Intra-Site Analysis of Dwellings in Neolithic Tamsagbulag, Mongolia

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Abstract

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Recent work at the site of Tamsagbulag, Mongolia, suggests it predates both agriculture and herding in the broader region by more than 2000 years. These excavations showed a more intensive use than expected, consistent with a hypothesis of year-round sedentism alongside a primary reliance on large game. This is noteworthy because, while sedentary hunter-gatherers are known, they are often heavily reliant on plant foods and/or small prey such as fish.

Based on the evidence, this thesis concludes that the dwellings are most likely seasonally used rather than year-round settlements. Studying patterns in artifact distribution can inform our understanding of *relative* length of occupation through a study of accretion and depletion as they relate to habitation, abandonment, and post-abandonment processes. This research utilizes spatial analyses to visualize level-specific patterns in artifact distributions within each excavated dwelling and identify specific clusters of artifacts that may hold insight into potential waste management practices.

Keywords: Site Formation Processes, House floor assemblages, Habitation, Abandonment, Post-Abandonment, Seasonality, Sedentism, Spatial analyses, Cluster analyses, Kernel Density Estimation, Ripley's K, Neolithic, Mongolia,

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Chapter 1: Introduction

This thesis is about the interpretation of the spatial patterning of artifacts associated with household assemblages from pre-agricultural communities of Neolithic Mongolia, and what this can inform us about the degree of sedentism at these sites. The concept of sedentism has been difficult for archaeologists to define due to its many complexities, but it is important to identify archaeologically because how people move strongly influences culture and society (Dow and Reed 2015; Kelly 1992, 2013: 104). Overall, the problem often lies not in the differences but in the fact that the definition in use is often not explicitly stated (Rafferty 1985).

Sedentism can best be defined as the process where humans reduce mobility to the point where they remain residentially stationary year-round (Hitchcock 1982; Kelly 1992). Another important term in the study of mobility/sedentism is sedentary settlement systems, which are systems in which at least a part of the population remains at the same location throughout the entire year (Kelly 1992; Rafferty 1985). This is important as it encompasses transhumant patterns, the temporary absence of some members from the site, and settlements exhibiting varying degrees of permanence (one year to thousands, depending on the site) (Rafferty 1985). There have also been many theories involving the origins of sedentism, which are beyond the scope of this thesis, but have been outlined in greater detail elsewhere (Dow and Reed 2015; Hitchcock 1982; Kelly 1992; Price and Brown 1985; Simpson and Jones 2020).

Many traits have been discussed as evidence for sedentism in the archaeological record. Some of these include measuring the abundance of resources, the ratio of formal to informal tools and local to exotic raw materials in stone tool technology, site structure, larger investments in dwellings, increases in burials, site-specific investments in food processing and storage facilities, and differing models of abandonment behavior (Cameron and Tomka 1993; Dow and Reed 2015; Friesem et al. 2024; Hardy-Smith and Edwards 2004; Kelly 1992; Rafferty 1985). This thesis focuses on the site structure, dwellings, and abandonment behaviors, and what these and their formation processes can reveal about the possible degree of sedentism at the Neolithic site of Tamsagbulag in Eastern Mongolia.

1.1 Thesis Research Goals and Hypothesis

The main goal of this thesis is to determine the nature of the relationship between artifacts/clusters found within each dwelling so far uncovered at Tamsagbulag and habitation, abandonment, and post-abandonment/formation processes. I use this information to answer questions regarding whether these dwellings were only used once- either for many years or just a single season- and whether dwellings were abandoned and reused. Waste management (i.e., expedient or standardized cleaning of living spaces and opportunistic or formal discard) speaks to the relative degree of sedentism both within dwellings and at the site level.

My thesis will evaluate the intensity of site use to test the hypothesis that pre-agricultural, pre-pastoralist peoples in the steppes of eastern Mongolia were fully sedentary, despite the lack of evidence for intensive use of plants or small game. I employed GIS and statistical testing to create maps of several dwellings at the Neolithic site of Tamsagbulag in Mongolia and use these data to interpret dwelling use, cleaning, and re-use over time. Artifact distribution analysis was also used to identify whether spatial patterning (artifact variation) is characteristic of cleaning, reuse, and maintenance.

1.2 Thesis Chapter Outline

This thesis is divided into six chapters. Chapter 2 begins with the archaeological setting, providing a brief review of Mongolian prehistoric climatic phases. I then introduce the Neolithic site of Tamsagbulag and the history of excavations conducted there prior to the Gobi-Steppe Neolithic Project. I end that chapter with the central question and hypothesis that will be addressed through the analysis. In Chapter 3, I introduce the theoretical approach I employ, based on the site formation processes of household assemblages. I explain LaMotta and Schiffer's (1999) model for analyzing house floor assemblages, including each formation process that can occur after habitation, abandonment, and post-abandonment. It continues to discuss site formation processes and length of dwelling occupation, wrapping up with the expectations we would see and how those expectations are tested. Chapter 4 introduces the data sources and methods used to analyze the dwellings at Tamsagbulag. First, each of the units included in the analysis is described in detail, followed by the artifact categories created to aid in analyzing the artifacts themselves. The final portion discusses the methods, including a brief explanation of each type of spatial analysis used. Chapter 5 presents the results for each of the units, including all data gathered from running the statistical tests/spatial analyses introduced in the previous chapter. Chapter 6 discusses what the findings mean in terms of interpreting site formation processes, degree of sedentism, and waste management at Tamsagbulag.

Chapter 2: Archaeological Background

2.1 Prehistoric Mongolian Climate Phases

Three distinct phases have been proposed for the sequence of post-Last Glacial Maximum groups in the Gobi Desert region of Eastern Asia. Oasis 1 dates to between 11,500-6500 BCE and spans massive fluctuations in climate, including the end of the Bolling-Allerod interstadial, the Younger Dryas, and the early Holocene. It broadly corresponds to what other archaeologists have termed the Mesolithic and the Epipaleolithic, and is characterized by a microblade toolkit lacking pottery (Janz 2024) . Oasis 2 dates to 6500-3000 BCE, coincides with the Holocene Climatic Optimum, and corresponds to the widespread expansion of lakes, rivers, and wetlands. It generally corresponds to the Neolithic period and is defined by the regular use of grinding stones, pottery, chipped/polished stone tools, and a larger microlithic toolkit (Janz et al. 2017). Oasis 3, which corresponds to the Bronze Age/Eneolithic, dates to 3000-1000 BCE and appears to be the transitional period between hunting and gathering and the adoption of pastoralism (Janz 2024; Janz et al. 2015, 2017).

Oasis 2, which radiocarbon dates place Tamsagbulag, corresponds with the Holocene Climate Optimum, which is a period of enhanced precipitation driven by strengthening and resulting northward migration of the East Asian Monsoon System (Janz 2024). Paleoenvironmental proxies indicate a corresponding expansion of lakes, rivers, and wetlands, shifts towards desert-steppe and steppe ecosystems within the Gobi, as well as the development of riparian and high elevation woodlands, and forest-steppe along the less arid southern boundary (Janz 2024). The establishment of pit-dwelling communities in the far eastern steppe of Mongolia, such as Tamsagbulag, was likely enabled by changing ecological conditions associated with increased precipitation (Janz 2024).

2.2 Site Information

Tamsagbulag is a Neolithic site located in Dornod Province, Mongolia, in the steppe region of eastern Mongolia, about 30-40 km from the border with Inner Mongolia (Okladnikov and Derevyanko 1970) (see Figure 1). Tamsagbulag sits on a cliff terrace above the incised meander of a Pleistocene riverbed. Today, springs entering the riverbed below the cliff face maintain a seasonally wet freshwater marsh. Three separate dwellings were discovered (Derevyanko and Dorj 1992). Originally excavated in the mid-20th century, it was first thought to be a cattle-rearing agrarian community because of the immense amount of aurochs (wild cattle) remains and ample evidence of pestles, grinders, and graters (Derevyanko and Dorj 1992). At that time, it was stated that agriculture appeared to develop independently in Eastern Mongolia, with its origins in food-gathering. Fish remains recovered during the excavation suggested that fishing may have been common (Derevyanko and Dorj 1992).The most recent research conducted by the joint Mongolian-Canadian Gobi-Steppe Neolithic project (https://gobisteppe.com/) counters these interpretations. Radiocarbon dates indicate that the site was used during the Mongolian Early Neolithic period, or Oasis 2 (Janz et al. 2015), from approximately 8400 - 6000 cal BP, and most intensively between 7800 - 7500 cal BP (Zhao et al. 2021). This predates any clear evidence of agriculture in neighboring Northeast China, and even the latest dates predate evidence of herding in eastern Mongolia by more than 2000 years (Janz et al. 2017; Zhao et al. 2021). These new excavations showed a much more intensive level of site use than expected alongside a primary reliance on large game (Janz et al. Nd), which is noteworthy; while sedentary hunter-gatherers are known, they are often heavily reliant on plant foods and/or small prey such as fish (Stiner et al. 2000). Indeed, Tamsagbulag is one of only two known sedentary hunter-gatherer sites in Mongolia and presents evidence against a unilinear model of progressive sedentism and resource management. In the absence of proof for agriculture or intensive fishing, it is essential to assess the potential role of large game in supporting long-term site occupation- a strategy that is largely unknown in the absence of animal domestication. Here, the underlying goal is to determine the degree of sedentism, including assessing whether intensive seasonal use might mimic year-round occupation. This is the first step in evaluating the observed pattern.

Figure 1: Tamsagbulag in eastern Dornod province, Mongolia

2.2.1 Discovery and previous excavations of the site

The Neolithic settlement was discovered at the beginning of the 20th century by Mongolian scholar Demchigi Buddar (Odsuren et al. 2021: 6). The site was researched by a Mongolian-Russian Joint archaeological expedition, led by C.B. Kiselev, from 1947 to 49. It was excavated by Mongolian archaeologist D. Dorj and Russian archaeologist A.P. Okladnikov during a Mongolian-Russian Historical and Cultural expedition from 1969 to 1989 (Odsuren et al. 2021: 6; Tumen 2005). During these excavations, they discovered what they believed to be three separate dwellings and published an article in both Russian and Mongolian describing their findings (Odsuren et al. 2021: 6). Stone tools were common, mostly consisting of cores, including core scrapers. These included classical and Tamsagbulag types, the latter of which is distinct to this area, showing a beveled striking surface fashioned by transverse chipping (Derevyanko and Dorj 1992). The lithic industry was microblade-based and included many microblade cores, microblade flakes, flake tools, awls, and scrapers (Derevyanko and Dorj 1992). Polished adzes were also found, along with bone used to make composite knives or daggers and other tools (Derevyanko and Dorj 1992). Pottery was mainly grey, thick-walled, and decorated with deeply geometric-incised lines (Derevyanko and Dorj 1992). Dwellings were described as rectangular in plan, containing large numbers of faunal bones and lithic fragments, often within a rich, organic black soil layer. One house appeared to have a foundation trench dug 50-80 cm into the ground, two rows of post holes, and a pyramidal roof (Derevyanko and Dorj 1992).

