Spatial Logic and Maya City Planning: The Case for Cosmology

Kristin Landau

Spatial logics are guiding ideals for how space should be structured, as determined by the culturally embedded decisions of architects and builders. I test various spatial logics within sub-communities at the city of Copan, Honduras, to better understand principles behind the planning of paired groups. Results support a prevailing cosmological logic, in keeping with work on concepts of directionality, and particularly with the significance of north and salience of a north–south building axis. The anthropology of space and place has gained much from an increased reliance on archaeological literature, as well as the closely related fields of geography and empirical Geographic Information Systems (GIS) analyses. Because we shape and are shaped by landscapes, consideration of spatial relationships should help us evaluate and refine our conceptions of social relations.

Landscape archaeology, settlement pattern research and urban planning studies show how and why patterns appear as they do: Why does Teotihuacan have a gridded plan? Is ancient Cuzco really in the shape of a puma? Why are the windows at the 'observatory' of Chichén Itzá oriented towards very specific directions, and not towards others? More than likely, multiple material and social conditions were at play. Although it may be impossible and unproductive to tease them apart, investigating the salience of some variables over others reveals the spatial logics — and by extension, social relations — that influenced past behaviours. By spatial logic, I refer to the guiding ideals of how space should be structured as determined by the prevailing culturally embedded reasoning of architects and builders, or those who managed land use (Hutson & Stanton 2007; Prem 2000). A focus on spatial logic also suggests *ideal* spatial practices that may or may not be realized on the ground, due to environmental factors, historical processes or both (Hauser-Schäublin 2004; Lefebvre 1991, 38–9, 250).

In this article I address paired groups within sub-communities at the ancient city of Copan, Honduras, and employ Geographic Information Systems (GIS) analyses to evaluate the possible influence of various factors affecting city layout. Essentially, I re-evaluate Wendy Ashmore's (1991) hypotheses concerning Maya city planning principles using GIS-derived methods, and discuss the dominant spatial logic that could have resulted in Copan's particular urban pattern. My overall goal is to decipher space (*sensu* Lefebvre 1991) in order to reveal spatial practices, and thus something about the social relations of Copan's ancient residents (Richards-Rissetto & Landau 2014).

Debates on Maya city planning

In a well-known 1991 paper, Wendy Ashmore proposed a model for ancient Maya architectural arrangements based on the understanding of cardinal directions as symbolically charged positions. She offered a set of planning principles — or a spatial template — linking Maya cosmovision to material, physically grounded, urban designs. Ashmore (1991) tested the spatial template at a pair of elite building compounds within a sub-community known as Salamar to the north of the city centre of Copan. She expected that the pair as a whole would demonstrate symbolism associated with how the Maya perceived north and, in addition, that each side of the north–south oriented pair would complement the other in dualistic fashion.

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At the conclusion of the excavation season, Ashmore (1991, 216) found the northern and southern sides expressed symbolisms relating to the north and south directions in Maya cosmovision, and that indeed 'architecture occupying the northern position is itself a microcosmic arrangement', nested within the larger Copan city layout.

In a series of follow-up articles in the early 2000s, Ashmore and colleagues Jeremy Sabloff, Michael Smith and Ivan Šprajc discussed questions of scientific rigor and subjectivity in the study of cosmology and Mesoamerican urban planning (Ashmore & Sabloff 2002; 2003; M.E. Smith 2003; 2005; Šprajc 2005). While Michael Smith (2003, 222; 2007, 33) argues that clear and direct evidence exists for the cosmological design and planning of *some* ancient cities, he believes it difficult to identify the role of cosmology in Maya or Mesoamerican urban cultures due primarily to a lack of texts that describe urban planning ideals. Without such direct evidence, M.E. Smith (2003, 223) cautions Mesoamerican archaeologists to consider alternative explanations for urban planning, such as conscious efforts to maximize energetic efficiency for local mobility or emulation/memorialization of other major cities. While there are no known Classic Period texts that describe or represent an ideal city in the Maya area, particular iconographic representations of sensing in sculpture and later in books, as well as concepts such as *–ichnal,* defined and discussed below, can provide insight into past cognition. In the following, I more fully describe the paired group phenomenon at Copan and then review the methods and results of various GIS-based analyses designed to evaluate potential city planning factors, specifically energetic efficiency and cosmology.

Maya cosmology and astronomy

Scholars in the Maya area have long studied how astronomy, cosmology and religion are expressed in spatial form. This research tendency is likely due to the prevalence of images (sculpture, iconography) and writing that attest to the fundamental role celestial events played in worldview, and exploration into how they may have been expressed through material culture and spatial practices. Since the 1970s, the interdisciplinary field of archaeoastronomy, as developed by Anthony F. Aveni and colleagues, has offered the most systematic and empirical examinations of the relationship between astronomy, cosmology and architecture (e.g. Aveni 1977; 1980; 1989; 2001; 2008; Aveni & Hartung 1986; Benson 1981). Today, such writing ranges from popular accounts (e.g. Aveni 2009; Freidel *et al.* 1993; Schele & Freidel 1990) to scholarly descriptions based on ethnographic, ethnohistoric, linguistic, or archaeological evidence (e.g. Aveni & Hartung 1986; Broda 1982; Gossen 1974; Hanks 1990; Jones 2000; León Portilla 1988; Tedlock 1982). Here, I limit the term cosmology to its religious sense, where it signifies particular conceptions of the earth and wider universe, as well as the creation and end of the world. While the Classic Maya (AD 250–900) were not a homogenous group, consistent cosmological themes across space and time include a three-planed universe entailing a watery nine-layered Underworld, terrestrial Middle World and sacred Upper World, divided into 13 parts (Hanks 1990; León Portilla 1988, 71; Tedlock 1982). Elements such as Ceiba trees, pyramidal structures that entombed royal ancestors, or particular gods like the Bacabs were each seen as an *axis mundi*, connecting the layers of the universe and holding up the sky.

While the terrestrial world is separated into four parts according to the cardinal directions, linguists are divided on whether ancient Mayan contained words for north and south, or if north and south were considered 'moments between', or to the right and left, of the sun's path east (sunrise) to west (sunset) (Ashmore 1991; Bricker 1983; Brotherston 1976; Coggins 1980; Gossen 1974; Vogt 1976; Wisdom 1940). Byron Hamann (2002, 712–13) makes clear that for modern Mam speakers, *jawni* and *kubni* may reference north and south, but primarily signify up and down, such that elevation is referentially more important than direction. For the indigenous people of Chamula, Mexico, east is the primary direction, north signifies the sun at zenith (when it is directly overhead, or up), and south and west connote the dark, damp underworld (Coggins 1980; Gossen 1974).

Archaeologists are increasingly attentive to how ancient landscapes might have been perceived, and the Aristotelian five senses are believed to provide a link to cognitive understandings of the local and broader environment (Fahlander & Kjellström 2010b; Hamilakis 2001; Hamilakis *et al.* 2002b; Houston & Stuart 1998; Houston *et al.* 2006; Houston & Taube 2000; Ingold 2000; Shiffman 2011). Spatial perception envisions human beings as sensible creatures who experience signs, signals and outside cues embedded into spatial form and aesthetic; evocative spaces produce emotional effects in viewers (A.T. Smith 2003, 73; Taçon 1994).

