km beyond the edge of the 9.3-km^2 polygon. The goal of the transects was to sample areas of the site that could not be mapped completely and to locate the edges of the site in areas where the 9.3-km^2 polygon failed to do so. In areas where the 9.3-km^2 polygon had already pinpointed site edges, the goal of the transects was to get a sample of "intersite" settlement patterns.

METHODS FOR MAPPING THE 9.3-KM^2 POLYGON

In the field, our methods were driven by relics of previous land-use that allowed us to establish points of reference: *mecate* markers and *planteles*. A mecate is a 20-by-20-m unit of measure that was extensively used in Yucatecan plantations in historic times, and it has its origins in the prehispanic Maya vigesimal system. Nearly all of the area that we mapped was at one time under henequen cultivation and henequen workers gridded fields into *mecates*. Henequen laborers were generally paid by the number of *mecates* worked, or the area covered. At the corner of each *mecate*, they erected a stone cairn (*mojonera* in Spanish) as a marker. In most places, the markers are still preserved today. High-precision GPS equipment showed that rows of 25 *mecate* markers, which should each measure 500 m long, came to within a meter or two of being 500 m long. We accepted this level of error and therefore used the *mecates* to orient our measurements.

Planteles are polygons, often oddly shaped, that contain anywhere from 20 to 80 ha (between about 500 and 2,000 *mecates*). The *mecate* grids were normally oriented within 15 degrees of the cardinal directions, but the specific orientation of the *mecate* grid in one plantel was often different from the specific orientation of the *mecate* grid in another *plantel*. Therefore, we mapped one *plantel* at a time and within a particular *plantel*, we assigned grid coordinates to each *mecate* marker, labeling them with flagging tape. Our workmen cut *brechas* (narrow paths) between *mecate* markers in order to connect each *mecate* marker with its north, south, east, and west neighbors. Cutting such *brechas* represented a substantial investment (theoretically 307 km of *brecha* for the central 9.3-km^2 polygon!), though in some places recent brush fires or cattle grazing eased the job. In a minority of the *planteles*, *mecate* markers were not available. In these *planteles*, we laid out 100-by-100-m grid squares using a theodolite. Using these larger squares for control, workmen established a 20-by-20-m grid within the squares by triangulating with measuring tapes.

To draft features in the field, we transferred the *mecate* grid to graph paper (or mylar laid on top of graph paper) at a scale of 1:1,000. Thus, each 20-by-20-m *mecate* occupied a 2-by-2-cm square on the graph paper. We sketched features onto the graph paper by pacing their displacement (along both the *x*-axis and *y*-axis of the grid) from the nearest *mecate* marker. Heights of features were estimated. For features below 2 m, we often rounded our estimates to the nearest 0.25 m. Such estimates likely carry an error of up to plus or minus 20 cm, although we did not test to see what our average error was. Since the accuracy of our height estimates probably diminished for features above 2 m high, such features were normally estimated to the nearest half meter. The heights of most features above 5 m were measured with a theodolite.

Once an entire *plantel* was mapped, the graph paper sheets were conjoined and retraced either manually or digitally to create a composite map of the entire *plantel*. High-precision GPS points[1] were taken at the corners of the each *plantel* as well as other salient points. Using these GPS points, each *plantel* map was geo-referenced in ERDAS Imagine and ENVI, thus allowing us to combine all the *plantel* maps into a single composite map. To create the maps in this book, all mapped features were traced into vector format using Adobe Illustrator. A separate GeoMedia Professional GIS database was created to store, analyze, and display all archaeological data collected during mapping and excavations (Magnoni and Hixson 2010).[2]

METHODS FOR MAPPING THE TRANSECTS

Five transects were mapped beyond the central 9.3 km^2 (figure 2.1; see online content for transect maps). As mentioned above, the goal of these transects was to locate the edges of the site and sample the periphery of the site. The five transects include four cruciform transects (cf. Puleston 1983; Ringle and Andrews 1990) oriented approximately 45 degrees off the cardinal directions, and a fifth transect placed opportunistically alongside a modern road running eastward in the direction of Oxkintok, a large site 27 km away. The northeast transect measured 200 m wide, the other four

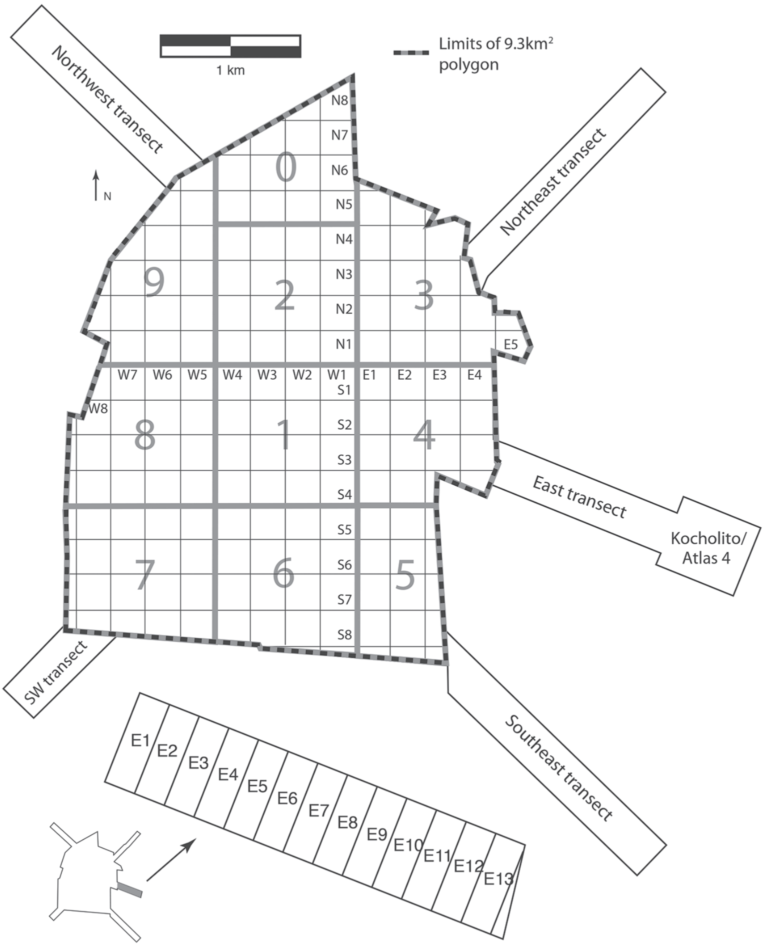

Figure 2.1. Map showing the extent of 100%-coverage mapping at Chunchucmil, as well as the subdivisions within the 9.3-km^2 polygon (250-by-250-m quads and 1-km^2 blocks) and subdivisions along a sample transect (below). Online component is available here: http://upcolorado.com/university-press-of-colorado/item/3076-ancient-maya-commerce.

