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Edited by

John Morris, Jaime Awe,
Melissa Badillo and George Thompson
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XX MAYA MONUMENTS AND SPATIAL STATISTICS: A GIS-BASED EXAMINATION OF THE TERMINAL CLASSIC PERIOD MAYA COLLAPSE

Claire E. Ebert, Keith M. Prufer, and Douglas J. Kennett

Many studies of the Classic Maya "collapse" have relied upon terminal monument dates to investigate the dynamics of Terminal Classic (~AD 730-910) sociopolitical disintegration. These efforts employed statistical analyses of epigraphic sources to characterize the timing of the collapse, and point to a directional abandonment of Classic Period polities from southwest to northeast. We retest this hypothesis by analyzing 90 terminal dates from the Maya Hieroglyphic Database. Spatial patterning is not consistent with previous hypotheses, but rather suggests a spatial contraction of polities in multiple core regions throughout the Terminal Classic. Of seven core regions identified, the Usumacinta-Pasión region, the Southern Belize region, and the Petén region including sites in central Belize such as Caracol and Xunantunich, demonstrate distinct sub-regional abandonments of monument carving. This suggests that these areas were affected by similar processes (e.g. warfare, ecological disasters, depopulation, and climate change) that led to the cessation of monument dedication due to their geophysical proximity.

Introduction

Glyphic texts recorded on carved stone monuments have played an essential role in the study of the ancient Maya. Monuments incised with glyphic writing, including stela, altar stones, and other types of dedicatory objects, have been interpreted as evidence for social and political complexity (Hamblin and Pitcher 1980; Bove 1981; Whitley and Clark 1985). The stela cult of the Classic Period Maya (ca. AD 250-900) continued traditions of dedicating stone monuments other inscribed media associated with elite peoples. This trend of monument dedication, coupled with the number of sites engaged in erecting monuments increased over time during the Classic Period (Lowe 1985), suggests that a growing number of high-status individual were able to commission the elaborately carved works. Towards the end of the Classic Period, this trend significantly decreased, until the practice of creating large stone monuments was largely abandoned.

Due to major advances in the decipherment of Maya hieroglyphs over the last 50 years we now know that texts recorded on carved monuments relate important historical information focused on political history and the lives of Maya leaders who controlled a series of interconnected polities during the Classic Period. Intricate histories have been worked out at many of the largest of these sites in the Maya Lowlands, and include records of births, deaths, marriages, succession, political alliances, and warfare (Martin and Grube 2000). These

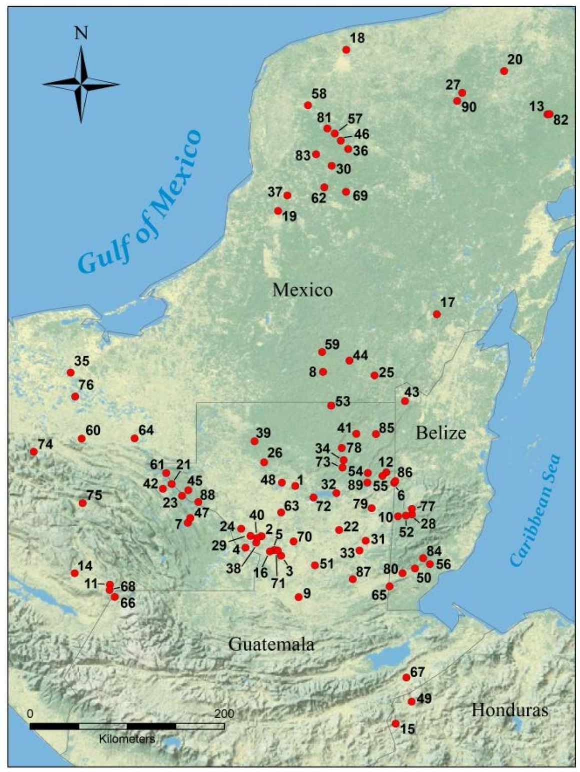

Figure 1. Map of Maya Lowlands, with 91 sites used in this study shown. Numbered sites correspond to Table 1.

histories are temporally grounded in long count calendrical dates, considered to be contemporaneous with the carving and erection of the monument, thus ascribing a date to the object that can be correlated with the Gregorian calendar. Taken together, historical records and precise dates recorded on monuments provide a

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foundation upon which to examine patterns spatial patterning of Classic Period Maya political systems (Mathews 1991, Munson and Macri 2009).

Attention has recently focused on the collapse of sociopolitical networks during the collapse that occurred during the Terminal Classic Period (ca. AD 750-900) in the southern Maya Lowlands (Figure 1). We define "collapse" as the disintegration of a distinct set of political institutions and economic relationships closely associated with elite royal families described in hieroglyphic texts as *ajaw*. This form of political leadership, practiced at multiple polities across the southern Maya Lowlands beginning in the Late Preclassic (400 BC – AD 250) and Early Classic periods (AD 250-500; Freidel and Schele 1998), was characterized by highly networked lineages of paramount elites who ruled individual polities by self-proclaimed divine authority (Houston and Stuart 1996; Martin and Grube 2000). Archaeologists define this type of rulership by the presence of monumental art and architecture, writing, advanced mathematics, and calendrics. The collapse represents the end of those traditions associated with the *ajaw* rulership evidenced by the cessation of monument erections, the abandonment of public political and ceremonial spaces, and disruptions in the trade and consumption of prestige goods during the eighth and ninth centuries AD. Accompanying political disintegration was a decentralization of economic systems, depopulation of many large urban centers, and the cessation writing systems and other media that recorded elite dynastic histories.

Causes of the collapse have been variously attributed to climatic perturbations, warfare, resource exhaustion, disease, and failure of elite governance. Instead of focusing upon the cause(s) of collapse, we examine at the abandonment of the writing tradition using carved monuments as an indicator of the spatial patterning of the collapse across lowlands. Understanding the timing, directionality, and overall duration of collapse at over 100 polities may lead to better models of the collapse and hypotheses regarding causality.

To build a chronology of the collapse, we consider the terminal dedicatory dates on carved monuments an appropriate proxy for this cultural phenomenon. Terminal long count dates refer to the final known date associated carved on a stone monument or other dedicatory object at a site that can be correlated with the Gregorian calendar. The cessation of dated monuments is taken to represent an irreversible decline in political and economic networks and a general disintegration of the polity. Previous efforts to use Maya calendar dates to characterize the timing of these changes concentrated on statistical analyses of epigraphic sources that searched for broad spatial trends (Bove 1981; Whitley and Clark 1985; Kvamme 1990; Neiman 1997; Premo 2004), and suggest that the disintegration of Maya polities occurred during the Terminal Classic Period either in a southwest-to-northeast trajectory in a relatively abrupt manner (Bove 1981; Kvamme 1990) or outward from core areas in the central Petén Region of Guatemala (Neiman 1997).

In this paper we reexamine the results of previous studies with a larger updated dataset of 90 terminal monument dates integrated into a Geographic Information Systems (GIS). First assess whether terminal long count dates found on inscribed monuments exhibit broad-scale spatio-temporal patterning. Earlier studies have suggested some spatial patterning, but others indicate that no meaningful spatial trends can be derived from terminal long count dates (Whitley and Clark 1985; Premo 2004). We also investigate whether regional and sub-regional spatio-temporal patterns of sociopolitical disintegration can be identified by the termination of monument dedication. We compare results of analyses to well published archaeological data from the Central Petén and Central Belize region and from Southern Belize. The aim is to demonstrate how regionally specific analyses may help clarify the relationships between archaeological and epigraphic observations.