The corpus of figural representations of seeing, smelling, hearing, tasting and touching has greatly facilitated archaeological detection of sensory perception among the Maya. While some argue that archaeologists' Western bias leads to an overvaluation of, and thus emphasis on, vision as *the* experiential

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mode (Fahlander & Kjellström 2010a; Hamilakis 2001; Hamilakis *et al.* 2002a, 5), Tim Ingold (2000, 269) argues conversely that the Western bias holds an impoverished concept of vision and creates a false opposition between vision and the other dominant sense of hearing; cross-cultural research suggests that the distinction between vision and hearing is not natural nor universal, but a historical artefact of western cultures. Nonetheless, archaeological, ethnohistoric and ethnographic evidence all point to a pan-Maya prioritization of sight.[1] In near synaesthetic fashion, involving more than one sense, visual stimuli triggered perception in hearing and smell. Similar to the ancient Greeks and medieval descriptions of vision, it seems the Maya held a 'communion-oriented notion of sight' that combined internal will and external result (Houston *et al.* 2006, 136). Therefore one could effect change simply through the agentive act of seeing; observation of ritual acts or ceremonies was not epiphenomenal to, but constitutive of, the very acts themselves. Observers witnessed, authorized and validated the events they saw. Similar to more recent theoretical conceptualizations of landscape, for the Maya seeing was relational and interactional. The Maya also associated seeing with power. As the *Popol Vuh* creation story relays, the first people of the present creation were all-seeing and all-knowing; they were thus too much of a threat to the gods who created them and were blinded (Houston & Taube 2000, 281). Likewise, it was the eyes, and sometimes ears and mouth, which were destroyed in acts of monument mutilation, in order to deface the king by destroying his perceptive capabilities (Houston & Stuart 1998, 88; Houston *et al.* 2006, 170; Normak 2010).

The Maya concept of *–ichnal* refers to a corporeal field of interaction that includes the totality of objects within view, each conceived as a participant (Hanks 1990, 89; Houston & Taube 2000, 287). Significantly, Stephen Houston and colleagues note that the appearance of this term in Classic Period hieroglyphic inscriptions is so intriguing because 'Without exception, the entity to whom an *–ichnal* belongs is either a ruler or a deity' — some person or being in power (Houston & Taube 2000, 287; Houston *et al.* 2006). For the Maya, individual perception was not simply a landscape vista or an all-embracing view of architecture, but a reciprocal act predicated heavily on the involvement of others. Shannon Plank (2003, 98, 178, 183) adds that Maya buildings must be conceived as actors and possessors of *–ichnal* fields — they can have identities as specific cosmological beings — in order to understand Maya city planning. 'Buildings were configured according to sensory properties that can only be understood through culturally bound ideas about sight and its creative and ratifying qualities' (Houston *et al.* 2006, 134).

For the Classic Maya, the perceptual field was preferably 'down,' to overlook and encompass lower-ranking persons. The complementary pairs of right/left, up/down and back/front are hierarchically related, with preeminence for right/clockwise/male/east/up (right hand, great, large, principal, true) over left/counterclockwise/female/west/down (subordinate, left-handed, untrue). Sidedness signified social status and was also a fundamental organizing principle for structure and meaning in ancient Maya art (Gossen 1974, 31; Palka 2002, 423; Vogt 1976).

Based on these spatially anchored elements of Maya cosmology and worldview, two major factors affecting city planning involve elevation and vision. On a sensual level, the Maya primacy of vision and its association with powerful people's *–ichnal* suggests that the more powerful classes would have had a greater view downward to the less powerful factions, and that ceremonial events would have occurred at the less powerful area, where more powerful residents could oversee, observe, witness, and authorize them. I would therefore expect higher-status residents to have a commanding view (in GIS parlance, 'viewshed') of surrounding areas if a cosmological spatial logic had a dominant role. They would look 'down' on lower-status people and the wider area.

Copan and its paired groups

The city centre of Copan lies in the most fertile of five alluvial pockets, or valley subdivisions, along the Copan River of western Honduras (Fig. 1). In the late 1970s, the first phase of the Copan Archaeological Project (PAC I) intensively surveyed and mapped a 24 km^2 portion of this pocket, defining five distinct physiographic zones (Baudez 1983; Fash 1983; Leventhal 1979; Turner *et al.* 1983; Willey & Leventhal 1979) (Fig. 2). PAC I archaeologists also demarcated smaller organizational units they called sub-communities, according to the natural terrain, *quebradas* (small stream cuts) and settlement density; as explored elsewhere, these sub-communities may represent ancient neighbourhoods (Arnauld *et al.* 2012; M.E. Smith 2010). There are 20 sub-communities within the Copan pocket (Fig. 3), though various other settlement areas existed to the far north, west and east. The boundary lines used in this study are approximated from the published descriptions of the original surveyors (Fash 1983; Fash & Long 1983; Leventhal 1979). Various numbers of architectural groups were

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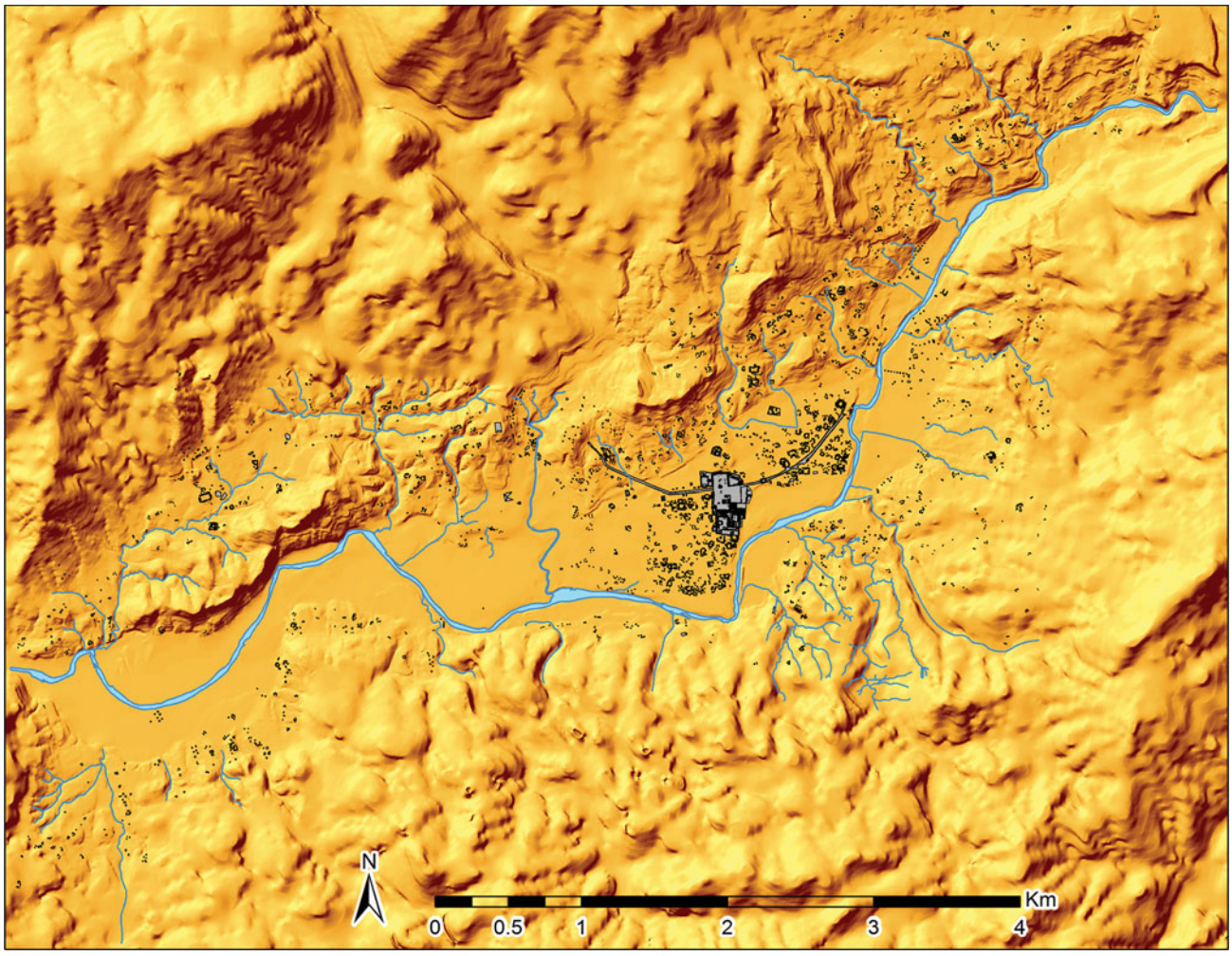