measured 300 m wide. The area mapped by these transects is 2.37 km^2, bringing the total size of Chunchucmil's mapped area to 11.67 km^2. The northwest transect (0.48 km^2) is 1.6 km long and extends 3.47 km from the site-center datum. The northeast transect (0.54 km^2) measures 1.8 km long and extends 2.94 km from the site-center datum. The southeast transect (0.60 km^2) is 2 km long and extends 3.97 km from the site-center datum. The southwest transect (0.18 km^2) is 0.6 km long and extends 3.35 km from the site-center datum. The east transect (0.57 km^2) connects to a cluster of mounds, named Kocholito, on a 0.6-by-0.5-km *milpa*. When combined, the mapped *milpa* and east transect are 1.9 km long, extending 2.95 km from the site-center datum.

Each transect was mapped using the "fishbone" survey method, which consisted of cutting a baseline (the "backbone") running the length of the transect and narrow lines ("ribs") running perpendicular to the baseline, crossing it every 100 m (Puleston 1983). Three to five staff members walked from one rib to the next, with 20 m spacing between each walker. Any feature found while combing the ribs was mapped with handheld GPS, measuring tape, and compass.

SUBDIVISIONS OF THE MAP

A blank stela located 50 m southwest of the site's tallest building (the Chakah pyramid) serves as the site-center datum. The map has been gridded into blocks that are either exactly or approximately 1 km^2, as well as 250-by-250-m quads (figure 2.1; since the 9.3-km^2 polygon is an odd shape, most of the quads at the edges of the map are not 250-by-250 m). The square-kilometer blocks are numbered 0 to 9. These blocks, never before published, are available as supplemental digital files, currently in jpeg format (http://upcolorado.com/university-press-of-colorado/item/3076-ancient-maya-commerce). We use such blocks to stratify our excavation sample spatially (see chapter 3) and to refer to general areas of the site. The 250-by-250-m quads establish a system of spatial reference. Each 250-by-250-m quad takes its name from its position north/south and east/west of the site-center datum. The quad immediately northeast of the site center datum is named N1E1. The quad directly north of this quad is named N2E1. The quad directly west of N2E1 is named N2W1, and so forth. These quad names are used in providing distinct names for each building on the map (see below). We did not use quads to subdivide the transects. Rather, we divided each transect into 100-m strips (see figure 2.1). For example, on the east transect, the strip closest to the site core takes the name E1. Since the NW, SW, SE, and E transects are each 300 m wide, each strip measures 300-by-100 m.

FEATURES OF THE MAP

We classify mapped features into six categories: buildings, linear features, depressions, special stones, historic features, and excavations. Figure 2.2 contains a key showing how these and other features are represented. The following sections describe these features, provide quantitative data (in most cases) for the features, and, when necessary, elaborate on naming conventions and representational conventions.

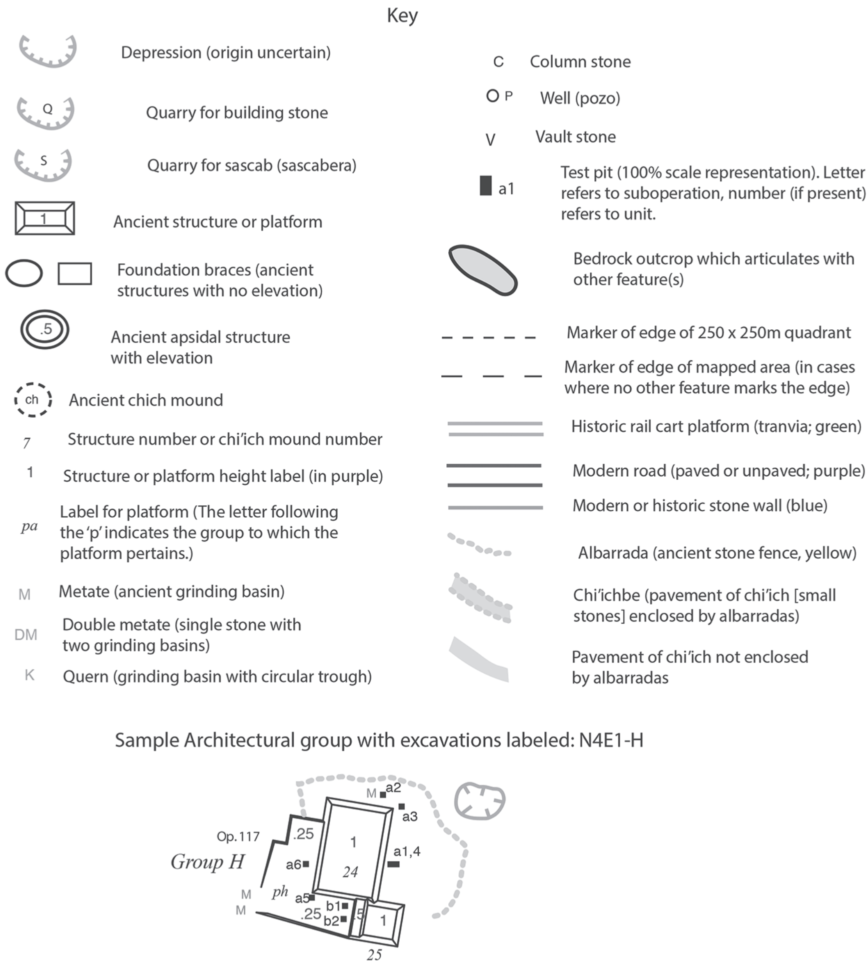

FIGURE 2.2. Key to the detailed Chunchucmil site map and a sample group (N4E1-H). Online version of this figure shows the proper colors and is available here: http://upcolorado.com/university-press-of-colorado/item/3076-ancient-maya-commerce.

