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Classic Maya Settlement Systems Reveal Differential Land Use Patterns in the Upper Belize River Valley

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Abstract: Land use practices have had important implications for structuring household inequalities and broader political systems in the past. Our contribution examines settlement patterns in relation to political structure, household wealth, ecological productivity and agricultural techniques. Combining settlement pattern data with high–precision soils data, we examine the extent to which different trajectories of polity formation impact the settlement location and land use practices of intermediate elites and commoners. The Classic Maya (CE 250/300–900) polities of Baking Pot and Lower Dover in the Upper Belize River Valley serve as enlightening case studies because despite being situated near one another, the two centers emerged along very different trajectories. Whereas the polity of Baking Pot arose slowly, in tandem with surrounding demography, the neighboring polity of Lower Dover arose rapidly in the Late Classic period (CE 600–900) in an area which was already home to established local populations. Our analysis shows that while Baking Pot had substantial settlement clustering around its epicenter, populations at Lower Dover aggregated around secondary and tertiary centers farther away from the polity core. Analyses also demonstrate that most commoner and intermediate elite residences were situated on the most productive agricultural lands in the region, though some intermediate elite households were situated on hilltops or in border zones with marginal soil productivity for political and tactical reasons. Commoner households were situated on a range of productivity zones reflecting diverse land–use practices which had implications for household wealth. Our case study illustrates the importance of integrating land use practices into our reconstructions of ancient political hierarchies, especially in terms of understanding political strategies and household wealth.

Keywords: settlement patterns; political dynamics; ancient Maya; agricultural strategies; intermediate elites; household inequalities

1. Introduction

The upper Belize River Valley is one of the most intensively studied archaeological regions in the world. The Belize River Valley was the birthplace of Maya settlement archaeology [1]; recently, however, lidar (light detection and ranging) survey and full coverage pedestrian survey has changed our understanding of settlement patterns in the region [2–12]. While regional settlement was once considered to form a "continuous ribbon–strip" which ran along the alluvial valley, we now know that commoner settlement clustered around minor centers and, in some cases, major centers [13]. Drawing on recent survey and excavation data gathered by the Belize Valley Archaeological Reconnaissance (BVAR) Project, this study compares residential clustering and environmental land productivity in two Classic Maya polities in the Belize River Valley: Baking Pot and Lower Dover (Figure 1). These polities are good case studies for such an investigation as they both have seen extensive settlement survey and excavation of both commoner households and the central monumental cores. Research has highlighted the fact that similarly sized, neighboring polities can represent very different political systems [14–16]. Despite being situated just 7 km apart, Baking Pot and Lower Dover formed through different developmental sequences and appear very different in terms of the relative power of their apical elite rulers and intermediate elite district heads, and the amount of surrounding territory which fell under their hegemony. The goal of this article is to further refine our understanding of settlement patterns by combining multiple recent analyses of lidar and pedestrian survey data. Moreover, these data are combined with architectural volume estimates of major and minor centers, and soil productivity data to assess land use practices by different hierarchically arranged social actors.

This article poses two overarching research questions. The first question being, to what extent did the divergent developmental trajectories of the Baking Pot and Lower Dover polities result in different settlement patterns? Hypothetically, the longer political trajectory at Baking Pot might lead to a greater degree of settlement aggregation around the core, as is common at other well established Maya polities [12,13], while settlement clustering at Lower Dover might remain more dispersed or aggregated around long–standing minor centers, as is the case at the nearby late forming center of Xunantunich [17]. Alternatively, the opposite may be true, and despite emerging late in the regional trajectory, Lower Dover may have served as the focus of residential aggregation to the same extent, or to an even greater extent than Baking Pot. If proven, this scenario may indicate the emerging Lower Dover apical regime employed specific policies to attract or move commoner subordinates to the emerging polity [18,19]. The second research question being: to what extent did highly productive agricultural land play a role in structuring settlement patterns in the area? Hypothetically, given the fact that most Classic Maya commoners were farmers [20–22], highly productive soils would have been the focus of commoner residential aggregation [23]. Settlement aggregation away from productive lands would suggest commoners had different priorities in situating their residences, or top–down policies impacted their ability to settle in ideal locales. Discerning between these possibilities will provide a better understanding of the political and economic factors which structured Classic Maya settlement patterns.

Figure 1. Map of Mesoamerica showing sites mentioned in the text and other important sites with an inset showing the Belize River Valley and the locations of Baking Pot and Lower Dover.

The upper Belize River Valley covers an area of ~125 km², reaching eastward from the Late Classic political center of Xunantunich and the modern Guatemala/Belize border 30 km downriver to the Preclassic center of Blackman Eddy (Figure 1). The Belize River forms at the confluence of the Macal and Mopan Rivers in the modern towns of San Ignacio and Santa Elena, near the ancient polity of Cahal Pech, and then flows 100 km eastwards to the Caribbean Sea. The specific portion of the upper Belize River Valley under investigation begins at the easternmost edge of the modern town of Santa Elena (the edge of the Cahal Pech polity) and extends 14 km east to the modern village of Unitedville. This sub–region encompasses 71 km² and was once controlled by the political regimes centered at the polity capitals of Baking Pot, Lower Dover, and Blackman Eddy. The topography of this sub–region is characterized by expansive alluvial plains in the western half around Baking Pot, which extend to the foothills immediately north and south of the river [24,25]. The eastern half of the area, around Lower Dover, is more undulating as the southern foothills protrude north towards the river. Immediately north of the Belize River at Lower Dover is the alluvial plain upon which the ancient settlement of Barton Ramie, where Maya settlement archaeology was pioneered, was situated [1,26].

The Belize River Valley has long been regarded as a highly productive ecological niche within the Maya Lowlands [1,23,24,27]. The Classic Maya of the Belize River Valley preferentially resided on or near more productive soils for hand cultivation [23] (pp. 24). Impressions of maize cobs on pottery and the recovery of cupule fragments indicate that maize was central to upper Belize Valley foodways as early as 1200 BCE [28]. Stable isotope paleodietary studies suggest that a maize–rich diet (>70% of dietary protein) remained relatively constant from the Preclassic to the Colonial period in the region [29]. Although many other plant resources were also cultivated and consumed [30,31]. During the Classic period, water management systems supported agricultural production in the valley, and terracing was constructed in the southern foothills to feed growing populations [32,33]. Some evidence also indicates that cacao, an important luxury crop, was likely

cultivated on the alluvial plains [23,34]. For example, ethnohistoric sources describe Postclassic cacao plantations in the region that were controlled by the Itza ruler Can Ek at Noh Peten [35] (pp. 102–105), see also [36]. The region continued to fulfill this role in the early Colonial period when Spanish cacao–producing *encomiendas* were established in the region [37,38]. Willey and colleagues [1] (pp. 529, 574) also identified the impression of a cacao bean on a Middle Preclassic daub fragment from Barton Ramie, see also [39]. The 1:50,000 scale soil map used by Fedick [23], and considered in this study, suggests that 20% of the region's soil was likely suitable for cacao cultivation. Recently, Ford and colleagues [40] have employed laser mass spectrometry to detect the cacao biomarker, Theophylline, in residues on ceramics. Intriguingly, the results showed that cacao was accessed by a large percentage of households, irrespective of status, in both the alluvial valley bottoms and the surrounding uplands. While it seems likely cacao was cultivated in these regions, it could also have been imported from surrounding cacao producing regions such as southern or northern Belize [41,42].

Survey and excavations by the BVAR Project and other archaeological projects have uncovered a long developmental sequence in the region (Table 1), beginning in the Early Preclassic (1200–900 cal BCE) with the formation of sedentary villages at Actuncan [43,44], Blackman Eddy [45], Cahal Pech [46–48], and Xunantunich [49]. These villages grew into sizeable communities with evidence of socio–economic inequalities by the Middle Preclassic (900–300 BCE), including monumental architecture and differential burial practices [50–53]. The Late Preclassic saw Actuncan [54], Baking Pot [25,55], Blackman Eddy [45,56], and Cahal Pech [46,47,55–57], develop into the capitals of small regional polities as indicated by the construction of increasingly large monumental architecture and the first royal burials. By the Classic period, the region was home to several nominally autonomous polities centered at Actuncan, Arenal, Baking Pot, Blackman Eddy, Buenavista del Cayo, and Cahal Pech [25,46,56–61]. Most of these centers grew considerably in the Late Classic, and several newer royal centers such as Lower Dover, Tipan Chen Uitz, and Xunantunich formed in their midst [62–64]. The capitals of the Belize River Valley polities comprised large, monumental cores surrounded by commoner settlement, with all the architectural features associated with Classic Maya major centers [57,59,60,65–67]. Moreover, despite falling in and out of the aegis of powerful external suzerains such as Tikal, Caracol, and Naranjo [60,68,69], most have large eastern triadic structures/assemblages (pyramidal eastern elite ancestral shrines with northern and southern wings alike to E Groups) where elite lineage members were interred, often with the trappings of kingship [57,59,70]. Regional populations at this time were relatively high, with populations of 2000–8000 people living within these polities [26] (p. 60). Major centers in the Belize River Valley form the top tier (Tier 1) of the settlement hierarchy. These polity capitals were associated with royal regimes and generally possess a full suite of monumental architecture [7,60]. In contrast, minor centers (Tiers 2–3) have a more limited array of monumental architecture [71]. While major centers were home to apical elites, generally minor centers show evidence of intermediate elite occupation in terms of scaled–down residential architecture and smaller lineage shrines. Tier 2 minor centers housed powerful secondary elites who seem to have been allied with apical elites based at major centers [71,72]. These Tier 2 centers commonly have ballcourts, *sacbeob* (processional causeways), and causeway termini groups, but no eastern triadic structures [71–73]. In contrast to the small number of Tier 2 minor centers, each polity had many Tier 3 minor centers each situated at the hearts of dense clusters of commoner settlement with sizeable eastern triadic structures which, similarly to their larger counterparts at major centers, served as the locus of elite interment and ancestor veneration [71]. Tier 2 centers likely played a role as top–down integrative hubs, at the polity scale, whereas Tier 3 centers represent the residences of multiple competing elite lineages (Figure 2). Surrounding all of these centers are generally high densities of house mounds which served as residences for high and low–status commoner households. Architectural investment has been employed as a metric of socio–political status in the region as it commonly reflects the amount of labor different households could muster [5,74–79].

The main difference between high and low–status commoner households is the amount of labor invested in construction over time. High–status commoner residences generally included three or more residential mounds situated around a central patio that range in architectural size from 300 to 1000 m^3 [26,71]. Low–status commoner households are much smaller and generally include a single or sometimes two structures, usually associated with a constructed patio. Low–status commoner households generally range in architectural size from 50 to 300 m^3 [26] (pp. 47–48). Commoner households are generally dispersed across the landscape with sufficient space between them for various forms of infield cultivation [80–83]. In contrast to status, researchers have employed portable wealth items included in funerary interments, residential fill, and middens as a metric of wealth [25,84–86]. In addition to wealth, we employ the concept of affluence to refer to contexts with access to particularly significant sumptuary items which were gifted down elite tributary networks, potentially to specific individuals [87]. Collectively, these apical elite, intermediate elite, and commoner households represented nodes in numerous overlapping hierarchical socio–political networks. Understanding politics requires the reconstruction of the personal relationships between actors situated at these nodes [19,88–96].