Spatial Analysis of Dated Monuments

Multiple studies have examined the spatial distribution of terminal long count dates and geographic trends in the decline of monument dedication at Classic Period polities. Studies by Bove (1981) and Whitely and Clark (1985) both considered terminal dates from 47 sites restricted

	Site	Terminal Date AD	Long Count	Monument	Number of Dedicatory Dates at Site	Latitude	Longitude
1	Aguacatal[b]	762	09.16.00.00.00	Stela 1	2	17.04612	-90.06948
2	Aguas Calientes[a, b]	790	09.18.00.00.00	Stela 1	2	16.57915	-90.38083
3	Aguateca[a, b]	790	09.18.00.00.00	Stela 7	6	16.39889	-90.19995
4	Altar de Sacrificios[a, b]	849	10.01.00.00.00	Stela 2	15	16.47268	-90.53070
5	Arroyo de Piedra	711	09.14.00.00.00	Stela 7	2	16.45155	-90.26459
6	Benque Viejo[a]	849	10.01.00.00.00	Stela 1	2	17.07502	-89.15277
7	Bonampak[a, b]	792	09.18.01.02.00	Room 02 Mural Caption 41	8	16.70360	-91.06500
8	Calakmul[a, b]	810	09.19.00.00.00	Stela 15, Stela 16, Stela 64	25	18.10450	-89.81033
9	Cancuen[a, b]	800	09.18.10.00.00	Stela 1	3	16.01470	-90.03841
10	Caracol[a, b]	859	10.01.10.00.00	Stela 10	28	16.76395	-89.11760
11	Chinkultic[a, b]	830	10.00.00.00.00	Stela 7	4	16.12893	-91.78492
12	Chunhuitz	790	09.18.00.00.00	Stela 1	2	17.17216	-89.22487
13	Coba	781	09.17.10.00.00	Stela 20	7	20.49104	-87.73307
14	Comitan[a, b]	874	10.02.05.00.00	Stela 1	2	16.23606	-92.11024
15	Copan[a, b]	821	09.19.11.14.05	Altar L	70	14.84107	-89.13885
16	Dos Pilas[b]	790	09.18.00.00.00	Panel 11	12	16.43713	-90.30333
17	Dzibanche	733	09.15.00.00.00	Wood Lintel	2	18.63841	-88.75866
18	Dzibilchaltun	716	09.14.05.00.00	Stela 9	2	21.09091	-89.59723
19	Edzna	810	09.19.00.00.00	Stela 9	10	19.59667	-90.22908
20	Ek Balam	842	10.00.11.11.10	Vault Cover 1	3	20.89200	-88.13583
21	El Cayo[a, b]	780	09.17.10.00.00	Stela 2	4	17.06436	-91.21246
22	El Chal[b]	761	09.16.10.00.00	Stela 4	2	16.63806	-89.66350
23	El Chicozapote	824	09.19.14.01.11	Lintel 02	2	16.95522	-91.11824
24	El Chorro[b]	771	09.17.00.00.00	Altar 4	2	16.64949	-90.56957
25	El Palmar[a, b]	884	10.02.15.00.00	Stela 41	5	18.06991	-89.33344
26	El Peru[b]	790	09.15.00.00.00	Altar 1	3	17.26605	-90.35578
27	Halakal	870	10.02.01.00.00	Halakal Lintel	2	20.69124	-88.52362
28	Hatzcap Ceel	835	10.00.15.00.00	Altar 1		16.78239	-88.98929
29	Itzan	780	09.17.10.06.08	Stela 17	5	16.58237	-90.48285
30	Itzimte[b]	910	10.04.01.00.00	Stela 6	3	20.01552	-89.73161
31	Ixkun[a, b]	800	09.18.10.00.00	Stela 5	4	16.53799	-89.41604
32	Ixlu[a, b]	879	10.02.10.00.00	Altar 1	3	16.97843	-89.68702
33	Ixtutz[b]	780	09.17.10.00.00	Stela 4	2	16.44692	-89.47524
34	Jimbal[b]	889	10.03.00.00.00	Stela 2	2	17.28488	-89.61956
35	Jonuta[b]	790	09.18.00.00.00	-----	2	18.09649	-92.14775
36	Kabah	860	10.01.10.00.11	Doorjamb	2	20.24802	-89.64770
37	Kayal	744	09.15.13.00.00	Glyphic Stone 1	2	19.74009	-90.14098
38	La Amelia[a, b]	807	09.18.17.01.13	Panel 1	2	16.52024	-90.42965
39	La Corona	771	09.17.00.00.00	La Corona Panel A & Stela A	8	17.46034	-90.44616
40	La Florida[a, b]	766	09.16.15.00.00	Stela 7	2	16.56166	-90.42209

41	La Honradez[a, b]	771	09.17.00.00.00	Stela 7	2	17.52812	-89.50226
42	La Mar[a, b]	805	09.18.15.00.00	Stela 2	3	17.01900	-91.29396
43	La Milpa[a, b]	780	09.17.10.00.00	Stela 7	2	17.83297	-89.05321
44	La Muneca[a, b]	889	10.03.00.00.00	Stela 1	6	18.20787	-89.56734
45	La Pasadita	766	09.16.15.00.00	Lintel 2	2	17.00501	-91.05982
46	Labna	862	10.01.13.00.00	Mask over Doorway	2	20.17118	-89.57872
47	Lacanha[b]	746	09.15.15.00.00	Lintel 1	2	16.74831	-91.03981
48	Laguna Perdita[b]	742	09.15.11.02.17	Altar 1	2	17.07722	-90.19373
49	Los Hijos (Los Higos)[b]	781	09.17.10.00.00	Stela 1	2	15.04492	-88.99020
50	Lubaantun[a, b]	754	09.16.03.05.08	Figural Plaque #6	2	16.28044	-88.95915
51	Machaquila[a, b]	841	10.00.10.17.05	Altar B	11	16.30947	-89.88701
52	Mountain Cow[b]	835	10.00.05.00.00	Altar 1	2	16.77116	-89.04437
53	Naachtun[a, b]	761	09.16.10.00.00	Stela 10	11	17.79005	-89.73556
54	Nakum[a, b]	849	10.01.00.00.00	Stela D	2	17.16568	-89.39683
55	Naranjo[a, b]	820	09.19.10.00.00	Stela 32	23	17.13839	-89.26065
56	Nim Li Punit[b]	810	09.19.00.00.00	Stela 7	6	16.32042	-88.82272
57	Nohpat	858	10.01.09.00.00	Altar 1	2	20.31509	-89.70344
58	Oxkintok	859	10.01.10.00.00	Stela 9	8	20.57533	-89.95042
59	Oxpemul[a, b]	830	10.00.00.00.00	Stela 7	6	18.28834	-89.81970
60	Palenque[a, b]	799	09.18.09.04.04	Initial Series Vase	35	17.48400	-92.04583
61	Piedras Negras[a, b]	795	09.18.05.00.00	Stela 12	46	17.16641	-91.26298
62	Pixoy	711	09.14.00.00.00	Stela 5	2	19.81505	-89.80102
63	Polol[a, b]	790	09.18.00.00.00	Stela 1	2	16.79924	-90.19866
64	Pomona[b]	790	09.17.00.00.00	Panel	2	17.48664	-91.55691
65	Pusilha[a, b]	751	09.16.00.00.00	Stela F	8	16.11450	-89.19443
66	Quen Santo[a, b]	879	10.02.10.00.00	Stela 2	4	16.01720	-91.73944
67	Quirigua[a, b]	810	09.19.00.00.00	Structure 1B-1 Step	19	15.27023	-89.04007
68	Sacchana	879	10.02.10.00.00	Stela 2	2	16.08030	-91.78753
69	Santa Rosa Xtampak	750	09.15.19.17.14	Stela 5	2	19.77257	-89.59877
70	Seibal[a, b]	889	10.03.00.00.00	Stela 18 & 20	7	16.53175	-90.08511
71	Tamarindito[b]	762	09.16.11.07.13	Hieroglyphic Stairway 2, Step 1	3	16.44769	-90.23125
72	Tayasal-Flores[a, b]	869	10.02.00.00.00	Stela 1	2	16.93987	-89.90035
73	Tikal[a, b]	869	10.02.00.00.00	Stela 11	52	17.21732	-89.63163
74	Tila[a, b]	830	10.00.00.00.00	Stela A	2	17.36193	-92.49054
75	Tonina[a, b]	909	10.04.00.00.00	Monument 101	25	16.88618	-92.03831
76	Tortuguero[b]	711	09.14.00.00.00	Monument 2	4	17.87492	-92.10640
77	Tzimin Kax[a]	835	10.00.05.00.00	Altar 21	2	16.83338	-88.98859
78	Uaxactun[a, b]	889	10.03.00.00.00	Stela 12	14	17.39795	-89.63775
79	Ucanal[a, b]	849	10.01.00.00.00	Steal 4	2	16.83933	-89.36180
80	Uxbenka[b]	780	09.17.10.00.00	Stela 15	5	16.23677	-89.07467
81	Uxmal	907	10.03.18.09.12	Capstone 2	5	20.36031	-89.77066
82	Uxul[a, b]	751	09.16.00.00.00	-----	3	20.49359	-87.71295
83	Xcalumkin	765	09.16.14.00.00	Capital 5	4	20.12244	-89.87664