Figure 1. *(Colour online) Copan alluvial pocket of the Copan Valley.*

situated within each sub-community, some larger and more elite, others small house platforms (Table 1). Although for the purposes of GIS analyses these boundaries are absolute,[2] in social reality they are rough estimates for spatial areas where individuals resided and would have had face-to-face encounters on a daily basis (M.E. Smith 2010).

Each sub-community contains a different number of architectural clusters labelled according to a grid system (e.g. Group 8L-10). Almost all of the surface settlement that the PAC I surveyors mapped and test-pitted dates to Copan's major growth in the Late Classic Period (AD 600–800) (including the groups discussed here), while earlier settlement may lie below at least two metres of post-abandonment deposition (Fash & Sharer 1991). The sub-communities addressed in this study, because they contain paired groups, include Ostuman (in Zone 5, with two paired groups), Salamar, Rastrojon and Mesa de Petapilla (in Zone 3), as well as San Lucas and Titichon (in Zone 4) (Fig. 4).

In the late 1970s, Gordon Willey and Richard Leventhal (Leventhal 1979; Willey & Leventhal 1979) devised a typology for Copan's architectural groups, ranging from the smallest house mounds (Type 1) to the largest and most elaborate elite settlements (Type 4), which the PAC I surveyors later utilized (Fash 1983; Fash & Long 1983; Freter 1988). The typology is primarily based on the volume of stone masonry and complexity of the architectural group, regardless of form or interior plan. Originally the typology was thought to indicate structure function (Willey & Leventhal 1979), but today it colloquially signifies socioeconomic status (Table 2).

Results from spatial statistical tests, such as Spatial Autocorrelation, show a less than one per cent likelihood that the patterning of settlement at Copan is random (Global Moran's I Index = 0.8;

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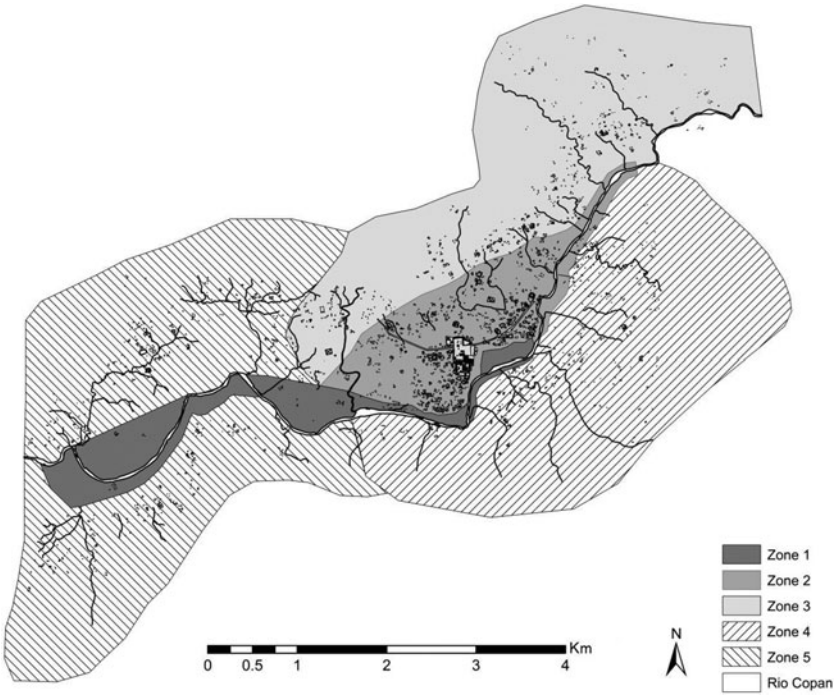


Figure 2. *Ecological-topographical zones in the Copan Valley (after Willey & Leventhal 1979, figs. 6 & 7). Zone 1: floodplain; Zone 2: northern low river terrace, most densely settled; Zone 3: northern foothills in the east, settlement clusters around water sources; Zone 4: foothills south of the river, most fertile soil; Zone 5: floodplain, high river terrace, foothills and intermountain pocket in the west.*

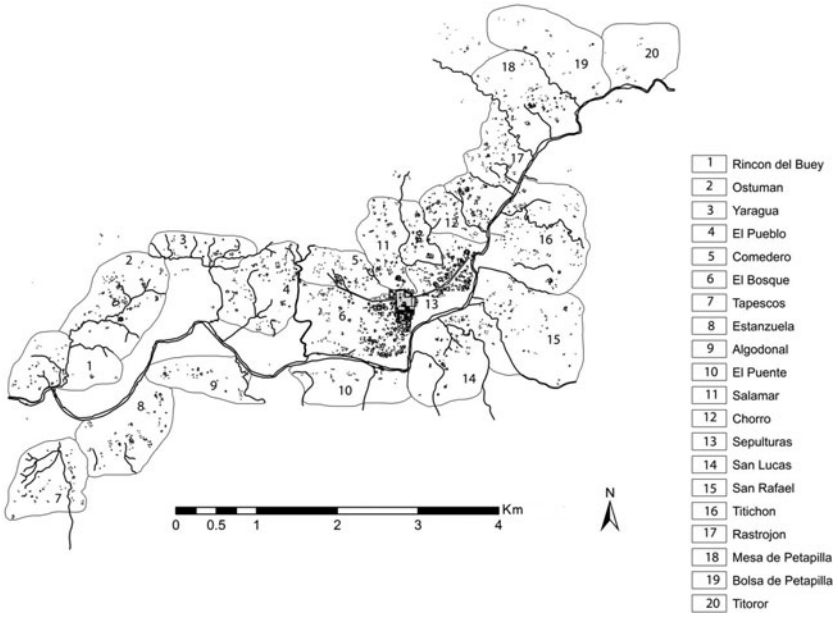


Figure 3. *The 20 sub-communities (neighbourhoods) of Copan.*

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Table 1. *Size and settlement density of sub-communities in Copan pocket, from west to east. Bolded names contain paired groups.*

Sub-community	Total Area (km^2)	No. of Architectural Groups	Density (per km^2)	Zone
1. Rincon Del Buey	0.82	14	17.1	5
2. Ostuman	**1.13**	**26**	**23.0**	**5**
3. Yaragua	0.43	11	25.6	5
4. El Pueblo	0.91	21	23.1	3, 5
5. Comedero	0.45	23	51.1	2, 3
6. El Bosque	1.06	93	87.7	2, 3
7. Tapescos	0.78	16	20.5	5
8. Estanzuela	0.93	25	26.9	5
9. Algodonal	0.55	16	29.0	5
10. El Puente	0.68	10	14.7	4, 5
11. Salamar	**0.79**	**57**	**72.2**	**2, 3**
12. Chorro	0.30	18	60.0	2, 3
13. Sepulturas	0.65	54	64.3	2
14. San Lucas	**0.84**	**22**	**26.2**	**4**
15. San Rafael	1.60	44	27.5	4
16. Titichon	**1.39**	**35**	**25.2**	**4**
17. Rastrojon	**0.82**	**52**	**63.4**	**2, 3**
18. Mesa de Petapilla	**0.95**	**41**	**43.2**	**3**
19. Bolsa de Petapilla	1.04	18	17.3	3
20. Titoror	0.67	5	7.4	3
Average	*0.84*	*30*	*36.3*	