BUILDINGS

We mapped 10,163 buildings in 11.67 km^2. This category contains three different elements: structures, platforms, and chich mounds. We do not include all built features into the category "building." For example, we placed *sacbes*, *callejuelas*, *albarradas*, and *chichbes* (each defined below) in the category "linear feature." The total number of buildings mapped is large compared to the number mapped at other sites: 6,345 in 30 km^2 at Calakmul (Folan et al. 2008:299); 6,595 in 17.5 km^2 (21 km^2 for all zones) at Cobá[3] (Folan et al. 2009), 8,390 in 19 km^2 at Dzibilchaltún (Kurjack 1974:94), and 3,382 in 16 km^2 at Tikal (Rice and Culbert 1990:table 1.1). The Chunchucmil map shows that buildings very often cluster into what we call groups. Unlike most other features on the map, each building and group received a distinct name. Furthermore, the conventions for representing structures and platforms are complex. Therefore, this section contains not just descriptions of the three types of buildings and the criteria by which we identified groups, but also discussions of naming conventions and representational conventions.

Structures

Structures are bound spaces that served one or more of a number of functions—housing, food preparation, ritual, storage, and so on. Structures take the form of mounds (a pile of rocks elevated above the ground surface) or foundation braces (stone outlines of buildings with no elevation). We also assume that there were ancient structures that are no longer visible (Chase 1990). Such invisible structures include buildings made entirely of perishable materials and placed on top of platforms as well as perishable and/or nonperishable buildings that have been buried by means of cultural or natural formation processes. We address buried structures in the section below on sources of error. Though not all invisible Maya structures were residences (Tourtellot 1988:437), many could have been (Johnston 2004; Pyburn et al. 1998:42). We account for invisible structures in chapter 5 by increasing our tally of residences by 5 percent when estimating population. This adjustment is purposefully small because of minimal vegetation and soil accumulation as well as the abundant use of rock for construction. Both mounds and foundation braces can be either polygonal (the most common shape being a quadrilateral) or apsidal (shaped like an oval or circle). Several mounds are "split-level": one portion will have a different elevation than another. If one level has a rather small surface area (less than 20 m^2), that level is called an "extension" of the structure. If both levels have a large surface area, we consider the building to be two separate structures, particularly if the building takes the shape of an L, and each arm of the L has a separate elevation. Mounds usually represent the collapsed ruins of buildings that had stone walls, but can also serve as bases on top of which a perishable superstructure was built. In this latter case, the base would have nearly the same surface area as the superstructure. A total of 7,677 structures were mapped in the 11.67-km^2 area.

Platforms

Platforms are stone mounds that usually support several structures and therefore have a much larger surface area than do structures. Also, whereas most structures had roofs, platforms probably never did; their surface areas would have been too large. The structures that stood on the same platform were often arranged on the edges of the platform, leaving a partially enclosed courtyard or patio in the center of the platform. This makes their arrangement equivalent to patio groups (Ashmore 1981). Platforms are sometimes built up from the natural ground surface on all sides, though they are often more like terraces, being built up from the ground surface on some sides but grading imperceptibly into the natural ground surface on others. A total of 1,350 platforms were mapped in the 11.67-km^2 area.

Chich *Mounds*

Chich mounds are low, oval or circular piles of *ch'iich*, a Yucatec word meaning "limestone cobbles" (usually < 15-cm diameter) and gravel (Barrera Vásquez 1980:134; Bricker et al. 1998:83). They rarely measure more than 35 m^2. A *chich* mound is different from similarly-shaped apsidal structures because *chich* mounds do not have larger (usually > 25-cm diameter) facing stones clearly delimiting the edges of the mound. Larger *chich* mounds could serve as platforms for permanent residences (Pyburn et al. 1998) or temporary fieldhouses (Kunen and Hughbanks 2003). Because *chich* mounds allow tree roots to gain purchase and provide good drainage in clayey soils, they may also serve as planting surfaces for tree crops (Kepecs and Boucher 1996). All buildings (structures, platforms, *chich* mounds) are represented by black lines (see note on representational conventions below), though the line for a *chich* mound is dashed. A total of 1,136 *chich* mounds were mapped in the 11.67-km^2 area, yet this number is not as accurate as the number of structures and platforms. Whereas the aligned stones of the retaining walls of platforms and structures often make these features unmistakable in the field, it is hard to be certain that a low, vaguely circular or oval-shaped pile of small rocks is an intentionally built *chich* mound or just a naturally degraded bedrock outcrop.

Groups

Groups can be more of a construct of the archaeologist than a discreet feature left by the ancient Maya. This is because a group consists of a collection of features—be they buildings or linear features or something else—that has been grouped together by the archaeologist by processes of both lumping and splitting. Furthermore, the collections of features that we identify as groups take many forms at Chunchucmil. The most easily identifiable form consists of structures that cluster together to form a patio group (Ashmore 1981). Though we first mentioned patio groups in the context of platforms, many patio groups do not contain a platform (and some groups contain multiple platforms). At Chunchucmil, we benefit from an additional set of features absent at most other sites that help identify groups: stone walls. Such walls, described further below as *albarradas* in the section on linear features, often encircle a set of structures, making it easy to distinguish one group from another. When the Maya themselves built a cluster of structures that share a patio and a similar alignment, or when they built a stone fence around a set of structures, we can argue strongly that such groups are not just the constructs of archaeologists but housed a social unit—usually an extended family household—that was meaningful to the ancient Maya. In chapter 5 we use excavation data to discuss what kind of social units inhabited some groups at Chunchucmil. Nevertheless, even with patio groups and *albarradas*, it can be difficult to draw boundaries between groups. For example, the same two patio platforms that would be designated as separate groups in the absence of *albarradas* must be considered a single group if a single *albarrada* wall surrounds them (see Group S5W6-G). When structures do not cluster into patio groups and when albarradas are absent, there is more room for error in delimiting groups. Isolated structures were not considered to be a group unless they were large (> 100 m^2) or if they were affiliated with some other feature, such as an *albarrada* fragment, a *metate*, or a *chich* mound. Clusters of *chich* mounds were not considered a group unless they had a grinding stone or were at least partially encircled by an *albarrada*. Excavations of a group of *chich* mounds (Op. 84, Group N3E7-A) suggest that, unlike other groups, these may not be the remains of households in themselves but a part of a household or other social group centered elsewhere. To reiterate, these considerations mean that we did not assign certain isolated structures to any group. A total of 1,477 groups were inferred in the 11.67-km^2 area. Of these groups, perhaps a dozen were not completely mapped because portions of them extended beyond the bounds of our map.