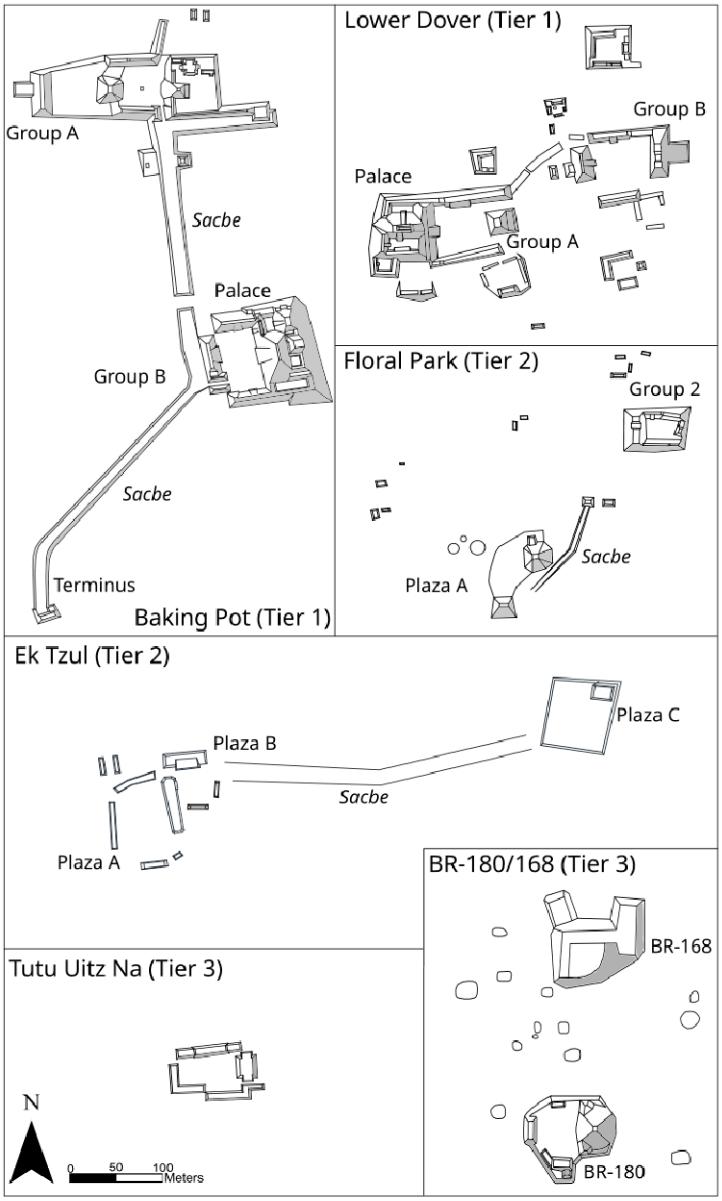

Figure 2. Maps of major and minor centers in the Baking Pot and Lower Dover polities showing different structure types, adapted from [1,26,97–101]. (Figures 143, 177 and 179; Figures 6.18, 6.96 and 6.124; Figure 4.1; Figure 1; Figure 2; Figure 1; Figure 1).

Archaeologists have previously reconstructed the geographic extents of Classic polities in the upper Belize River Valley using a combination of analyses such as settlement densities, gravity models and Thiessen polygons [2,4,7]. Settlement and excavation data suggests that each site was characterized by a multi–tiered settlement hierarchy associated with nested levels of residential clustering. Commoner households typically cluster into small neighborhoods focused around high–status commoner households, and these neighborhoods form larger districts that are usually headed by intermediate elites based at minor centers (for commoner clustering around minor centers see [13,19,71,102–112]. Multiple districts cluster into larger regional polities with major centers and their associated apical elite royal courts at the center [13,110–112]. The districts controlled by the intermediate elites provided a range of resources to their overlords which could be drawn upon in their political negotiations with one another, their apical suzerains, and their commoner subordinates. These resources could include the labor of their followers, staple and luxury crops grown within their respective districts, and items crafted in these regions such as high value ceramics and textiles [36,113].

Table 1. Chronology for the Belize River Valley (based on radiocarbon dating and ceramic analysis see [114–117].

Time Period	Date Range
Postclassic	CE 900/1000–1521
Terminal Classic	CE 750/800–900/1000
Late Classic	CE 600–750/800
Early Classic	CE 250/300–600
Terminal Preclassic	CE 150–250/300
Late Preclassic	300 BCE–CE 150
Middle Preclassic	900–300 BCE
Early Preclassic	1200–900 BCE

Despite their proximity and architectural similarities, the polities of Baking Pot and Lower Dover represent very different political entities (Figure 3). Baking Pot's royal court is situated on highly productive soils (Class I—see below) immediately south of the Belize River. Although, similarly to Lower Dover, the extent of the polity extends to the north of the river. Substantial research has revealed Baking Pot grew gradually from a Late Preclassic center to the capital of a sizeable Late Classic kingdom, alongside steady increases in regional demography [7,25,55,65]; see also [1,118,119]. Late Classic Baking Pot was one of the largest political centers in the region with a civic–ceremonial center comprising 280,000 m^3 of monumental architecture. Densely nucleated settlement is apparent around the Baking Pot core, where approximately 3000 people lived. Intermediate elite architecture in this core zone is generally small (300–2400 m^3), although excavations indicate that some intermediate elite households (e.g., the Bedran Group) possessed substantial portable wealth including overt material markers of affluence such as jade, eccentrics, and incised ceramics with glyphic bands listing royal titles [120,121]. While spatial analysis to date provides a solid understanding of the dense clustering around the central civic–ceremonial core of Baking Pot, the extended periphery of the Baking Pot polity contained numerous important minor centers such as Bacab Na, Esperanza, North Caracol Farm, Spanish Lookout, and possibly Ek Tzul, which are analyzed alongside the core here [1,5,100,122–126].

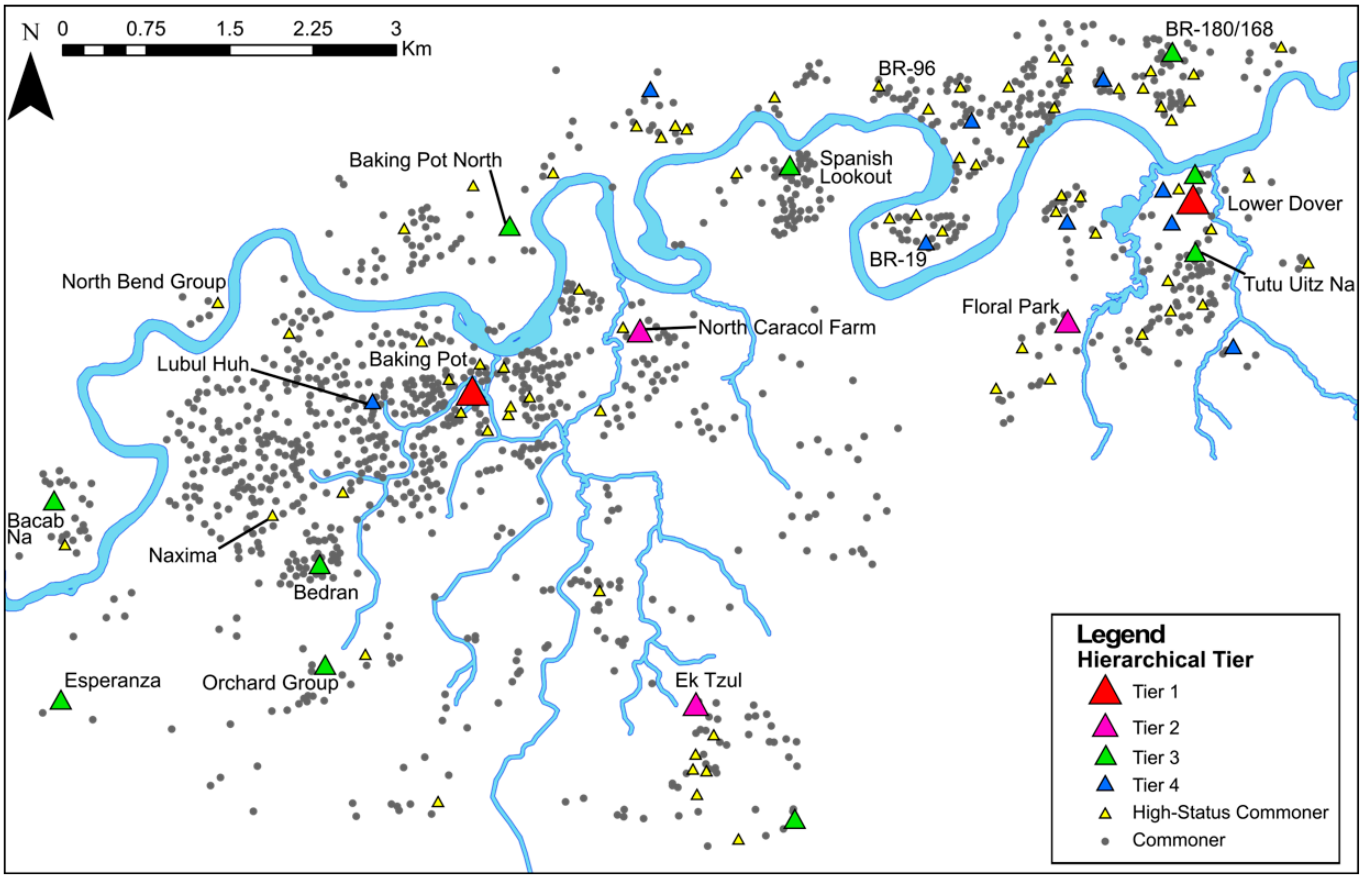

Figure 3. Map of Baking Pot and Lower Dover.

In contrast, the Lower Dover civic–ceremonial center was about half the size of Baking Pot (148,000 m^3). The polity capital of Lower Dover is located on the southern bank of the Belize River on fairly productive Class II soils (see below) [26] (Figure 6.2). Whereas Baking Pot grew slowly, in tandem with its population, Lower Dover represented a Late Classic imposition on an already densely settled landscape [63,127]. Our current understanding is that Lower Dover likely represented a top–down intrusion by a fairly powerful external elite regime [26] (p. 67). The emergence of Lower Dover marked a shift in power from the pre–existing center of Blackman Eddy just 3 km to the east [56]. We examine the extent to which Late Classic commoner settlement shifted to aggregate around the new Lower Dover core in the Late Classic period.

2. Materials and Methods

Pedestrian survey data generated by the BVAR Project and the Harvard Peabody Survey Project are available for approximately 85% of the region under investigation [1]. This is coupled with lidar remote sensing data for the other 15% of households, which await ground truthing but are included in the analysis and on the maps. Classic Maya households commonly involve groups of low mounds, the remains of stone platforms situated around a central patio [128]. Unlike households in other parts of the Maya lowlands, most Belize Valley household groups did not aggregate into larger groups with four structures around a patio [129,130]. Patios are defined as smaller flat, open areas associated with one or more structural platforms (of 50–350 m^2), whereas plazas are larger open spaces (>350 m^2). At Baking Pot and Lower Dover, all patios are associated with commoner households, whereas plazas are only found in intermediate or apical elite contexts. The volume of household architecture was extracted from lidar data [71]. Settlement pattern and architectural volumetric data (described below) were combined with 1:50,000

scale soils data [23], to assess settlement clustering and the land use strategies of hierarchically arranged actors.