The next group of excavations was conducted by a Mongolian-French team, led by B. Gunchinsuren and M. Seferiades, who conducted a small-scale research project in the area in 1998 (Seferiades 2004). They excavated in three different regions and unearthed a variety of information. An intensive survey was conducted in Tamsagbulag 1, where Seferiades found several hundred stone tools and potsherds dating from the Neolithic period (Seferiades 2004). He claims hunters may have situated themselves upon the 10-12 m high cliff, directly above a large spring, where they could await their prey. Four excavation units were dug in the area. No artifacts were found, but the units were able to tell the archaeologists a great deal about local stratigraphy (Seferiades 2004). The second area, Tamsagbulag 2, contained mainly stone and ceramic artifacts from historic times and little to no artifacts dating to the Neolithic (Seferiades 2004). Tamsagbulag 3, the third area, was located on the eastern side of the meander, which yielded important lithic and ceramic materials appearing to come from a Neolithic camp/habitation site not far from the terrace (Seferiades 2004). Between 2011 and 2012, Japanese archaeologist H. Obata began a research project in collaboration with several Mongolian researchers, but the excavations were not completed due to time restraints (Odsuren et al. 2021: 6).

Detailed excavations began again in 2018 with the Gobi-Steppe Neolithic project, co-directed by D. Odsuren, L. Janz, and with D. Bukhchuluun 2018. The focus of the 2018 excavations was to determine the chronology and extent of the site in more detail, as well as collect faunal assemblages for further analysis. Both small (<5 m^2) (TB3, TB4-TB8) and large-scale (>30 m^2) (TB1, TB2, TB9) excavation units were dug based on artifact distribution and surface morphology, with the aim of identifying dwellings and understanding occupation intensity (depth of anthropogenic soils) across the southern terrace (Odsuren et al. 2019: 64). Based on survey work conducted that year by Canadian geoarchaeologist William Fox, it was concluded that stone for lithic production must have been transported to the site from a distance of more than 100 km.

No excavations were conducted in 2020 due to the COVID-19 pandemic, and due to travel restrictions, 2021 saw excavations conducted by Mongolian researchers with virtual participation from Janz. Several units from 2018 were continued, along with new test units (TB10-13). The large amount of faunal remains also helped lead to the possible conclusion that meat consumption was high, and that even though the area did not have raw materials for making tools, the abundance of food led the people to settle here for quite a long time. The presence of freshwater shells and fish bones suggests the consumption of aquatic food as well, though in low quantities (Janz et al. Nd).

The focus of the 2022 field season was to continue excavations at TB13, one of the larger test units begun in the previous year. Here, the bottom-most layer contained the rich deposits of animal bone with a significant decrease in lithics. The most recent field season in 2023, involved a large-scale shovel-test survey to determine the location and coverage area of the settlement, collection of soil samples, and the excavation of one burial (EX-01) (all in Area 2 – see Figure 2) and two additional dwellings (TB14, TB15) (Areas 2 and 3). Based on radiocarbon dates from the 2018 excavations on the western edge (Area 3) of the occupation area, researchers proposed that TB14 might predate intensive occupations, as evidenced in Area 2 (Odsuren et al. 2023: 49). Differences included the types of artifacts present, some variation in the raw materials used to craft them, less evidence of aurochs bone (dominant in Area 2), and a much greater quantity of fish and small mammal remains (Odsuren et al. 2023).

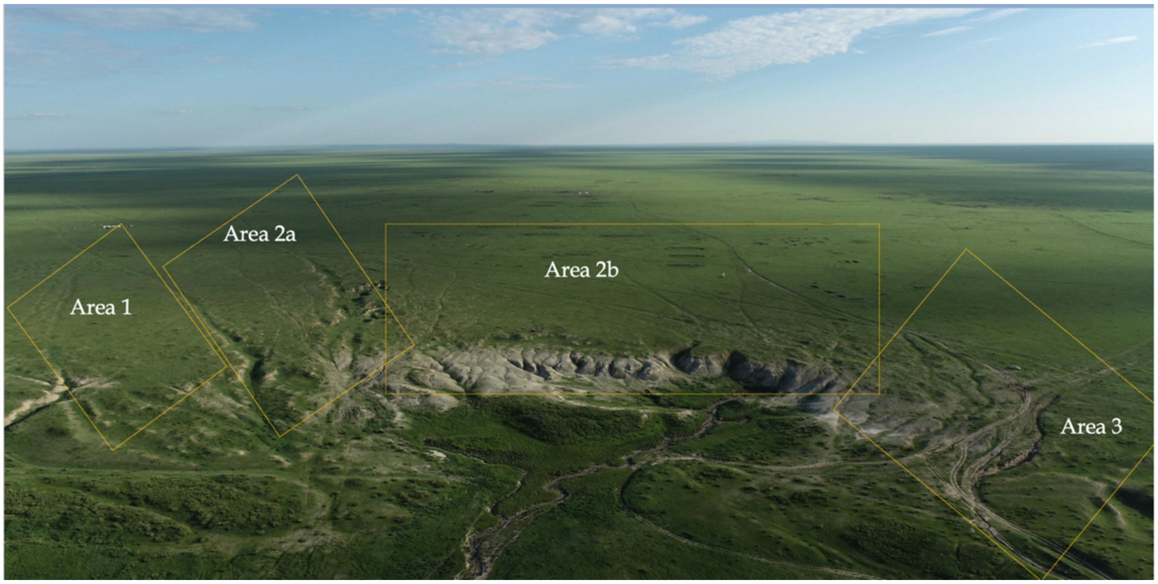

Figure 2: Areas of Tamsagbulag denoted based on when/where excavations took place (Area 1 contains TB1; Area 2 contains TB2 and TB9-13; Area 3 contains TB14)

2.3 Research question and hypothesis

The main question I aim to answer about the excavations at Tamsagbulag is the following: Do the units/dwellings at Tamsagbulag represent seasonal or full-time sedentism? This question is important to answer as Tamsagbulag predates agriculture and herding in the broader region by more than 2000 years. These excavations showed a much more intensive use than expected, consistent with a primary reliance on large game. This is noteworthy because, while sedentary hunter-gatherers are known, they are often heavily reliant on plant foods and/or small prey such as fish (Stiner et al. 2000). In answering this, I aim to evaluate the archaeological deposits to test the hypothesis that the site of Tamsagbulag represents an example of a fully sedentary village. The hypothesis considers both the formation processes of the archaeological record, and the behaviors typically associated with household maintenance. This is the subject of the next chapter.

Chapter 3: Site Formation Processes and Household Assemblages

The following chapter first introduces the idea of site formation processes and house floor assemblages, focusing on how deposits accumulate and are transformed through time. House floor assemblages are then discussed regarding the duration of occupation and the possible use of dwellings after abandonment. This will be done with consideration of what this means for the relative length of occupation.

3.1 House Floor Assemblages and Their Formation Processes

Site formation processes have long been used by archaeologists to help understand how past human activities turn into an archaeological record (Binford 1978, 1980; Hardy-Smith and Edwards 2004; Hitchcock 1982; Murray 1980; Porcic 2012; Schiffer 1972, 1983, 1987; Stevenson 1982). Formation processes, both cultural and non-cultural (i.e., natural), transform the material activities of past societies, and archaeologists must consider these when interpreting evidence (Schiffer 1983). Material traces of organizational patterns can often be disturbed and new patterns created by diverse processes of both humans and nature, so in order to infer the "systemic" properties of interest, archaeologists must identify and consider these formation processes (Schiffer 1983).

The study of house floor assemblages in particular and their formation processes has developed more recently as a method for archaeologists to help gain insight into how prehistoric people lived and what their social organization was like (Onfray 2022). Beginning in the early 1960s, most analyses of house floor assemblages assumed variation in each dwelling had to do with activities carried out in those particular structures (LaMotta and Schiffer 1999). Since the 1970s, however, more effort has been put into identifying additional sources of variability; mainly in the formation processes of the archaeological record (LaMotta and Schiffer 1999).

Here, I use LaMotta and Schiffer's (1999) model outlining the timing of different cultural and non-cultural processes that may have contributed to the creation of house floor assemblages. They define two distinct processes: (1) accretion, which results in the deposition of objects within a domestic structure, and (2) depletion, which either removes objects from archaeological deposits within a structure or prevents objects once used within the domestic structure from being deposited at their locations of use. With these two processes in mind, they could recognize three stages of a structure's life history: habitation, abandonment, and post-abandonment. Both accretion and depletion are processes that apply to all three stages.

3.1.1 Habitation

The first stage is habitation, where the accretion results from the daily activities of people that reside in the dwelling, such as food processing and preparation, and the manufacture/maintenance of tools and activity areas (LaMotta and Schiffer 1999). One common accretion process is primary deposition, which occurs when objects enter the archaeological record at their location of use either through discard as 'primary refuse' or accidental deposition as 'loss' refuse (LaMotta and Schiffer 1999). This is the strongest line of evidence as the artifacts relate directly to habitation, but it has been found ethnographically that this type of deposition is often not the case. Provisional discard is another accretion process where broken/worn objects are not discarded; instead, they are stored with the expectation that they will serve a useful purpose later (LaMotta and Schiffer

1999). Secondary deposition involves the removal of refuse from an activity area and its deposition in a spatially removed location such as a midden (Hutson et al. 2007; LaMotta and Schiffer 1999).

Middens are most commonly identified as deposits rich in refuse with evidence for sequential accumulation at one location (Needham and Spence 1997). There must also be evidence of episodic dumping, often deduced from evidence such as articulated bone groups, refit distributions, and alternating lenses of differing compositions (Needham and Spence 1997). One primary function of middens stems from the production and processing of items, such as debris from artifact production, as well as initial butchery waste (including heads, lower limbs, and other unwanted carcass parts) (Needham and Spence 1997). Another primary function is site management, as described above; certain zones may be kept refuse-free, and there may be periodic refuse clearance from living quarters to improve hygiene (Needham and Spence 1997). Implicit in the definition of a midden is the survival of 'structure' evidence for the episodic way deposits build up, as well as the repetitive deposits of similar character will almost inevitably be found, which together can give the appearance of formality in the placing of refuse (Needham and Spence 1997).