NAMING CONVENTIONS FOR BUILDINGS AND GROUPS

Structures

Within each 250-by-250-m quad, structures are named numerically, beginning with the number 1. Thus, a sample structure name would be N4E1–25. On the N4E1 quad map, the number 25 appears next to this structure (figure 2.2). Structure numbers are to the side of buildings and they are italicized and presented in a font with serifs, whereas the numbers that indicate structure heights (when present) are at the top of the building and not italicized and are represented with a non-serif font. In the full-color digital maps, structure numbers are black and height numbers are purple.

Groups

Names of groups include the name of the quad they are in plus a distinct letter. Thus, structure N4E1–25 pertains to Group N4E1-H. On the N4E1 quad map, the label "Group H" appears at the group (figure 2.2). Groups that have been excavated (see table 3.5) carry an additional "Op." label (see below: "Excavations/Operations"). For example, group N4E1-H received eight 1-by-1-m test pits. The label "Op. 117" refers to these excavations. Therefore, on the map, the label "Op. 117" accompanies the label "Group H." Finally, the first 40 or so groups to receive test pits were also given informal names, taken from Yucatec Maya names for trees and animals. Operation numbers supersede this earlier nomenclature, though most of these names can still be found on the map.

Platforms

Platforms are labeled with a *p* and then the letter of the group that they are a part of. In other words, the platform in Group H of quad N4E1 is named N4E1-ph (figure 2.2). On the map itself, only the label *ph* appears. If a group, such as Group N1E1-G, has more than one platform, they are labeled sequentially: *pg1*, *pg2*, and so on. If what appears to be a single platform has two separate elevations and the difference is 20 cm or greater, each area with a distinct elevation is considered a distinct platform. In some cases, the same platform supports enough structures to delimit two or more courtyards that are completely sealed off from one another. As long as the elevation of each courtyard is the same, each courtyard is considered to be part of the same platform. In order to provide a system of reference that distinguishes between sealed-off courtyards, however, the first courtyard of N1E1-pg1 will be labeled *pg1a* and the second *pg1b*.

Chich *Mounds*

We assigned names to *chich* mounds in roughly the same way that we assigned them to structures, but *chich* mound names always carry the preface *ch*. For example, the full name of the fifth *chich* mound in quad S5W7 is S5W7-ch5. On the map, most *chich* mounds also have the label *ch* inside them so that the number given to them is clearly understood to be a *chich* number as distinct from a structure number.

Conventions for Representing Platforms and Structures

In one of Jorge Luis Borges's (1975) fictional worlds, the emperor's cartographers make a map that is the same size as the empire itself. In the world of nonfiction, however, all maps are reductions. Not only are they smaller than what they represent, they carry less information. Much like other maps of Maya sites, the conventions for representing features at Chunchucmil are standardized. The standardization of representational conventions contributes to the reduction of the amount of information carried by the map. For example, the inhabitants of Chunchucmil used a variety of techniques to construct stone boundary walls of various sizes (see below for more information on *albarradas*). However, in our map, we use a representational convention that communicates only the length and direction of *albarradas*, regardless of variation in width, height, or construction technique. The most notorious standardization found in maps of Maya and other sites is the convention used to represent ancient mounds whose specific dimensions and other details—such as presence or absence of rooms—are not apparent before excavation. This convention uses nested polygons to represent mounds—which today look like disorderly piles of stone—as geometric prisms. Prisms are not straightforward representations of what is on the ground today. Some of the earliest makers of Maya maps noted that buildings that were once rectangular took on the shape of ovals after they collapsed (Bandelier 1884:316). In his map of Copán, Maudslay (1889–1902:1:18) noted that the "lines on the plan are more regular than those presented to the eye at the ruins." Though explorers such as Stephens and Catherwood used prisms well before Teobert Maler, the turn-of-the-century explorer, some archaeologists colloquially refer to the use of prisms as Malerization. Unlike our technique for representing *albarradas*, the use of prisms is not a straightforward reduction because the goal is not to represent, in simplified form, the shape of the disorderly stone piles as they appear today. Rather, the goal is to extrapolate from these piles the clean, polygonal shapes that the buildings had before they crumbled. Therefore, creating prisms requires more than just sketching what is on the ground. It requires "professional vision" (Goodwin 1994): interpretative judgment informed by prior experience with Maya architecture.

Different archaeologists follow different procedures for transforming what they see on the ground into prisms. In other words, prisms represent a family of techniques, rather than a single technique. Published commentary on procedures for drawing prisms is rare (G. Andrews 1984; Carr and Hazard 1961; see Wolf 1997 for the most thorough history of Maya maps). This no doubt contributes to the existence of multiple and conflicting versions of prisms, which means that it is not always possible to infer certain dimensions of the building that a prism represents. In our map, the outer polygon of the prism represents what we believe is the outer edge of the original building. With low mounds, the stones that mark the actual edge of the building are often visible before excavation. However, with high mounds, the actual edge stones are often buried, which means that the higher the mound, the more room for error in our placement of the edge. We follow Carr and Hazard (1961) in using the distance between the outer polygon and the inner polygon to communicate the height of the mound as is visible today. Thus, for a 2-m-high mound, the distance between the inner and outer polygons of the prism will be two scaled meters. The height of most mounds is also written on top of the mound. Because of the convention that the distance from the outer polygon to the inner polygon represents the height, prisms give the impression that the slope between the base and the top of the building is a constant 45 degrees. This impression is often not correct (Hutson 2012a).