2.1. Survey and Remote Sensing Methods

Settlement survey at Baking Pot is still ongoing, partly due to the sheer scale of the polity in comparison to Lower Dover [125]. While 85% of the polity has been documented through pedestrian survey, high resolution lidar data and TPI (Topographic Position Index) analysis reliably fills in the gaps in the remaining 15%. TPI analysis produces a raster, comprising equally sized cells. The values of these cells reflect the difference between the elevations within one cell and the average elevation of any cells lying within whatever search radius is included. The method is employed at very small scales to identify house mounds which have sloping sides and thus differential elevations [2,4,11]. TPI analysis of lidar has proven to be a very effective way of detecting settlement. It therefore remains highly likely that our remote sensing data for the 15% of the region that has not seen pedestrian survey is accurate. Unsurveyed residences are located in the northwestern sector of Baking Pot, but not in an important borderland region. Lidar data show similarities between the scale, form, and position of these remotely sensed house mounds and those recorded through pedestrian survey. All surveyed house mounds in the region (n = 800) show evidence of Late Classic ceramics on the ground surface, and all the excavated house mounds (n = 96 at Lower Dover, and n = 30 at Baking Pot) have Late Classic occupations. Therefore, it is highly likely that the unsurveyed features at Baking Pot were also occupied during the Late Classic and possibly earlier. For these reasons, our analysis is primarily synchronic, focusing on the Late Classic period, although data from earlier phases is drawn upon when available.

Multiple survey and settlement datasets were compiled for the Lower Dover polity [1,97,98,101,131,132]. A full coverage pedestrian survey using TPI analysis generated from the lidar was used to fill in gaps and resurvey areas with problematic coverage [2,4] (p. 285). The full extent of the polity ~16 km^2 has seen full coverage pedestrian survey. Moreover, extensive excavation data generated by multiple projects in the region has been compiled into a single polity–wide settlement dataset comprising 96 households, or 27% of the total 352 households in the Late Classic polity [26] (p. 195). Attempts to reconstruct house mound chronologies using test–pits did not provide sufficient material for dating [132] (p. 39). For this reason, the presence of temporally diagnostic surface ceramics was used to reconstruct the settlement history for most house mounds at Lower Dover [4,25,133]. A combination of extensive bioturbation and modern land use practices such as plowing, ranching, and artillery testing meant that substantial amounts of ceramics were apparent on the ground surface at Lower Dover. Systematic surface collections undertaken during survey revealed an abundance of ceramic sherds dating to the Late Preclassic and Early Classic phases on the ground surface of most larger house mounds, and some of these residences also had Middle Preclassic ceramics on the surface. Temporal designations based on surface ceramics were largely corroborated through comparison with excavation data from the sample of 96 house mounds.

2.2. Settlement Pattern Analyses and Focal Nodes

Classic Maya settlement patterns are famously dispersed, but scholars have long noted the presence of settlement clusters, especially around major and minor centers [104]. Rather than representing a continuous ribbon strip [1], settlement in the Belize River Valley clusters to varying degrees around centers, leaving demographic drop–offs between these nodes [26]. Modeling the demographic drop–offs between such clusters can provide a good idea of the scale and extent of communities of various spatial sizes [13,134,135]. Generally, smaller clusters are present around high–status commoner households. These units are comparable to those described by Smith [112] as neighborhoods, although kin–based or corporate relations may have played an important role in structuring membership [136–141]. Larger clusters, which equate to districts, are generally apparent around

minor centers. To understand the differential extents of residential clustering around the Baking Pot and Lower Dover civic–ceremonial centers, and the extent to which commoner settlement aggregated around minor centers or, highly productive soil zones, we employ a series of different spatial analyses which are commonly used in archaeology for this purpose. Three approaches, namely: kernel density analysis, inverse distance demographic contours, and Xtent modeling, were used to assess the extent of population aggregation around the two polity capitals, surrounding minor centers, and highly productive soils. The first two approaches rely on the distance–interaction principle, that people located spatially close to one another interacted more [142,143], see also [144]. In contrast, the Xtent model projects labor catchments onto the settlement. Despite the ease with which cost–distance can be incorporated into these spatial models, we relied upon Euclidian distance because cost distance was rendered problematic by the many possible impediments to movement at this localized scale of analysis, such as rivers and creeks. We could not gauge the impacts of these riverine features on movement without knowledge of the whereabouts of bridges, fords, and crossing points and their passability during different seasons.

2.2.1. Kernel Density Analysis

Kernel density analysis offers one way of modeling demographic clustering on a landscape. The approach we use is based on the method employed by Thompson, Meredith, and Prufer [145], who successfully used the method to identify multiple scales of clustering associated with the polities of Uxbenká and Ix Kuku'il, as well as internal districts and neighborhoods, see also [146,147]. The initial results of this analysis at Baking Pot and Lower Dover were presented in a recent comparative article [13]. Kernel density analysis was conducted using ArcMap 10.8.2. An arbitrary distance value of 125 m was used to create district scale kernel density clusters.

2.2.2. Inverse Distance Demographic Contours

The inverse distance demographic contour approach was developed by Drennan and Peterson [148] to assess the spatial distribution and density of demography on a landscape with the overarching goal of identifying larger political units (supra–local communities or polities), and their internal constituent parts (communities, or districts and neighborhoods). The approach involves the creation of a topographic surface in which higher elevations represent higher densities of people in prehistory. Following their method, different degrees of mathematical smoothing are applied to these surfaces with the goal of representing demographic densities. Settlement data was input into Autocad Map 3D 2022 and a raster was created in Idrisi Selva. The population contours were created from this raster using Golden Software Surfer 8.

2.2.3. The Xtent Modeling Using High–Status Commoner Households, Minor Centers, and Major Centers as Focal Nodes

Another option for delineating Classic Maya socio–spatial aggregations involves first identifying focal nodes where people would have gathered [19,111,112,149,150]. Focal nodes represent locations where people might aggregate such as fields, reservoirs, shrines, or most relevant for this study, high–status commoner, or intermediate elite households with ceremonial architecture or economic functions. These intermediate elite minor centers generally have lots of commoner households clustered around them. High–status commoner households frequently have larger patios and eastern shrines, and higher proportions of ceremonial artifacts such as *incensarios*, musical instruments, as well as food production and serving vessels related to communal consumption events [26] (pp. 578–620). In some instances, such contexts also have higher proportions of stone tool debitage, or more specialist tools for production activities [26] (pp. 544–578). These patterns are even more distinct at the intermediate elite centers, which commonly have plazas that

are large enough to incorporate district or even polity populations, higher proportions of ritual objects, and decorated serving vessels associated with communal events, as well as larger monumental architecture such as eastern triadic structures, ballcourts, and *sacbeob*, and in some cases stelae and altars [60,73]. While some minor centers contain higher proportions of artifactual indicators of wealth item production, many also likely acted as small marketplaces where commoners could engage in commercialized exchange [25,26,151–153]. Apical elite polity cores show more extensive evidence of ritually integrative facilities and large open plaza spaces suggesting commoners (at times) were attending ceremonial events or markets in their cores [60]; see also [154–158]. The provision of these services is not surprising given the fact that commoner labor was necessary for their construction. The role of such spaces as focal nodes means that labor catchments can be projected to assess the extent to which the surrounding commoner population was engaged in construction activities [159]. Generally, there is a high degree of correspondence between the size of spatial clusters (commoner populations), the scale of monumental architecture (labor tax), and plaza size (inclusion of subordinate populations in gatherings, events, markets, etc.) [26] (pp. 593–597).

The Xtent model was developed to project labor catchments or political units from centers [160]. For this reason, the method provides one way of assessing the degree to which Baking Pot or Lower Dover controlled the peripheral zone between the two polities and the labor catchments associated with subordinate intermediate elites in both polities. This model was developed by Renfrew and Level [160] to define polity territories using the size or population of a core, see also [161,162]. We constructed an Xtent model calculator in Microsoft Excel and then modeled the resulting clusters in ArcMap 10.8.2. We employed the architectural volumes of focal nodes (high–status commoner households, minor centers, and major centers). The Xtent equation is shown below:

$$I_{xy} = (A_y)^a - (k \times D)$$

Following Stoner [162] (p. 388), I represents the amount of influence that center y at location x exerted over surrounding settlement. A reflects the architectural volume of center y (m^3). The importance of A is exponentially modified by a (an experimental constant). D is the Euclidean distance between center y and commoner household x. k is an experimental constant that changes the importance of D. Following the logic of the model [162], we maintained an a value of 0.25, and modified the k value to shift the importance of distance (D). In essence, this allowed us to emphasize different nested scales of settlement clustering around either major centers using a k value of 3.26, or minor centers and high–status commoner households using a k value of 28. These two possibilities reflect differing degrees of political centralization. The first arrangement provides an idea of the extent of polity–level entities, and the second arrangement models districts and large neighborhoods [26] (pp. 206–207). At the most decentralized end of the spectrum, the value placed on k could be reduced to the point where territory is constructed equally around centers irrespective of their size in a similar manner to a Voronoi diagram [163].

Our application of the model is slightly different from how it was initially intended. The model was designed to project territorial divisions in contexts where reliable size or population estimates were available for large centers, but settlement data was lacking [160]. Our application of the model uses a similar logic but applies it to full coverage settlement data to assign polity, district, or neighborhood affiliations to commoner households given the architectural size of these entities based on the assumption that, all things being equal, patterns of labor division were somewhat equal between centers. Given temporal issues with regional settlement data this method is employed in a synchronic fashion and uses the cumulative size (volume of households) as a metric of importance. This approach allows us to effectively model from which households labor was drawn for construction and provides insight into nested levels of labor control within and between polities. In essence, the method provides a good comparison to the kernel density clusters

and inverse distance modeling because, whereas those methods focus on household location (and can be construed as more bottom–up), the Xtent model projects similar scale units using the architecture of a center (which is inherently more top–down).

2.3. Integrating Landscape Productivity Analyses

Understanding the underlying factors associated with demographic clustering on the landscape also requires an understanding of landscape productivity and the types of locales Maya commoners (who were predominantly farmers) would have preferred to live [20]. Table 2 shows the relatively large–scale resolution soils data for the region which were compiled by Fedick [23] based on pre–existing 1:50,000 scale soils data collected by the Land Resources Development Centre (LRDC) survey by Jenkin and colleagues [164] and Birchall and Jenkin [165], with revisions based on Baillie and colleagues [166]. Fedick [23] used the published soil attribute data to conduct a capability evaluation that rated levels of potential agricultural productivity under conditions of hand cultivation technology, as opposed to mechanical cultivation [167]. This distinction is important since shallow soils on rocky hillsides can be highly productive under hand cultivation but not modern mechanical cultivation [168–170]. Slow–draining lowlands dominated the upper Belize River Valley, where Baking Pot and Lower Dover are situated, although well–drained alluvial soils are prevalent around the Baking Pot core, and the minor centers of BR–180/168 (Barton Ramie), North Caracol Farm, and Spanish Lookout [170] (pp. 20–24). The thin, but well–drained upland soils common along the flanks of the Belize River Valley were likely far more productive under swidden cultivation than modern mechanical cultivation [167] (pp. 108–110). Moreover, unlike surrounding regions, riverine and closed–depression seasonal swamps which pose issues for cultivation are almost non–existent in the region [23] (pp. 16–34). Some Class III soils in the region clearly had drainage related issues however, a good example being those situated on the southwestern periphery of Baking Pot around Bedran [7] (p. 22). The Class III Meditation series soils common in this area, could be modified into productive agricultural areas by improving drainage through ditching resulting in otherwise productive lands that could be easily worked by hand.

Table 2. Agricultural capability assessment for all soil series in the study area. Adapted from Fedick [23] (Table 1) with the addition of previously unpublished assessments by Fedick for soils on the south side of the river.

