Watchful realms: integrating GIS analysis and political history in the southern Maya lowlands

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Travellers naturally prefer to use the most passable routes and establish staging points on the way. Cost surface analysis predicts the easiest routes and viewshed analysis the territory visible from a staging point or destination. Applying these GIS techniques to the Buenavista Valley Corridor, our authors write a history of travel and exchange that vividly reflects the rivalry of two polities and the rise and fall of their nodal settlements.

Introduction

The use of Geographical Information Systems (GIS) has become common on archaeological projects owing to an increased interest in spatial relationships and modelling, landscape archaeology, and quantitative methods (Lock 2000; Wheatley & Gillings 2002; Conolly & Lake 2006). Aside from its cartographic functions, GIS technology offers novel approaches to the human experience of past landscapes, notably studies of visibility and pedestrian movement. Research on movement typically uses cost surface analysis (CSA) and least cost paths, which assign a cost to traversing the earth's terrain and determine likely paths for travel. In turn, visibility studies employ viewshed models to estimate the total area visible from specified points on a topographic surface (Wheatley & Gillings 2000). Both CSA and viewshed allow spatial inquiry that might otherwise be too expensive or logistically difficult to address in the field. This applies especially to the Maya lowlands, where humid

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subtropical forest covers large areas, land rights are contested, thus affecting access, and illegal activities, including drug trafficking and logging, inhibit ground survey. However,
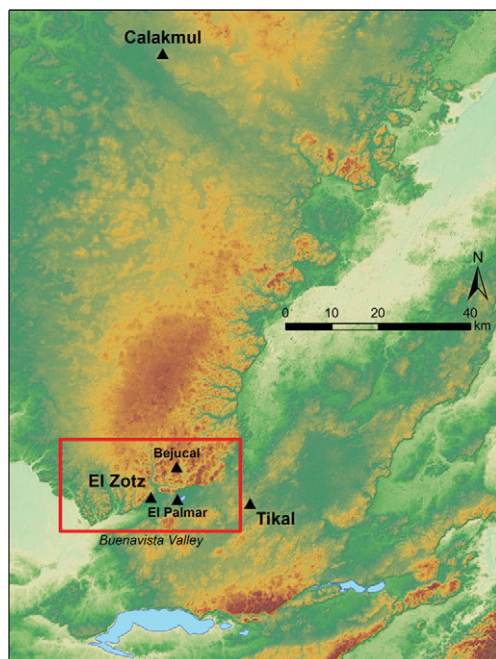
very few researchers have applied CSA in regional settlement analysis, despite the prevalent scholarly role that trade items and inter-site interaction play in Maya archaeology (McAnany 1989; McKillop 1996; Masson & Freidel 2002). This article applies CSA and viewshed analysis to an archaeological case study centred on the Buenavista Valley in the central southern Maya lowlands (Figure 1).

The goal is to integrate GIS analyses with settlement survey and epigraphic data to evaluate possible spatial scenarios for waxing and waning control of exchange routes between two Classic Maya polities (*c.* AD 250–900). The analysis utilises CSA and viewshed models for known periods of conflict and political aggression, especially between the Calakmul and Tikal polities that dominated dynastic interaction during the Late Classic period (*c.* AD 550–800). Such analysis demonstrates the value of CSA and viewshed methods in addressing

Figure 1. *Location of the Buenavista Valley and major sites mentioned in the text.*

archaeologically the impact of communication routes and visibility on ancient populations, and probes more deeply into dynamic, conflictive political landscapes of the ancient world.

Modelling movement and visibility

The principle governing CSA is that two locations on the earth's surface may be the same linear distance from one another but unequal in the amount of effort or time needed to reach the other when travelling. A series of GIS methods creates raster images that assign a cost to each pixel, costs that accumulate in the digital elevation model (DEM) from a fixed point of departure. The costs are generally determined by slope, based on the premise that human physiology favours slopes at differential rates. After computing the cost of travelling over each pixel, GIS software generates a line vector representing the 'least cost path' traversing neighbouring cells with the lowest value (Madry & Rakos 1996: 113; Bell & Lock 2000; Harris 2000; Bell *et al.* 2002; Howey 2007).

CSA cost can be considered isotropic, or the same in all directions, partially anisotropic, or operating from a particular direction, or fully anisotropic, wherein change in direction of travel increases or decreases cost (Conolly & Lake 2006: 215; Bevan 2008: 4). Anisotropic cost surfaces based on slope often factor in aspect (direction), because cost increases when moving uphill, but decreases on the downward slope (Krist & Brown 1994; Bell & Lock

2000: fig. 4; Llobera 2000; van Leusen 2002: 5–6). A non-linear formula for calculating cost involves dividing the tangent of the angle of the pixel slope by the tangent of $1°$, creating a cost surface that reflects the "comparative difficulty in traversing steep terrain" (Bell & Lock 2000: 88–89). Anisotropic costs can also be calculated by including surface features of high or low costs, such as bodies of water or known pathways. A different approach to CSA includes modelling cost based on time taken. Most time-based computations (see Carballo & Pluckhahn 2007) utilised a function developed by geographer Waldo Tobler (1993), based on empirical data collected in the Alps. The utility of the generated line vector, in either effort or time models, depends on the resolution of the original DEM used to compute the cost friction surface. In other words, a DEM with a large pixel size (e.g. SRTM 90m) would calculate a path that is 90m wide, probably larger than most pre-modern transportation routes (see McKee *et al.* 1994). Therefore, depending on the availability of high-resolution data, a multi-scalar analysis involving least cost 'corridors' may lead to better understandings of communication networks at a regional scale (Bell & Lock 2000: 93; Bevan & Conolly 2006; Carballo & Pluckhahn 2007). As DEM resolution improves, the resulting least cost paths will become more fine-grained and useful at the site or inter-site scale.