Z Score = 181.24 standard deviations); and architecture is not distributed evenly across the landscape. Paired groups are dual architectural complexes that exhibit a north–south orientation and are usually located within 250 m of one another. Although Ashmore (1991) did not recognize the paired group within the Salamar sub-community (Groups 8L-10 and 8L-12) as a repeating architectural configuration in writing at the time, researchers have identified six others: William Fash (1983, 284–90) originally recognized this pairing pattern at Titichon, Mesa de Petapilla, and Ostuman. Heather Richards-Rissetto (2010) proposed additional paired groups around the pocket within the Rastrojon and San Lucas sub-communities. Because paired groups appear in the full diversity of physiographic zones, socioeconomic statuses and directional positions at Copan, but maintain their characteristic pairing, we can hypothesize that construction of these compounds followed a particular spatial logic.

Methods and results

All maps used in this paper were digitized from the PAC I maps made in the late 1970s (Fash & Long 1983; Hohmann & Vogrin 1982), georeferenced, attributed and shared with me by Richards-Rissetto. Richards-Rissetto (2010) analysed accessibility and visibility across five scales in the Copan Valley; the current study was originally conceived as an additional sixth scale of analysis — *within* paired group sub-communities (Richards-Rissetto & Landau 2010). While many factors affect city layout, such as the availability of resources and topography on a regional scale, or kinship and proximity to pre-existing settlement on a local scale, I focus on energetic efficiency and cosmology, because these are the major factors affecting city planning that Ashmore, Sabloff and M.E.

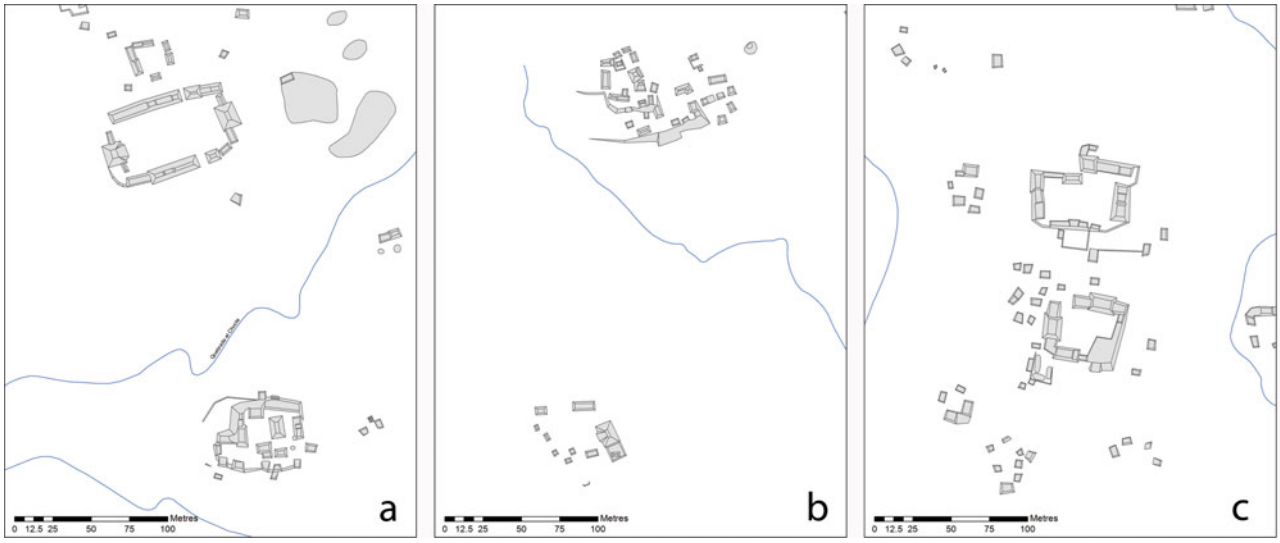


Figure 4. *(Colour online) Examples of paired groups across the Copan Valley. (a) Ostuman; (b) Mesa de Petapilla; (c) Salamar.*

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Table 2. *Copan typology (from Willey & Leventhal 1979, 82–3).*

Type	No. of Mounds	No. of Plazas	Mound Height (m)	Construction	Total no. in survey area
1	3–5	0–1	0.25–1.25	Earth fill, undressed stone rubble	16
2	6–8	1–2	2.50–3.00	Mostly undressed, but some dressed surface stone	24
3	6–8	1–2	3.00–4.75	Much more dressed stone	11
4	8+	2+	4.75–10	Large stones, rough and dressed, vault stones	434

Smith discussed and because there is demonstrated merit for both in the Maya area. In the discussion below, I consider mean centre and least cost paths to assess energetic efficiency, and elevation and viewshed to explore cosmological influence.

Mean centre

Mean centre addresses energy efficiency in terms of socioeconomic hierarchy and political centralization. To minimize energetic expenditure, the largest and most important buildings in any urban area should be constructed at the centre of a settlement to maximize energetic efficiency to reach them (Nielson 1995, 58). These buildings should be physically larger and better made because the more powerful people who lived or operated in them could summon the construction labour of the less powerful (Abrams 1994; Carrelli 2004; McAnany 1995). In the Maya area, architectural volume is believed to be a 'relatively stable indicator of the economic and political power of the central authority to collect tribute and organize labor' (Inomata & Aoyama 1996, 293; also Adams & Jones 1981).

In GIS, the mean centre tool identifies the geographic (or concentration) centre for a set of features. I calculated the architectural centre of each of the six sub-communities by inputting all architectural settlement and weighting it by volume. I multiplied the area of each structure by its height to determine volume; Richards-Rissetto (2010, 181–9) had estimated height through trigonometric functions derived from Copan's typology, which give a maximum length and width for each structure type. Taking an average of architectural volume across the sub-community, the tool generates a single point at the greatest density. To maximize efficiency, the paired group — the largest architecture within each sub-community — should be located at the volumetric centre of all architecture. If the paired group is not at the architectural volumetric centre, its residents were either not hierarchically more powerful within the sub-community (and thus the size of buildings does not directly indicate wealth or power to summon labour), or were not geographically situated in such a way as to reduce energetic output to travel to them. Of the 14 cases tested, the northern side of Mesa de Petapilla is the only group located at the height of architectural density of the sub-community (Fig. 5). Mean centre analysis does not therefore indicate that either side of the paired groups was located at the centre of architectural density within sub-community boundaries (cf. Inomata & Aoyama 1996; Peterson & Drennan 2005). Least cost paths provide another metric for assessing whether paired groups within sub-communities were organized by energetic efficiency.

Least cost paths

The least cost paths method examines the role that social interaction played in Maya urban planning. Although working at a regional scale, if, as Takeshi Inomata and Kazuo Aoyama (1996, 292) state, it is 'probable that cost minimization in the interaction between centers and the local population was an important factor affecting the distribution of centers', central places can be defined by heightened interaction. Less costly paths from one place to another represent greater potential for social interaction than more costly paths, because more people would travel along them more frequently (Llobera 2000; Llobera *et al.* 2011; Richards-Rissetto 2012). Therefore, social interaction potentially occurred most frequently at architectural groups with the lowest travel costs to reach. In addition, because this analysis incorporates local topography, roads, barriers and other ecological features, it takes the natural and built environments under consideration, a contribution to GIS applications in archaeology. I performed distinct analyses for each type of architectural group (Types 1–4), so as not to confuse differences in interaction due to status with differences in interaction due to energy expenditure.