Capability Class	Soil Series	Rating Factors					
		Fertility	Erosion	Root Zone	Workability	Drainage	Rating Total
I	Listowel	2	1	1	1	1	6
I	Listowel (sand)	2	1	1	1	1	6
I	Morning Star	1	1	1	1	2	6
I	Young Girl	1	1	1	1	1	5
I	Young Girl (gravel)	1	1	2	1	1	6
I	Young Girl (sand)	1	1	1	1	1	5
II	Barton Ramie	1	1	3	1	3	9
II	Camelote	1	2	2	2	1	8
II	Chorro	1	2	2	1	1	7
II	Esperanza	1	1	4	1	3	10
II	Mount Hope	1	2	3	2	1	9
II	Piedregal	1	2	3	1	1	8
III	Central Farm	2	1	4	2	2	11
III	Meditation	2	1	4	1	3	11
III	Meditation (pale)	2	1	4	1	3	11
III	Mount Hope (hill)	1	4	4	2	2	13
III	Society Hall	2	1	3	4	3	13

III	Tambos (shallow)	2	1	3	3	2	11
IV	Beaver Dam	3	1	4	4	4	16
IV	Iguana	3	3	3	3	4	16
IV	Kaway	4	1	4	3	4	16
IV	Santos Pi Ri (gravel)	4	2	4	3	2	15
IV	Sayab Camp	3	1	4	4	3	15
IV	Spanish Lookout	2	2	4	4	3	15
IV	Tambos	2	1	4	4	3	14
IV	Tambos (pale)	2	1	4	4	3	14
IV	Willows Bank	4	1	4	3	3	15
V	Akalche	4	1	4	4	4	17
V	Akalche (sand)	4	1	4	4	4	17
V	Branch Mouth (sand)	1	1	1	1	1	5
V	Cadena Creek	2	3	4	4	4	17
V	Duck Run	4	2	4	3	4	17
V	Garbutt *	1	1	1	2	1	6
V	Garbutt (gravel) *	1	1	3	2	1	8
V	Garbutt (sand) *	1	1	1	2	1	6
V	Hattieville	4	2	4	3	4	17
V	Norland	3	3	3	4	4	17
V	Pucte	4?	1	4	?	4	9+
V	Young Girl (wet)	1	1	2	1	4	9

Note: the ratings with higher numbers denote greater limitations adapted from [23]. Capability Class divisions are based on rating total, with 5–6 = Class I, 7–10 = Class II, 11–13 = Class III, 14–16 = Class IV, 17–20 = Class V. * Included in Class V due to severe limitations of annual or nearly annual flooding.

Following Fedick [23], we rank soils into classes based on their capability for hand cultivation given five variables (based on the United States Department of Agriculture system) [171]: drainage, effective root zone, fertility, susceptibility to erosion, and workability. Each variable was given a rating based on its limitations (higher numbers reflect greater limitations). Capability Class divisions were based on the total of these ratings, a combined rating score of 5–6 = Class I, 7–10 = Class II, 11–13 = Class III, 14–16 = Class IV, 17–20 = Class V. Previously, soil capability assessments have been published for the north side of the Belize River Valley only [23,172]. Table 2 presents the agricultural capability assessment under hand cultivation technology for all soils in the study region, including previously unpublished soil types present only on the south side of the river. Class I soils represent the alluvial soils present along the valley floor. Class I soils were the prime soils present in the area and had the fewest number of limitations in terms of hand cultivation, could support a wide array of plants including cacao, and are highly fertile, deep, well–drained, level, and easily worked. Class II soils have few limitations overall but would support a slightly narrower array of plants than Class I soils, or may be shallower, have erosion issues, or be less fertile. Class III soils are primarily situated along the upland valley flanks. As such Class III soils have a greater array of limitations and may only support specific plants such as maize, these soils could however, be improved through drainage systems or terracing. Class IV soils present severe limitations because they suffer from similar problems as Class II and III soils but to a far greater degree and may also be more susceptible to flooding. For this reason, Class IV soils could only support a very restricted array of specific plants, and these would likely require constant management. Class V soils are generally unsuitable for agriculture unless massive modifications were made. Some of these soils have serious drainage issues (such as Garbutt series soil) but are otherwise productive when adequately drained. Generally, the Class V soils would have been the worst in the region for hand cultivation.

The USDA system which the soils classification is based upon is designed for its simplicity and flexibility, and differs from the other main classificatory system (the Food and Agriculture Organization system) in that it refers to general land productivity and not specific crops or agricultural techniques [23]. Application of the USDA system makes sense given ongoing debate about the proportions of different crop types employed and the methods used to cultivate them [30,31]. In essence, most of the Maya lowlands comprised soil Classes II and III, and both of these classes clearly supported commoner households in terms of the production of staple crops without any overt issues [23] (p. 15). Therefore, the Class I and II soils in the Belize Valley could clearly support the greatest diversity of different crop types. As such these soils would be ideal for household gardens with perennial crops. This would explain their direct association with settlement. The soils could also be used to cultivate higher yields of staple crops such as maize. Class I soils which are restricted to the alluvium of the valley bottoms are unique because they are the only soils suited to the cultivation of cacao, which requires a deep rooting zone and good drainage. Determining the proportions of different crop types cultivated on different soil classes in the Belize River Valley is one future angle of paleoethnobotanical research.

While the resolution of the soils data is particularly high, it is only sensitive enough for district and neighborhood level comparisons, not household scale comparisons [9,170,173]. Overall, the soils data provide a solid basis for assessing the relative productivity of different polities, districts, and some neighborhoods in the Belize River Valley. Further refinement for the scale of soil–map data could be accomplished in future studies through the use of lidar derived data on topography, a prime factor in soil classification for the region [174].

3. Results

3.1. Settlement Pattern Analysis: Residential Clustering

Visual inspection of the kernel density analyses shown in Figure 4 reveals the presence of multiple variably sized clusters. District–scale entities (100–300 people) are apparent as larger clusters and are generally common around intermediate elite nodes, such as Bacab Na, Baking Pot North, Bedran, BR–180/168, Ek Tzul, Floral Park, North Caracol Farm, the Orchard Group, Riverside, and Spanish Lookout. Much smaller clusters, comparable to neighborhood–scale entities (50–100 people), are more common around the high–status commoner households such as the North Bend Group. The aforementioned larger districts also contain smaller neighborhood sub–units [26] (p. 50). In many cases, however, the neighborhood scale of organization is obscured by district, or even polity–level clustering, such as in the Baking Pot core zone. These smaller neighborhoods at Baking Pot have a striking spatial homogeneity and may well have been laid out on an informal grid [175].

Differences between the two polities are perhaps the most visually apparent finding of the kernel density analysis. Whereas Lower Dover exhibits a segmentary pattern with the demographically disembedded polity core surrounded by populous districts with intermediate elite heads, Baking Pot has a dense and relatively homogenous aggregation of commoner settlement surrounding its polity core. The presence of multiple high–status commoner households at the epicenter of larger districts in this core area speaks to a similar dynamic as at Lower Dover, although at Baking Pot these districts have much lower–status head households.

The inverse distance modeling produced a similar picture to the kernel density analysis, the major difference being that the contours accentuated the differences in demographic centralization between the two polities (Figure 5). At Lower Dover, the scale of demographic clustering at the district–level produces a series of small hillocks around the core. Conversely, district level aggregations at Baking Pot are barely visible given the vast scale of demographic clustering around the civic–ceremonial center itself. These differences in demographic centralization are likely tied to the differential trajectories through

which these polities were formed and the implementation of settlement patterns and the allocation of land plots to individual households see [7] (p. 33). Whereas Baking Pot grew alongside surrounding demography, Lower Dover represented a top–down imposition in the midst of surrounding, established districts. The inverse distance modeling also revealed a distinct drop–off in settlement density between the two polities; see also [4] (p. 287). This borderland is discussed in further detail below in relation to the Xtent modeling and the soils analysis.

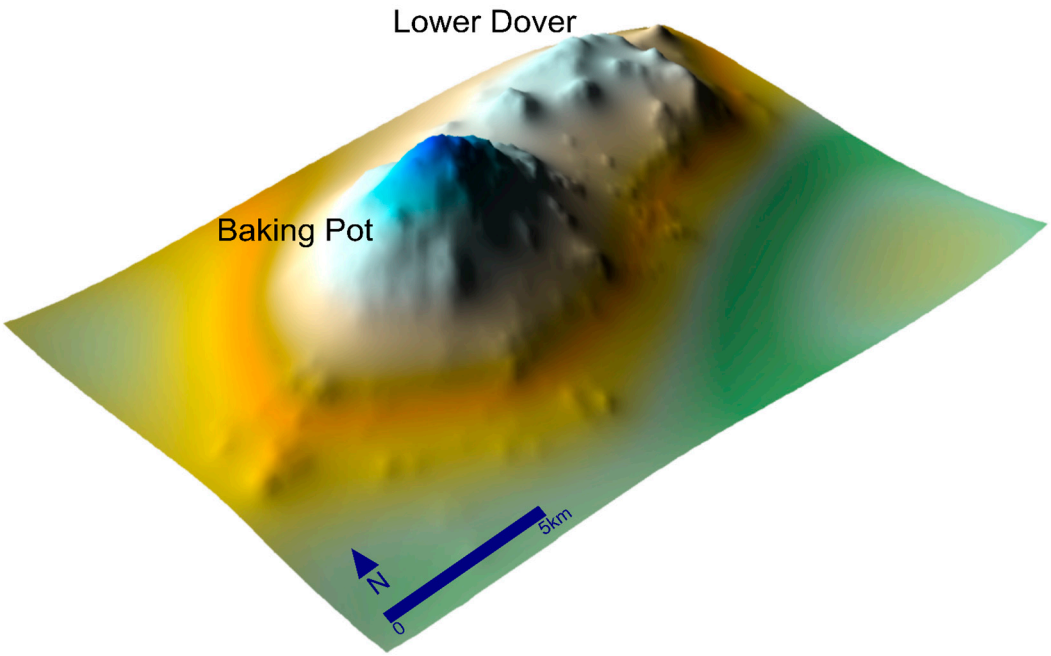

Figure 5. Topographic surface showing demographic centralization at Baking Pot (lower left) and Lower Dover (upper right).

The projection of polity territories using the Xtent model (a = 0.25 k = 3.26) further emphasizes the differences between Baking Pot and Lower Dover (Figure 6). This analysis largely corroborated previous efforts to reconstruct the scale of the two polities [7,125]. Given the larger size of monumental construction at Late Classic Baking Pot, the associated projected territory is much larger, encompassing the surrounding centers of Ek Tzul, Esperanza, and Spanish Lookout. Conversely, the polity of Lower Dover is smaller. The Xtent modeling provides a clearer picture of the demographic drop–off between the two polities. Except for Spanish Lookout, which likely represented an important borderland center between the two polities, there is a surprising dearth of settlement in this region, especially given the relatively high productivity of soils in these areas (see below).