84	Xnaheb	780	09.17.10.00.00	Stela 2	2	16.37527	-88.88435
85	Xultun[a, b]	889	10.03.00.00.00	Stela 10	13	17.52729	-89.32183
86	Xunantunich[b]	830	10.00.00.00.00	Stela 9	3	17.08926	-89.14145
87	Xutilha	840	10.00.10.00.00	Stone 1	2	16.18167	-89.53725
88	Yaxchilan[a, b]	808	09.18.17.13.14	Lintel 1	41	16.89617	-90.96750
89	Yaxha[a, b]	796	09.18.05.16.04	Stela 21	2	17.07584	-89.40210
90	Yula	874	10.02.04.08.12	Lintel 1	2	20.61686	-88.57001

Table 1. Terminal monument dates from 91 Lowland Maya sites used in these analyses, including data in Gregorian and Maya long count (calculated using GMT).

to the Central Petén region. Bove, using Moran's *I* to examine spatial patterns, argued that the spatial distribution of terminal dates showed a southwest-to-northeast trend. Whitley and Clark (1985) using similar methodology, however, found no recognizable spatial pattern in the data. Kvamme (1990) analyses, however, supported the interpretation that terminal dates have a strong spatial correlation, or that that similar dates that are located nearby each other are not randomly clustered. However, he pointed out the need for analyses that also focused upon regionally specific trends in addition to broad-scale patterning (Kvamme 1990).

In another study Neiman (1997) examined the spatial nature of the collapse positing that inscribed monuments represented a form of costly signaling between Maya polities. Neiman's analysis considered 69 terminal long count dates derived from previous studies in addition to some data from the Petén region. His analyses suggested that the latest terminal dates were located in the periphery of the Maya region and the earliest terminal dates in the central Petén. In other words, polities did not collapse from southwest to northeast, but crumbled outwards from the core to the periphery (Neiman 1997).

Premo (2004) was the last researcher to consider terminal monument dates and the disintegration of Maya polities during the Terminal Classic. He noted that while broad-scale examinations had previously been used to characterize the spatio-temporal nature of the collapse, analyses that identified regional trends are better suited to investigate the collapse since individual Maya sites existed in specific biophysical spheres and interacted in regional and sub-regional sociopolitical spheres. To address this problem, Premo introduced the Getis-Ord *G* statistic in addition to Moran's *I* to examine spatial trends at a regional scale (Premo 2004:857). In his re-evaluation of the same dataset used in Bove's (1981) initial study, Premo noted two localized clusters of terminal dates in the Central Petén and the Usumacinta-Pasión regions.

Methods

In order to examine the spatial patterning of the collapse, we adopt Premo's statistical approach, using both Moran's *I* and the localized Getis-Ord *G* statistic, and combine this with Nearest Neighbor analyses, to reevaluate spatial trends in terminal monument dates using a GIS approach since it offers a forum to reevaluate previous research on the spatial trends in terminal long count dedicatory dates across the Maya region.

A dataset consisting of Maya sites with terminal long count dates was compiled from the Maya Hieroglyphic Database (MHD) Project (Macri and Looper 1991–2011). The MHD includes epigraphic data inscribed on known Maya architecture, artwork, portable objects, and carved stone monuments. The database itself is organized by individual glyph blocks (currently over 40,000) located on inscribed monuments at 186 archaeological sites, as well as data from three Pre-Columbian Maya codices.

The dataset used in this study consists of 90 sites with Terminal Classic dates from the Maya Lowlands ranging from AD 711 to AD 910 (Table 1). Initial Series long count dates and calendar round dates that could be confidently correlated with the long count were considered since they are believed to be concurrent with the original time of dedication were chosen for the study. Distance numbers

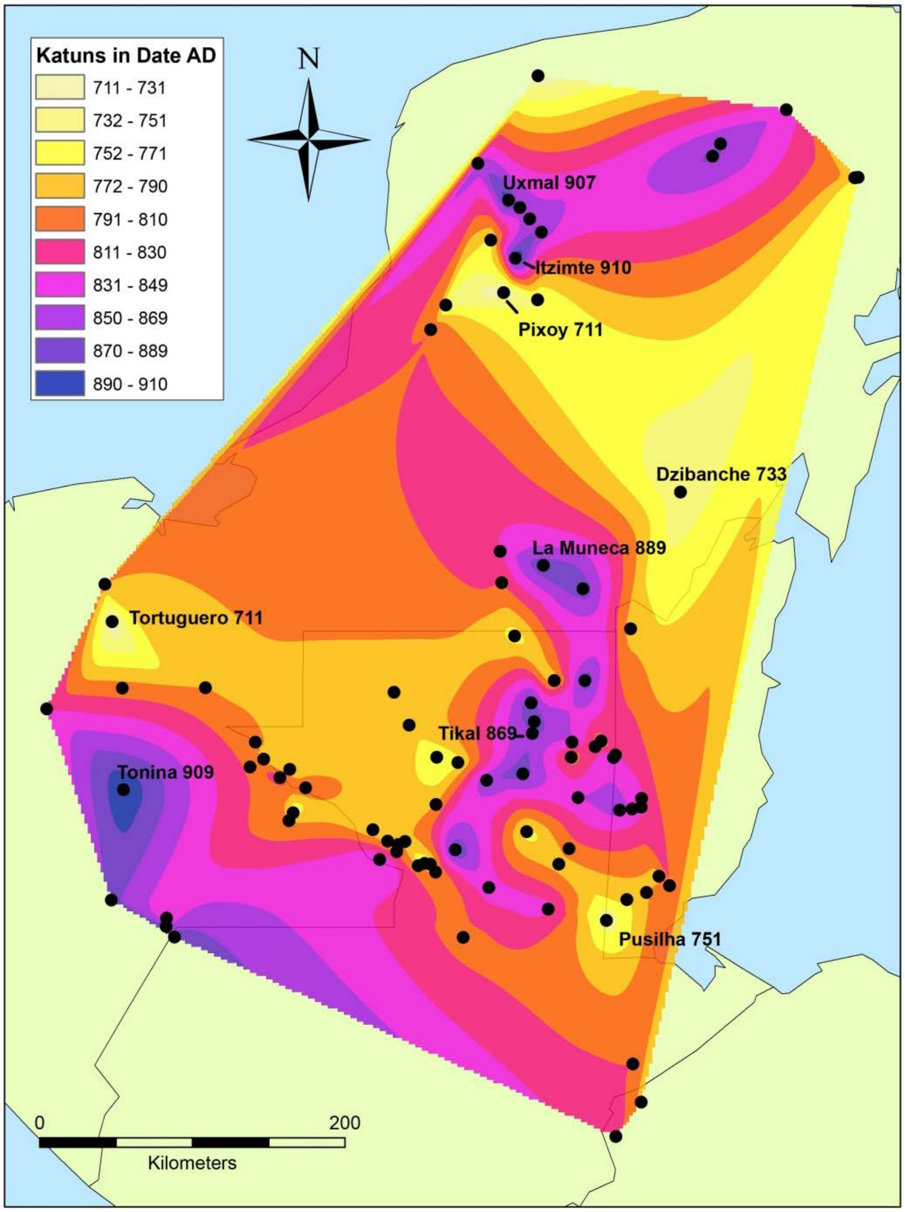

Figure 2. Trend raster image of calculated NN statistics showing broad-scale trends in terminal long count dates across the Maya Lowlands.

were not considered terminal dates. Sites with only one recorded date were excluded from the dataset as a terminal date cannot be determined. Sites possessing only two recorded dates were also included, as a linear regression suggested that the terminal date is not significantly biased due to the number of dates recorded at the site.