In one study, Schiffer (1972) divided the activities in which durable objects such as tools, machines and facilities participates in during its life into five processes: (1) procurement of materials, (2) manufacture of items, (3) use of items, (4) any maintenance that may be required, and (5) the eventual discard when the item is no longer usable (Schiffer 1972). Each process consists of one or more stages, such as the manufacturing of a lithic tool, with each of these consisting of one or more activities (Schiffer 1972). He also highlighted that not all elements follow a unilinear path, as some may be reused and go back through a previous process (Schiffer 1972). Schiffer defined two types of reuses as well. The first is recycling, which is the routing of an element at the completion stage either back to the same or a different manufacturing stage (Schiffer 1972). The other is lateral cycling, which is the termination of an element's use in one set of activities and resumption in another (often only maintenance, storage, and transport intervening) (Schiffer 1972).

Similarly, Binford (1978) recognized five different manipulative acts that resulted in items occurring on surfaces within an ethnographic site. Dropping was the most common, which occurs when elements are detached from an item already held in hand. One example includes a bone being cracked for marrow, as it was observed that after a bone had been split to collect the bone marrow, the leftover pieces that did not contain the marrow were allowed to drop to the floor while the main piece that included the marrow was held. Tossing most often occurred upon completing an action, such as an item being held in hand, tossed aside, or removed from the area of its use. Resting, or items purposely set down, is also seen ethnographically through setting a rifle and coffee down and leaving them placed where they were when the group members heard something about a hunt, and their focus was elsewhere. The positioning of items (or items being "placed") was often seen if there was some attempt to aggregate several items, place them somewhere they would be out of the way of ongoing activities and ensure easy retrieval at some future date (this is difficult to identify in the archaeological record, but most archaeologists would consider this to be the equivalent of caching). The last act is dumping, which is the accumulation of dropped or resting items, generally into a container, which are then picked up and dumped elsewhere (Binford 1978).

Binford 1978 observed several main points. The first is that at any one time at the site, activities conducted simultaneously were independently organized in space (Binford 1978). Over time, the same activity appears to be undertaken around the same area each time, although that specific area is not dedicated solely to that activity. Finally, he realized that the intensity of use was not evenly distributed among recognized use areas, and that various activities were not evenly distributed among the several areas (Binford 1978).

3.1.2 Abandonment

The second stage is abandonment, which includes de facto and refuse deposition as accretion processes (LaMotta and Schiffer 1999). Deposition of de facto refuse involves the abandonment of still usable objects within a structure: these are often items that are difficult to transport and easy to replace. Depletion processes include curation and ritual depletion. Curation behavior occurs when objects are transferred from old to new activity locations: such items are often highly portable and still usable. Archaeologists must be aware of ritual abandonment of structures at this stage, as it can be confused with de facto refuse, as artifacts were left behind for ritual purposes rather than being difficult to transport or because of the intent to return (LaMotta and Schiffer 1999). Although this study focuses entirely on larger debris uncovered from excavation, it has become increasingly important to study and analyze minute residues: microrefuse (bones and artifacts <1-2cm), phytoliths, organic residues, and stable isotopes (Milek 2012). This work is currently underway.

3.1.3 Post-Abandonment

The third stage is post-abandonment, with both cultural and natural processes contributing (LaMotta and Schiffer 1999). Schiffer (1987) defines these laws as general regularities in formation processes, such as *c*-transforms (for cultural) and *n*-transforms (for non-cultural/environmental) (Schiffer 1987). N-transforms are easier to investigate/explain as they generally fall within the theoretical systems of other fields such as chemistry and biology (Schiffer 1987). *C*-transforms are just as fundamental to our knowledge of the archaeological record but can be more difficult to generalize as human behavior can vary greatly.

Several accretion processes are involved in post-abandonment, including reusing refuse depositions, secondary refuse deposition, structural collapse, and other disturbances after the structure is abandoned. Several depletion processes include scavenging (human or animal), disturbance, and decay, such as floral or faunal bioturbation (Table 1) (Hutson et al. 2007; LaMotta and Schiffer 1999). Keeping these formation processes in mind is essential for understanding the patterning of remains within the remaining archaeological record.

Table 1: Illustration of Most Common Examples of N- and C- Transforms (Wood and Johnson 1978)

Type	Description
Pedoturbation	involves the various processes of soil mixing that can affect the archaeological record
Floralturbation	the process of mechanical mixing of soils due to either root growth/decay as well as treefall
Faunalturbation	the mixing of soils by animals (ex: animal burrows in one soil horizon commonly filled in with material of a different color/texture from a different horizon)
Cryoturbation	the disturbance of soils by freeze-thaw action (ex: when frost penetrates the ground and can move up an artifact due to several processes; and frost cracking, which occurs when cracks form in seasonally frozen ground (which can also subsequently be refilled with other soils/sand))
Graviturbation	the mixing/movement of soil/rock debris downslope under gravity without the aid of a medium of transport (ex: creep, or the movement of human created/natural objects being dragged downslope that drags the soil with it)
Argilliturbation	caused by seasonal swelling and shrinking of expansible clay in soils
Aeroturbation	soil gas disturbs the fabric of the soil, or when wind blows finer grains from the soil, leaving behind coarse particles as a mixed deposit (occurs most often in the desert)

These processes, as outlined by LaMotta and Schiffer, highlight several central themes to keep in mind when studying house floor assemblages. One is that there is not necessarily a one-to-one relationship between objects/artifacts found in a structure and the activities in that space (LaMotta and Schiffer 1999). Both accretion and depletion processes can relocate artifacts from where they were first used, most commonly discarded elsewhere, or reused for another purpose. The preserved assemblages likewise may not necessarily be from the same phase in the structure's history, as many structures undergo differing formational processes during each of the three stages defined above (LaMotta and Schiffer 1999). Since distributions are often more closely related to the effects of trampling, cleaning, and abandonment processes (related to artifact size, weight, and robustness) than to primary deposition in floor deposits, it is essential to study these factors before incorporating artifacts in analyses (Milek 2012). Archaeologists must also be careful when using ethnographic models, as dwellings are still being used and are not subject to post-abandonment processes like archaeological sites are (Hutson et al. 2007).

3.2 Site Formation Processes and Length of Occupation

One of the primary considerations regarding site formation processes is the length of occupation. Occupational intensity – how long and at what density a site is occupied – will influence both *n*- and *c*-transforms, though here I will talk primarily about cultural activities. Binford (1980) described two extremes at the ends of a continuous spectrum in hunter-gatherer mobility: foragers and collectors. Similarly, others have characterized hunter-gatherers as following either immediate or delayed return foraging strategies, with the difference related to the role of food storage (Barnard 2004; Kelly 2013:20; Martin and Shirk 2008; Woodburn 1980, 1982). Immediate-return foragers do not store food but rather gather it daily; they gather food on an "encounter" basis, then return to their residential bases each afternoon/evening (Binford 1980). There is often variability in the group size, the number of residential moves they make in one year, and the relative redundancy of land use from year to year, which can all affect the "visibility" of the archaeological record (Binford 1980). Two main types of spatial context for the discard/abandonment of items were also identified: a residential base, which was the hub of subsistence activities, and a location, which was a place where extractive tasks were exclusively carried out (Binford 1980). Delayed return foragers, or collectors, on the other hand, are characterized by storing food for at least part of the year and consist of logistically organized food-procurement parties (Binford 1980). They may often be close to one critical resource but far away from another. They send small, specialized groups not to search but to procure specific resources in specific contexts (Binford 1980). Binford identifies at least three other types of sites based on the logistical character of their procurement strategies. One is a field camp, or a temporary operational center for a task group (where the task group occupies when travelling away from the residential base) (Binford 1980). Another is stations, sites where special task groups are localized when information gathering (such as game or other humans) (Binford 1980). The last is caches, which are standard temporary "field storage" done in regular facilities to deal with bulk items (Binford 1980). Generally, foragers move consumers to goods with frequent residential moves, while collectors move goods to consumers with fewer residential moves (Binford 1980). Given different settlement-subsistence/mobility systems, they may expect various types of sites to result from different technological organizations.

It is essential to remember that some groups may be foragers during some seasons and collectors in other seasons, while others may be collectors all year round, but in different locations. This makes it clear that these designations are dualistic and that many variations exist, and groups might sometimes practice either strategy. Based on the intensity of site occupation, we know that Tamsagbulag best fits a collector-model of occupation; however, what we do not know yet and what we are attempting to answer is whether the inhabitants of Tamsagbulag were collectors year-round (perhaps acting more as foragers part of the year or using a seasonal rotation of residential bases) to determine whether they were entirely or only partially sedentary.

Zhao (2020) lists several points to pay attention to when attempting to determine both occupation length of a dwelling and its usage after abandonment in northern China, the region he discusses (survey region in northeast Huade County) is geographically relevant as it is also located on the Mongolian Plateau though along the south edge. He explains that many Chinese archaeologists view pit houses, like those at Tamsagbulag, as signs of sedentary villages. However, he argues that people can still live relatively mobile by making two or more settlements in different areas across different seasons. He also contends that the disposal pattern of lithics and the specific features of dwellings are essential in determining the stability/intensity of house use. As the intensity of occupation increases, people are likely to keep their living places cleaner, and lithic debitage/other refuse would be moved from the living area to a disposal area (Hayden and Cannon 1983). Lithics found within the dwelling should then only reflect use and discard right before abandonment, as people leaving a dwelling for the last time would be less inclined to ensure the living space was clean. If they were cleaning the floors periodically, as more sedentary people should, there would be little lithic waste within the home, with most redeposited adjacent to the dwelling or within a dedicated midden. Zhao (2020: 82) found that lithics in such pit houses were often scattered across different depths inside the dwellings, indicating accumulation over a relatively long period and implying lengthier occupation times.

Zhao (2020: 106) also explains how the level of investment put into building each dwelling can give clues as to occupation length. The existence of post holes suggests the construction of wood-framed structures. Hearths often appear slightly higher than the house floors, implying that people repetitively used one specific area for hearths, allowing ash layers to accumulate over time (Zhao 2020: 106-107). Both characteristics suggest that substantial time was invested in building and maintaining the dwellings, indicating that people expected to use these spaces for extended periods. Similar investments, with post-molds and built-up hearths, are present at Tamsagbulag, and the depth and extent of anthropogenic soils at the site suggest intensive occupation at least during the main period when Area 2 was occupied 7800-7500 cal BP (Zhao et al. 2021).

Zhao (2023) examines four Chinese sites that date to similar periods as Tamsagbulag and show various ways of living; these include Hag, Baiyinchangan, Yumin, and Simagou (Figure 3). The Neolithic occupation of Hag dates to between 8600-8000 cal BP, where a large house with an area of 56.08 m2 was revealed entirely. Within it, post holes and many stone/bone tools were unearthed in the dwelling floors, and seven ash pits that date to the same period as the house were most likely used as storage outside the dwelling. Few plant remains and no domestic crops were located, but many animal bones were found densely distributed. The most common species include fish, birds, raccoons, and rabbits, while larger grassland mammals were rare (Zhao et al. 2023).