Another promising avenue of CSA research for archaeology includes integration with viewshed analysis to model optimal paths for the visual detection of places or things (e.g. Madry & Rakos 1996; Estrada Belli & Koch 2007: 266), paths that are least visible (Lu *et al.* 2008), or other scenarios (Lee & Stucky 1998). Viewshed analysis creates a binary raster layer of area visible and not visible from a fixed vantage point based on elevation. Viewsheds can be single, multiple, or cumulative. Single viewshed analysis records the area visible from one vantage point, multiple viewshed maps record areas visible from at least one of many viewpoints, and cumulative viewsheds are the sum of two or more single viewshed maps (Wheatley 1995: 173; Conolly & Lake 2006: 227–28).

There are many critiques of viewshed analysis (see Wheatley & Gillings 2000: 2; Conolly & Lake 2006: 228). Most important to the present discussion are the implications of using the modern landscape—whether digital or actual—in computing the visibility in past topographic space. DEM quality is also a major factor, as it affects the agreement between predicted and surveyed viewsheds, more so than different algorithms or different software packages (Riggs & Dean 2007). Furthermore, archaeologists can never reconstruct exactly what was visible, invisible, or even whether visibility was uniformly meaningful to all members of past populations. Other critiques highlight the lack of consideration of the effect of vegetation on intervisibility (Wheatley & Gillings 2000: 5). In response, recent technological advances have attempted to model vegetation in viewsheds (Spikins 2000; Tschan *et al.* 2000; Kumsap *et al.* 2005; Llobera 2007). A final pragmatic issue about visibility studies concerns what was actually visible to the human viewer in the past; for example, targets may have been of high or low contrast, possibly creating a gradual reduction in intervisibility with an increase in distance (Conolly & Lake 2006: 231). Other factors contributing to the reduction of intervisibility include the height of the observer, air quality, the time of day of viewing, or gradient of vision accuracy. Regardless of the potential shortcomings, viewshed analysis and CSA provide an inexpensive method to investigate past landscapes, especially in areas hampered by modern building, heavy vegetation or conflict.

Studying movement in the Maya lowlands

Items obtained by ancient settlers in Mesoamerica, such as artefacts made of marine shell, obsidian, jade, and many other materials, imply sophisticated trade networks requiring extensive foot travel by settlers across the landscape. Recent studies have incorporated GIS into the study of trade and communication networks to link theoretical and analytical models with actual 'corridors' on the terrain in Mesoamerica (Carballo & Pluckhahn 2007; see also Hare 2004). In the Maya area, the epigraphic record also presents scholars with a wide range of political interactions that took place between royal courts (Martin & Grube 2008). Presumably the same routes used for material exchange channelled such intercommunication. In the Classic period Maya lowlands, stuccoed 'causeways' existed within and between some sites, but most probably performed a ritual function (Hansen 1998: 75; Chase & Chase 2001; Folan *et al.* 2001). Trade routes were probably footpaths (McKee *et al.* 1994), similar to paths created by modern populations harvesting rainforest products (see Gould *et al.* 1998). The initial traverse of the terrain would have required clearing of vegetation but thereafter involved little daily maintenance. Because of this, CSA in the Maya area has had limited applications, mainly in conjunction with viewshed analysis for predictive site location (see Anaya Hernandez *et al.* 2003; Estrada-Belli & Koch 2007; Podobnikar & Šprajc 2010), or access and visibility studies (Richards-Rissetto 2010).

Therefore the goal of this CSA is not to illuminate ancient Maya exchange routes *per se*, which were very likely ephemeral and highly susceptible to changes in course by its users; rather, it evaluates the effect of probable exchange corridors on settlement patterns. For this study, exchange is held to include a spectrum of interactions, with both economic and political dimensions. Such an analytical approach seeks to provide spatial analysis to complement historical events recorded by the Classic Maya rulers. Textual references to actual journeys, diplomatic missions, and conflicts provide chronological controls that enrich GIS research with evidence of actual individual and collective choices in the past. Thus the exchange routes resulting from CSA analysis here transcend conventional microeconomic approaches that "describe humans as rational actors who optimize their livelihood by maximizing socioeconomic 'gains' and minimizing socioeconomic 'costs'" and move towards a 'political landscape approach' (Kosiba & Bauer 2012). Archaeologists can now dispense with hypothetical arrows on a map to indicate movement of people and ideas, and begin to analyse the effect of movement on the socio-political lives of ancient populations.