The least cost paths are based on three cost surfaces: (1) friction, (2) slope and (3) aspect (Fig. 6). The friction surface reclassifies all architectural, hydrological and road (*sak'b'e* in Mayan, 'white road'; pl. *sak'b'eob'*) features into obstacles or facilitators for walking paths. For example, because the *sak'b'eob'* would have acted as a conduit for movement, they were reclassified as facilitators; conversely, architecture was reclassified as an obstacle. Rivers and streams were reclassified as obstacles for crossing with various degrees of difficulty (current thought is that the Copan River was not navigable; larger streams require

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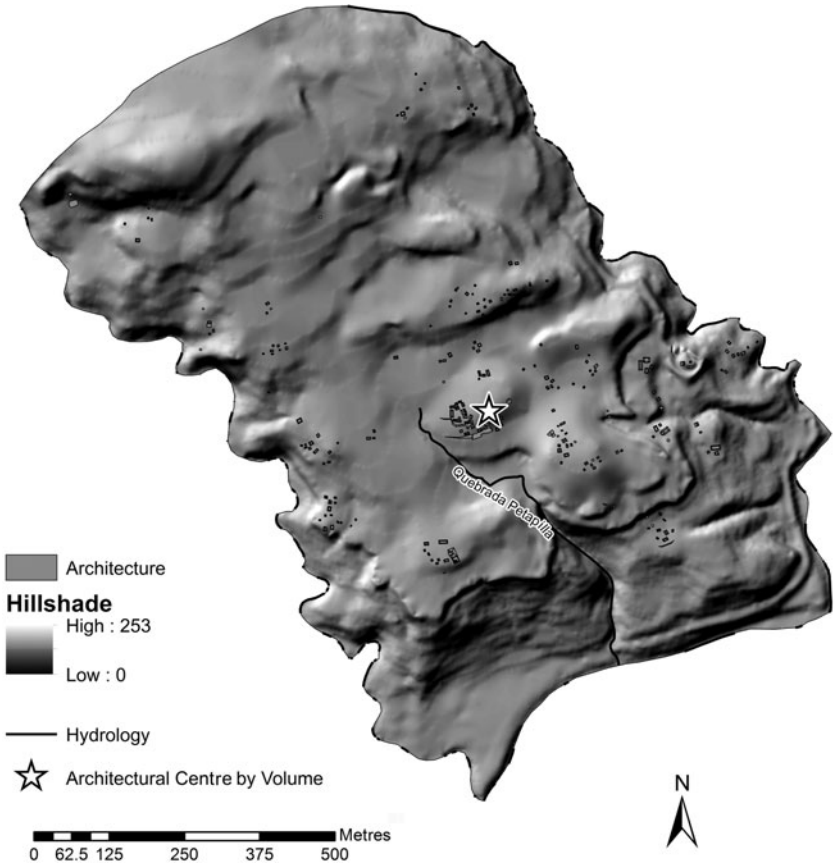


Figure 5. *Group 5O-1 of Mesa de Petapilla sub-community at architectural volumetric centre.*

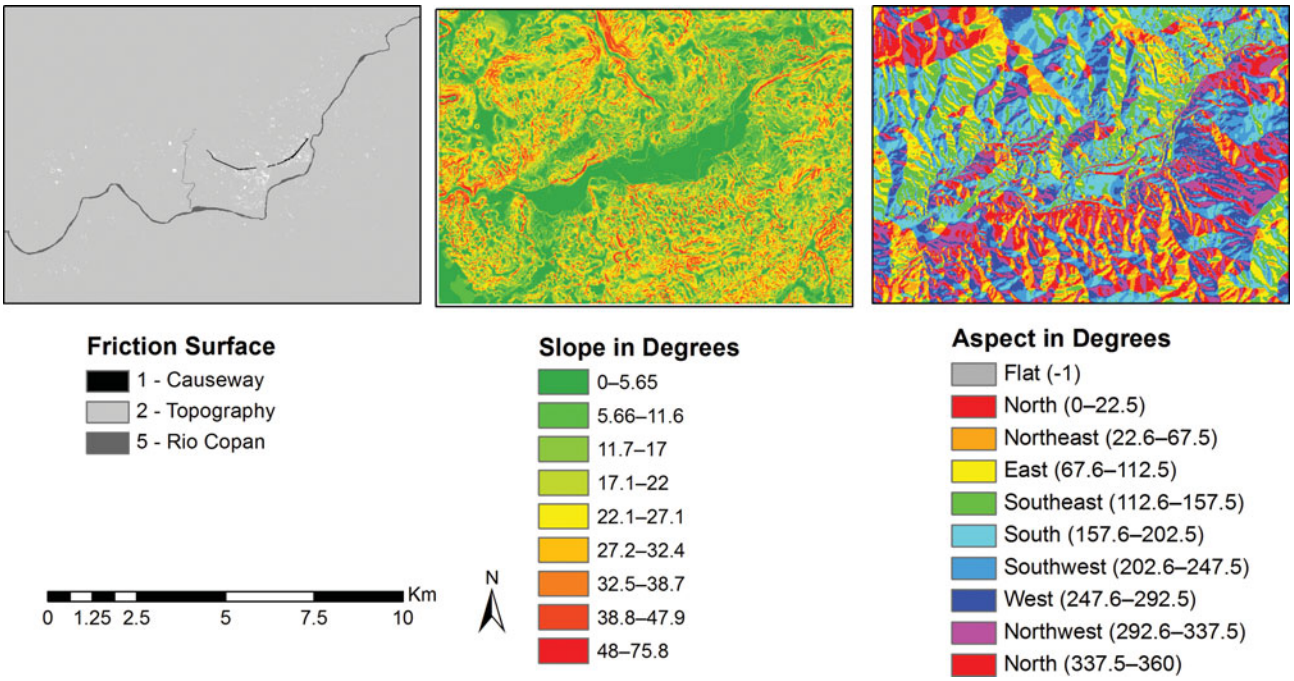


Figure 6. *(Colour online) Friction, slope and aspect surfaces that compose the cost-distance surface map and backlink raster.*

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stepping stones). The slope surface was generated based on contour lines from the original maps (Baudez 1983). Rather than simple elevation change (i.e. the Digital Terrain Model), the slope surface represents the rate of elevation change, a more accurate variable that predicts human movement across the landscape (Llobera 2000). Aspect is calculated from the slope surface and shows direction of slope change. Expressed in 360°, as around a compass, aspect dictates direction of the maximum change of slope, which influences movement. Including the aspect surface also makes this analysis anisotropic, meaning that the cost of going away from a place can have a different value than the cost of returning, due to moving up or down hill.