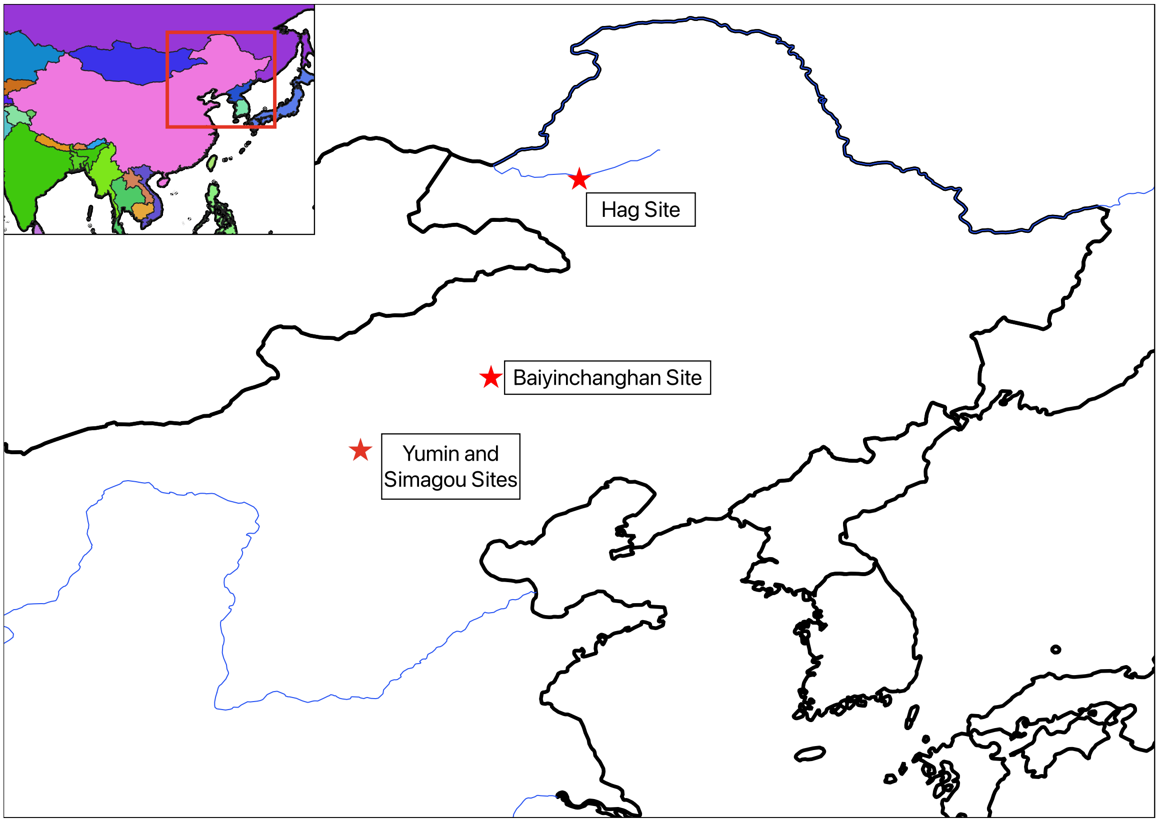

Figure 3: Hag, Baiyinchanghan, Yumin, and Simagou sites mentioned in Zhao et al, 2023

Bayinchangan is distinct as there are both residential sites and two cemeteries. The Xinglongzhu culture occupation dates to 8000-7300 cal BP, and 25 semi-subterranean dwellings were located. Ground stone tools were the most common type of stone tools at the site, with the Cervidae family accounting for most of the faunal remains. The primary source of meat appeared to come from medium/to large-sized mammals at the intersection of forests and grassland. Many artifacts were piled on the living surface of the dwellings, complete in form, and some were arranged in sets/placed in corners, showing they were placed intentionally. Typical prehistoric sedentary settlements contain artifacts that are scarce/broken on the living surface, since residents typically clean the floor periodically and move useful items away from the site once it is abandoned. Placing practical artifacts in groups suggests they may temporarily leave the site and move on for various reasons, but have plans to return and resume the site's use. For these reasons, Zhao et al. (2023) argue that the site was most likely used intermittently and repeatedly rather than continually.

Yumin and Simagou sites also have settlements consisting of groups of houses, and were occupied between 8400-7600 cal BP. The Yumin dwellings were mainly round or oval in shape, while those at Simagou were either oval or square in shape. Neither showed signs of artificial repair on living surface of dwellings; they do show evidence of debris at different levels from the production of stone tools and animal bones discarded from food, indicating as the time of dwelling use increases, the more the living surface in a dwelling gradually increases (the thickness in several dwellings exceeded 50 cm). These sites combine agricultural and foraging subsistence economies, but have less agriculture than at Baiyinchangan. Grinding tools make up a larger proportion of stone tools, with the number of animal bones being abundant (between that of Hag and Baiyinchangan). Based on artifact collections, the Yumin site may have been used in autumn/winter, and the Simagou site was used in spring/summer (Zhao et al. 2023).

Though geographically far removed, Keatley Creek, located in British Columbia, Canada, offers another important example where archaeological evidence for extreme occupational intensity corresponds with seasonal site use rather than year-round habitation. Keatley Creek was a large village dating between 7000 and 200 cal BP, with housepits dating between 3500 and 200 cal BP. This site also contained enormous housepit residential structures: semi-subterranean houses with timber roofs covered with earth and sod (Hayden 2005: 6). The material analyzed from the floor represented all types of materials generated by the inhabitants, with two apparent exceptions: items of significant value appeared to be taken away and often buried with the individual, and most whole/useful tools were simply carried around until broken or used up, and so few whole tools were found in deposits (Hayden 2005: 38). Both these clues indicate the houses were not abandoned in a rush, and overall, it appears the objects left behind were either of little value or were small and had been lost during occupation (Hayden 2005: 39).

It was found that pithouses, as a labor-intensive type of shelter, are best suited to environments with severe winters (Hayden 2005: 44). These dwellings appear to have been densely occupied, with body heat hypothesized to have been the main way to stay warm during the winter (Hayden 2005: 44). The fact that there was little overlap of pithouses suggests a large percentage of the structures were occupied simultaneously (Hayden 2005: 45). There was little/no evidence of hearths in small pits, suggesting heavy reliance on body heat (Hayden 2005: 49). Larger dwellings appeared to contain several hearths, but a lack of ash accumulation suggested only intermittent use (Hayden 2005: 51). Large storage pits were also found inside some of the excavated house pits, between houses, and in special areas on the peripheries of the site (Hayden 2005: 52).

Therefore, we are left with a range of possible scenarios to explain what appears to be high levels of occupational intensity at Tamsagbulag. Radiocarbon dates suggest that the site was regularly used over about two thousand years (~8500-6500 cal BP), with a period of high-intensity use at ~7800-7500 cal BP (Zhao et al. 2021). However, this does not mean that the site necessarily functioned as a year-round occupation during this entire time, or even during the period of greatest occupational intensity. While further lines of information (e.g., analysis of faunal and botanical remains) are needed to determine seasonality, an investigation of patterns in artifact distribution can inform our understanding of *relative* length of occupation through a study of accretion and depletion as they relate to habitation, abandonment, and post-abandonment processes. I use spatial analysis to visualize level-specific patterns in artifact distributions within each excavated dwelling. This analysis will hypothesize site formation processes and build a series of testable models for future investigation of relative occupational intensity.

3.3 Expectations for Full Sedentism versus Seasonal Sedentism

We expect to see different outcomes depending on the intensity of occupation at Tamsagbulag, and whether the site is fully or only seasonally sedentary. If the site were established as a fully sedentary village, we expect to see secondary deposition spatially removed from each dwelling, most likely in centrally located, substantial midden deposits (Hitchcock 1982). We would also expect to see several middens among the dwellings; perhaps one close to each dwelling, or a larger communal midden located a bit farther away. The variability of artifacts within each midden/dump area could also hint at how often dwellings were occupied, as the longer the inhabitants are in one spot, the more variability, the longer they were there (Kent 1993). The ability to reuse abandoned dwellings as middens also suggests the site was inhabited for a lengthy period and reused/revisited often. Actions such as dropping, tossing, and placing objects/artifacts would most likely end up within middens or relocated directly outside, as inhabitants living in their dwellings full time would be periodically cleaning/sweeping the dwelling, and are unlikely to live directly on their trash (Hardy-Smith and Edwards 2004). Items stored or cached for future use might be arranged in certain areas of the dwelling, showing the intentionality of returning to them (Stevenson 1982). After a formal dwelling was abandoned, it could have been turned into its midden, and inhabitants of other dwellings may end up dumping their waste on top of the abandoned structure. These dwellings will also show evidence of more effort being put into building (e.g., post molds, formal hearths) since the inhabitants would expect to use them for extended periods. There might also be evidence of maintaining the overall structure of the dwelling.

However, if a site is occupied only seasonally, we are more likely to see less formal cleaning and trash removal. If middens developed among small camps, their distribution may also be similarly clustered to how the dwellings are clustered, as there would not be a reason to spread out quite so much. As mentioned above, lower levels of sedentism might also be reflected in some waste accumulation *within* the dwelling, mainly if inhabitants only used the dwelling once for a prolonged period and then did not return (Graham 1993; Stevenson 1982). If people were using dwellings for only a few weeks or months, we are more likely to see secondary deposition within specific areas of the dwelling, especially if removing waste from the dwelling was challenging (e.g., entrance through the roof, as hypothesized by Derevianko and Dorj 1992 and Seferiades 2004). Since debris from dropping and tossing would be swept to keep the main living area clean, such objects would end up in the secondary sweeping deposits. If less cleaning occurs, there may also be evidence of dedicated work areas and artifacts left in situ.

Variables associated with two types of sedentism (full versus seasonal) are summarized in Table 3.2. Faunal and botanical evidence are outside the scope of this thesis, while what we currently know about the positioning of houses will be briefly discussed in Chapter 6. My analysis of site formation processes will focus on using computational spatial analysis to describe and identify patterns of trash disposal and house floor maintenance. The expectations outlined in Table 3.2 will be used to test the results of my data to determine whether it is more likely that sedentary village communities or seasonally sedentary groups characterized the occupation of Tamsagbulag.

Table 2: Variables when comparing full versus seasonal sedentism

Type of Evidence	**Fully Sedentary**	**Seasonally Sedentary**
Faunal	All ages and species	Restricted ages and species
Botanical	All species and plant parts	Restricted species and plant parts
Trash disposal	Larger middens present, separate from the dwelling	Small, informal middens, most likely within the dwelling
House floor maintenance	Periodic cleaning, with piles of cleaned waste deposited outside dwelling	Small collections within dedicated areas of the dwelling
Positioning of houses	Formal site layout	Little formal layout with houses overlapping and more randomly positioned

Chapter 4: Data Sources and Methods

The main goal of this chapter is to outline the data sources analyzed in this project and the methods used to conduct the analysis. First, I list the excavated units from the Gobi-Steppe Neolithic project that held the most data, and include what was found during the excavations of these units. I then identify the three main artifact categories used in the artifact distribution analysis and the kinds of artifacts that fall into each category. Finally, I outline the methods used to analyze each unit in detail to outline what their results help answer.