Sixty-six sites from previous studies correspond to those used in this study. Both Mountain Cow and Tzimin Kax, considered by some to be the same site, were included in the analyses as two sites with two different UTM coordinates in order to remain consistent with previous studies. Sites from previous studies were excluded if they could not be located geographically. Chichen Itza was not included in this study since its final interpreted long count dedicatory date of AD 997 falls well into the Postclassic Period.

A small number of earlier terminal long count dates exist in the Maya Lowlands, but AD 711 was used as the starting point based on

Lowe's (1985) proposal that the number of dated monuments peaked in AD 721 and represents the apex of the Classic Period monument dedication. He argued that the steady decline in monument dedication after this time represented the breakdown of the authority of Maya kings. In this study we partition the sites into twenty years increments known by the Maya as *katuns*. The date AD 721 falls within the *katun* beginning in AD 711.

Data from the MHD was integrated into a GIS database. Lat/Long coordinates for large sites that could be visually identified from aerial photos were obtained from Google Earth where possible (Table 1). These coordinates come from the central plazas at these sites. For other sites not visible on satellite imagery we adopt coordinates provided by the Maya GIS project (Witschey and Brown 2010), based on a variety of published text and cartographic sources.

Nearest neighbor and spatial autocorrelation using Moran's *I* and the Getis-Ord *G* static were applied to the dataset to examine broad-scale trends in terminal long count dates. NN statistics were calculated using the Spatial Statistics Average Nearest Neighbor tool. NN statistics generated a raster that visually identified trends in the distribution of terminal long count dates. The raster was categorized into twelve discrete periods of 20 years each, (*katuns)* in the Maya long count, beginning with the period AD 711 to AD 731 and ending with AD 891 to AD 911 (Figure 2).

Moran's *I* and Getis-Ord *G* statistics were applied to determine if regional patterns existed in the data. When the two analyses are combined, the *G* statistic identifies discrete regions, referred to called neighborhoods in this study, of points and the Moran's *I* detects outliers within those neighborhoods. Moran's *I* values and Z-scores were calculated using the Spatial Autocorrelation tool in ArcGIS 10. Moran's *I* tests measure a set of point features and associated attributes in order to evaluate whether a spatial pattern is clustered, dispersed or random (Moran 1950). Getis-Ord values and Z-scores were calculated using the Hot Spot Analysis tool in ArcGIS10. *G* identifies features with higher or lower values that tend to cluster in a given neighborhood, but also tests specifically for whether above-average or below-average values cluster more strongly (Getis and Ord 1992). The same spatial analyses were applied to neighborhoods of sites identified in the broad-scale *G* statistic analyses to further investigate the existence of sub-regional patterning.

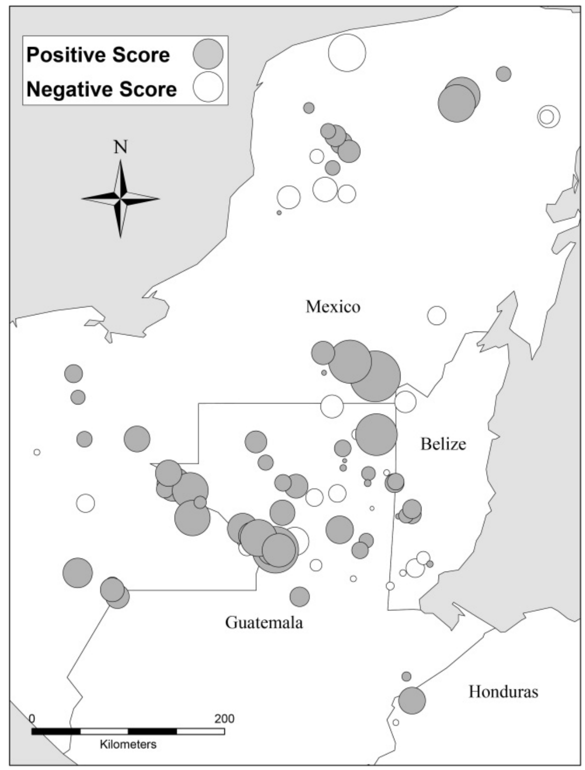

Figure 3. Bubble graph of Moran's *I* scores. Shaded bubbles represent positive scores, white bubbles represent negative scores, and bubble area is proportional to the absolute value of the score. Contemporary political boundaries appear in the background.

Results

A trend raster of calculated NN statistics (Figure 2) shows broad-scale trends in terminal long count dates on monuments across the Maya region. These data demonstrate no strong directional trends (e.g., southwest-to-northeast). Rather, early terminal long count dates are located in isolated pockets in the Puuc region of Yucatan, as well as southern Yucatan, the Campeche district of Mexico, southern Belize extending northwest into the Petén, and the Lower Pasión area. Clusters of sites that have the latest terminal long count dates include zones in the Puuc and Chichen areas around the