LINEAR FEATURES

Linear features consist of *albarradas*, *callejuelas*, *callejones*, *chichbes*, and *sacbes* (for additional detail about these features, see Magnoni et al. 2012). Each of these falls under Ashmore's (1981:45) category of integrative features: "entities which serve to channel access whether by facilitating movement or impeding it." All are human built, though they sometimes take advantage of natural features such as bedrock outcrops. *Albarradas* are alignments of rough-cut or unworked stone resembling stone field walls though nearly always completely collapsed (figure 2.3). They are represented as yellow lines with rounded dots on the digital map and gray lines with rounded dots in print figures. Most *albarradas* serve to encircle, at least partially, a group of structures, though a few do not appear to be affiliated with any particular structures. Given that they are most often associated with architecture, they are distinct from the field walls common all along the east coast of Yucatán at sites such as Cozumel, Xcaret, and Tulum. When an *albarrada* encircles a group of domestic structures, we refer to the enclosed land and architecture as a *houselot*. Figure 2.4 shows several examples of ancient houselots. Houselots enclosed by stone walls are common in villages across Yucatán today. Toward the center of the site, where settlement density is highest, most *albarradas* that encircle groups of structures also serve as boundary walls shared by the bordering houselot. *Albarradas* enclosed structures at other Classic-period sites such as Cobá (Benavides Castillo and Manzanilla 1987; Folan et al. 1983), Dzibilchaltún (Kurjack 1974; Kurjack and Garza Tarazona de González 1981), Becán (Thomas 1981), the Río Bec region (Turner 1983), Cuca (Kurjack and Garza Tarazona de González 1981), and Calakmul (Folan et al. 2008). At these sites, however, *albarradas* were not as extensive and were rarely shared between houselots (see Magnoni et al. 2012:316 for information on *albarradas* at Terminal Classic and Postclassic sites). We documented 200 km of *albarradas* within the 9.3-km^2 polygon.

Callejuelas are pairs of *albarradas* running parallel, delimiting walkways that serve as critical paths for movement from one part of the site to another. In other words,

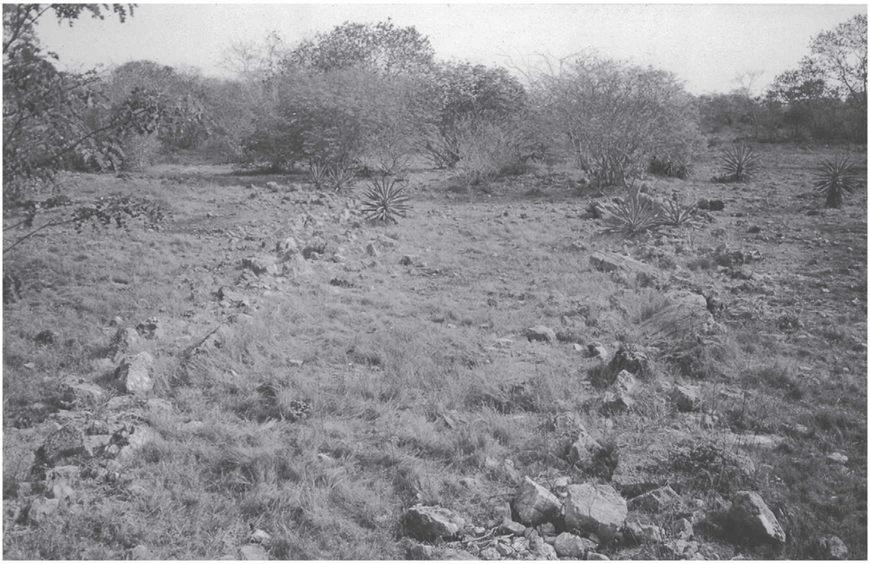

Figure 2.3. Photo of an example of paired *albarradas* that make up a *callejuela*.

callejuelas are like the public streets of a city. A *callejón* is a short *callejuela* that connects a group of structures to another *callejuela* or open space. A modern analogy would be a driveway that connects a house to a road. A *chichbe* is like a *callejuela* or a *callejón* that has a fill or pavement of small stones (< 15 cm) in between the *albarradas* that define its sides (figure 2.3). However, whereas *callejuelas* and *callejones* serve as walkways, not all *chichbes* at Chunchucmil have this function; some appear to serve as boundary walls around houselots. In fact, around some residential groups a portion of the group is enclosed by an *albarrada/callejuela* and a portion by a *chichbe*. At other sites, features resembling *chichbes* appear to have served exclusively as walkways and are therefore called *andadores* (Benavides Castillo 1981; Vargas Pacheco, Santillan, and Vilalta 1985). Some of the *chichbes* at Chunchucmil may have been used as *andadores*, to facilitate walking. We documented 43 km of *chichbes* within the 9.3-km^2 mapped polygon block. *Chichbes* are represented as *callejuelas*—a pair of lines with rounded dots—but with gray shading in between the lines.

Sacbes are raised, relatively straight causeways that connect directly with large architectural compounds. They consist of a rubble core held in place by a pair of retaining walls made of cut stone. *Sacbes* are represented by black lines and labeled on the map with numbers, beginning with Sacbe 1. We have documented 20 sacbes at Chunchucmil, 19 of which are in the central 9.3 km^2 (figure 2.5; Sacbe 20 is on the SE transect). Whereas *albarradas*, *callejuelas*, *callejones*, and *chichbes* meander,

FIGURE 2.4. Map showing examples of houselots in Chunchucmil from quad S2E1, in the residential core directly south of the site center.

sacbes generally run very straight (Shaw 2008). Three *sacbes* at Chunchucmil (1, 8, and 10) are composed of segments with different orientations. The most pronounced change in orientation is on Sacbe 8, which makes a 28-degree turn as well as some smaller turns. The fill of a *sacbe* often consists of the same small stones as the surface of a *chichbe*, but *sacbes* are straighter and have worked stones on their edges. *Sacbes* are also wider; they range from 4 m to 25 m wide whereas most *chichbes* are between 3 m and 5 m wide. Modern construction has damaged three of the sacbes (14, 16, and 17) and Late/Terminal Classic people damaged Sacbe 12 in the process of constructing later platforms. Two sets of features (the dotted lines to the west of Group S2E2-A and linear features to the east and west of Group S1W2-A) could