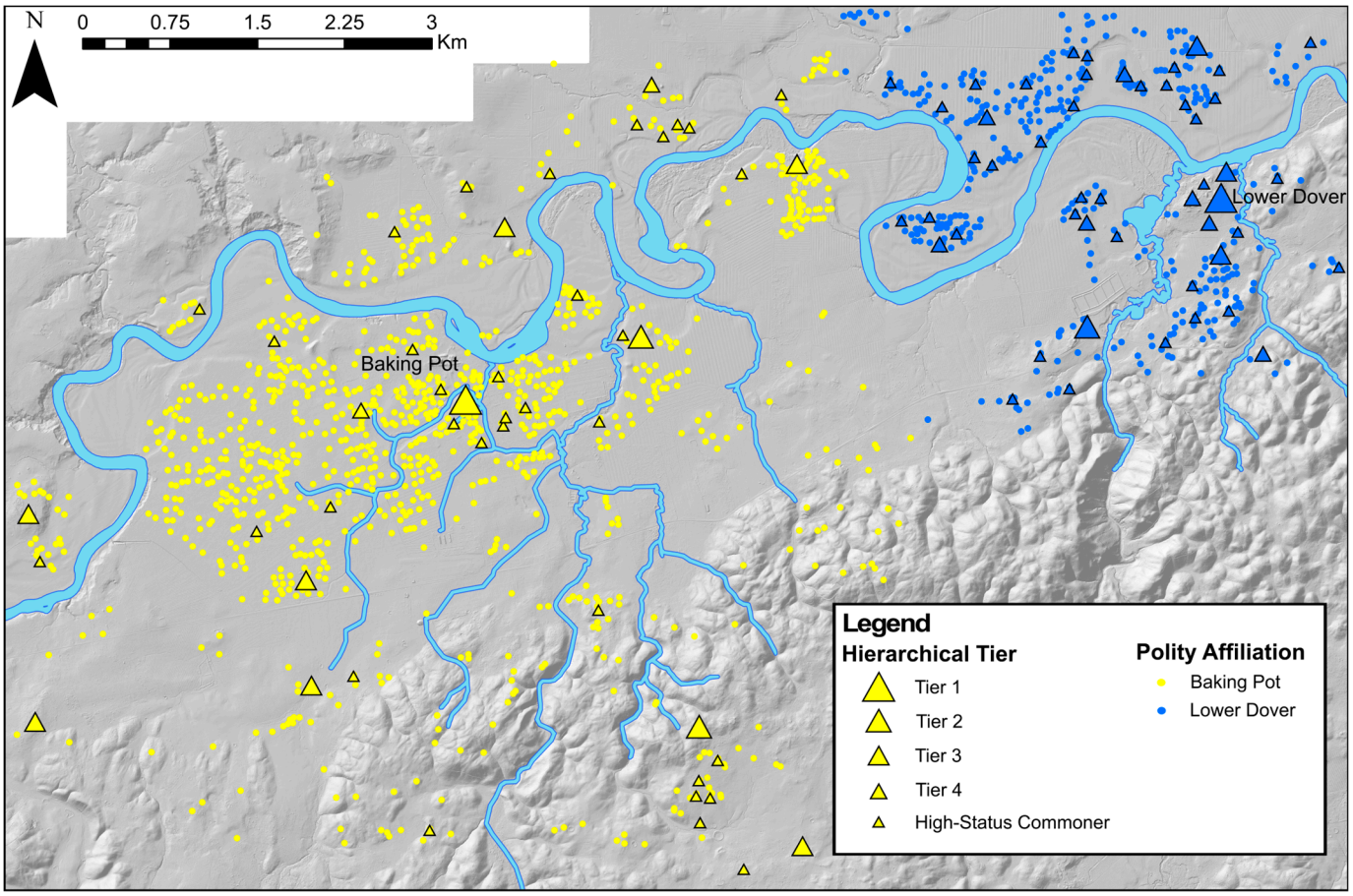

Figure 6. Xtent Model of Baking Pot and Lower Dover showing modeled labor catchments at the apical elite/polity scale.

The projection of district and neighborhood–level entities using the Xtent model (a = 0.25, k = 28) corroborated the kernel density analysis to some degree (Figure 7). The fact that both models produced similar results from two very different methods is likely suggestive of the fact that the settlement clusters of commoners were responsible for the construction of the minor centers at their epicenters [26] (pp. 505–514). The main difference between the two approaches is most evident when looking at larger minor centers (Tier 2) with smaller, or lower density clusters of commoners around them. Illustrative examples of this include Ek Tzul, Floral Park, and North Caracol Farm, which all possessed larger integrative architecture (e.g., ballcourts, pyramids, *sacbeob*, and termini). The sheer size of these centers (12,000–40,700 m^3) resulted in the projection of much larger district–level catchments that incorporated surrounding smaller neighborhoods. Floral Park incorporated much of the dispersed borderland settlement to the southwest, Ek Tzul incorporated the northern neighborhood around the Foothill Group, whereas North Caracol Farm had a modeled catchment which included Northeast Baking Pot, and other peripheral settlement to the east. Subsequently, Xtent modeling might be a more accurate way of reconstructing the districts associated with larger minor centers. However, the kernel density and Xtent approaches complement each other incredibly well when modeling the districts associated with smaller Tier 3 minor centers. For instance, the districts around Bacab Na, BR–180/168 (Texas District), the Orchard Group, Spanish Lookout, and Tutu Uitz Na are very similar to those modeled using the kernel density approach.

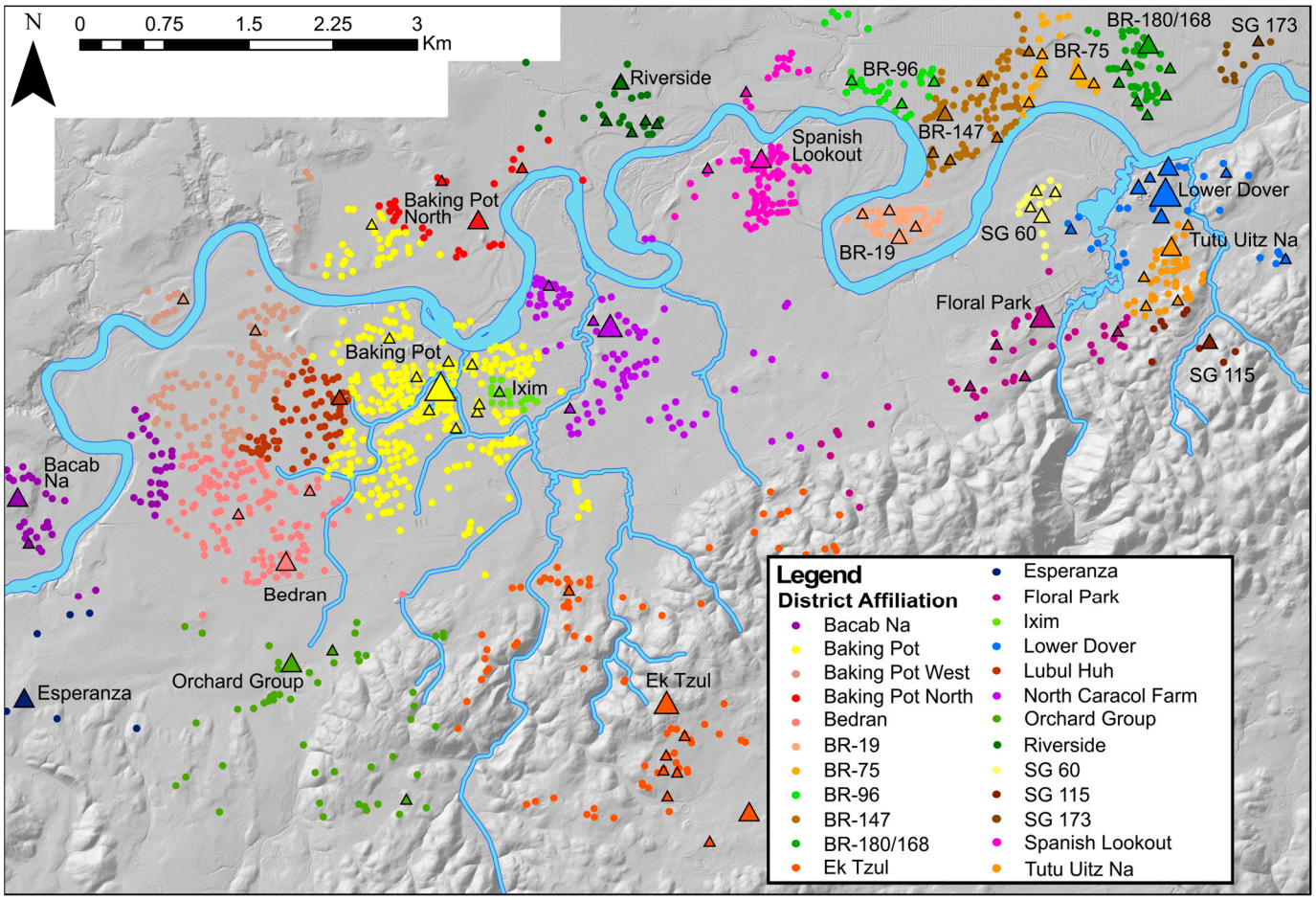

Figure 7. Xtent Model of Baking Pot and Lower Dover showing modeled labor catchments at the intermediate elite/district scale.

We modeled districts and neighborhoods using all of the different approaches described above in unison (Figure 8). This approach required some degree of interpolation and the incorporation of archaeological data. For instance, the larger Floral Park District modeled through Xtent analysis was reduced to a smaller cluster produced using the kernel density analysis. This decision was informed by extensive archaeological excavation at the Floral Park District, which revealed that nearby commoners were likely responsible for the construction of the larger Late Classic monumental architecture at the minor center. All six excavated commoner households witnessed a decline in the construction of household architecture while the minor center began extracting much higher labor tax rates. In contrast to Floral Park, the adjacent minor center of Tutu Uitz Na required much less labor from commoners living in the vicinity. These lower labor tax rates were reflected in the construction histories of commoner households. The 14 commoner house mounds excavated in the Tutu Uitz Na District show continuous architectural growth throughout the Late Classic (unlike their counterparts in the Floral Park District) [26] (pp. 521–528), see also [127]. Ultimately, testing whether these reconstructed geospatial districts represented emically meaningful, cohesive social entities in prehistory requires extensive excavation of commoner households to examine shared practices associated with local–level identities. Moreover, modeling elite labor tax rates in a diachronic fashion relative to commoner household construction provides a rough estimate of which commoners were engaged in elite construction projects. In some instances, this approach can be used to assess the boundaries of labor catchment units in prehistory. Labor tax calculations based on excavation data from the core strongly indicates control of this peripheral zone, as Late

Classic monumental construction in the Baking Pot epicenter would have required a large population [7,26,125].