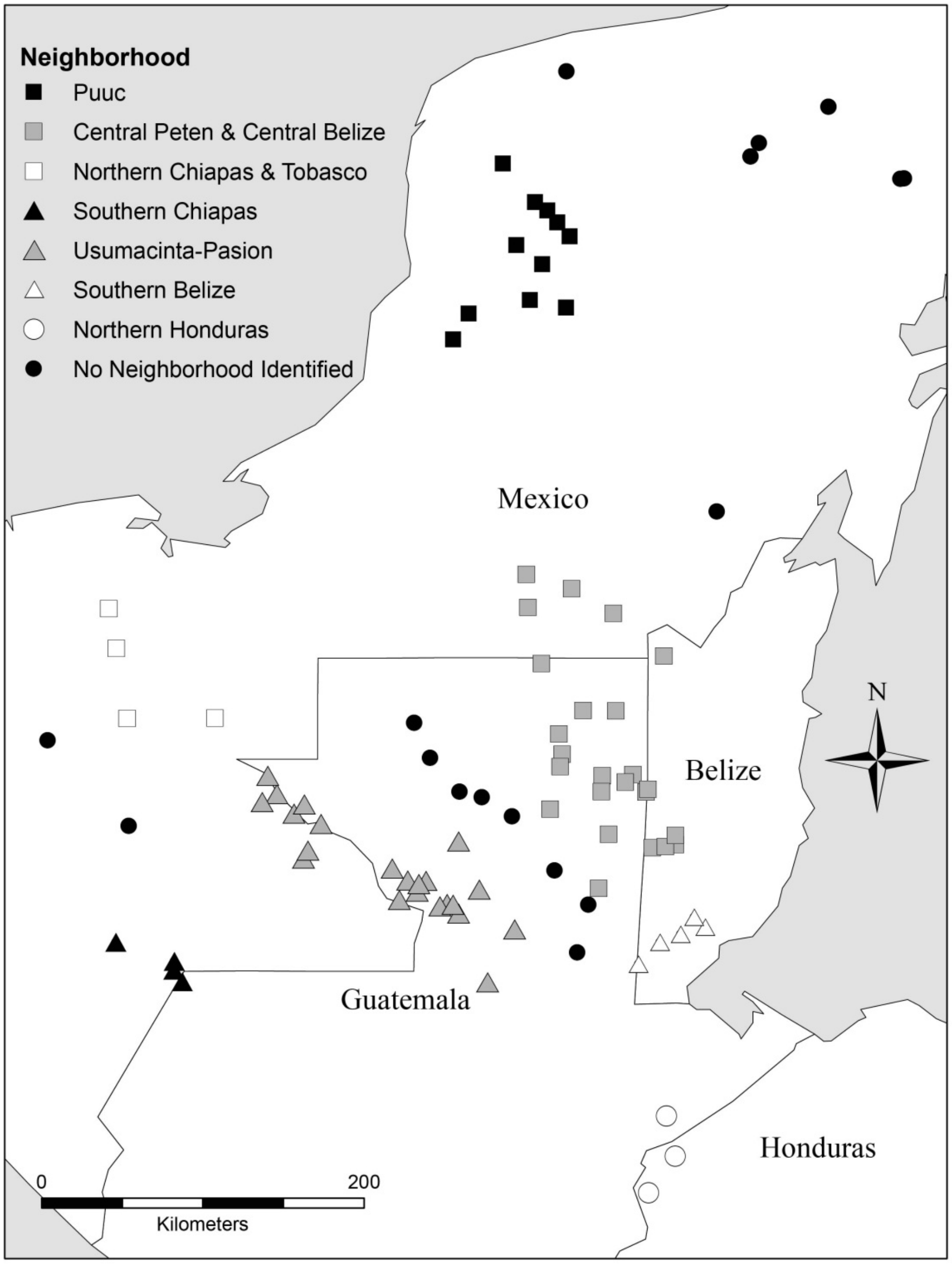

Figure 4. Neighborhoods defined by Getis-Ord *G* statistic, represented as spatially defined clusters of sites with similar terminal long count dates.

sites of Uxmal and Itzimte, southern Chiapas district of Mexico at Tonina and Chincultik, the Northern Petén around La Muneca, and the Central Petén in the area around Tikal, Naranjo, and into Central Belize along the Belize River Valley and the Vaca Plateau.

Moran's *I* scores distinguish spatially defined concentrations of comparable terminal long count dates. Large and positive scores represent sites that have similar terminal dates to those around them (Figure 3). Sites with negative scores have terminal dates that are dissimilar to their neighbors. Concentrations of similar dates are located in the Usumacinta-Pasión region, in the Central Petén and in central and southern Belize. Several explanations have been put forward to explain these site clusters. Premo (2004:862) suggested that clusters

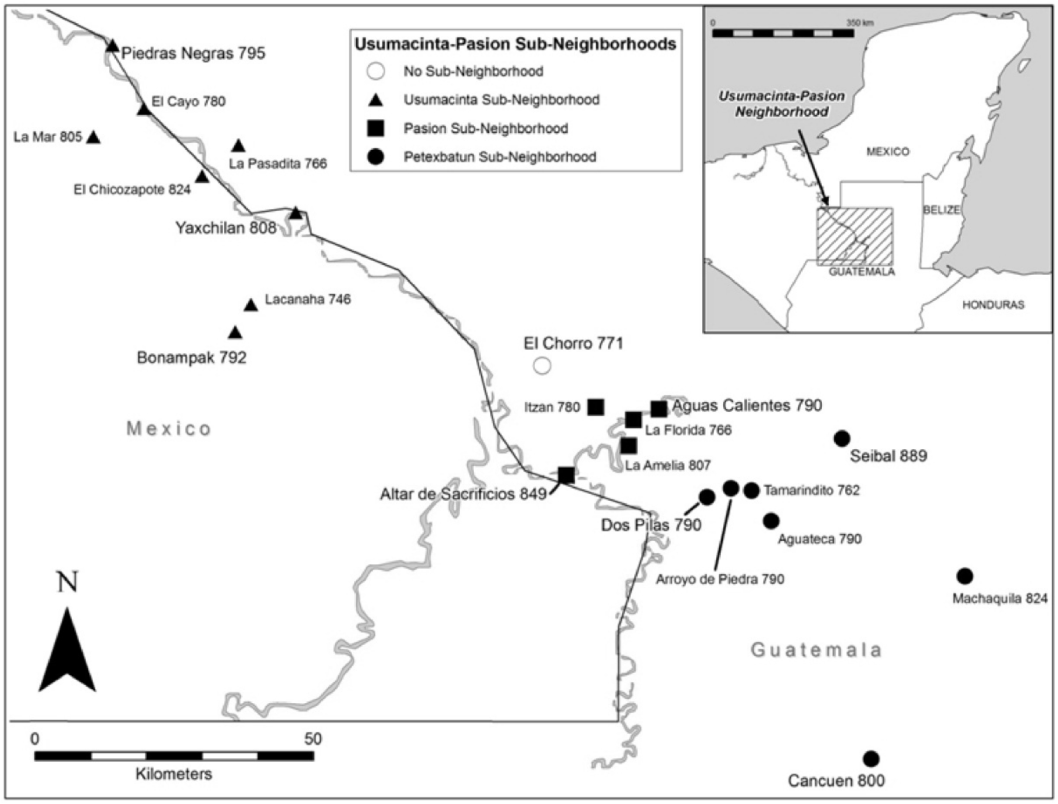

Figure 5. Map of the 22 sites which comprise the Usumacinta-Pasión neighborhood, with three sub-neighborhoods shown.

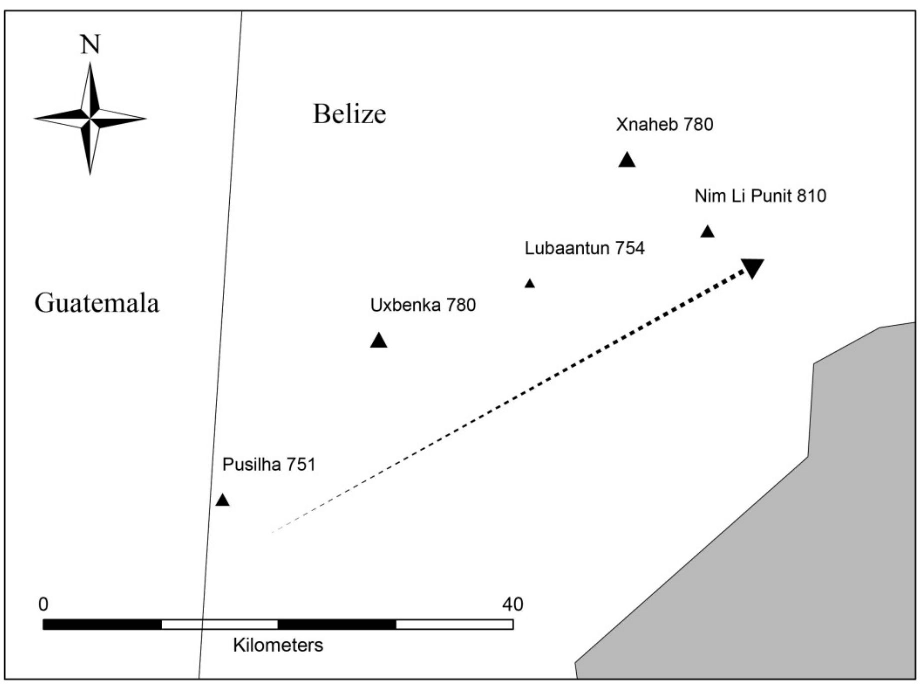

Figure 6. The Southern Belize neighborhood, with early to late terminal monument dates extending from Pusilhá northeast towards Nim Li Punit. Symbology (i.e. size of symbol) reflects this trend.

represent locations where either decentralized elite groups continued erecting monuments, while their neighbors discontinued this cultural practice, or that these clusters represent sites trying to re-establish authority over an area using monuments. Another interpretation may be that these sites were central locations that maintained the ability to carve monuments after others around them had lost their influence, in other words they were, at least for a time, impervious to factors that destabilized their neighbors.