4.1 Unit Descriptions

Fifteen units were excavated at Tamsagbulag by the Mongolian-Canadian collaborative archaeological expedition "Gobi-Steppe Neolithic Project" (GSN) during the 2018, 2021, 2022, and 2023 field seasons (Figures 4-5). Each unit is denoted first by the letters TB, short for Tamsagbulag, followed by its corresponding unit number. Levels were delineated based on sediment color, quality, and/or artifact densities and distribution changes. TB13, cultural levels within Level 2, were most clearly outlined by intervals of heavily compacted soils (interpreted as living floors). All units were initially thought to have been pit-dwellings' remains, although TB2 and TB9 have been hypothesized to have been midden deposits. Interpretation of these units will be addressed in the results.

Figure 4: Site map with excavation units TB10-14 identified (TB10 and TB11 were not used in this thesis as they did not produce any usable data)

4.1.1 TB2 (2018)

TB2 (Figure 5) was a 5 m x 10 m excavation unit placed where black soils were on the surface, where animal bones and stone tools were scattered on the surface, and into a ravine joining the edge of the terrace (Odsuren et al. 2019: 66). The black soils contained lithic tools, potsherds, and animal bones (Figure 6). Notable was a fox canine with a drilled hole and many pieces of hardened clay, interpreted as discarded hearth linings. Initial interpretations were that this was a midden deposit (Odsuren et al. 2019: 67). A total of 3 different levels were delineated based on depth (Level 1, Level 1B, and Level 2). Level 1 was the first 5 cm below the surface; Level 1B was the next 15 cm of darker soil; and Level 2 contained lighter colored soils beneath. Level 2 contained only two artifacts, so only

Level 1 and Level 1B contained a sufficient amount of each type of artifact to compare in this analysis.

Figure 5: Site map showing the location for excavation units TB2, TB9, TB10, and TB13 (TB10 was not used in this thesis as it did not produce any usable data)

Figure 6: Artifacts in situ within unit TB2

4.1.2 TB9 (2018)

TB9 (Figure 5) was a 10 m x 7 m excavation area immediately adjacent (7 m NE) to TB2, on the west-facing slope of the ravine (Odsuren et al. 2019: 68). Many artifacts and animal bones were in a large, mounded area with erosion channels on either side. Black soils between 50-80 cm thick were excavated and contained lithic tools, faunal remains, shell fragments, and ornaments (Figure 7) (Odsuren et al. 2019: 68). A deer antler tool, several bone awls and spears, an oval shell necklace with a hole in one end, and clay figures of animals were some of the most notable finds from this unit (Odsuren et al. 2019: 68). The ceramic sherds were mostly sand-tempered and low-fired. The unit revealed remains from large and some small animals, primarily aurochs (*Bos primigenius*), equids (*Equus* sp.), and gazelle (*Procapra gutterosa*), as well as wild boar (*Sus scrofa*), dog (*Canis familiaris*), fox (*Vulpes vulpes*), and hare (*Lepus tolai*) (Odsuren et al. 2019: 69). The levels for TB9 were identified based on observations of changes in color and texture of sedements and included Surface, Level 1, and Level 2, only the latter two of which were included in this analysis.

Figure 7: East side of TB9 baulk with flags denoting locations of soon-to-be-mapped artifacts

4.1.3 TB12 (2021)

TB12 (Figure 4) was located in Area 2B (Figure 2), where a small mound containing many lithic tools and faunal bones was excavated. The unit's upper 3 -5 cm was thick sandy soil (Level 1), under a dark soil layer (Level 2) (Odsuren et al. 2021: 24). Once the unit was expanded, an ash deposit was located in the SE corner, measuring 62 cm N-S x 67 cm E-W (Odsuren et al. 2021: 25). Large and small fragments of burnt/hardened clay were found around the ash deposit (Odsuren et al. 2021: 25). Most of the artifacts in Level 2 were derived from this area (Figure 8). The deposit was 12 cm thick and terminated in a layer of yellow soil. Once the unit was exposed, it was revealed that the dark soils created an oval shape, measuring 550 cm NW-SE and 347 cm SW-NE (Odsuren et al. 2021: 25). Most of

Level 1 contained cracked/broken debitage from stone tool production, while Level 2 included a rich collection of artifacts and faunal remains. TB12's levels were excavated in arbitrary 10 cm levels and labelled as follows: Level 1 (L1), Level 2 (L2), Level 2B (L2B), Level 2B Floor (L2BF), Level 3 (L3), and Level 3B (L3B). Only Level 2 contained significant numbers of artifacts.

Figure 8: TB12 during the excavation of Level 2

4.1.4 TB13 (2021-2022)

TB13 (Figures 4-5) was located in Area 2A (Figure 2), at the eastern edge of the ravine dividing Area 2A from Area 2B. TB9 was located SW of TB13 at a lower elevation. The black soils were identified by erosion due to natural processes and recent human and animal activity (Odsuren et al. 2021: 35). As in the other units, TB13 contained a deep layer of dark soils with lithics, ceramics, and faunal remains, beneath ~20 cm of more recent, essentially sterile soils. As excavations continued, a line of ash deposits was discovered at the south end of the dwelling, containing charred and uncharred bone, burned clay, and other scattered artifacts (Figure 9). A completely articulated dog skeleton was also unearthed along with many broken animal bones and ceramic fragments, although it is unclear whether this was a deliberate burial of ritual significance. Several post hole circles were located at the base of the dwelling floor, bolstering the idea that this unit was a dwelling (Odsuren et al. 2022: 34-55). TB13's levels were based on observable differences in soil color and structure. The transition between levels was recognized during excavation by a layer of more heavily compacted soil that was hypothesized to have been a house floor. These levels include Level 1 (L1), Level 2 (L2), Level 2 Hearth (artifacts within an identified hearth (L2H)), Level 2 Floor (L2F), Level 2B (L2B), Level 2B Floor (L2BF), Level 2C (L2C), and Level 2C Floor (L2CF). Only Level 2H and Level 2B Floor were omitted from analysis due to insignificant artifact numbers.

Figure 9: Multiple levels of TB13 being excavated simultaneously

4.1.5 TB14 (2023)

TB14 (Figure 4) was located in Area 3 (Figure 2), along a road connecting the former river's southern side to the northern side. The road had begun to erode due to high levels of rainfall, vehicle and animal activity occurring on a sloped portion, revealing black soils and artifacts on the eroded surface (Odsuren et al. 2023: 31). As excavations began, the soils turned darker, typically ~20 cm below the ground surface, and continued to reveal many artifacts similar to those seen in the previously excavated units (Odsuren et al. 2023: 32). After removing the first layer, the dark soils delineated a rectangular dwelling on a NW-SE axis (Odsuren et al. 2023: 49). Unlike in other dwellings, many lithics, faunal remains, and ceramic sherds were found (Figure 10). Radiocarbon dates from previous test units in Area 3 are earlier (8-8.5 kcal BP) than those from Areas 1 and 2 (Odsuren et al. 2023: 49). It is believed that this dwelling could be several hundred years older than the other dwellings. TB14 was excavated based on arbitrary levels at intervals of 10 cm; there was a 5-10 cm (west to east) deep layer of sterile soil between layers 2C and 2CFloor. TB14 was also split into the following levels: Level 2 (L2), Level 2B (L2B), Level 2C (L2C), Level 2C Floor (L2CF), and Level 3 (L3), with L3 being omitted from analysis.

Figure 10: TB14 level 2C during excavation

4.2 Artifact Categories

The three main artifact types found at Tamsagbulag are lithic, ceramic, and bone (Table 3). Using the original data collection forms for each unit, Excel spreadsheets were created containing data about the mapped artifacts by respective material types and level. Mapped artifacts were those with three (X, Y, Z) coordinates derived from total station (TB1, TB2, TB9, TB13-2022, TB14) or string/line-level mapping (TB12, TB13-2021). The site sits on an ancient alluvial plain, and all stone was imported from off-site; thus, all stone was considered an artifact. The most common types were raw material, flakes, debitage, cores, microblades (partial or whole), and scraper/tool (this category included all flakes with use wear and/or retouch). Any artifact that contained clay, whether fired or unfired, such as raw clay, clay objects, and fired ceramic sherds, was included in the “ceramics” category. Burnt and unburnt faunal bone was included under the “bone” category, unless modified to create a formal tool.

Table 3: Artifacts included in each material type

Material Type	**Artifacts included**
Lithic (Tool)	Microblades, scraper, tool, bone tool
Lithic (Debitage)	Raw material, flakes, debitage, cores
Ceramic	Raw clay, clay objects, ceramic sherds
Bone	Bone, burnt bone

4.3 Methods

Once the coordinates and relevant information about each artifact were collected, the data were plotted using the GIS software QGIS Version 3.42.1. To evaluate the relationship between artifact patterning and he use of space, I applied several different spatial tests, including both cluster and density-based analyses, as well as the Chi-Square test, to evaluate potential clustering of artifacts and to visually examine the data for patterns that can be identified about seasonality/dwelling occupation. Analysis primarily used QGIS Version 3.42.1, GRASS GIS Version 8.3, and the statistical program R Version 4.4.3.

4.3.1 Cluster Analysis

Analyzing point distribution patterns is essential for describing and interpreting the spatial characteristics of archaeological sites (Conolly and Lake 2006: 162). Specific points can represent anywhere from individual artifacts and features within a site to whole sites within particular regions (Conolly and Lake 2006: 162). Statistics can be used to measure the extent to which these points/features may be clustered, dispersed, or random (Mitchell and Griffin 2021: 186). These statistics compare the actual distribution of features (observed distribution) with a hypothetical random distribution of the same number of features over the same area (Mitchell and Griffin 2021: 186-87). The extent to which the observed data deviates from the random is the extent to which the pattern is either more clustered or dispersed than the random distribution (Mitchell and Griffin 2021: 187). One of the major issues that also needs to be considered when conducting cluster analyses is the size and shape of the study area, as it can affect the detection and characterization of patterning (Conolly and Lake 2006; Mitchell and Griffin 2021).

Nearest neighbor analysis is an older, better-known method of analyzing point distributions, easy to calculate, and provides a single value to interpret (Conolly and Lake 2006: 164). The system finds the distance between each feature and its closest neighbor, then calculates the average of these distances (or how similar the mean distance is to the expected mean distance for a hypothetical random distribution) (Mitchell and Griffin 2021: 216). It has several glaring limitations, however, including not being easily transferable to higher order analyses, and the size of the surrounding area can also have a profound effect on what ‘clusters’ are defined, depending on the amount of space contained within the survey area (Conolly and Lake 2006: 164). With enhanced computing technology in recent years, more sophisticated techniques have been developed to make cluster analysis easier and more precise, including Ripley's K function and k-Means analysis/DBSCAN.