Setting: the Buenavista Valley in the Classic period (*c.* AD 250–900)

The Buenavista Valley is a south-west to north-east running low-lying fault, approximately 5km wide and 30km long, in the central Petén department of modern Guatemala, north of the Lake Petén Itza region (Houston *et al.* 2011a). Since 2006, a multinational, interdisciplinary project has investigated the archaeological sites in the valley, including El Zotz, Bejucal, and El Palmar (see Figure 1). During the Preclassic period, El Palmar was the largest settlement in the valley, with an extensive monumental core located on the edge of a seasonal lake (Doyle *et al.* 2011). During the Late Preclassic period (*c.* 300 BC–AD 250), residents of El Palmar invested heavily in site planning and the construction of monumental

platforms. During this time, the site of La Avispa emerged about 2km west of El Palmar, although the relationship between the two sites is currently unknown (Garrison & Garrido 2011). By the Early Classic period (*c.* AD 300), the population completely abandoned these sites, and by the Late Classic period (*c.* AD 700) the monumental core of El Palmar lay in ruins.

A suggestive scenario is that elite families at El Palmar migrated away from the valley centre, perhaps to El Zotz or Tikal. El Zotz shows evidence of sparse Preclassic settlement with little monumental architecture. In the Early Classic (*c.* AD 400), El Zotz witnessed intense episodes of monumental construction, including the recently discovered tomb of a likely dynastic founder (Houston *et al.* 2011a). Inter-site random block survey indicates a clear divide in the Early Classic distribution of elite settlements and rural peripheral settlement. The Early Classic period was the time of greatest extent in inter-site non-elite settlement, but elite monumental architecture occurred only in elevated areas in the escarpment. Throughout the Early and Late Classic periods, El Zotz and its subsidiary groups show episodic periods of monumental construction (Houston *et al.* 2011a).

Epigraphic evidence from monumental carved texts at El Zotz and its environs provides other clues about the geopolitical relationships in the Buenavista Valley (Houston 2008; Houston *et al.* 2011a, 2011b). Monuments suggest that El Zotz and Bejucal were Early Classic affiliates, and a stela from Bejucal mentions a visit by an enigmatic figure from Teotihuacan in AD 378 (Stuart 2000). The name of the same figure, Sihyaj K'ahk', (Fire-Born) appears on a monumental text describing possibly an 'arrival' on 8 January 378 at the site of El Peru, located about 55km west of El Zotz. Only eight days later, on 16 January 378, Sihyaj K'ahk' 'arrived' at Tikal in a mysterious event that likely involved the death of a local ruler (Stuart 2000: 478–79). This historical figure (and his entourage) probably travelled through the Buenavista Valley on foot, and interacted with the rulers of El Zotz on his way from El Peru to Tikal (cf. Estrada-Belli 2011: fig. 6.3).

Epigraphic studies also demonstrate that El Zotz was an ally of El Peru, a vassal territory of the Calakmul kingdom, suggesting that El Zotz and Tikal were competing polities (Houston 2008). Clearly, the path between Tikal and El Zotz served as a vital conduit of political interactions in the valley, including embassies, royal visits or even hostile overtures. It also facilitated long-distance exchange in valued items from the Guatemalan highlands, especially obsidian and hard-stone, or prestige goods such as cacao or quetzal feathers. It would thus seem necessary to research the impact of actual routes of travel on settlement in the area.

Methods

Our study created partially anisotropic cost weighted surfaces with costs based on the effort of traversing the terrain, using three different DEMs: SRTM (90m resolution), ASTER (30m resolution) and AIRSAR (5m resolution). The study assigned a cost by using the equation $TAN(Slope)/TAN(1°)$, which models the increasing difficulty of foot travel as slope increases (Bell & Lock 2000: 88, fig. 3). Based on the lines of evidence for people and goods moving from the west toward Tikal, the cost raster factored in aspect and increased cost for west-sloping pixels (Bell & Lock 2000: fig. 4; see also Krist & Brown 1994: 1132). The cost surfaces also included bodies of water for dry and wet season conditions. The

presumption is that scrub *bajos*, or seasonal wetlands, would be passable in the dry season but impassable in the wet season; accordingly, wet season surfaces applied the maximum cost to *bajo* areas. These swamps were detected by a variety of remote sensing techniques that distinguish different vegetation patterns, including using a false colour LANDSAT image (RGB 4-3-1) which highlights *bajo* areas. The beginning point of the path corresponded to the midpoint of the western limit of the Buenavista Valley; the endpoint was central Tikal itself. The rationale for this path is that, throughout most of its occupation, Tikal would have sought to maintain an east–west trade route through the valley to obtain goods from the Guatemalan highlands; additionally, as mentioned above, we know of the actual journey of an individual from west to east through the valley.

To create viewsheds, the study utilised the standard Viewshed feature in the Spatial Analyst Toolbox in commercially available software, ArcGIS 10 by ESRI. Cumulative viewsheds created with five viewer points on all three DEM resolutions showed very similar areas of visible topography, which have been repeatedly ground-truthed at El Zotz, El Palmar and Tikal. For clarity, the current figures show the viewshed of the SRTM DEM (90m resolution), which illustrates the maximum possible visible area. Because sweeping views of the terrain still exist today, the study does not specify an exact viewer height or account for earth curvature with a refractivity coefficient (which, in ArcGIS 10, the default value is .13). On-going palaeoecological and geomorphological analysis will continue to yield information about the amount of vegetation or deforestation in the past that would have altered visibility, but too little conclusive data is available to include definitive models for vegetation. Vegetation is less relevant for the current models that place viewer points on known monumental buildings, which decidedly did not have vegetation on their summits or basal platforms when they were in use.