The Getis-Ord *G* statistic grouped sites into neighborhoods, with more negative Z-scores corresponding to sites with early terminal dates, and more positive values identifying sites with later terminal dates. The *G* statistics defined seven neighborhoods that represent clusters of sites with similar terminal long count dedicatory dates (Figure 4). These roughly correlate with major geographical regions in the Maya Lowlands and from which neighborhood names are derived. Clusters of sites compose discrete neighborhoods in the Usumacinta-Pasión region, consisting of sites along the Rio Usumacinta from Piedras Negras in the north down to Altar de Sacrificios, Dos Pilas, and Aguateca in the south; the Southern Zone of Northern Honduras; Southern Belize; the Puuc Hills region; the Petén region around Tikal, Uaxactun, and Calakmul, including parts of Central Belize centered around Caracol; four sites are located in Southern Chiapas; and four sites located in northern Chiapas and extending into Tabasco, the largest of which is Palenque. The regions defined along the Usumacinta, the Central Petén, and Southern Belize are also identified by Moran's *I* as groups of sites that had more similar terminal dates than other regions.

All sites do not necessarily fall within a statistically defined neighborhood. For example, a line of sites without a defined neighborhood extends from southwest to northeast between the Usumacinta-Pasión and Central Petén neighborhood. This is likely the result of their proximity, being relatively closer to the Central Petén neighborhood, and their earlier than average dates as compared to the Central Petén neighborhood.

A total of 22 sites comprised the Usumacinta-Pasión neighborhood (Figure 5). NN analyses performed within the neighborhood suggest a possible temporal gradient, from early to late, down the Usumacinta River from north to south, possibly corresponding to trade networks (Foias 2002). The sites of Seibal (A.D. 889) and Altar de Sacrificios (A.D. 849) have the latest dates in the area. Local *G* statistics performed in this region identified sub-neighborhoods that include the Usumacinta sub-neighborhood (AD 746 – 824), Pasión sub-neighborhood (AD 766 – 849), and Petexbatun sub-neighborhood (AD 762 – 889).

The Southern Belize neighborhood consisted of five sites (Figure 6). NN statistics indicate a dispersed pattern in which early to late dates extend steadily from Pusilhá in the south northeast towards Nim Li Punit. Moran's *I* and G statistic analyses for the neighborhood did not identify sub-neighborhoods but rather suggests that the pattern does not appear to be significantly different than random.

The neighborhood identified for the Petén region and extending into Central Belize consists of 24 sites. While patchwork of later terminal dates can be found throughout the Petén neighborhood, Moran's *I* analyses suggest that most of the dates are similar to each other overall. The *G* statistic did however identify three sub-neighborhoods that are restricted in the Central Petén (Figure 7). These sub-neighborhoods are associated with the largest centers and include:

1. Tikal, Uaxactun, Ixlu, Jimbal, Nakum (AD 849 – 889)
2. Naranjo, Xunantunich, Chunhuitz, Benque Viejo, Ucanal (AD 790 – 849)
3. Caracol, Tzimin Kax, Hatzcap Ceel, Mountain Cow (AD 835 – 859)

The neighborhoods in northern Honduras (n=3), Northern Yucatan (Puuc, n=9), Southern Chiapas (n=4), and Northern Chiapas and Tabasco (n=4) show no internal spatial trends in NN analyses and no statistically significant regional patterns were exhibited in our spatial autocorrelation analyses.

Discussion

Prior work has emphasized the examination of spatial trends in terminal long

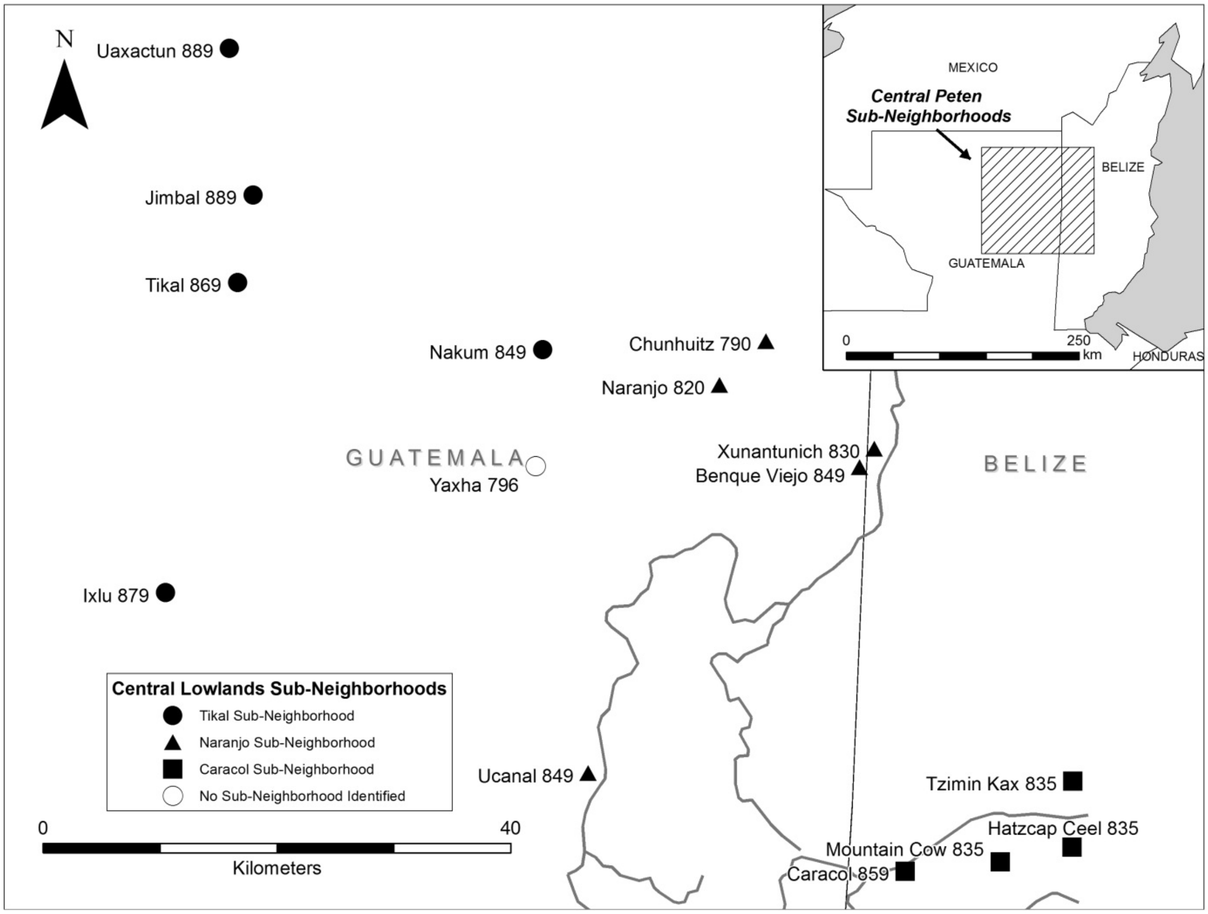

Figure 7. Three sub-neighborhoods in the Petén neighborhood restricted in the Central Petén. These sub-neighborhoods are associated with the largest centers in the area, Tikal, Naranjo, and Caracol.

count dates over broad areas. We expand the data-set to encompass data from throughout the known Classic Period Maya interaction sphere and include regionally specific analyses. More regionally specific studies afford added clarity in spatial patterning in that they identify neighborhoods and highlight sub-neighborhoods within those regions. That monument dedication was relatively coterminous in defined regions demonstrates that local spatial statistics are able to identify spatial indicators of what may be processes or behaviors that undermined kingship and elite rule, which ultimately led to the reduction in the number of complex polities in the Maya region. The identification of geographically specific neighborhoods and of sub-neighborhoods suggests that sites within neighborhoods were affected by similar processes (e.g. conflict, disruption of economic networks, natural or anthropogenic environmental change) that led to the cessation of monument dedication due to their geophysical proximity. This also implies that sites within neighborhoods and sub-neighborhoods were socially and economically interconnected at least in part through their elite populations. The terminality of monument dating in this study exists along a continuum from 24 to 127 years in sub-neighborhoods, suggesting that not all relationships were necessarily equal. Nevertheless, while we do not know exactly what processes facilitated the ability of elites to commission and erect new stone monuments at any particular site, these data suggest that events at one site may have directly or indirectly affected the capability of elites to maintain the authorization of new monuments.