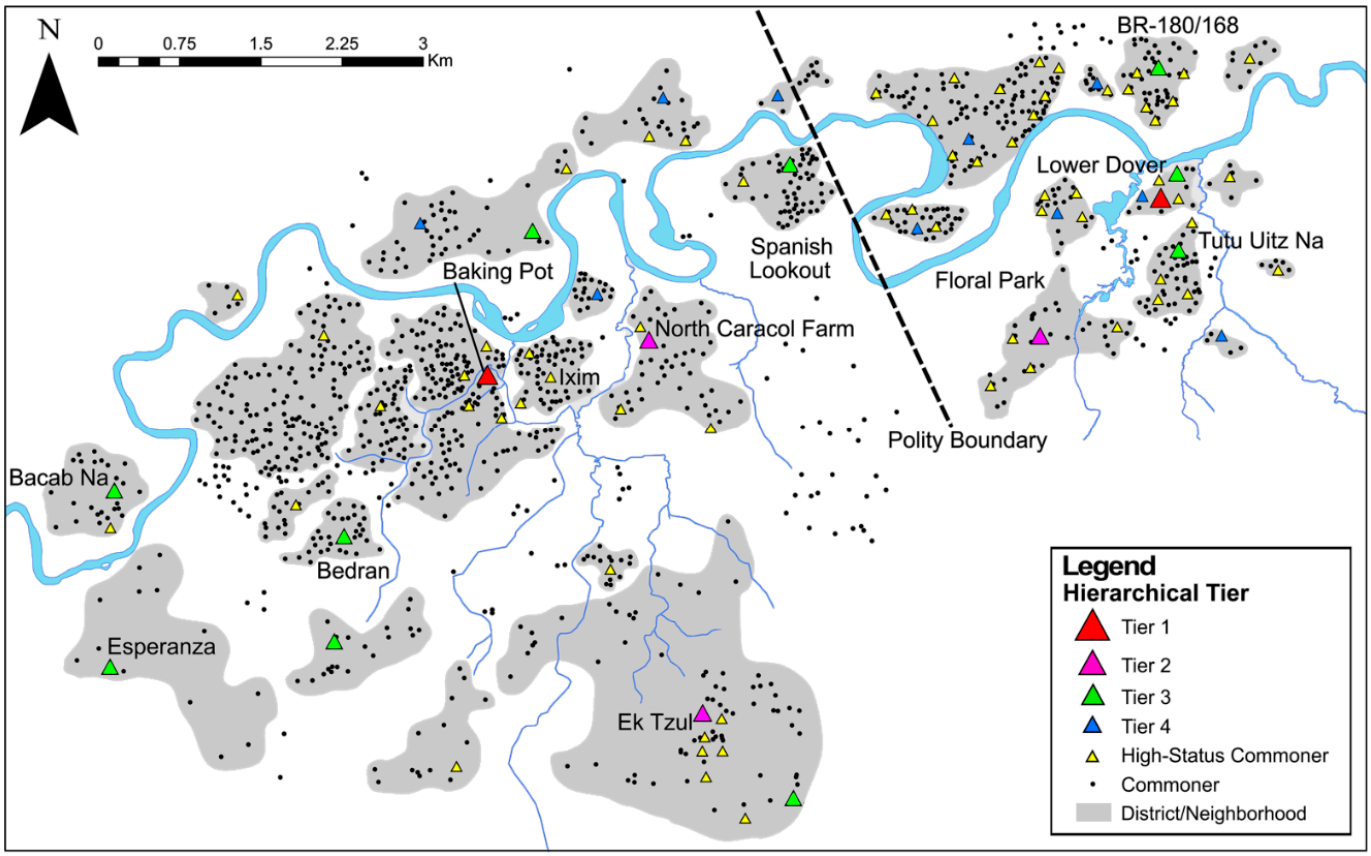

Figure 8. Reconstructed districts at Baking Pot and Lower Dover.

The results generally corroborate the hypothesis that Baking Pot and Lower Dover saw differential degrees of settlement clustering and this was to some degree a product of their developmental trajectories. While clear polity boundaries are not particularly evident from the kernel density analysis, both the inverse distance modeling and the Xtent modeling show a fairly clear buffer zone between the two polities, with the Spanish Lookout minor center in the middle. The population clustering (evident in the inverse distance approach) and the projected labor catchments (based on Xtent modeling) both suggest that this borderland was largely controlled by Baking Pot. We argue that these boundaries were likely meaningful in the past because the population clustering and labor catchment based approaches overlap. As mentioned above, labor tax calculations based on excavation data from the core strongly indicates control of this peripheral zone. Reconstruction of the two polities based on these approaches suggests that Baking Pot controlled a substantial amount of this peripheral region and was the seat of power for a Late Classic population of ~6500 people (927 households), residing within a 4 km radius of the core (a polity area of ~45 km^2). In contrast, the polity of Lower Dover extended over an area of ~16 km^2, and was home to ~2400 people living in 352 households.

The hypothesis that Lower Dover saw higher degrees of settlement dispersal than Baking Pot is also proven correct. The civic–ceremonial core of Baking Pot was surrounded by very dense aggregations of commoner settlement (as we have long known) [1]. Unlike Baking Pot, the civic–ceremonial core of Lower Dover was demographically disembedded and its immediate area was almost uninhabited. Instead population was densely clustered around the three large well–established minor centers at BR–180/168, Floral Park, and Tutu Uitz Na (each ranging from 3700–17,600 m^3 of architecture), which all pre–date Lower Dover [26] (p. 266). The emergence of the polity capital in the midst of

these established elite centers with associated populations implies Lower Dover may represent some form of disembedded capital [176–178], see also [179]. Excavation data from these intermediate elite households shows that their occupants drew upon surrounding commoners for labor in the Late Classic and hosted large ancestor veneration ceremonies to integrate populations under shared district–level identities [180]. At Baking Pot, very small minor centers, or high–status commoner residences were apparent at the centers of districts. While excavation of these focal nodes reveal that their occupant elites were engaging in similar strategies of commoner engagement (e.g., hosting ceremonies) as their peers at Lower Dover, these practices were on a much smaller scale than at centers such as BR–180/168, Floral Park, or Tutu Uitz Na. Moreover, the Baking Pot focal nodes such as Ixim and Lubul Huh were much smaller than their counterparts at Lower Dover indicating that commoner labor was not being harnessed by district level elites but was flowing up tributary networks to the apical elite level where it was invested in the much larger monumental architecture in the Baking Pot civic–ceremonial center [25]. The peripheries of the Baking Pot polity in many ways look similar to the core of the Lower Dover polity in that both these zones are comprised of multiple districts each containing fairly dispersed settlement situated around large intermediate elite minor centers. Good examples of this dynamic in the Baking Pot periphery are Bacab Na, Esperanza, and Spanish Lookout. One plausible reason why these zones may appear similar is that both the Baking Pot periphery and Lower Dover core were only integrated into their respective polities in the Late Classic. While substantial excavation has shown this to be the case at Lower Dover, Late Classic incorporation of the Baking Pot periphery under suzerains based at the core requires further investigation (see below).

It therefore seems likely that the differential developmental trajectories of the two polities, whereby Baking Pot grew slowly, in tandem with its population, and Lower Dover represented a Late Classic imposition on a densely settled landscape, did indeed result in different degrees of settlement clustering. Similar to nearby Xunantunich, Late Classic Lower Dover remained demographically disembedded long after its rise [17].

3.2. Residential Patterns and Soil Class

The second research question relates to whether landscape productivity structured commoner settlement choice. Several patterns emerge when settlement location is compared to the soil classes (Table 3). There is a clear preference for Class I soil, as 50% of households irrespective of status (n = 635) are situated on Class I soil despite these comprising a mere 20% of regionally available land. Class II soil, despite representing 21% of regionally available land, has much lower proportions of settlement, at 16% (n = 202). In contrast, Class III soil, which makes up 33% of the regionally available land contains 37% of households (n = 426). Finally, Class IV and V soils were avoided for settlement. Class IV and V soil makes up 6% and 15% of total regional land, respectively. Class IV soils has just 0.8% of commoner households situated on it. Class V soil has only 0.5% of commoner households situated on it. These households are situated right on the edge of these soil zones which suggests they were situated on poor soil adjacent to good soil for farming (Figure 9).

Table 3. Soil zones and total residential distributions.

Soil Zone Class	Soil Zone Area (km²)	Soil Zone Area (% Total)	Number of Households	Proportion of Households (%)
I	15	21	635	49.6
II	15	21	202	15.7
III	27	37	426	33.3
IV	4	6	11	0.9
V	10	15	6	0.4
Totals:	71	100	1280	100

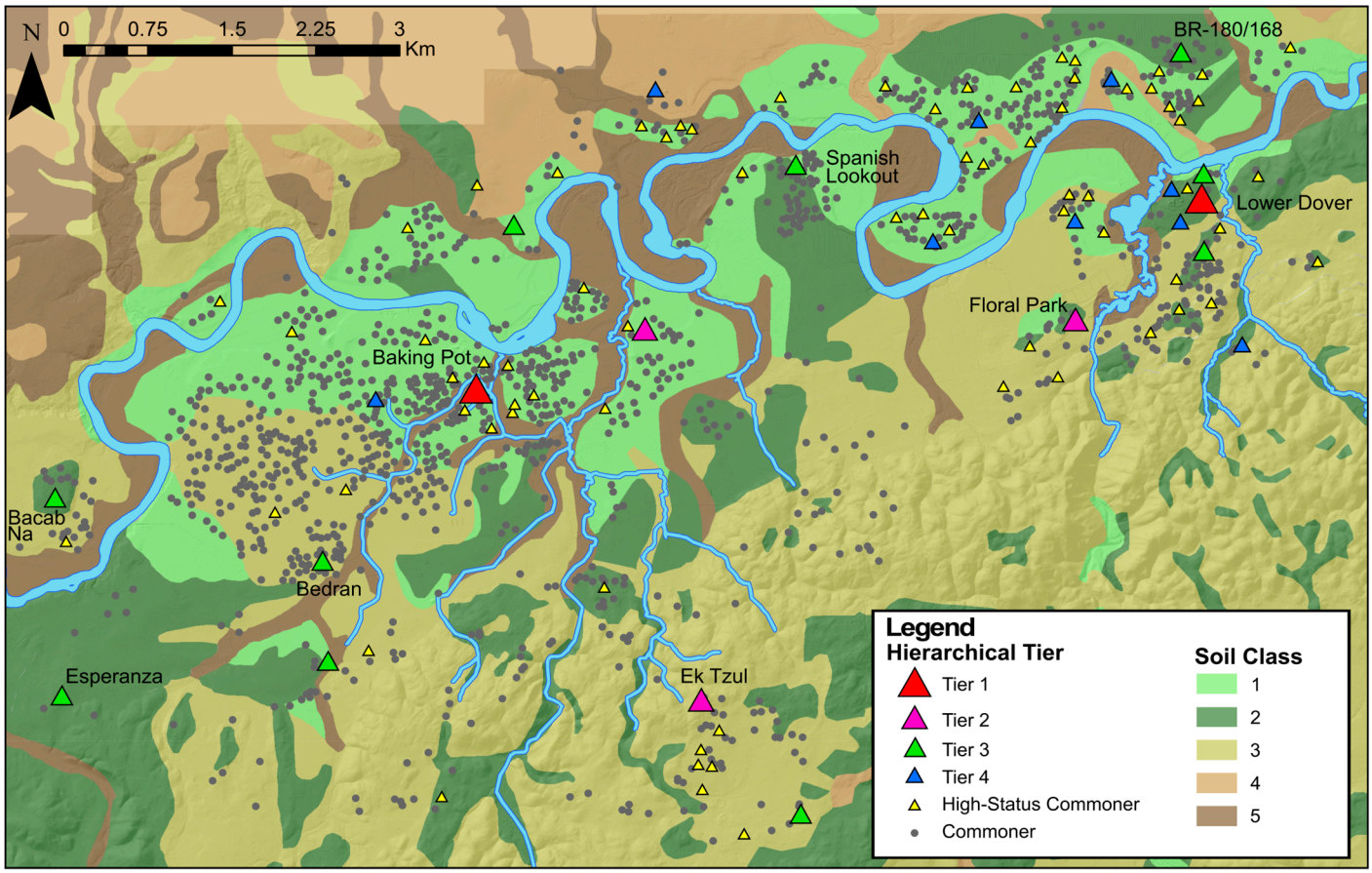

Figure 9. Map of Baking Pot and Lower Dover showing household location relative to soil classifications.