I then input these three cost surface maps (friction, slope and aspect) into the path distance tool — as cost surface, horizontal parameter and vertical parameter, respectively — to create a cumulative cost distance surface map and a backlink for each side of each paired group. Based on facilitators, obstacles, slope and direction, the cost distance map takes into account hills, mountains and built features to calculate the length of travel in kilometres from the source point to all other architectural groups within the sub-community. Similar to the aspect surface, the backlink raster identifies the direction of shortest path. Next, I used the cost path tool to generate least cost paths: first, between each member of the paired group (i.e. from the north group to the south group and vice versa); and second, from each member of the pair to other architectural groups within the sub-community. The destination points (e.g. Type 4, 3, 2, and 1 groups within Salamar), source path distance surface (e.g. Path Distance for Group 8L-10 or -12) and backlink surfaces (e.g. Path Direction for Group 8L-10 or -12) were input to generate least cost paths (Fig. 7).[3]

The resulting cost paths do not indicate any significant pattern in social interaction between the two sides of the paired groups alone; whether north or south side or typology, the cost of travel between the two sides is variable. This lack of strong patterning might suggest that the paired group should be considered as one complementarily functioning entity despite differences in cardinal direction and socioeconomic status. Archaeological evidence including stratigraphic history of construction, ceramic chronology and function is necessary to further understand the relationship between the two architectural groups composing each pair. For example, based on artefact assemblages, Stephen Whittington (1991) hypothesized that residents of the pair at Ostuman (Groups 10E-6 and 11E-2) performed complementary functions: the northern side was more open and could have been a ceremonial centre, while the southern side was more closed and focused on manufacturing.

Cost paths may exhibit a single definable pattern for potential social interaction from the northern member of each pair to other Type 1 architectural groups within the sub-community (Table 3). The pattern could indicate that northern group residents had greater accessibility and potential for interaction with their local, lowest-status neighbours. While caution must be exercised due to small sample size ($n = 7$), the least cost paths from Type 1 groups to the northern side are statistically significantly smaller than the paths from Type 1 groups to the southern side ($p \leq 0.05$); further exploration and interpretation of this peculiar finding is warranted and should incorporate additional lines of evidence. Because Maya cosmology suggests that elevation and viewshed might be important elements that shaped city planning, I now consider their significance in paired group sub-communities.

Elevation

Elevation and viewshed calculations were derived using a two-metre resolution Digital Terrain Model (DTM). The DTM is a raster or continuous surface interpolated from the Fash & Long (1983) contour lines with a single attribute: z or elevation data. I consulted the Copan Valley maps to determine absolute elevation of each side of each paired group including architecture.[4] If north were coterminous with up, the northern side of paired groups would be physically higher in elevation than the southern side, literally, up. However, north sides of paired groups were not systematically higher in elevation than south sides. Contrary to what Maya cosmological models might suggest, absolute elevation was not a (statistically) significant factor in placing the north or south side of paired groups (Table 4). Nonetheless, when both sides (the pair) are considered together, the Titichon and Rastrojon paired groups were placed at higher elevations than the rest of the architecture within their sub-communities. Because, significantly, elevation is not synonymous with vision (i.e. being high up does not necessarily enable wide views), the Titichon and Rastrojon paired groups could have been located at higher elevations in agreement with Maya cosmology where 'up' is sacred, or with practical reasons of seasonal flooding and/or more effective drainage (both of these sub-communities are located in hilly foothill regions of Zones 3 and 4). Next, I consider whether paired groups could have been planned to enable wide views over other people in their sub-communities.

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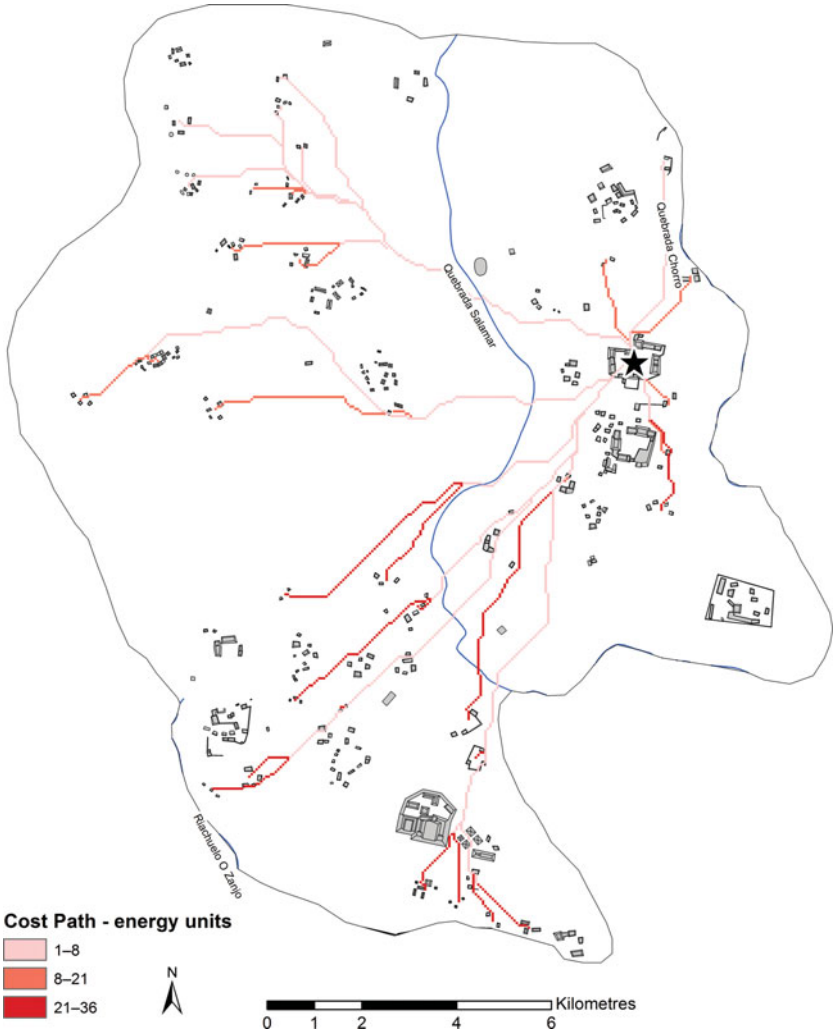


Figure 7. *(Colour online) Creating least cost paths from Group 8L-10 in Salamar to all Type 1 architectural groups in the sub-community.*

Viewshed

Viewsheds — areas visible and not visible from a certain vantage point — were calculated from the tops of architectural structures plus a 1.6 m observer height (Connolly & Lake 2006; Wheatley & Gillings 2000). Due to the difficulty of knowing just where a viewer stood while observing surroundings, I created multiple source points for each side of each paired group (as many as 50 points depending on area of the structures), constituting all possible views simultaneously. In other words, I created a point from every possible viewing location on top of each building of each architectural group, and the final number was dependent on the horizontal size of the group.[5] Additionally, rather than creating multiple viewshed maps from each source point and adding them together, I ran the viewshed tool from multiple points in a single shapefile (Doyle *et al.* 2012) (Fig. 8).

In every sub-community, the northern group had a statistically significant greater viewshed over other architecture than the southern group ($p \leq 0.05$). In other words, an observer at the northern group could see more architectural groups within the sub-community than an observer at the southern group (Table 5). The viewing pattern suggests that the northern side of every paired group was placed so as to produce the largest field of vision over the lower ranked architectural groups within the sub-community.