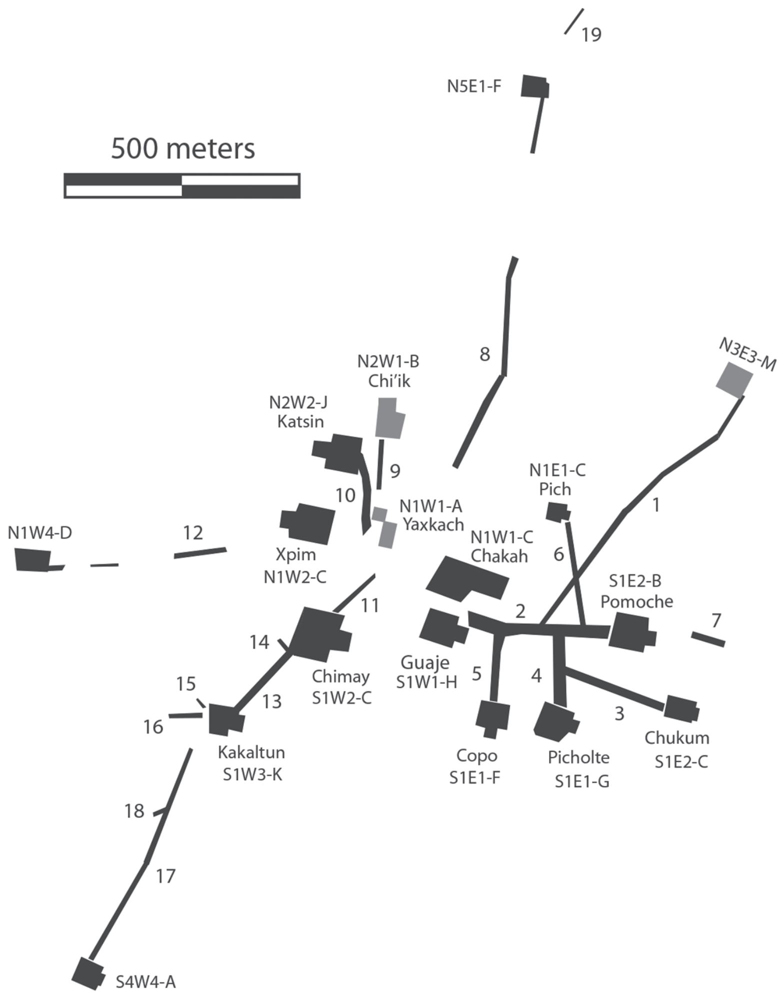

Figure 2.5. Map of the numbered *sacbes* at Chunchucmil as well as the quadrangles and other monumental groups (in gray) with their labels.

also potentially count as *sacbes* damaged by the ancient people of Chunchucmil, but the features by Group S2E2-A have almost no elevation and the features by Group S1W2A might instead be a *callejuela*. All but Sacbes 15 and 20 have well-defined destinations—architectural groups or other *sacbes*—at both ends. For Sacbe 15, modern damage as well as ancient reuses of space make it difficult to determine the intended western endpoint of Sacbe 15. Sacbe 19, the northernmost, appears not to have been completed in ancient times: it connects to a residential group on its west side but runs 60 m to the east, not aligned with anything farther to the east, before stopping in an area with no visible features. Fourteen sacbes have a monumental architectural compound at one or both of their ends, and 12 of these compounds are quadrangles, which we define in chapters 3 and 5 as the most common configuration of monumental architecture at the site. Sacbe 8, the longest one, measures 790 m, although it exists as a *callejuela* for 150 m and disappears for 100 m. The second longest is Sacbe 1, measuring 650 m. Sacbe 15 is the shortest, measuring 30 m.

Subsurface Features

Subsurface features include depressions, wells, quarries, and *sascaberas*. The latter three features are all marked on the digital map by green lines with hachures. Chapter 5 discusses their distribution across the site. Beginning in 1998, we added the labels *Q* and *S* to distinguish quarries and *sascaberas*, respectively. Unfortunately, the approximately 47 ha mapped in 1996 and 1997 do not contain these distinctions. This area is located in the NE corner of the map, in block 3, consisting of quads N1E5, N2E5, N2E4, N2E3, N3E4, N3E3, N3E2, and N4E3 and small portions of neighboring quads N2E1, N2E2, N3E1, and N4E2. The lack of such distinctions in this sector of the map means that the counts of quarries and *sascaberas* given below are slightly lower than the actual count.

Depressions

There are no *cenotes* (karstic sinks that extend to the water table, providing pooled water) or *dzadzes* (karstic sinks that extend close enough to the water table that the soil at the bottom is muddy; Houck 2006) and no major natural caves (Kepecs and Boucher 1996) at the site. Some depressions on the map are marked with an *R* for *rejollada*. *Rejolladas*, like *cenotes*, also result from dissolved limestone, but near Chunchucmil, they are relatively shallow (less than 2 m deep) and small (less than 20 m wide) and therefore are not comparable to the deeper (10–20 m deep), broader (sometimes more than 100 m wide) *rejolladas* found in the center of the northern plains (see chapter 6 for more information on *rejolladas*). Depressions with no evidence of cut rock whose sides have a slope of less than 90 degrees show up on the digital map with the customary green hachured lines, but with no letter. A total of 435 of these were mapped. Most of these are probably natural features for drainage of water, though some could be human-made quarries. The map likely underrepresents these depressions as their non-human-made appearance caused mappers to ignore them from time to time, particularly when they were not in association with buildings or linear features.

Wells

Ancient wells are infrequent but often distinguishable from wells built after the conquest because they normally have large stone blocks around the surface. Most modern wells can be distinguished based on the engineering of the shafts and building materials around their rims. Sometimes, however, mappers could not determine on the spot whether a well was ancient or historic. We located 18 ancient wells, three wells that may or may not be ancient, and dozens of modern wells in the 9.3-km^2 polygon. The water table occurs at about 3 m below the surface. It is possible that ancient wells were reused in modern times. The number of ancient wells we found is small, considering the size of the site and density of occupation. An unknown number of wells were probably filled in and were therefore invisible to us in the field.

Quarries

Depressions with at least one vertical or near vertical face (e.g., 90-degree slope) with exposed stone were recorded as quarries and labeled with a *Q*. Since there are natural bedrock formations that resemble what we labeled as quarries, we admit that some depressions which we labeled as quarries may actually be natural features. A total of 210 quarries were mapped.

Sascaberas

Depressions with at least one overhanging face were recorded as *sascaberas*. A *sascabera* is a location where people have dug underneath the capstone to extract *sascab*, a soft, friable limestone used to manufacture plaster (Littmann 1958; see also chapter 6, this volume, for additional details). *Sascaberas* were labeled with an *S*. There is wide variation among *sascaberas*. Some were dug so intensively as to leave caves with multiple passages (Dahlin et al. 2011). Though it is quite rare, some *sascaberas* extend to the water table. Others were shallow and small, not very distinct from what we recorded as quarries, though erosion and collapse of the capstone may have concealed a larger cavity. By the same token, such erosion and collapse could have concealed *sascaberas* to a degree that they are not recognizable at all. A total of 270 *sascaberas* were mapped.