Results

A crucial finding here is that all the proposed eastward direction paths pass within an area of about 2km width between the start and end points (Figure 2A). The area within the paths, excluding the SRTM path because of its low resolution, was the most likely west–east travel pathway, and the Buenavista Valley Corridor (Figure 2B). The analysis of exchange in the Buenavista Valley Corridor during the Classic period focuses on three chronological instances of east–west travel and its effect on settlement patterns: (a) Preclassic to Classic transition; (b) Early Classic elite nucleation and visible territories; and (c) Late Classic conflict.

Preclassic to Classic transition (*c.* AD 250–350)

The ASTER and AIRSAR dry season corridor passes directly through the site of El Palmar and very close to the site of La Avispa. These sites were thus located near the most probable exchange routes to Tikal, which perhaps contributed to demographic growth, reaching an apogee in the Late Preclassic period. By about AD 0–100, Tikal possibly became the dominant polity in the Buenavista Valley, controlling and increasing foot traffic on a pre-existing east–west exchange route. Viewshed analysis from El Palmar indicates
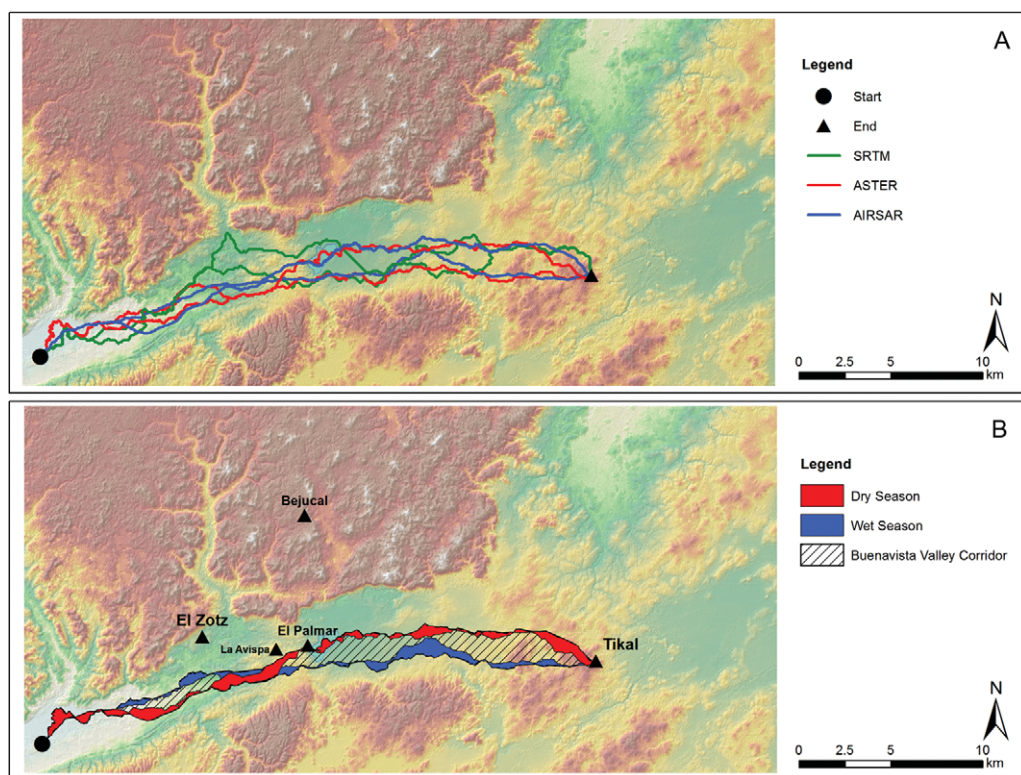
Figure 2. A) Least cost paths through the Buenavista Valley; B) the Buenavista Valley Corridor, for the dry season (red) and wet season (blue).

a clear lack of visibility to the west of the site core, where the proposed corridor lies (Figure 3A). El Palmar's low-lying location did not offer much visual contact with the likely exchange paths, possibly contributing to political instability and ultimately migration, as people passed to and from Tikal. In contrast, the viewshed from the site of La Avispa extends further westward along the corridor, a possible motivation for its monumental constructions in the Late Preclassic period (Figure 3B). The later growth of exchange into and out of Tikal may have contributed to the migration of elite residents of El Palmar and La Avispa away from the Buenavista Valley Corridor.