Discussion

Positive results emerged from viewshed and elevation analyses. Most importantly, viewsheds from each side of the paired group within every pair revealed that residents of the northern group could always see more architecture than those of the southern group. Residents

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Table 3. *Values for least cost paths. The higher the value, the more energetically costly the path and the lower potential for social interaction.*

Paired Group	Group	To Type	Average Cost
Ostuman I	10E-6 (T4)	11E-2 (T3)	861
		Type 1	875
		Type 2	1437
		Type 3	1319
	11E-2 (T3)	10E-6 (T4)	1123
		Type 1	1260
		Type 2	1913
		Type 3	1081
Ostuman II	10F-1 (T3)	10F-3 (T3)	755
		Type 1	1350
		Type 2	781
		Type 3	712
		Type 4	1003
	10F-3 (T3)	10F-1 (T3)	762
		Type 1	1404
		Type 2	643
		Type 3	1112
		Type 4	1003
Salamar	8L-10 (T4)	8L-12 (T3)	220
		Type 1	1477
		Type 2	1321
		Type 3	1293
		Type 4	828
	8L-12 (T3)	8L-10 (T4)	489
		Type 1	1575
		Type 2	1441
		Type 3	1105
		Type 4	701
San Lucas	11M-10/11 (T2)	12M-1 (T2)	1053
		Type 1	732
		Type 2	481
	12M-1 (T2)	11M-10/11 (T2)	964
		Type 1	1416
		Type 2	1177
Titichon	9P-1 (T2)	9P-5 (T2)	397
		Type 1	1567
		Type 2	1489
	9P-5 (T2)	9P-1 (T2)	732
		Type 1	1896
		Type 2	1575
Rastrojon	6N-1 (T2)	6N-2 (T2)	288
		Type 1	1206
		Type 2	1551
		Type 3	2033
	6N-2 (T2)	6N-1 (T2)	369
		Type 1	1112
		Type 2	1212
		Type 3	1795
Mesa de Petapilla	5O-1 (T3)	5O-8 (T3)	798
		Type 1	1123
		Type 2	753
	5O-8 (T3)	5O-1 (T3)	702
		Type 1	1486
		Type 2	1001

Table 4. *Absolute elevation for each paired group (taken at highest point of each group).*

Paired Group	Group	Elevation (m)
Ostuman I	10E-6 (north)	618
	11E-2 (south)	614
Ostuman II	10F-1 (north)	626
	10F-3 (south)	639
Salamar	8L-10 (north)	632
	8L-12 (south)	624
San Lucas	11M-10/11 (north)	645
	12M-1 (south)	661
Titichon	9P-1 (north)	670
	9P-5 (south)	662
Rastrojon	6N-1 (north)	683
	6N-2 (south)	665
Mesa de Petapilla	5O-1 (north)	680
	5O-8 (south)	666

of the northern group could observe a greater number of the lower status Type 1 and Type 2 groups in the sub-community. If the Maya cosmologically linked north with the supernatural sanction of authority, then the higher visibility of non-elite groups by the northern side of the pair could be a spatial materialization of this principle.

While elevation results did not reveal any discernible patterns between each side of the paired group, in two of the sub-communities the paired group as a whole was settled on significantly higher ground than other architecture. Further archaeological testing, especially with an attention to chronology and the evolution of building form, would be helpful for discerning the reasoning behind the groups' comparatively higher elevation.

No strong patterns emerged from the mean centre or least cost path analyses, suggesting that sub-communities within Maya cities were not planned according to these principles or in a predominantly

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Table 5. *Viewsheds. 'NA' indicates that Type 4 and Type 3 groups did not exist in the sub-community and are thus Not Applicable.*

Sub-community	Group	Number of Architectural Groups Visible	Number of Groups Visible by Type			
			4	3	2	1
Ostuman I	10E-6 (north)	22	1	2	2	17
	11E-2 (south)	19	1	2	2	14
Ostuman II	10F-1 (north)	17	1	2	2	12
	10F-3 (south)	16	1	2	2	11
Salamar	8L-10 (north)	31	2	4	8	17
	8L-12 (south)	30	2	4	10	15
San Lucas	11M-9–11 (north)	15	NA	NA	4	11
	12M-1 (south)	5	NA	NA	3	2
Titichon	9P-1 (north)	13	NA	NA	2	11
	9P-5 (south)	13	NA	NA	3	10
Rastrojon	6N-1 (north)	27	NA	NA	5	22
	6N-2 (south)	21	NA	NA	6	15
Mesa de Petapilla	5O-1 (north)	20	NA	2	3	15
	5O-8 (south)	18	NA	2	5	11

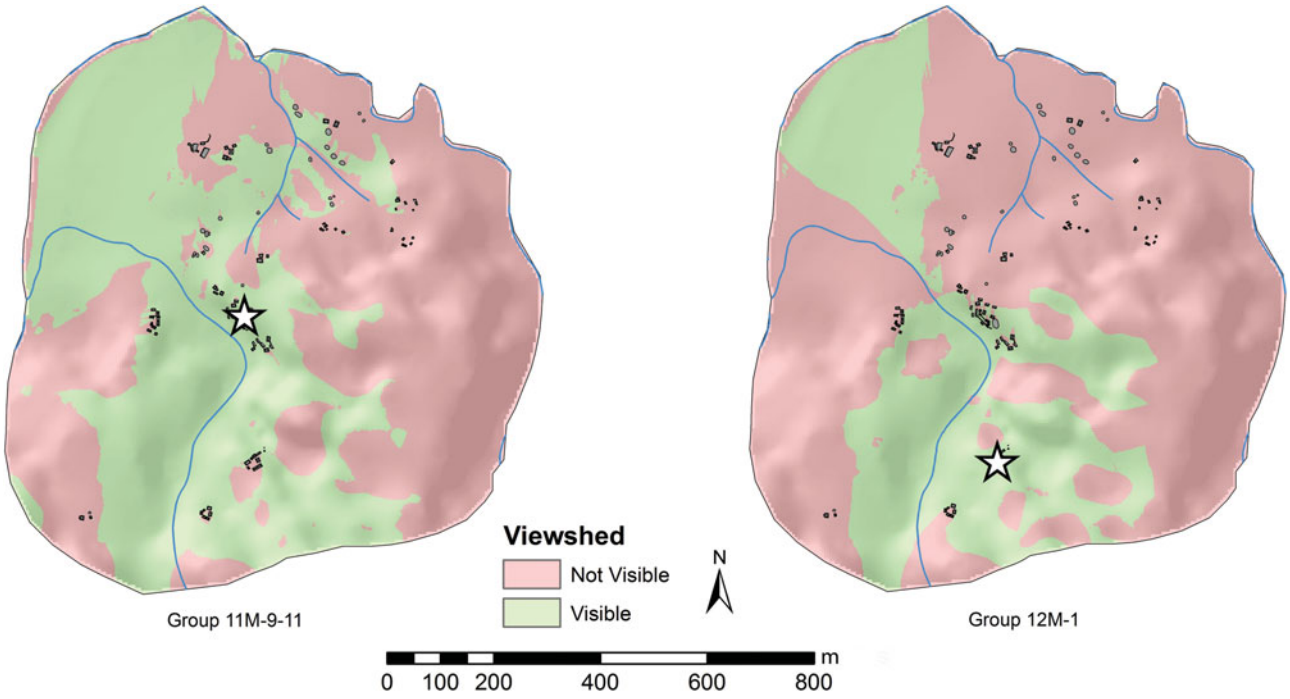


Figure 8. *(Colour online) Different views from the sub-community of San Lucas. Many more architectural groups are visible from the northern Group 11M-9–11 than the southern Group 12M-1, despite the latter's higher elevation.*

economically efficient manner more generally. On the whole, paired groups were not situated at the architectural centre of their respective communities by volume. Following Inomata and Aoyama (1996), if the paired group were hierarchically dominant, other settlement would have appeared in a regular form around it. The paired group would have been the most important settlement in the community, its inhabitants offering necessary goods and services; residents not living at the paired group would have wanted to minimize energy expenditure to it and so would have lived at an optimal distance around the pair. Be-

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cause this specific distribution of architecture was not spatially realized in any community and because the paired group was not located even at the centre of architectural volume, the optimal placement of the most important groups to conserve energy was not likely a dominant political, economic or social paradigm by which ancient residents of Copan organized themselves within sub-communities.