Metates, Columns, and Other Distinctive Stones

Special stones include *metates*, querns, double *metates*, columns, vault stones and Puuc stones. A *metate* is a broad stone with a trough in the middle made by grinding various materials with a handheld stone called a *mano*. *Metates* at Chunchucmil can be subdivided into those with rectangular troughs ("trough" *metates*; Pritchard Parker 1994) and those with have circular or oval troughs ("basin" *metates*; see

Watanabe 2000 for metric variation among *metates* at Chunchucmil). We made no distinction between trough and basin metates while mapping the site but Watanabe's subsequent detailed study of metates, reviewed in chapter 10, explores this difference further. A total of 2,708 metates were mapped in the 11.67-km^2 area. Chapter 5 discusses their distribution across the site. We classify 74 of these 2,708 metates as querns. Querns are similar to basin *metates* but the profile of the interior side of the basin is concave, such that the rim of the basin has an overhang. Querns also have spillways leading outside of the basin. We attempted to distinguish querns from other *metates* while mapping but admit that it was not always clear in the field whether or not to classify a *metate* as a quern. Stones with two troughs, usually side by side, are called double *metates*. Of the 2,708 metates, we classify 22 as double *metates*. In other words, we found 11 stones at Chunchucmil that each hosted a pair of *metates*. Columns are circular stone discs of variable diameter and height. Some were found in situ. Vault stones have a vaguely triangular or boot-shaped profile and pertain to Late and Terminal Classic corbel vaults. Stones from vaults of earlier buildings are not nearly as diagnostic. Thus, we assume that our map grossly underrepresents the number of true vault stones and therefore the number of vaulted buildings at the site. Puuc stones are very finely worked architectural stones with flat faces or faces with geometric designs. There are relatively few of these and they cluster near platforms with lots of diagnostic ceramics from the Late/Terminal Classic periods (see chapter 3).

Historic Features

A series of features were built after the Spanish conquest. Most were built in the twentieth century. These include stone fences, wells, corrals, feeding troughs, quarries, and, more than anything else, dozens of kilometers of *tranvías*: low, linear, stone platforms for rail carts that carried agave spears to the hacienda at the beginning of the twentieth century. The key in figure 2.2 shows how we distinguish these modern features on the digital map.

Excavations/Operations

The map shows the location of excavations. When PREP began, each of the different kinds of archaeological work received an operation number. Operation 1 was mapping, operation 2 was surface collections, operation 3 was test pits, operation 4 was excavations of *sascaberas*, operation 5 was excavations of ancient wells, operation 6 was excavations of natural drainage features, operation 7 was soil pits, operation 8 was cleaning of looters' pits, and operation 9 was broad excavations of buildings. Letters after each of these numbers referred to the location of the operation. The first group to receive test pits would therefore carry the operation label 3a, and the first group to receive horizontal excavations would carry the operation label 9a. To accommodate the fact that the number of test-pit operations soon greatly exceeded the number of letters in the alphabet and to simplify cases where the same structure group carried more than one operation designation—for example group S2E2-F contains both Op. 3g and Op. 9c—we changed the system in 2000 so that each structure group to be excavated received only one operation designation, regardless of the type of excavation. As noted above, the first 40 or so groups to receive test pits were also given informal names, taken from Yucatec Maya names for trees and animals, for ease of reference in the field. Where possible, we gave suboperation designations to particular buildings and the space around them within a structure group, and each excavation square within the suboperation had its own number. Thus, Op. 117b2 refers to the second excavation unit in suboperation b (near structure 25) of Op. 117, which took place in Group N4E1-H (see figure 2.2). In total, 167 areas of the site received at least one form of excavation and this includes 161 specific architectural compounds in the 9.3-km^2 polygon (see the discussion of sampling strategy in chapter 3 and the tables in that chapter).

The map shows the location of every test pit and block excavation dug at Chunchucmil, not including 50-cm by 50-cm shovel tests. Such shovel tests were extensively deployed in five groups—S2E2-K/Xnokol (Op. 9b/3f), S2E1-G/Kaab' (Op. 9d/3h), S2E2-F/Aak (Op. 9c/3g), S2E2-C/Muuch (Op. 10) and S4W8-F/Balam (Op. 33) (Hutson et al. 2007; Magnoni 2008). Excavations are represented at their correct scale. Each excavation operation contains both the operation label (e.g., Op. 117) and the name of the structure group where the operation was located.

SOURCES OF ERROR

We are confident that we succeeded in finding most of the built features that have had the good fortune of being preserved as visible features on the current land surface. We are also confident that our maps accurately show where these features are located. We believe our map represents an improvement over the work at Dzibilchaltún, where *albarradas* were not recorded and where some spaces between large clusters within the 19-km^2 map were never surveyed (Kurjack 1974:80). We also believe our map compares favorably with Folan's maps of Cobá, where the maps from zones II, III, IV, and XIII do not show actual spatial relations between features (Folan 1983:8). Furthermore, recent work (Magnoni 2015) as well as comparisons between Folan's zone 1 map and Garduño Argueta's (1979) maps reveal inaccuracies with the zone 1 map. Nevertheless, several conditions generated sources of error at Chunchucmil. We begin by discussing vegetation. Folan (1983:7–8) has argued that the map of Cobá improves upon Puleston's (1983) survey work at Tikal because of better visibility at Cobá. At Chunchucmil, grazing animals, frequent wildfires, and mild vegetation (due to less soil, less rainfall, and more bedrock) made visibility even better. Low-scrub forests in some parts of the site occasionally made walking difficult, but maneuverability on such terrain is far easier than in the henequen fields that covered Dzibilchaltún when that site was mapped. Visibility was generally good enough that we did not systematically take notes on visibility conditions. Stark and Garraty (2008) distinguish topographic visibility (ability to detect minor changes in elevation) from surface visibility (ability to see the ground surface). In the 9.3-km^2 contiguous polygon, rare patches of knee- to waist-high grass impeded both topographic and surface visibility, probably causing us to miss surface features such as *metates* and topographic features such as low (< 0.2 m) buildings. Patches of high, thick brush with poor topographic and surface visibility occurred on the transects, though these patches were rarely larger than a few thousand square meters.