The abandonment of the monumental core of El Palmar between AD 0 and 250 coincides with the sudden growth of sites like Tikal, El Zotz and Bejucal, supporting the assertion that local migrations occurred within the Buenavista Valley region. Further evidence of local migration comes from a comparison of the known inter-site settlements between the Late Preclassic and Early Classic periods in relation to the proposed Buenavista Valley Corridor (Figure 4A). Early Classic non-elite residences with significant architecture are also located along the escarpment, further away from the corridors (Figure 4B). Obviously, other factors, such as internal political pressures or environmental unpredictability, could also have contributed to the abandonment of Late Preclassic sites in the valley. However,
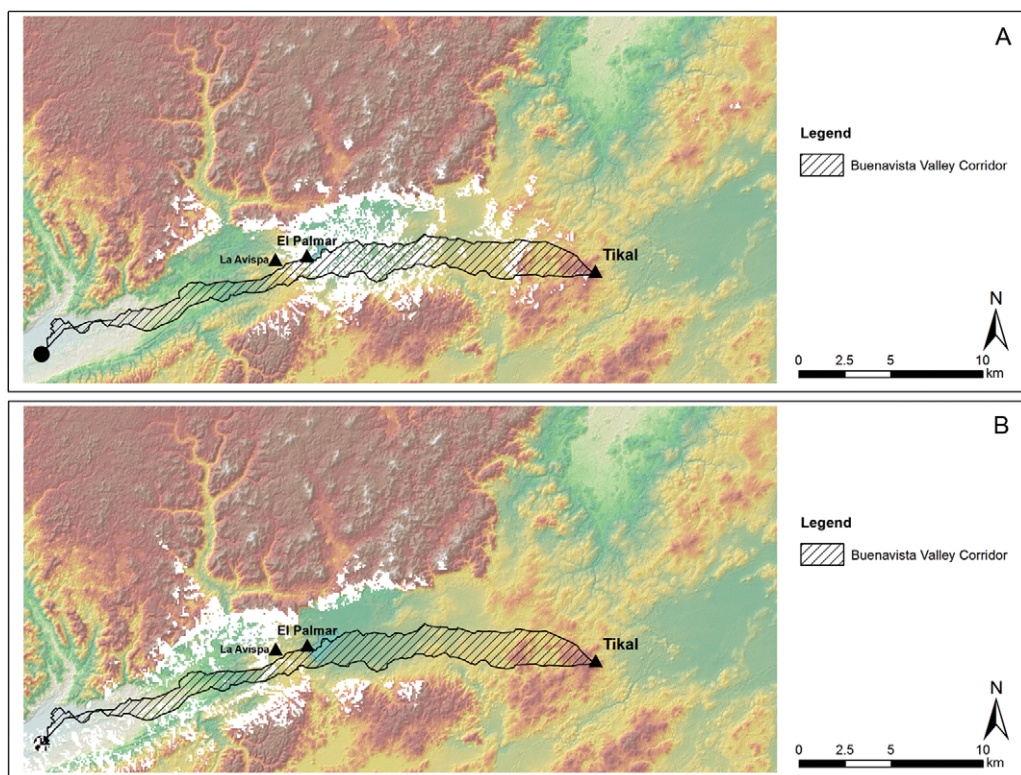
Figure 3. Viewsheds (marked in white) from (A) El Palmar and (B) La Avispa, Late Preclassic period.

the seemingly rapid growth of the upland, defensible locations of El Zotz and Bejucal in the Early Classic, coupled with inter-site architectural growth, suggests that a location at a distance from the exchange routes, but maintaining visible access, was desirable to Maya elites.

Early Classic elite nucleation and visible territories (*c*. AD 350–550)

Based on the Preclassic to Classic transition findings, it seems that Early Classic elite residents built settlements away from the likely exchange routes to create a more defensible and secure location for daily life. Archaeological evidence demonstrates that El Zotz was the Early Classic seat of a dynastic kingdom known by the hieroglyphic name of *pa'chan*, 'Split Sky' or 'Fortified Sky' (Houston 2008; Houston *et al.* 2011a). The same time period saw the florescence of an equivalent, if demonstrably older, dynastic polity at Tikal. Given the probable exchange corridor in the Buenavista Valley, what were the possible connections between the two polities in relation to their control over the corridor? One clue to the relationship between the neighbouring polities comes from viewshed analysis from the El Zotz site centre and the El Diablo group, and, at Tikal, from their contemporaries, the Mundo Perdido and the North Acropolis (Figure 5). The viewsheds seem to be exclusive, i.e. non-overlapping, although each centre had a clear linear view of the other (see Doyle
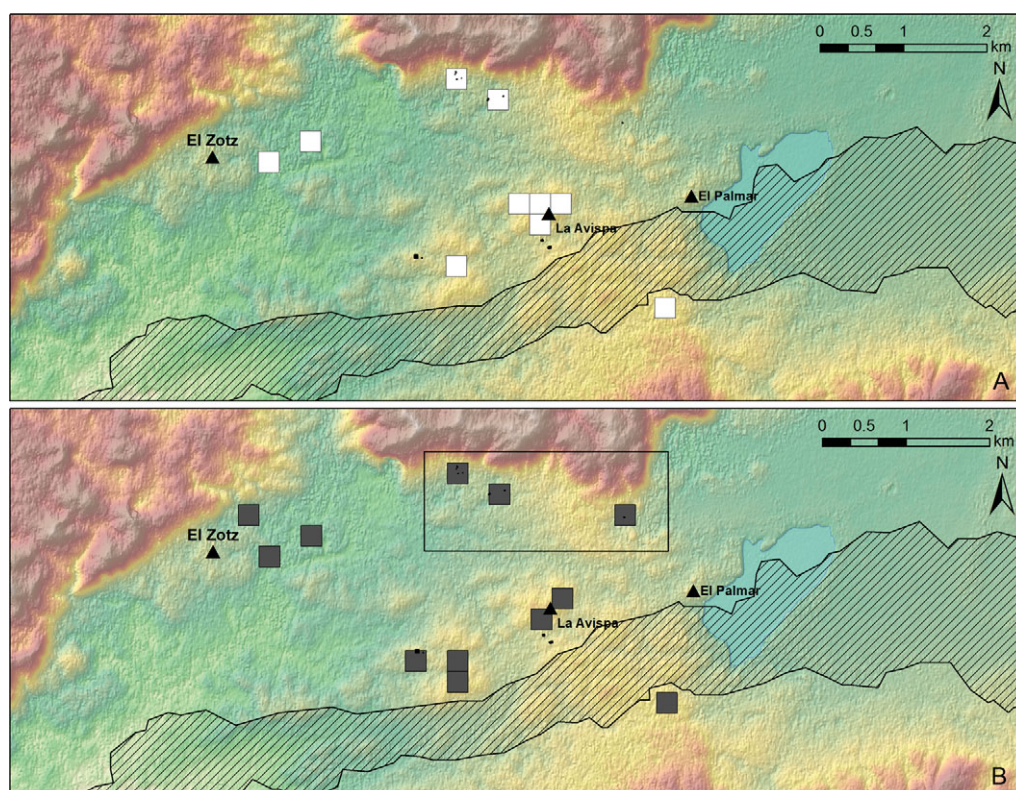
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Figure 4. Inter-site settlement showing (A) Late Preclassic and (B) Early Classic occupation. Settlements with major architecture are outlined in black.