4.3.1.1 Ripley's K

Ripley's K function is a GIS-led technique utilized in archaeology to tackle some of the problems of more simplistic cluster analyses (i.e., those like nearest neighbor), such as the difficulty with managing multiple scales of clusters within the same area (Conolly and Lake 2006: 166; Mitchell and Griffin 2021: 240). The function is designed to look at the clustering of data without paying too much attention to the shape/size of the study area, as with those like nearest neighbor, this can seriously impact the creation of clusters (Conolly and Lake 2006: 166). The statistic is a function of distance and works by estimating the frequency of neighbors within a certain radius at an arbitrary point within the distribution (Brunsdon and Comber 2015: 238; Conolly and Lake 2006: 166). K refers to the distance bands established around each feature or point, and the comparison of observed K values at each distance to the expected K value for a random distribution is conducted (Mitchell and Griffin 2021: 238). Estimates must be made using the sample, as it is essential to test whether the sample is sufficiently unusual concerning the distribution of K estimates one might expect to see under complete spatial randomness (CSR) to provide evidence that the generating process for the sample is not CSR (Brunsdon and Comber 2015: 239). Once complete, all the values can be plotted on a chart, with K values on the y-axis against distances on the x-axis (Mitchell and Griffin 2021: 241). To determine if the pattern is statistically significant, the system randomly generates confidence limits that create windows on either side of the random expected values line (Brunsdon and Comber 2015: 240; Mitchell and Griffin 2021: 244). Observations from the sample data above the upper limit represent a statistically significant clustered pattern for that distance. In contrast, anything below the lower limit is a statistically significant dispersed pattern (Mitchell and Griffin 2021: 244). Overall, this function determines to what degree there may be clustering within a given area and whether that clustering is significant.

4.3.1.2 k-Means Analysis/DBSCAN

If clustering is present, the next step is determining the location, number, and concentration of clusters within the study area. Density-based clustering methods can identify spatially concentrated points and distinguish between signal (distinct spatial clusters) and noise (spatially sparse and unstructured points) (Mitchell and Griffin 2021: 329). They are also known as unsupervised machine-learning clustering algorithms as they do not need any prototype data to determine what defines a cluster, and can detect patterns using only the spatial locations of points and their neighboring point distances (Mitchell and Griffin 2021: 334). A few basic concepts that underlie these types of methods include: (1) a minimum number of points, where the number depends on the question and purpose of analysis), (2) core distance, which represents the minimum distance required to travel from each point to the closest neighbor, (3) reachability, where every point pair has a mutual reachability distance, and (4) search distance, which acts as a cutoff threshold such that points within a cluster cannot exceed said search distance (Mitchell and Griffin 2021: 334-36).

K-Means analysis is one such test that is used particularly when the number of objects/points is large (usually >100) and is an example of a partitioning cluster technique, which divides groups of objects into a specified number of clusters (Conolly and Lake 2006: 170). Density-Based Spatial Clustering of Applications with Noise, or DBSCAN, is analogous to k-means analysis, except that it does not require any prediction of the potential number of clusters. DBSCAN specifies a search distance to indicate the maximum separation between and among points in a cluster, focusing primarily on point densities to detect clusters (Mitchell and Griffin 2021: 336). The *knndistplot* function can be utilized in R to distinguish the distances between each point and its *k* nearest neighbor, plotting these distances on a chart from smallest to largest. Determining where the elbow of this graph is can determine the best eps value for DBSCAN. It is most useful when there is a good idea about cluster size, and the driving variable for detecting clusters is the search distance (Mitchell and Griffin 2021: 336).

Once the clusters have been calculated and identified, they can be displayed by assigning a different color to each cluster and mapping them on a chart. This can be done through R using the *fviz_cluster* function, which provides an easier way to represent clusters on a chart. Several factors influencing the results of density-based clustering methods like DBSCAN include changing the minimum number of points per cluster, modifying the search distance, or using different clustering methods (Mitchell and Griffin 2021: 362). For DBSCAN, the search distance should be set to reflect how dense the clusters are, with cluster membership and spacing around the clusters defined by this distance (Mitchell and Griffin 2021: 364).

Clusters were detected and located using DBSCAN for each level of every unit to compare and see if concentrations of artifacts may have changed locations during different occupations, and whether the clusters contained more of one artifact type or were more homogenously mixed. This was only used for those without a baulk, as that space can sometimes create artificial clustering.

4.3.2 Kernel Density Estimation

Using methods like DBSCAN is beneficial to a certain extent, but at some point, the cluster membership may be difficult to identify due to circumstances such as the sheer quantity of points or unclear boundaries of concentrations (Brunsdon and Comber 2015: 226-30; Conolly and Lake 2006: 173). Intensity analyses allow archaeologists to describe and visualize the changing frequency of observations within a particular area, rather than identifying and documenting individual clusters (Conolly and Lake 2006:173). It is often used to compare different phenomena within the same area or against the same phenomenon in other areas (Conolly and Lake 2006: 174). Kernel Density Estimations (KDEs) are one such method that creates a smoother and easier to interpret result by creating a 'kernel' within which the shape (although not often) and radius can be changed to get differing outcomes (Conolly and Lake 2006: 175). This kernel represents a two-dimensional probability density function placed over observed data to create a smooth approximation of its distribution from the center out (Conolly and Lake 2006: 175). This method then works by averaging a series of small 'bumps' centered on each point or 'kernel', and can be displayed as filled contour lines to demonstrate where the densest areas are located (Brunsdon and Comber 2015: 227). The two parameters that can be changed are the shape of the kernel (although this is most often set to a quadratic function and cannot be changed) and the radius of the kernel, usually referred to as bandwidth (Conolly and Lake 2006: 175). Some algorithms can help calculate the appropriate bandwidths, as using a too small radius can create peaks that may not accurately represent the distribution, while using a too large radius can overly smooth the distribution and possibly miss some areas (Brunsdon and Comber 2015: 228-29; Conolly and Lake 2006: 175).

KDEs were performed on the individual levels of each TB unit to help answer several questions/make observations. It will be used to gauge where the largest densities of each type of material (faunal, lithic, ceramic) are in an individual level, then the results will be compared against other levels from the same unit with the same material to see if there was any change in usage of said material over time.

4.3.3 Chi-Square Statistical Test

The Chi-Squared statistical test can assess the correspondence between the distributions of two nominal, or categorical variables, and determine whether any relations hold significance (Shennan 1988: 65). One way to calculate the Chi-Squared test is by comparing the expected vs observed frequencies of two variables you are analyzing and looking to see if there are any significant differences between the two (Shennan 1988: 66). These values are calculated by the equation $\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$, which in words reads as follows: "for each category subtract the expected value from the observed value, square this difference, and divide the result by the expected value; once this has been done for each category, sum the results for all the categories. The result is a calculated chi-squared value" (Shennan 1988: 67-68). To test these values for statistical significance, they must be compared to a value within a group of tables based on the level of significance and the degrees of freedom (number of categories – 1) (Shennan 1988: 68). These values today can be calculated using a statistical program such as R, which, based on a table input to the program, can calculate the exact chi-squared value, the degrees of freedom, and the significance (p-value).

This thesis uses the chi-squared test to look at two groups of nominal (categorical) variables to answer questions about variability within potential house floors. The first will look at the clusters created using DBSCAN as mentioned above and compare the three different materials (faunal, lithic, ceramic) for each level of a single unit to see if any specific clusters contain significant levels of said materials. The *Z*-Scores/standardized residuals calculated through the Chi-Square test can be used to determine which combinations may have been significant. Any combination greater than +1.96 or less than -1.96 was considered significant; anything above meant more of that artifact type within a particular cluster, while anything below meant less of that artifact type than was expected. This could help identify any work areas or specializations within a dwelling and could be compared between layers to see if the use of a dwelling may have changed over time when multiple house floors are identified. The second chi-square test will compare the proportions of the three different material types against the levels of each unit/dwelling to see if there is any vertical variability of the materials or whether they are evenly distributed among the levels.

These methods can determine the distinctiveness of levels, which can be used to interpret the validity of level classifications and/or the degree of intermixing between levels. For example, the levels might be mixed or arbitrary if there is no patterning. In the context of post-depositional fill, mixing levels could suggest a single dumping episode, highly irregular and unsystematic dumping over a long time, or extreme post-depositional mixing. If precise patterning is present, including distinctive variation in the distribution of artifact classes, it would suggest discrete depositional periods, with lengthy intervals between them. This has implications for how dwellings and/or midden deposits were formed, which can inform our understanding of how dwellings were used over time and how trash was managed. The latter is an essential part of understanding the density and duration of occupation; intensive occupation results in large amounts of trash that need to be regularly and quickly deposited, while prolonged occupation should result in systemic waste management strategies. Seasonal occupation of a dwelling is more likely to result in more strategic locations of artifacts, as the floor that was left may reflect the habitation of the inhabitants right before they abandoned the dwelling, as they may not have felt the need to clean since they were abandoning the dwelling and most likely not coming back.

4.4 Conclusion

In this chapter, I have outlined the methods I have used for this study. First, I identified each unit excavated during the GSN project pertinent to my research and included information about each. Then, I identified the three artifact categories and which were included under each category. Finally, I explained which spatial analysis and statistical tests are most relevant to answering my research questions. In the next chapter, I discuss the results of the spatial analyses and statistical tests for each excavation unit.

Chapter 5: Results

Utilizing the methods outlined in Chapter 4, the following chapter will present the results for each analyzed unit (i.e., TB2, TB9, TB12, TB13, and TB14). Each section will be dedicated to an individual unit and present the statistical tests and spatial analyses for each. Overall, the analysis suggests that there is significant patterning in some but not all deposits. The results are outlined below, and their implications will be discussed in detail in Chapter 5.

5.1 Evaluating Patterning in TB2

The first question answered in this section is whether there is statistically significant clustering of artifacts in TB2. The results of a Ripley's K analysis indicate that there is clustering, and this occurs between 0.2 and 0.3 m for Level 1 (Appendix: Figure 29) and close to 0.1 m for Level 1B (Appendix: Figure 30) as that is where the observed value passes outside the bounds of the upper envelope on the graph. Since it passed Ripley's K, the next question answered is where these clusters are located. Density-Based Spatial Clustering of Applications with Noise, or DBSCAN, was run on both levels to determine the number and size of said clusters within TB2. For Level 1, only one cluster was identified, along with several outliers (labelled as its own cluster – Cluster 0) (Figure 11). A Chi-square test was run to determine whether the differences in artifact types between each cluster were significant. The significant standardized residuals were also determined to answer which cluster/artifact type combinations held the most significance. For Level 1, it was found that the difference between the clusters with respect to proportions of bone, lithic and ceramic is significant ($\chi 2 = 13.06$, $df = 2$, $p < .01$). The significant standardized residuals were found to be between ceramic and both Cluster 0 (outliers) and Cluster 1, with Cluster 0 containing more ceramics than expected and Cluster 1 containing less ceramics than expected (See Table 4). There were no significant standardized residuals between lithic and bone for either cluster, meaning these materials were distributed evenly.