When understood as values approximating potential for social interaction, least cost paths at Copan's sub-communities do not conform to energetic efficiency in settlement patterns. Least cost paths tested the relationship between the paired group and the remaining architectural groups in the sub-community. It was not easier for residents of one side of each paired group to access the other. However, there was greater potential for social interaction between the north side of the pairs with Type 1 residents than the south side of the pairs with Type 1 residents; it was easier for Type 1 residents to access the north side of the paired group within their communities, perhaps for economic or political reasons.

Conclusion

In examining the factors that may have influenced ancient Maya city planning, I proposed the concept of spatial logic, referring to the culturally guided ideals of how spaces should be formed. As 'spatial practices in fact secretly structure the determining conditions of social life' (de Certeau 1984, 96), urban planning practices should reflect the prevalence of different spatial logics that, in turn, reflect and influence individuals' social lives and cultural ideals. I considered energetic efficiency (mean centre, least cost paths), and cosmological variables (elevation, viewshed) as they relate to architectural planning. On one hand, mean centre analysis and least cost paths indicate that logics based on economic efficiency likely did not play a dominating role in sub-community layout. On the other hand, viewshed and elevation analyses may support a cosmological spatial logic for ancient Maya city planning at the sub-community level.

In line with Ashmore's (1991) original template, paired groups at Copan demonstrate a marked north–south axis, though such an axis could also be due to the dominantly east–west river valley. In addition to the symbolic significance of the northern cardinal position, spatial logic dictated that it also have the greatest views of a circumscribed area. Broad vistas were an important cosmological element that governed sub-community planning during Late Classic Copan.

As Houston, David Stuart and Karl Taube have noted, the ancient Maya considered eyesight to be agentive, wilful, and authorizing, as 'the individual who 'sees' is always someone of high status, an overlord or crucial visitor' (Houston & Taube 2000, 287) (Houston & Stuart 1998; Stuart 1996). Even though the northern group of each pair is either the same size or larger than the southern group according to the current typology, perhaps the very ability to see conferred higher status readable only through survey and perception (Doyle *et al.* 2012; Epperson 2000; Gagnon *et al.* 2011). Tracy Sweely (1998) explores the relationship between seeing and power at Joya de Cerén, El Salvador, showing how a particular arrangement of *metates* suggests asymmetrical power relations, control and a divide-and-conquer stance through visual surveillance among *metate* users. In traditional India, Lindsay Jones (2000, 136) explains that the rigid caste stratification of Hindu society was reflected not only in the horizontal layout of the city, but also in the relative heights of the dwellings of each class. In fact, she finds that the correlation between physical height and social status provides the most cross-culturally common means for expressing and perpetuating social rank via architecture. The overall Maya emphasis on 'seeing' as the primary sense and the elite status of those with *–ichnal* underscore the likelihood that residents of the north group were perceived to have greater power. That power could have served to witness or authorize activities of the southern group, or functioned alternatively to keep an eye on agricultural lands or irrigation systems (e.g. Fash 2005; Lucero 2006).

Power differentials between pairs at Copan have been noted by other researchers. Based on the patterning of pectorals worn by the figures depicted on Structure 11's bench and Altar Q from Copan's city center, Rene Viel (1999) proposed that a 'dual partnership system' had existed since the beginning of the dynasty; rulership would have passed not from father to son, but between matrilineal cross-cousins from two functional (and possibly ethnically distinct) groups. There is also evidence on a regional scale of paired centres that may have marked different zones of control within the larger Copan state (Barnes 2008). Based on a chronological assessment of regional political economy in association with spatial layout and excavation data, archaeologists suggest that Copan engaged in a strategy of resource extraction and network control through the construction of outposts near and *overlooking* the centres of rural indigenous populations (Bell & Canuto 2008; Canuto & Bell 2013; Manahan & Canuto 2009). Such a strategy resulted in a paired centre pattern, seen in four cases (El Cafetal/El Paraíso, El Abra/El Puente, Los Higos/Roncador and Río Amarillo/Piedras Negras) throughout the active exchange

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sphere between the Maya and probably ancient Lenca regions. Whether paired groups within the immediate Copan settlement zone and paired centres in the southeastern region are parallel examples of similar strategies or demonstrate equifinality, the association of visibility with authority provides additional evidence for the spatial materialization of ancient Maya *–ichnal*.

These findings also highlight the contribution of GIS-based analyses for archaeological settlement pattern studies. Researchers may operationalize specific ideas into the kinds of questions GIS software can help answer, for example, applying the concept of spatial logic to decipher planning principles behind urban centres. The spatially specific parameters of Ashmore's (1991) template allowed for a relatively simple suite of four analyses in GIS: (1) mean centre, (2) least cost paths, (3) elevation and (4) viewshed. Computer-based analytical work can afford archaeologists many rigorous and systematic lines of evidence. The indirect relationship between physical altitude and vista is underscored by the fact that elevation and viewshed data do not overlap. Maya beliefs link vision and height to power and the northern groups' broader landscape vistas suggest that their very positions may have carried greater cosmological significance.

This study contributes to the growing trend of productive engagement between so-called phenomenological and hypothetico-deductive epistemologies in landscape archaeology (Barrett & Ko 2009; Lake 2007; Llobera 1996; Miller 1995; Sui 1994; Thomas 2004; Tilley 1994; Wheeler 1994). Following Gillings (2012, 610), the goal should not be to find a middle ground that combines quantitative and qualitative techniques, but to build new conceptual frameworks drawing from current debates in both experiential and technological approaches to landscape studies. These new conceptual frameworks incorporate robust middle-range theories that enable researchers to 'translate' broad social concepts into specific parameters they might explore through GIS (e.g. Gillings 2012; Kosiba & Bauer 2012; Llobera 1996; Webster 1999). Concepts such as cosmology and efficiency, stemming from social and economic ideals, may be evaluated using GIS applications to refine anthropological theory.

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Notes

1. Most discussion on 'seeing' and 'vision' treat the two synonymously. It may be that biological 'seeing' was cognitively different from perceiving visions. For the ancient Maya, 'visions' may have been restricted to shamans and rulers (Nancy Gonlin pers. comm. 2014).
2. However, see Wang and Hall (1996) on 'fuzzy' boundaries.
3. Unfortunately, it is not possible to derive least cost paths from multiple source points to a single destination point and vice versa. Such an algorithm remains under the purview of experimental GIS (Connolly & Lake 2006, 255). Cost paths are complicated for two additional reasons: (1) the numeric 'cost' is not an absolute number but an unknown unit value relative to other configured costs; and (2) the cost paths branch from the source point to multiple destinations as a tree branch, not as individual paths. Therefore, it is not straightforward to compare the cost between points A and B, and points A and C, for example. For now, the numbers generated represent averages between each side of the paired group and all architectural groups of each type (total cost divided by number of architectural groups of that type). See Richards-Rissetto and Landau (2014) for an example using Tobler's Hiking Function, which converts these values to time expended (Kantner 1997).
4. Now that LiDAR has been flown over Copan by the German Archaeological Commission and post-processed by the Bruno Kessler Foundation in Italy, viewsheds should be run again, subtracting estimated current mound height and adding estimated ancient structure height.
5. Different than a cumulative viewshed (Wheatley & Gillings 2000; Lake & Woodman 2003), the data generated represent only buildings visible and not visible from one side of each paired group; intervisibility was not tested (Wheatley 1995).

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