2012). Notably, the Early Classic non-elite residences in the inter-site survey fall under the visual topography of the El Zotz polity (Figure 6).

The elevated location of El Zotz provided strategic vantage points of the valley with direct line-of-sight contact with central Tikal, facilitating surveillance of the east–west exchange route. Although the role of visual surveillance from a site such as El Zotz is speculative, the epigraphic record shows that the power of dynastic rulers was connected to particular points on the landscape with high visibility (Garrison 2009; Golden 2010). In fact, the references to "seeing" (*'ilaj* 'it is seen' or *y-ilaji*, 'he sees') in the Classic Maya inscriptions are indicative that the "physical presence of the overlord or visitor held singular importance," and that surveillance of certain activities conveyed the power of the divine ruler (Houston *et al.* 2006: 172–73). The desirability of trade route supervision at El Zotz gains credence from the discovery of an Early Classic royal tomb there, dating from about AD 350–75 (Houston *et al.* 2011a). Excavators discovered 15 cube-like ingots of red pigment laced with specular hematite, possibly from highland Guatemala (Moholy-Nagy 2002: 51). The regular size and weight of the ingots suggest that they were in the form of trade goods. Chemical testing in progress will reveal the source of the pigment, but if these were goods from highland Guatemala, it is probable that they arrived via the Buenavista Valley Corridor. Their inclusion in the burial assemblage of a royal tomb along with other long-distance trade
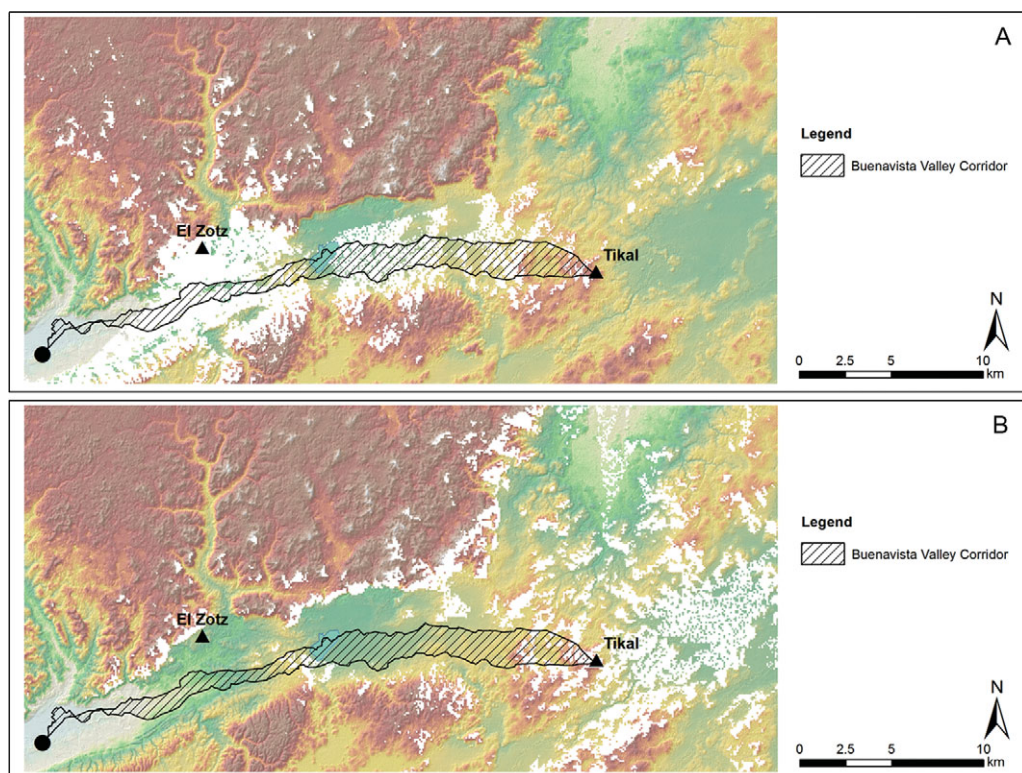
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Figure 5. Early Classic period viewsheds (in white) from (A) El Zotz and (B) Tikal.
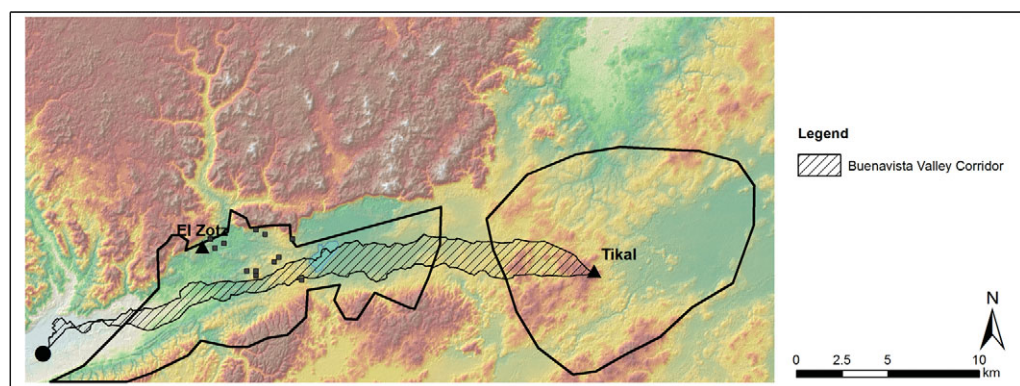