High status commoner households and intermediate elite centers are located in the most productive soil zones (Table 4). The preference for Class I soil is highest among high–status commoners, 61% are situated on the best soils. These households may well have focused on the orchard cultivation of cultivars such as cacao or high yields of staple crops such as maize and geophytes (which need deeper soils). This pattern probably reflects founding households settling prime locations early and then subsequently being able to build up wealth over time [23] (pp. 16–34). This pattern was also noted in the survey transects of the Belize River Archaeological Settlement Survey (BRASS) established by Ford and Fedick [5], and analyzed by Fedick [167] (Tables 7.3 and 7.4), who argued that the Class I alluvial bottomlands were controlled by wealthy households that maintained cacao plantations. Late emerging households in contrast are more likely to be situated on less productive soil which required modifications. In contrast, only 36% of intermediate elites are situated on Class I soil. Moreover, only 13% of high–status commoners are situated on Class II soil, compared to 45% of intermediate elites. As many as 25% of high–status commoner households are situated on Class III soil, compared to only 14% of intermediate elite households. Only one Tier 3 minor center, Riverside, is situated on Class IV soil, though this site is immediately adjacent to a band of Class I alluvial soil to the south suggesting that the household was not directly situated on the best agricultural land to maximize the farming potential [181] (p. 216), see also [182]. Some minor centers are particularly well situated on spatially circumscribed "islands" of productive soil. Good examples include Bacab Na, the North Bend Group, Northeast Baking Pot, the Foothills Group, the Orchard Group, SG 41, SG 60, and SG 92, to name a few examples.

Table 4. Soil zone capability classifications and the counts and proportions of commoner households and minor centers associated with these zones.

Soil Zone Class	Soil Zone Area (km²)	Soil Zone (Proportional Area)	Low–Status Commoner Households	Proportion of Low–Status Commoners	High–Status Commoner Households	Proportion of High–Status Commoners	Minor Centers	Proportion of Minor Centers
I	15	21	583	49	44	61	8	36
II	15	21	183	15	9	13	10	45
III	27	37	405	34	18	25	3	14
IV	4	6	10	1	1	1	1	5
V	10	15	6	1	0	0	0	0
Totals:	71	100	1187	100	72	100	21	100

While the soil classification map corresponds closely with the settlement map, the intermediate elite preference for Class II soil zones requires explanation. Generally, the higher proportions of high–status commoners than intermediate elites on Class I soil seems to reflect initial settlement location priorities. For instance, high–status commoners were directly involved in agriculture, unlike intermediate elites. Minor centers generally show statistically significant decreases in the proportions of agricultural tools such as stone adzes, axes, and grinding stones over time [26] (p. 545). Intermediate elites balanced multiple factors when choosing a settlement locale, including political priorities which were less grounded in agriculture. For instance, BR–180/168, Floral Park, the Orchard Group, and Spanish Lookout are all situated on small hillocks, comprising Class II soil, immediately adjacent to expanses of Class I soil. The locations of these minor centers suggest these were situated in locales from which elites could oversee land, resources, and commoners and offer tactical advantages. Moreover, elite monumental architecture appeared more impressive when situated on the highest point in the immediate landscape. Other political and economic factors were likely important, especially for those minor centers situated in borderland zones between polities, e.g., Ek Tzul, Esperanza, and Spanish Lookout [100,183], see also [184]. Much of the southwestern settlement of Baking Pot around the Tier 3 center of Bedran, and high–status commoner household of Naxima are situated on Class III lands dominated by Meditation series soil (Table 2). These lands could be modified into productive agricultural areas by improving drainage through ditching, which has previously been documented there [4,23,33]. It remains unclear whether these features were constructed primarily for draining land during times of increased precipitation and flooding, or irrigation during times of decreased precipitation. It remains highly likely that the ditched field system reflects an intentional attempt to counter these drainage issues. The aforementioned Tier 3 intermediate elite at Bedran possessed atypical levels of funerary wealth despite residing in a relatively small minor center [120,121]. Still, seemingly vast amounts of labor were invested in the ditched field system which comprised ~24 km of ditches [33] (p. 113), in the area which increased the agricultural productivity of the Class III soil. It seems, however, that only intermediate elite households controlled sufficient labor to construct and manage such agricultural features. Kirke [185] initially also noted the presence of a similar ditched field system at Floral Park associated with Class III soil around the center, although these features were not visible on the lidar and could not be corroborated by full coverage pedestrian survey [101]. Class III alluvial soil, once adequately drained, could be fairly productive for a wide range of crops including annual maize and beans, as well as perennials such as tree crops and geophytes [30,31,167].

The correlation between funerary furnishings and soil productivity requires further investigation. Commoner households situated on Class I alluvium have produced incredibly lavish funerary assemblages which would not seem out of place in royal pyramids and palaces. For instance, at Barton Ramie, BR–260 possessed lavish burials which included offerings such as a monolithic axe with a short glyphic inscription, a ceremonial slate "monkey wrench" mace, and a long ceremonial serpentine celt [1] (p. 269). Another commoner household, BR–1 also possessed some very elaborate burials. BR–1 Burial 6

contained 20 ceramic vessels including several polychromes, marine shell jewelry, a turtle carapace, as well as chert and obsidian eccentrics [1] (pp. 545–546). Lastly, Hoggarth [25] (pp. 226–228) identified an incredibly wealthy Early Classic burial at Mound 112, a commoner household in Settlement Cluster C. This interment had three complete vessels, two limestone spindle whorls, two obsidian adornos, two marine shell adornos, 20 marine shell pendants/beads, and a necklace of 589 greenstone and marine shell beads. The position of these households on Class I soils suggests that these sumptuary items may have flowed down tributary networks in exchange for commodities such as cacao, sensu [36,41]; see also [186]. The aforementioned presence of similar sumptuary items at Bedran may indicate that the drainage system facilitated the cultivation of some high–value crops such as cacao. Overall, such patterns of portable wealth and their correlation with commoner agricultural strategies requires further investigation.

To summarize our findings related to the second research question, highly productive land clearly played a major role in structuring settlement location in the region. Commoners show a clear preference for more productive land although there are other factors which also structured settlement choice. This is perhaps most evident in the reduced number of commoners living on Class II lands. Figure 9 shows that the vast majority of Class II land is situated on the buffer zones. The smaller number of commoner households resident in these areas might therefore relate to socio–political factors. For instance, commoners may actively have avoided buffer zones for political reasons, or simply decided to settle near pre–existing kin or neighbors. The high degrees of settlement clustering around the Baking Pot civic–ceremonial core could be due in part to the prevalence of highly productive Class I soils in this area. However, political and social factors leading to commoner aggregation in this zone were also likely important because this aggregation spills over onto surrounding Class III land which was less productive and certainly would not have supported a similar range of crops. Dating this settlement (to the southwest of the core) is an ongoing effort but excavation at the Bedran Group suggests that this minor center was founded in the Early Classic [121]. While our understanding of the regional trajectory in this area of Baking Pot remains tentative, the most likely possibility is that the demography around the core expanded during the Terminal Preclassic/Early Classic transition resulting in many people living on less productive land, which was then the subject of landesque capital intensification through ditching around the Early Classic/Late Classic transition. At Lower Dover, populations were densest on the most productive Class I land north and west of the civic–ceremonial center, although substantial populations also clustered around the minor centers of Floral Park and Tutu Uitz Na. While, Floral Park and Tutu Uitz Na were situated on productive Class II lands, the surrounding commoners were largely situated on Class III land indicating that decisions to live near intermediate elite patrons may have overrode other factors in structuring commoner settlement locations. These mixed status–districts may potentially reflect a range of different social units ranging from managed estates to stratified lineages, see for instance [102,111,112,187–190].

4. Discussion

There are several key findings that warrant discussion. These include: (1) the variability in settlement patterns between the Baking Pot and Lower Dover polities and their developmental sequences, (2), district and neighborhood reconstructions and the degree to which these represent socially meaningful units on the landscape, and (3**)** soil productivity, political status, and household wealth and affluence.

There is a growing understanding among Maya archaeologists that similarly sized, adjacent polities can emerge through dramatically different political circumstances and have quite different types of governance [14–16]. Most of the spatial analyses employed in this study strongly suggest that Baking Pot and Lower Dover were likely very different political and demographic entities, despite their relatively close proximity to one another. The sheer scale of the central civic–ceremonial architecture, and areal extent of the polity all indicate the Baking Pot apical elite wielded substantially more power and had tighter

control over their immediate subordinates than the Lower Dover apical elite. Lower Dover, on the other hand, shows a more segmentary pattern with a demographically disembedded core surrounded by sizeable powerful intermediate elites which exerted a centripetal effect on surrounding demography. This variability between the two polities likely resulted from their divergent developmental trajectories. While our focus here has been on settlement patterns and land use, excavation data from Lower Dover indicates that many surrounding intermediate elite groups (e.g., BR–180/168 and Tutu Uitz Na) likely hosted large scale integrative events at the district level, which may have promoted local identities and intermediate elite ancestry in a manner that potentially clashed with top–down apical elite ideologies [180]. In contrast, Hoggarth's excavations suggest that the Ixim elite at Settlement Cluster C were well–integrated into the Baking Pot polity by the Early Classic period because less labor flowed into the district center at this time, instead being diverted for massive remodeling and additions to the Baking Pot epicenter [25] (pp. 40–41). Similarly, the previously mentioned excavations at Bedran revealed an affluent intermediate elite residence with access to sumptuary wealth items, such as two cacao drinking vessels with a hieroglyphic band containing royal titles, which given their inscriptions were likely gifted through tributary networks from apical elites at the epicenter [120,121,191]. Despite the wealth of grave items, however, residential architecture at Bedran is relatively small. The opposite situation was clearly at play in the Late Classic Lower Dover polity, where intermediate elites saw a decrease in access to more generic portable wealth items (including jade jewelry but mainly local imitation polychromes and marine shell), but they were able to command increasing amounts of labor from their commoner subordinates to build much larger architecture [26] (pp. 239–243).

The Baking Pot periphery around Bacab Na, Ek Tzul, Esperanza, North Caracol Farm, and Spanish Lookout requires more systematic investigation. While these large intermediate elite centers appear to have long developmental trajectories, the most imposing construction phases and remodeling events date to the Late Classic. Willey and colleagues [1] (p. 301) show Spanish Lookout was occupied as early as the Middle Preclassic, but suggest, based on their limited excavations, that much of the architectural volume was Late Classic in date. This pattern of early formation and late fluorescence is also apparent at Ek Tzul where recent investigations have shown the ballcourt, *sacbe*, and much of the monumental architecture to be Late Classic in date [100,192]. Moreover, the monumental eastern structure seems to change usage from a local elite residence or shrine to more prosaic administrative architecture during this transition. These shifts at Ek Tzul are very similar to those evident at Late Classic Floral Park (following its incorporation by Lower Dover). While investigations are ongoing, Ek Tzul likely represented a Tier 3 minor center throughout most of its trajectory (Late Preclassic–Early Classic) but was dramatically modified into a Tier 2 center following Late Classic incorporation by an external hegemon, likely Baking Pot. Though heavily plowed, survey of North Caracol Farm's central elite residences and pyramidal mounds show evidence of continuous occupation from the Middle Preclassic through the Terminal Classic, though the ballcourt (which is mostly destroyed from plowing) is primarily associated with Late Classic ceramic material [124] (p.26). Limited excavations at Esperanza suggest the sizeable intermediate elite plaza group and pyramid were constructed in the Late Classic, possibly as a borderland center between Baking Pot and Cahal Pech [126]. Focus on these borderland centers could be particularly insightful for understanding the nature of political control exercised by apical elites in polity cores [15,193,194]. In theory, these uniform Late Classic changes which are present at most minor centers in the Baking Pot periphery may represent evidence of Late Classic incorporation of this zone by the Baking Pot regime (as presented in the polity–level Xtent model). Collectively, these patterns confirm the hypothesis that Baking Pot's longer developmental trajectory (with the gradual growth of centralized power alongside increases in regional demography) probably played a major role in its Late Classic size and dominance over a much larger area than late forming Lower Dover.