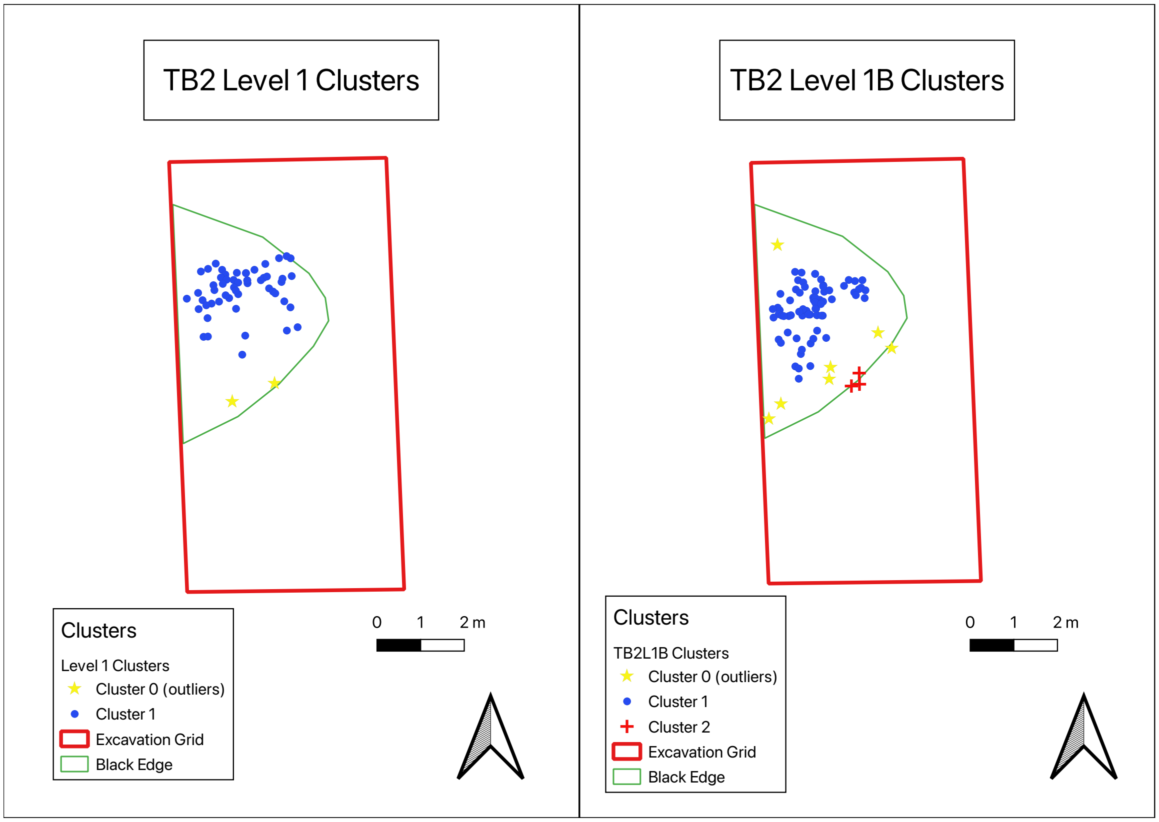

Figure 11: Illustrations showing clusters in TB2

Level 1B contains 2 clusters, plus outliers (cluster 0) (Figure 11). The difference between the clusters identified for Level 1B with respect to proportions of bone, lithic, and ceramic was also found to be significant ($\chi^2 = 10.53$, $df = 4$, $p = 0.03$). Lithic appears significant for both the outliers (Cluster 0) and Cluster 1, with the outliers containing more lithic and Cluster 1 containing less than expected. Cluster 1 also includes more bone than expected, while bone appears evenly distributed among Clusters 0 and 2. Ceramic does not seem significant, so it is evenly distributed among each cluster. Cluster 2 is the only cluster that did not calculate any significant residuals, so each artifact type is evenly distributed within it.

Table 4: Significant Cluster/Artifact Type Observations for TB2

Unit	Level	Cluster	Material	Residual	Observation
TB2	1	0 (Outliers)	Ceramic	3.60	Cluster 0 contains more ceramic than expected
TB2	1	1	Ceramic	-3.60	Cluster 1 contains less ceramic than expected
TB2	1	0 (Outliers)	Lithic	2.81	Cluster 0 contains more lithic than expected
TB2	1B	1	Bone	2.20	Cluster 1 contains more bone than expected
TB2	1B	1	Lithic	-2.80	Cluster 1 contains less lithic than expected

Artifact scatter maps and Kernel Density Estimations (KDEs) were developed for each of the three artifact types at each level to analyze the distribution of artifacts. Bone appears to be clustered similarly within both levels, the densest area being slightly north but central within the black organic edge (Figure 12). There are fewer ceramic artifacts for both levels than for bone, but from analysis, it appears Level 1B is more evenly distributed than Level 1 above (Figure 12). Lithic is similar because the density seems more spread out in Level 1B than in Level 1 (Figure 12). When comparing the density analysis of each artifact type within the same level, bone and lithic appear to have similar clustering, while ceramic is more spread out in Level 1 (Figure 13). Level 1B seems to have the densest areas within the same sections for each artifact type, but each is more spread out than in Level 1 (Figure 13).

A Chi-Square test was run comparing the levels of TB2 and the proportions of the three artifact material types to determine if there is any vertical variability between them (i.e., does one level contain more/less of a/several material type(s)). It was determined that the difference between the levels of TB2 with respect to proportions of bone, lithic, and ceramic is not significant ($\chi\ 2$ = 4.31, *df* = 2, *p* = 0.12). There were also no significant standardized residuals, meaning every level contains an even distribution of all three material types.