Figure 6. Approximate visible territories (outlined in black) and inter-site settlement (grey) in relation to the Buenavista Valley Corridor, Early Classic period.

items signals a thriving Early Classic exchange, of patent importance to the rulers of El Zotz (Houston *et al.* 2011a).

The viewsheds of El Zotz and Tikal may represent early territories, as inferred from complementary areas of visible topography, including observable and controllable land within the likely exchange corridor. As Lock and Harris (1996: 225) note, viewsheds provide
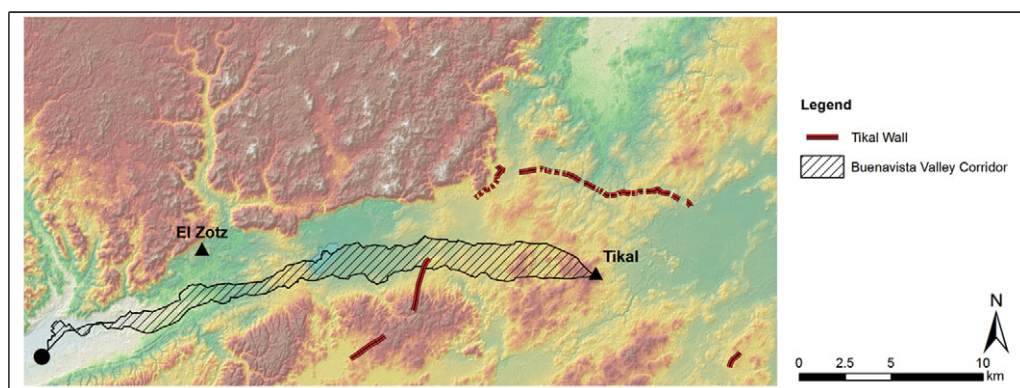
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Figure 7. The Buenavista Valley Corridor in relation to the location of the Tikal 'wall' (Webster et al. *2007: fig. 3).*

a "more robust and useful measure for identifying territoriality as a basis for sociopolitical units than Thiessen polygons." Roughly, the three DEM viewsheds define territories of 90km^2 for El Zotz, and 130km^2 for Tikal (see Figure 6). The Tikal viewshed does not allow for extensive views of the Buenavista Valley Corridor, and the territory extends more to the east (see Figure 6). In contrast, the viewshed from El Zotz covers roughly 17km of the corridor. Domination of the valley, through a system of 'watches' that triggered closer contact, would likely have been a goal of two sites known to function as the competing seats of local royal courts.

Late Classic conflict

Maya warfare is a complex topic earning intense scholarly attention (e.g. Martin 1993; Webster 2002). Defensive features at many sites suggest a need or desire for protection from invasion by outsiders. Although the precise function of the Tikal 'wall' has been questioned in recent years (see Silverstein *et al.* 2009), the suspicion is strong that it is in part defensive, in part a marking of patrolled or defended territory, to judge from the long history of recorded historical conflicts between Tikal and its neighbours. The segmented wall along the western border of the Tikal epicentre is odd in its discontinuity, but the breaks in the wall coincide with *bajo* areas that would have been seasonally flooded and impassable (Figure 7). The survey team examining the wall recorded several Classic period residential groups near the western wall (Webster *et al.* 2007). These groups lie due west of Classic period subsidiary centres such as Chikin Tikal and Tintal, as also noted by Puleston (1973).