Beyond vegetation, burial by sediment also causes mappers to miss ancient features (Johnston 2004). Fortunately, the absence of rivers and the extremely flat topography at Chunchucmil mean that natural alluviation and colluviation have had little or no effect. Natural sedimentation and soil-formation processes consist mostly of the weathering of bedrock and wind-blown deposition of volcanic ash and Saharan dust (Muhs et al. 2007; Perry et al. 2003), processes that rarely bury ancient features. Bioturbation can also bury features, but the extremely shallow biomantle depth around Chunchucmil (average 30 cm) limits the degree to which stone buildings sink and soil rises. The main contributor to the burial of ancient features is later construction by the ancient Maya, and in this case, later structures are directly on top of earlier structures. Of the 800 plus test pits that were dug in areas that today appear to have had no mounds whatsoever, only one test pit recovered a buried structure. In this particular case (Operation 32/Group N1W2-E), the buried structure was within 5 m of the edge of a later structure. Since the later structure was not excavated, we cannot tell precisely how the earlier structure was buried, but we suspect that it was intentionally buried by the later builders in order to create a flat space.

Though we feel that very few features were overlooked in our mapping efforts, we concede the effects of human error. About a dozen different people mapped features in the field. Though all people who contributed to the map were given ample training, double checking of work revealed mistakes of two different kinds. First, aspects of features were overlooked. For example, double-checking the work of a less-experienced mapper revealed that a split level platform in which one side is 25 cm higher than another was represented as having a single, constant height. Or, a low apsidal/oval structure was represented as being rectangular. The second kind of error involves dismissing small, somewhat ambiguous, artificial features as natural features or classifying natural features as artificial features. We believe such errors are few, however, because mappers who struggled were soon assigned to other tasks and much of their work was redone by people with more experience. Those who ended up doing most of the mapping were those who proved themselves to have an excellent eye in the field. Good mappers, however, are also fallible. Taylor (1974:39) has shown that different people mapping the same feature map it in slightly different ways simply because of small differences in how people see things on the ground. Furthermore, we have found that the same person might see something differently after many years. Both of the coauthors of this chapter, who have done more mapping than anyone at Chunchucmil, have had the experience of returning to an architectural group mapped years before and seeing in one's own early map a detail or two that ought to be fixed. Such experiences instigated another quality-control measure. As we got to know more and more of the site and had a better idea of what spatial patterns were normal and what patterns were abnormal, we double-checked some areas of the map that, even if mapped by experienced mappers, struck us as abnormal, suggesting that they may have been mapped incorrectly. Unfortunately, we were not able to double-check all such areas. An area with abnormal configurations of buildings that was not fully double-checked is at the south edge of the map, in a densely settled area in the south central portion of block 6.

Human alterations to the landscape also mitigate the accuracy of our map. We refer to these disturbances in the following section.

DISTURBANCES OF THE RUINS

Luckily, the ruins of Chunchucmil have suffered rather little disturbance over time. The main sources of disturbance are prehispanic modifications to earlier prehispanic features, and twentieth-century activities. The former source of disturbance has been discussed above and in detail by Magnoni (2008; Magnoni et al. 2008). Modern disturbance consists of damage from several activities, listed from most destructive to least destructive: henequen harvesting, the construction of transportation features, ranching, and irrigation projects for citrus and papaya. Much of the land occupied by the ancient ruins was under henequen cultivation in the first half of the twentieth century. To move agave spears from the fields to the processing facilities at the core of the Chunchucmil hacienda, laborers built an impressive system of tracks for rail carts (marked as green parallel lines on the map). The rail tracks are common in blocks 0, 1, 2, 6, 7, 8, and 9, and are usually less than 2 m wide. Though they plow right through any structure that is less than 2 m high, they usually swerve to avoid taller structures. Transportation features consist of a paved road connecting the contemporary villages of Chunchucmil and Kochol and three unpaved roads originally built as rails but traversable today by automobiles. Both types of road are marked as blue parallel lines on the map. Long double parallel black lines on the map are ancient Maya roads: *sacbes*. The paved road (and an earlier, parallel, unpaved road immediately to the south) has destroyed all features along a roughly east/west swathe that measures anywhere from 15 to 30 m wide, cutting through blocks 1, 4, 8, and 9. The three unpaved roads (running north/south in blocks 1 and 2, north/south in blocks 1, 3, and 4, and east/west in blocks 6 and 7), each about 4 m wide, have damaged portions of buildings. Ranching has resulted in the salvaging of stones from archaeological features in order to construct long fences (marked as blue lines on the map) throughout the site and small features such as troughs and sheds. Irrigation projects have resulted in the construction of dozens of wells, most of which are south of the paved road. The wells are small (no more than 2 m in diameter) and are usually placed in areas without architecture.

CONCLUSIONS

Perhaps the most important conclusion drawn from the results of the map of Chunchucmil is the large number of buildings (over 10,000) found within a relatively small space (less than 10 km^2). This finding suggests that the city had a large, dense population and poses the question of how so many people fed themselves. We cannot go further along this line of thought, however, until other pieces of the puzzle are in place. For example, we cannot estimate population until we know what portion of the city was occupied contemporaneously and where the site's high densities drop off. Therefore, subsequent chapters discuss the chronology of the site (chapter 4) and the shape of the city (chapter 5), with particular attention to thresholds in settlement density, which assist in delimiting the city's edges and estimating population. Furthermore, we cannot talk about a city's food supply until we understand the local environment and the crucial links between those who lived at Chunchucmil and those who lived in its hinterland. Thus, chapters 6 and 7 discuss the natural resources near Chunchucmil and chapter 8 discusses Chunchucmil's hinterland settlement.

NOTES

1. GPS points were collected with a Trimble 4700 receiver and differentially corrected with a secondary receiver, which provided coordinates with an accuracy of 1 cm horizontally. We thank UNAVCO for loaning us the equipment.

2. See Magnoni and Hixson 2010 for a technical review of tools and technologies used for the recording, storage, processing, analysis, and visualization of the archaeological data of Chunchucmil.

3. The figure of 17.5 km^2 was arrived at by georeferencing the Cobá survey zones for which mapping methods have been described (zones I, II, II, IV, XIII: see Folan 1983:figure 1.3). An additional area of at least 3.5 km^2 has been surveyed, though the survey methods have not been described.