The proposed neighborhoods are not solely defined by shared monument dates. All of the sites examined in this study fall within 27 physiographic adaptive regions in the Maya Lowlands proposed by Dunning et al. (1998). They found these physiographic regions to associate not only with regional geological and geographic variability but also with specific agricultural potentials and practices. This is especially true of neighborhoods with sub-regional patterning. Our Usumacinta-Pasión neighborhood lies within Lacandon Fold (Zone 17) and the Rio de la Pasión regions (Zone 20), the Petén neighborhood sits mostly on the Petén Karst Plateau (14), sites in Belize extending into the Belize River Valley (Zone 22) and Vaca Plateau (Zone 23) and the Southern Belize neighborhood, in an area known as the Karstic Piedmont (Zone 26) (Dunning et al. 1998). Other identified neighborhoods also lie within geophysically bounded areas. A twenty-eighth zone was added to Dunning and colleagues original 27 in order to encompass sites in southern Chiapas. Clustering of specific neighborhood within defined physiographic regions supports a more regionalized view of social and environmental processes, as opposed to broad-scale, which may have influenced local changes during the Terminal Classic.

The spatial pattern of terminal monument dates from the Central Petén and Central Belize neighborhood corresponds well with what has been archaeologically documented during the Terminal Classic in the region. The area was marked, like the Usumacinta-Pasión region, with warfare between the rival sites of Tikal, Naranjo, and Caracol (Schele and Friedel 1990; Martin 2001; Chase 2003), which define sub-neighborhoods for the region. Further status rivalry has been documented in the Central Petén sub-neighborhood during the eight century that stimulated competitive architectural programs. The secondary sites of Uaxactun, Ixlu, Jimbal, and Xultun declared their independence from Tikal. This pattern has been interpreted as representing shifting seats of ceremonial performances and that Tikal may have used this mechanism as a power-sharing device (Rice 2006). However, by AD 830 populations at Tikal began to decline and secondary sites gained power over their former overlord. Like the events that played out in the Usumacinta-Pasión neighborhood, military campaigns likely contributed to the decline and cessation of monument dedication in this region with the final date recorded at Uaxactun (AD 830) referring to warfare with its neighbors. Caracol also experienced a similar fate to Tikal and Uaxactun. Chase and Chase (2004) note a dramatic reduction in architectural construction and evidence of burning and warfare in the Caracol site core. At all these sites, archaeological data suggests that squatter populations still occupied the site following these events (see Stanton and Magnoni eds. 2008).

The description of the collapse in the Southern Belize neighborhood is more varied. While some centers experienced a decline in terms of population and monumental constructions, other sites - such as Ixtonton, Ucanal, Sacul – expanded. Laporte (2004) has suggested that these sites were influenced by the Puuc region in the Northern Lowlands, which fluoresced into the Post Classic Period. In comparison to the rest of the Maya world, little research has been carried out in Southern Belize on the Belizean side of the border. Terminal long count dates in the area suggest a relatively quick sociopolitical disintegration of major open-air sites extending first from the south at Pusilhá (AD 731) to the northeast towards Nim Li Punit (AD 810), a distance of only 30km. Hieroglyphic texts and excavations at Pusilhá, the largest and most politically dominant site in the area, suggest that the polity persisted at least through AD 790 (Braswell 2001; Braswell and Prufer 2009:48), an event that likely played a role in dynamics of collapse in the rest of the area. At Lubaantun the ceramic assemblage, dominated by Tepeu 2/3 Petén styles of the Late Classic suggests that the site was founded in AD 731 ± 20 years (Hammond 1975). The last text from the site dates to 790 and is taken to be the general time of site abandonment. At Nim Li Punit most of the published chronological material comes from 26 carved monuments located in the elite core of the site. Stelae at the site were erected between AD 711 and AD 830 indicating a short dynastic history for the polity and likely a short occupational span at the site (Grube et al. 1999; Hammond et al. 1999). The overall picture painted through GIS analyses and archaeological exploration for Southern Belize supports the disuse of writing by elites followed quickly by the abandonment of large centers in the region between AD 730 and AD 850. Large and small polities, including those in the nearby Maya Mountains appear to have been depopulated during this span of the Terminal Classic as well. However, it should be noted that this characterization applies only to the inland sites but the coastal sites investigated by McKillop (1996, 2005) have Postclassic elements, which likely are linked to an increase in coastal trade after the end of the Classic Period.

Conclusion

The idea of regionally specific investigations is not new and archaeological work in the Maya Lowlands during in the last decade has increasingly focused on the regional scale (Ball and Taschek 2003; Scarborough et al. 2003; Demarest et al. 2004; Rice and Rice 2007; Prufer et al. 2011), underscoring the importance of social and economic integration between polities. In this paper we have presented a geospatial and temporal model of polities grouped into neighborhoods at the time of the collapse, providing the foundation for a new way of identifying regional similarities and differences. Bove (1981) and others hypothesized that sites with similar terminal long count dates should cluster and correlate with geographic regions, but the information available at the time was limited and isolated to the Petén. An expanded dataset, including the Northern and Southern Maya Lowlands, facilitates spatial studies that can help to define groups of sites geographically that may have experienced similar changes and potentially clarify relationships between sites during the political turmoil of the Terminal Classic.

The spatial neighborhoods identified in these analyses correlate with previous regional archaeological interpretations and assessments of socially important ecological zones (Dunning 1998) suggesting that polities within neighborhoods were economically linked. Economic interdependency has been repeatedly suggested to have been a factor in the disintegration of Classic Period institutions, though there is little agreement structure or form of what were clearly complex systems of production, exchange and consumption (e.g. Dahlin et al. 2011; Rice 2009; Scarborough and Valdez 2009). Establishing spatial and chronological links between sites during critical end days preceding their political collapse provides another avenue to explore social and ecological bases of cultural change over time.

The disintegration of Maya polities during the Terminal Classic was a complex sociopolitical process and recorded dates on stone monuments provide only one way of examining these processes. Spatial analyses of the Terminal Classic collapse through terminal long count dates provide information about the role of interaction networks in processes of decentralization and disintegration. Identifying and understanding patterning may lead to better discussion, hypotheses, and testing of causality. Yet, researchers should remain wary of the possible problems that such analyses present. This study is constrained by some of the same problems as previous research. Sample sizes are relatively small and written texts only provide part of the story with clear biases. Furthermore, though epigraphic texts are invaluable indicators of elite activities, chronological and spatial dimensions of the collapse must also be examined through the recovery and analysis of archaeological data at the regional level. Though spatial representations of the collapse are not able to tell the exact cause, they can help researchers define some of the parameters contributing to the reduction in the number of Maya polities at the end of the Classic Period.

References Cited

Aimers, James
2007 What Maya collapse? Terminal classic variation in the Maya lowlands. *Journal of Archaeological Research* 15:329-377.

Ball, Joseph W. and Jennifer T. Taschek
2003 Reconsidering the Belize Valley Preclassic: A case for multiethnic interactions in the development of a regional culture tradition. *Ancient Mesoamerica* 14:179-217.