The construction of a territorial wall to the north and west of the centre of Tikal could have been motivated by acts of violence orchestrated by rival rulers of Calakmul in the area. In the early Late Classic, *c.* AD 550, the Calakmul polity began forging marriage and trade alliances with kingdoms across the lowlands (Martin & Grube 2008: 104). Given that El Zotz and other sites further west were probable Calakmul allies in the Late Classic, it is significant that the Buenavista Valley Corridor passes directly through the western wall of Tikal (Figure 7). This finding highlights the possibility that the Tikal wall represents a barrier against aggression along pre-existing footpaths during the wet season, when it seems
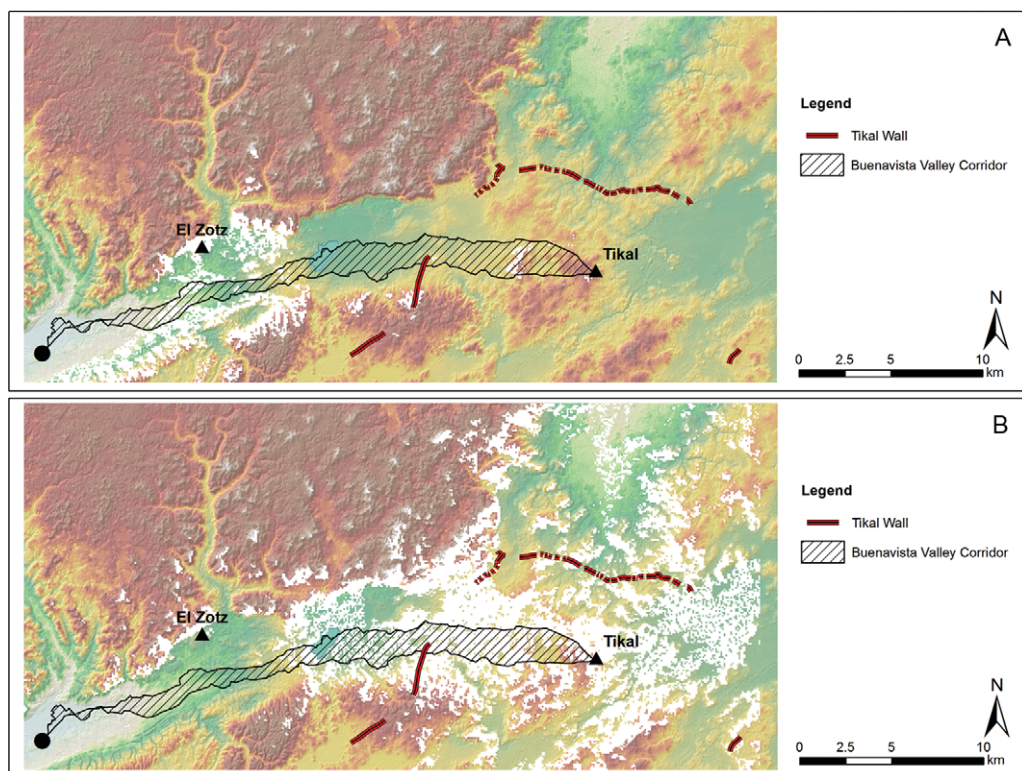
Figure 8. Late Classic period viewsheds (in white) from (A) El Zotz and (B) Tikal.

that El Zotz became a strategic location for eastward political aggression from Calakmul against Tikal.

Furthermore, all the wet season paths converge equally on an area known to have Classic period residential groups affiliated with Tikal (Webster *et al.* 2007). These settlements during the Late Classic period perhaps established a strong physical presence by Tikal affiliates. The foundation of such settlements could correspond to the late seventh and early eighth centuries, when the royal dynasty at Tikal experienced resurgence due to military campaigns that resulted in a probable enlargement of territory to the west (Martin & Grube 2008: 44–47). The presence would have allowed Tikal rulers to defend against attacks or provide warnings of imminent hostile activities by means of non-verbal communication, such as fires, smoke or musical instruments like drums and trumpets, both attested in Maya imagery and archaeology (Miller 1988). This early warning system would provide a time advantage to counteract surprise attacks or raids on the epicentre.

Viewshed analysis provides further evidence that Tikal's western wall and settlements during the Late Classic sought to establish both a territorial barrier and surveillance over the east–west least cost corridor leading from El Zotz into their home centre. Archaeological evidence from El Zotz indicates that the El Diablo group, which commands a significant view over the landscape, was abandoned by the Late Classic period (Houston *et al.* 2011a). A revised viewshed from El Zotz reveals a significantly decreased visible territory, and less visual contact with the corridor (Figure 8A). In contrast, Tikal's subsidiary settlements and

residential groups near the western wall extend the viewshed past the ruins of El Palmar in the Buenavista Valley (Figure 8B). Near El Zotz, inter-site survey demonstrates that the known Late Classic non-elite settlements concentrated within a reduced territory, as deduced from areas visible from the site centre, signifying reduced control of the valley. Although preliminary, the evidence could demonstrate that the rulers of Tikal expanded their influence into the Buenavista Valley Corridor, motivating the residents of the valley to move westward.

Conclusions

The Buenavista Valley Corridor was likely a key exchange route to Tikal and the eastern Maya lowlands from the Guatemalan highlands. Least cost paths through the valley establish that Preclassic settlements, namely El Palmar, were located very close to probable exchange routes. Waning fortunes at El Palmar and exponential growth at Tikal, as measured by architectural changes, could suggest that Tikal became the dominant power in the Buenavista Valley before AD 250. Perhaps the El Palmar settlers' relationship to the landscape changed significantly because of heightened foot travel or even aggression by the growing urban power of Tikal, accentuated by a lack of visual access to exchange routes. The Early Classic elite settlements in the Buenavista Valley are located in upland, defensible positions with a clear view of a large territory, including a large portion of the corridor. During the Early Classic, the competing royal courts at Tikal and El Zotz seem to have had similar access to the exchange routes, while, to a notable extent, non-elite populations remained throughout the valley.

However, political activities of the polity of Calakmul in the mid sixth century altered the political landscape of the valley. With the expedient alliance with the kings of El Zotz, Calakmul rulers may have created stages for hostile activities towards Tikal. This resulted in Tikal's marking and populating its western borders to maintain control of the eastern Buenavista Valley and, perhaps, to facilitate warnings of hostile travel along the corridor. More broadly, the Buenavista Valley case study confirms the value of viewshed analysis and CSA as inexpensive, predictive tools that help to evaluate human movement and past settlement during periods of regional strife.

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