The districts and neighborhoods which we modeled through the varying spatial analyses may or may not represent units which were emically important to the Classic Maya. There are several reasons, however, to think that these spatial units reflect social entities. First, the presence of focal nodes at the epicenters of neighborhoods (high–status commoner households) and districts (minor centers) suggests these spaces formed the nexus where people in their respective districts or neighborhoods met to conduct communal activities. This is corroborated by the size of patio/plaza spaces which are generally sufficient to accommodate surrounding neighborhood and district populations [155], see also [195]. Second, the artifactual evidence of ceremony, ritual, feasting, and economic endeavors such as production, and possibly exchange, within these spaces compared to low–status commoner households further substantiate their role as neighborhood and district–level focal nodes [25,26]. Third, the fact that the labor catchments associated with these entities (derived from Xtent modeling) overlay almost directly onto the spatial clustering further reinforces the notion that these focal nodes were constructed by their surrounding populations.

Finally, and perhaps most crucially, variations in ritual practices between districts support the existence of district–level identities. Zooarchaeological materials from the Tutu Uitz Na District suggest residents engaged in different foodways compared to their peers at Barton Ramie and Floral Park. The Tutu Uitz Na elites and commoners consistently consumed much higher proportions of freshwater snails, known as *jute* (*Pachychilus* sp.) than elites and commoners in surrounding districts throughout the developmental sequence from the Middle Preclassic to the Terminal Classic, and routinely interred these shells in burials and caches indicating a specific local district–scale identity [26] (p. 588); for a nearby example see [196]. Continued excavation of the commoner households that comprised ancient districts at Belize Valley sites will allow further clarification on variability in local–level identities and affiliations. Moreover, such approaches provide independent lines of evidence to corroborate how cohesive such social units were, which in turn provides a clearer understanding of the efficacy of spatial models and how to fine–tune these to better deal with ancient social realities within a specific region.

Comparing settlement patterns with the productivity of soils under hand cultivation allows greater insight into how people arranged themselves on the landscape. The higher proportions of both commoner and intermediate elite residences situated on highly productive Class I soil is probably not surprising, but this pattern diverges from the settlement structure in the Mopan foothills to the west, where Fedick notes higher proportions of commoner households situated on Class II soil [23] (pp. 16–34), which was still fairly productive (Table 5). These differences are associated with variability in the terrain the two surveys covered. While the BRASS transects predominantly covered only a small fraction of the alluvial valley bottom and much of the uplands, the BVAR survey region around Baking Pot and Lower Dover includes a much larger proportion of the alluvial valley bottom. This landscape variability is largely responsible for the dramatic variability in the proportions of households situated on Class I and II soils in the two regions. The proportions of households situated on Class III, IV, and V soils is however almost identical in the two regions. A clear preference was shown for the best agricultural land in the two respective regions, whether it be Class I (in the BVAR survey region) or Class II (in the extensive uplands of the BRASS transects), but also a similar avoidance of lower ranked soil classes was also apparent. This variability might reflect differences in the developmental trajectories in the BVAR survey area whereby the expansive prime agricultural lands along the valley floor were settled prior to the uplands. The lack of settlement associated with Class II soils at Baking Pot and Lower Dover warrants some explanation. Interestingly, much of the Class II soil is situated in borderland zones between the polities, illustrative examples of this are the region directly between Baking Pot and Lower Dover, and to the east of Lower Dover (the borderland between this center and Blackman Eddy), and the area to the west of Baking Pot around Esperanza (which represented a buffer zone between Baking Pot and Cahal Pech). The high levels of soil productivity and absence of

settlement in these areas corroborates the idea that these spaces represented less inhabited border zones. This finding suggests that while the availability of productive land was important to Late Classic commoners at both polities, other socio–political factors also structured settlement location.

Table 5. Soil zones and residential distributions for BRASS transects [adapted from [23] Table 3]. (Compare with Table 3 above).

Soil Zone Class	Soil Zone Area (km²)	Soil Zone Area (% of Total)	Number of Households	Proportions of Households (%)
I	0.3	6	32	9
II	1	17	209	58
III	2.4	43	116	32
IV	1.2	21	4	1
V	0.7	13	0	0
Total	5.8	100	361	100

A general trend, which requires further investigation, involves the relative wealth and affluence of households situated within different soil zones. As outlined above, Class I soils in the valley bottoms were the only soils suited to cacao cultivation. In contrast, Class II soils were very good for cultivating a wide array of crops. There are several good examples of commoner households on Class I soil which clearly accessed not only high proportions of portable wealth but also some sumptuary items, e.g., ground stone maces, jade jewelry, figurines, and celts, and ceramics with inscriptions bearing elite titles [1,25,26]. These items denote a high level of affluence and potentially moved down tributary networks in exchange for high–value crops such as cacao that could only be grown on the deep, well–drained soils around these households [40]. In contrast, households situated on Class II and III soils rarely have access to such elaborate statements of affluence, but often still have high proportions of less elaborate wealth items such as polychrome ceramics and shell jewelry [26] (pp. 539–543). The area around Bedran was an exception, however. This minor center was settled at the onset of the Classic period, after the central core area of Baking Pot was settled [25,121]. The presence of the ditched field system here, and the presence of the types of sumptuary items usually only available to intermediate elites on Class I soils may suggest that the ditched field helped drain lands for the cultivation of high–value crops such as cacao. This finding requires further corroboration through the study of the ditched field system itself and the other commoner households of the Bedran District.

Another pattern noted in our results is the presence of intermediate elite minor centers on spatially circumscribed "islands" of higher quality soil. It was surprising to see such a neat correlation between these pockets of good soil and the presence of minor centers on these lands. The implications of this finding, and others relating to the spatial clustering of households on specific soil zones are limited by our lack of understanding of settlement histories for minor centers in the region. Future house mound excavations could provide an understanding of the extent to which commoner clustering around the Baking Pot core was tied to the productivity of soil versus a desire to live in the city. Extensive excavation of minor centers and commoner households at Lower Dover revealed some patterns which seem to play out at Baking Pot. Extensive excavation at the minor centers of BR–180/168, Floral Park, and Tutu Uitz Na revealed these centers all formed by at least the Middle Preclassic, and show evidence of relatively large ~1 m high ceremonial platforms and large plazas by the late facet Middle Preclassic (600–300 BCE) [26]. While it remains plausible that these minor centers evolved in situ and have smaller undiscovered Early Preclassic components, current evidence suggests that these centers were of slightly higher status from their initial founding and their locations reflect the choices made by emerging elites about where to settle on the landscape. BR–180/168 is on one of the largest

natural hillocks in a low–lying alluvial expanse, Floral Park is on the highest point in the surrounding landscape, next to Upper Barton Creek, and adjacent to pockets of Class I soil. Lastly, Tutu Uitz Na is situated on one of the highest hilltops, on a band of Class II soil. It remains entirely plausible that other minor centers in the region arose because they were situated on more productive soils, but the pattern at Lower Dover suggests the founders had the agency to choose the most optimal locales when they settled the region. There are several other minor centers and associated districts that were presumably situated on the landscape based on very different criteria. The Tier 2 center of Ek Tzul for instance, was positioned on the hilltop with a commanding view of the entire region and mountains to the south [100]. Given these criteria, it would be very difficult to situate the center on alluvial soils. Bacab Na is situated on a very circumscribed portion of Class II soils between the polities of Baking Pot and Cahal Pech. It seems in this instance, that the position of the center was grounded in political and ecological factors, such as control of a buffer zone and the alluvial plain [183].

Ultimately, definitively answering many questions about settlement positioning and land use requires a clearer understanding of developmental chronologies at minor centers and their subordinate commoner households. Once this is achieved, however, diachronic reconstructions of land use practices will allow us to relate the distinct developmental trajectories of each center and its associated district to one another, and tie these into the larger major centers and the political incorporation of settlement into these entities. The synchronic spatial modeling and land use reconstruction offered here, however, presents the first steps towards this goal.

5. Conclusions

We present a series of new analyses conducted on refined settlement pattern data. The approaches employed can be applied in a range of other ancient contexts to examine similar questions. Several future directions exist to further clarify and substantiate the patterns outlined. In relation to the settlement patterns and polity affiliations reconstructed above, future examination of the changing wealth, status, and activities of the intermediate elite and commoner residents of the borderlands between the two polities can help to define patterns of incorporation and affiliation. While all the spatial models strongly suggest the periphery between Baking Pot and Lower Dover was occupied by households that were integrated into the Baking Pot polity in the Late Classic period, this dynamic could be examined in greater detail through excavation of the minor centers on these frontiers. Fairly limited work has been conducted in these locales generally. Willey and colleagues [1] (pp. 295–300) mapped the Spanish Lookout District and conducted excavations at the minor center and commoner households. Likewise, Schubert and colleagues conducted a single season of excavation at Esperanza [126], whereas Ford [129,197] as well as Hoggarth and colleagues [125] both conducted survey at Bacab Na. Still, we lack a fine handle on the developmental sequences, and relative wealth, status, power and authority of the residents of these minor centers. Walden [26] showed that intermediate elite incorporation into the Late Classic Lower Dover polity involved the eclipse of intermediate elite political control and a dramatic reduction in their access to portable wealth as it was siphoned off by the rising apical regime. The replication of these patterns at frontier centers may indicate their incorporation into the Late Classic Baking Pot polity. Such trends may be evident at Late Classic Ek Tzul, although this still requires further investigation [100,192]. Moreover, new genomic technologies have the potential to revolutionize our understanding of networked relationships between centers. Given the importance of political marriage alliances and kinship in Classic Maya society [198], ongoing aDNA focused kinship analysis examining biological relatedness between individuals at major centers, minor centers, and commoner households in the region has the potential to reflect changing patterns of polity affiliation. The application of new metabolomic approaches to dental calculus can identify cacao biomarkers [199]. The combination

of such an approach with chemical residue analysis of ceramics, has the potential to revolutionize our understanding of cacao consumption in the past by showing who was storing cacao in household ceramics versus actually consuming it [40,200]. When coupled with soil classification data and paleoethnobotanical analyses, such approaches could provide a solid understanding of ancient agricultural economies and tributary networks.

Combining multiple spatial models for examining settlement clustering and labor catchments reveals important insights into residential patterns, polity affiliation, and land use in the Belize River Valley. Perhaps our most important finding is that the trajectories through which ancient polities formed had tangible and important ramifications for the relative level of demographic centralization in the core. Despite being neighbors and relatively similar entities, Baking Pot and Lower Dover represented two very different political systems, given polity–scale land use practices and clustering. The various spatial models used to delineate district and neighborhood level entities seem to corroborate one another and reveal the presence of socially recognized ancient communities. This finding is strongly corroborated by the minor center/district–level excavation projects at BR–180/168 (Texas), Floral Park, Ixim (Settlement Cluster C), and Tutu Uitz Na. The combination of high–resolution soils data provides additional clarity on land use, settlement choice, and patterns of household wealth. However, ultimately, we still need a better understanding of the Preclassic settlement landscape to develop a clearer idea of how the human landscape changed, and how the ecological background impacted settlement decisions over the millennia.

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Data Availability Statement: Settlement pattern and survey data is freely and publicly available through the University of Pittsburgh Center for Comparative Archaeology (https://www.cadb.pitt.edu/waldenjaa/index.html) (accessed on 5 February 2023). Soils data is available through request at the Mesoamerican Research Center at UCSB (https://www.marc.ucsb.edu/resources) (accessed 5 February 2023).

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