Bove, F.J.
1981 Trend Surface Analysis and the Lowland Classic Maya Collapse. *American Antiquity* 46:93-112.

Braswell, Geoffrey E.
2001 Pusilhá Archaeological Project. Report Submitted to Foundation for the Advancement of Mesoamerican Studies, Inc., Crystal River, Florida.

Braswell, Geoffrey, and Keith M. Prufer
2009 Political Organization and Interaction in Southern Belize. *Research Reports in Belizean Archaeology* 6:43–55.

Chase, Arlen F. and Diane Z. Chase
2004 Archaeological Perspectives on Classic Maya Social Organization from Caracol, Belize. *Ancient Mesoamerica* 15(1):139-147.

Chase, Diane Z.
2003 Texts and Contexts in Classic Maya Warfare: A Brief Consideration of Epigraphy and Archaeology at Caracol, Belize. In *Ancient Mesoamerican Warfare*, edited by M.K. Brown and T.W. Stanton, pp. 171-188. Alta Mira Press, Walnut Creek, California.

Dahlin, Bruce H., Daniel Bair, Tim Beach, Mathew Moriarty, and Richard Terry
2009 The Dirt on Food: Ancient Feasts and Markets Among the Lowland Maya. In *Pre-Columbian Foodways*, edited by J. Staller and M. Carrasco, pp. 191-232. Springer, New York.

Demarest, Arthur A., Prudence M. Rice and Don S. Rice
2004 *The Terminal Classic in the Maya lowlands: collapse, transition, and transformation*. University Press of Colorado, Boulder.

Dunning, N., T. Beach, P. Farrell, and S. Luzzadder-Beach
1998 Prehispanic Agricultural Adaptive Regions in the Maya Lowlands. *Culture and Agriculture* 20 (4):87-101.

Foias, Antonia
2002 At the crossroads: the economic basis of political power in the Petexbatun region. In *Ancient Maya Political Economics*, edited by M.A. Masson and D.A. Freidel, pp. 223-248. AltaMira Press, Walnut Creek, CA.

Freidel, David and Linda Schele
1989 Kingship in the Late Preclassic Maya Lowlands: The Instruments and Places of Ritual Power. *American Anthropologist* 90(3):547-567.

Getis, A. and J.K. Ord
1992 The analysis of spatial association by use of distance statistics. *Geographical Analysis* 24: 189-206.

Grube, Nikolai, Barbara MacLeod, and Phil Wanyerka
1999 A Commentary on the Hieroglyphic Inscriptions of Nim Li Punit, Belize. *Research Reports on Ancient Maya Writing*, No. 41. Center for Maya Research, Washington, D.C.

Hamblin, R.L. and B.L. Pitcher
1980 The Classic Maya Collapse: Testing Class Conflict Hypotheses. *American Antiquity* 45(2): 246-267.

Hammond, Norman
1975 *Lubaantun: A Classic Maya Realm*. Monograph 2. Harvard University, Peabody Museum of Archaeology and Ethnology, Cambridge.

Hammond, Norman, Sheena Howarth, and Richard R. Wilk
1999 The Discovery, Exploration, and Monuments of Nim Li Punit, Belize. *Research Reports on Ancient Maya Writing*, No. 40. Center for Maya Research, Washington, D.C.

Houston, Stephen and David Stuart
1996 Of gods, glyphs, and kings: Divinity and rulership among the Classic Maya. *Antiquity* 70(268):289–312.

Kvamme, Kenneth
1990 Spatial Autocorrelation and the Classic Maya Collapse revisited: Refined techniques and new conclusions. *Journal of Archaeological Science* 17(2):197-207.

Laporte, J.P.
2004 Terminal Classic settlement and polity in the Mopán Valley, Petén, Guatemala. In *The Terminal Classic in the Maya Lowlands: Collapse, Transition, and Transformation*, edited by A.A. Demarest, P.M. Rice, and D.S. Rice, pp. 195-230. University Press of Colorado, Boulder.

Lowe, J.W.G.
1985 *The dynamics of apocalypse: a systems simulation of the classic Maya collapse*. University of New Mexico Press, Albuquerque.

Macri, Martha J. and Mathew G Looper
1991-2011 *Maya Hieroglyphic Database*. University of California, Davis.

Mathews, Peter
1991 Classic Maya Emblem Glyphs. *In Classic Maya Political History: Hieroglyphic and Archaeological Evidence*, edited by T. Patrick Culbert, pp. 19-29. Cambridge University Press, New York.

Martin, Simon
2001 Under a deadly star, warfare among the Classic Maya. In *Maya: divine kings of the rain forest*,

edited by N. Grube, E. Eggebrecht, and M. Seidel, pp. 174-185. Kónemann, Kóhn.

Martin, Simon and Nikolai, Grube
2000 *Chronicle of the Maya Kings and Queens: Deciphering the Dynasties of the Ancient Maya*. Thames & Hudson, London.

McKillop, Heather
1996 Ancient Maya Trading Ports and the Integration of Long-Distance and Regional Economies: Wild Cane Cay in South-Coastal Belize. *Ancient Mesoamerica* 7(1): 49–62.

2005 *In Search of Maya Sea Traders.* Texas A & M University Press, College Station.

Moran, P.A.P
1950 Notes on Continuous Stochastic Phenomena. *Biometrika* 37(2):17-23.

Munson, Jessica L. and Martha J. Macri
2009 Sociopolitical network interactions: A case study of the Classic Maya. *Journal of Anthropological Archaeology* 28(4):424-438.

Neiman, F. D.
1997 Conspicuous consumption as wasteful advertising: a Darwinian perspective on spatial patterns in Classic Maya terminal monument dates. In *Rediscovering Darwin: Evolutionary Theory and Archaeological Explanation*, edited by C.M. Barton, pp. 267-290. American Anthropological Association, Arlington.

Premo, L.S.
2004 Local spatial autocorrelation statistics quantify multi-scale patterns in distributional data: an example from the Maya Lowlands. *Journal of Archaeological Science* 31(7):855-866.

Prufer, Keith M., Holley Moyes, Brendan J. Culleton, Andrew Kindon, and Douglas J Kennett
2011 Formation of a Complex Polity on the Eastern Periphery of the Maya Lowlands. *Latin American Antiquity* 22(2):199-223.

Rice, Prudence M.
2006 *Maya political science: time, astronomy, and the cosmos*. University of Texas Press, Austin.

2009 On Classic Maya political economies. *Journal of Anthropological Archaeology* 28(1):70-84.

Rice, Prudence M and Don S. Rice
2007 The Terminal Classic to Early Postclassic Transition in the Central Peten Lakes Region. In *La Blanca y su entorno: cuadernos de arquitectura y arqueología maya*, edited by C.V. Lorenzo and G.M., pp. 145-160. Universidad Politécnica de Valencia, Valencia, Spain.

Scarborough, Vernon L., Fred Valdez, and Nicholas P. Dunning
2003 *Heterarchy, political economy, and the ancient Maya: the Three Rivers Region of the east-central Yucatán Peninsula*. University of Arizona Press, Tucson.

Scarborough, Vernon L. and Fred Valdez Jr
2009 An Alternative Order: The Dualistic Economies of the Ancient Maya. *Latin American Antiquity* 20(1):207–227.

Schele, Linda and David A. Freidel
1990 *A forest of kings: the untold story of the ancient Maya*. William Morrow and Company, Inc., New York.

Stanton, Travis W. and Aline Magnoni
2008 *Ruins of the past: the use and perception of abandoned structures in the Maya lowlands.* University Press of Colorado, Boulder.

Whitley, D. and W.A.. Clark
1985 Spatial autocorrelation tests and the Classic Maya collapse: Methods and inferences. *Journal of Archaeological Science* 12(5):377-395.

Walter R.T. Witschey and Clifford T. Brown
2010 The Electronic Atlas of Ancient Maya Sites: a Geographic Information System (GIS). http://mayagis.smv.org.