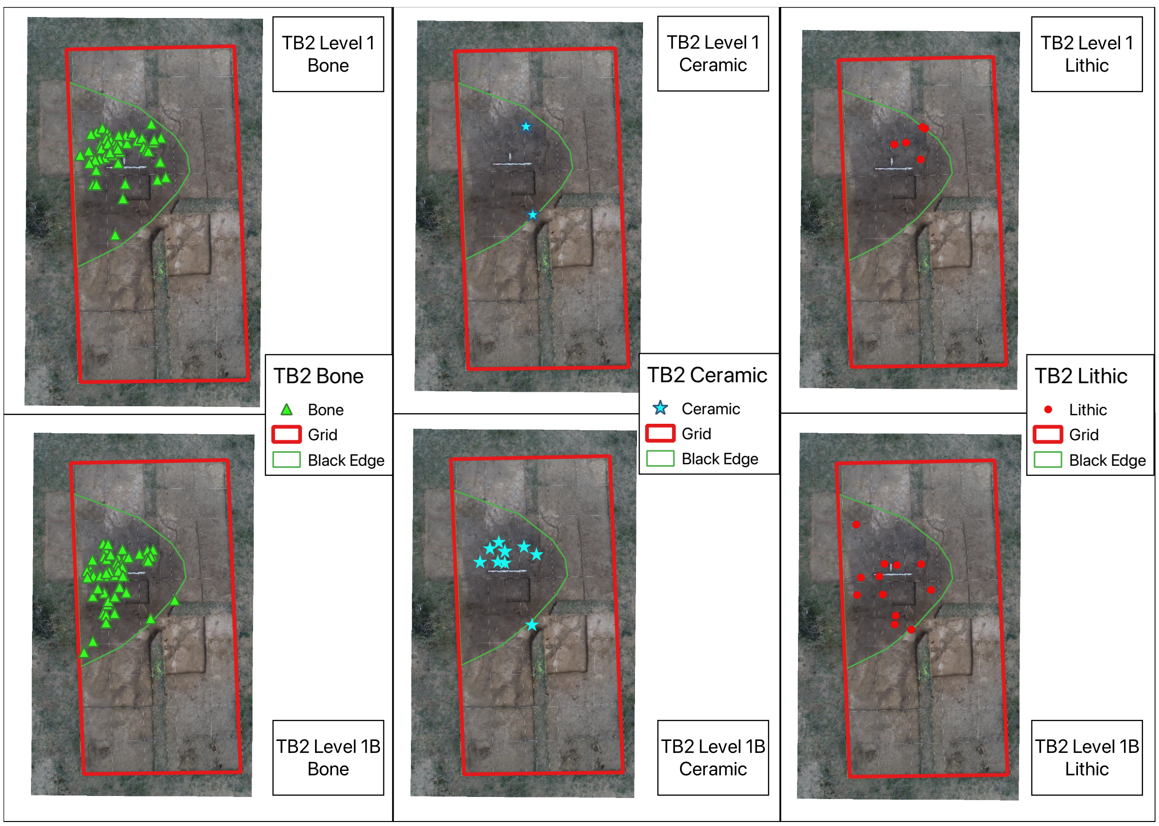

Figure 12: Significant Cluster/Artifact Type Observations for TB2

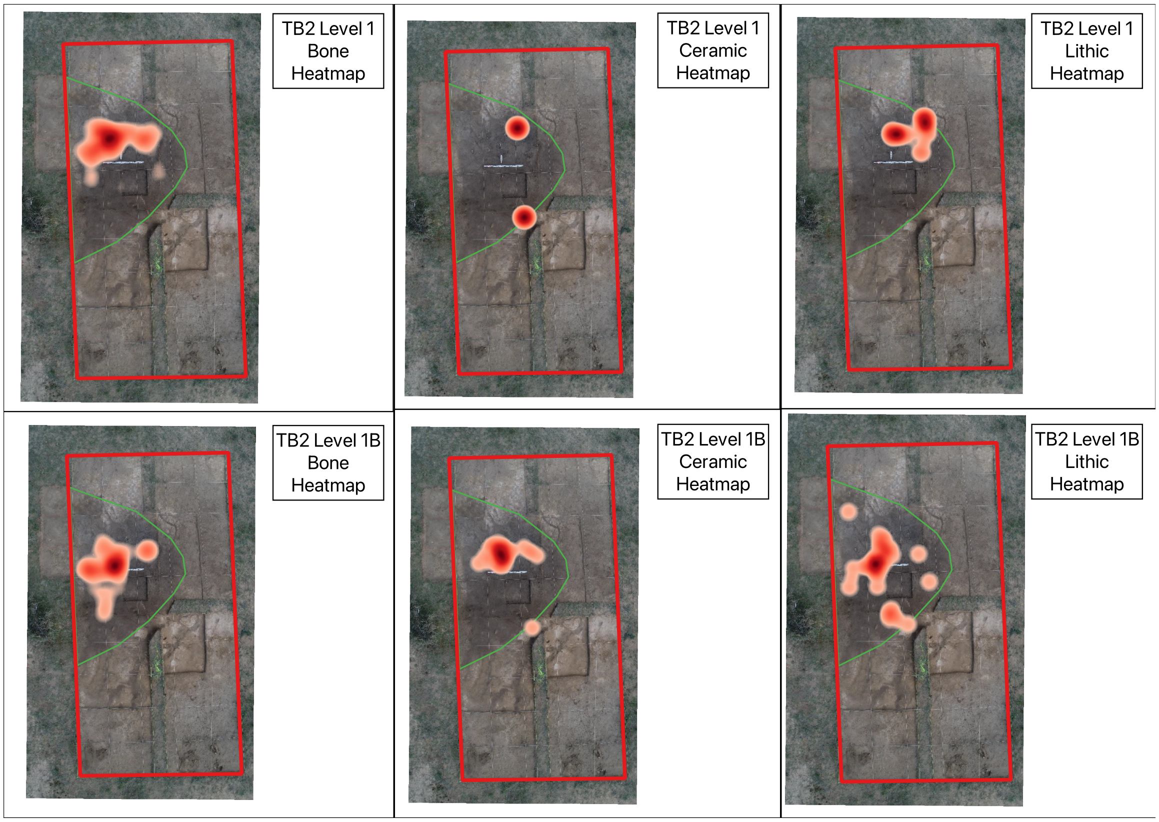

Figure 13: Illustrations of the heatmaps for TB2

5.2 Evaluating Patterning in TB9

The next question answered in this section is whether there is statistically significant clustering of artifacts in TB9. The results of a Ripley's K analysis indicate that there is clustering, which occurs around 0.5 m for level 1 (Appendix: Figure 31) and between 0.1 and 0.15 m for level 2 (Appendix: Figure 32). DBSCAN was thus run to determine the location of the clusters, along with a Chi-Square test comparing the clusters to artifact types to decide which combinations may hold any significance. The results for TB9 must be used with caution, as the baulk left unexcavated at the unit's center can cause sampling errors.

Level 1 contains four clusters plus outliers (Cluster 0) (Figure 14). The difference between the clusters for Level 1 with respect to proportions of bone, lithic, and ceramic is significant (χ 2 = 15.79, *df* = 8, *p* = 0.05). According to the significant standardized residuals, Cluster 1 contains more bone and less lithic material than expected. Cluster 2 is the opposite, containing less bone and more lithic than anticipated. It also appears that the outliers (Cluster 0) and Clusters 3 and 4 all contain even distributions of all three material types, along with ceramic across all 5 clusters (Table 5).

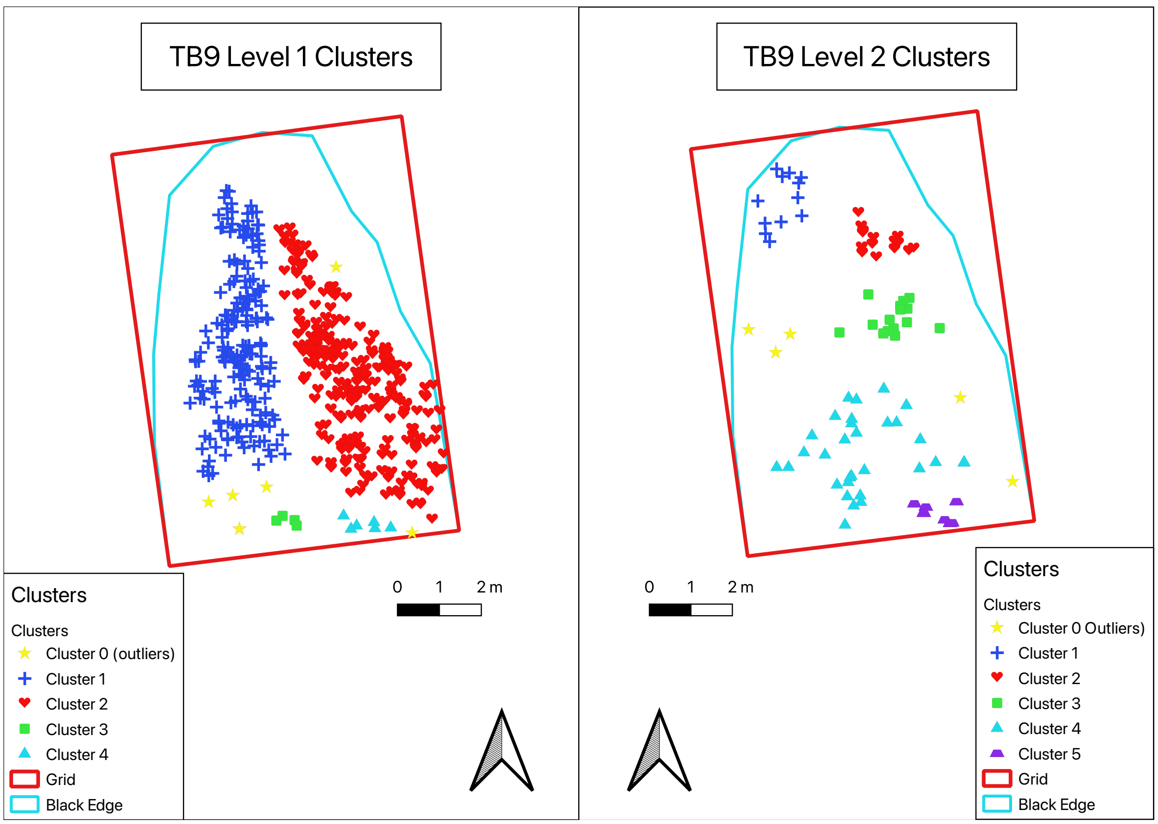

Figure 14: Illustrations showing clusters in TB9

The difference between the clusters of Level 2 with respect to proportions of bone, lithic, and ceramic is also significant (χ 2 = 31.32, *df* = 10, $p < 0.01$). Five clusters plus the outliers (Cluster 0) were identified, with clusters 2-5 containing significant standardized residuals (Figure 14). According to these values: 1) Cluster 2 contains more bone and less ceramic than expected; 2) Cluster 3 contains more ceramic than expected; 3) Cluster 4 contains more lithic than expected; and 4) Cluster 5 contains more ceramic than expected (Table 5). Clusters 0 (outliers) and 1 appear to have even distributions of all three material types.

Table 5: Significant Cluster/Artifact Type Observations for TB9

Unit	Level	Cluster	Material	Residual	Observation
TB9	1	1	Bone	3.12	Cluster 1 contains more bone than expected
TB9	1	1	Lithic	-3.12	Cluster 1 contains less lithic than expected
TB9	1	2	Bone	-3.13	Cluster 2 contains less bone than expected
TB9	1	2	Lithic	2.97	Cluster 2 contains more lithic than expected
TB9	2	2	Bone	3.12	Cluster 2 contains more bone than expected
TB9	2	2	Ceramic	-2.02	Cluster 2 contains less ceramic than expected
TB9	2	3	Bone	-2.24	Cluster 3 contains less bone than expected
TB9	2	4	Lithic	2.14	Cluster 4 contains more lithic than expected
TB9	2	5	Ceramic	3.38	Cluster 5 contains more ceramic than expected

According to the artifact scatter maps and Kernel Density Estimations (KDEs) run for unit TB9 to determine the distribution of artifacts, the differences between Level 1 and Level 2 are very similar for all three artifact types. Level 1 appears more spread out (at least more artifacts spread around), while Level 2 appears to have the highest density of artifacts near the central baulk (Figure 15). When comparing the densities for each of the three artifact types within Level 1, the portion to the east of the baulk appears denser and more widespread than the western portions for each (Figure 16). Level 2 has a more even spread across the unit for all three material types (Figure 16).

A Chi-square test was run to analyze vertical variability for TB9, and it was found that the difference between the levels of TB9 with respect to proportions of bone, lithic, and ceramic is not significant ($\chi\ 2 = 0.039$, $df = 2$, $p = 0.98$). Like TB2, there were no significant standardized residuals, meaning every level contains an even distribution of the three artifact types.

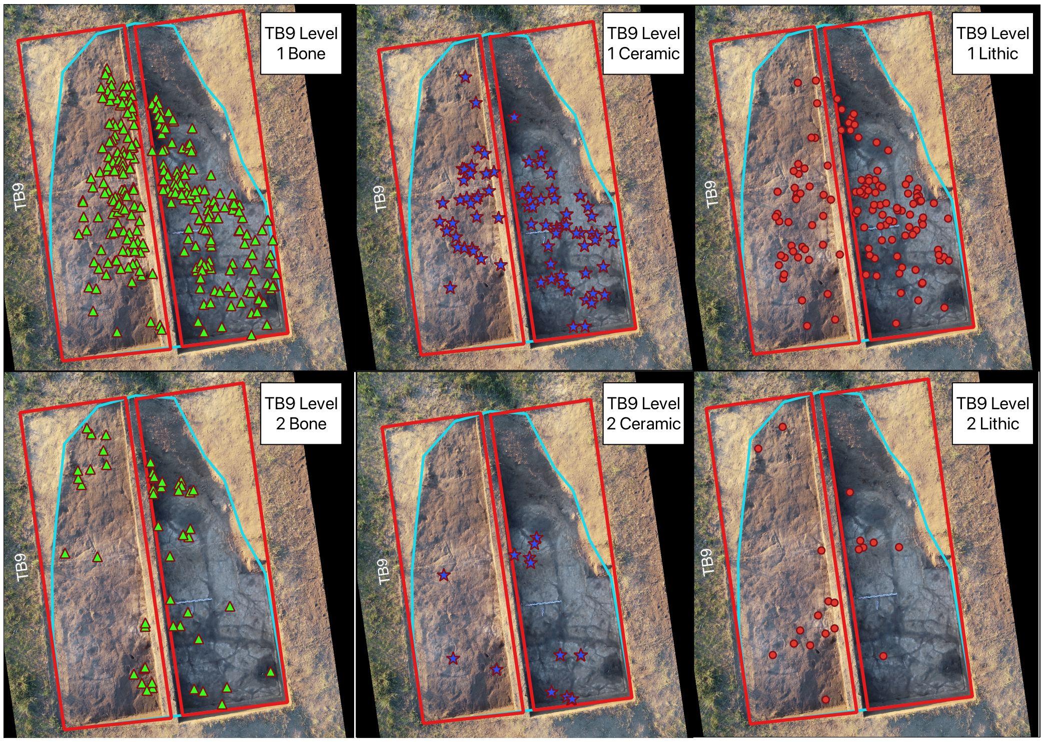

Figure 15: Illustrations of individual artifact locations for TB9

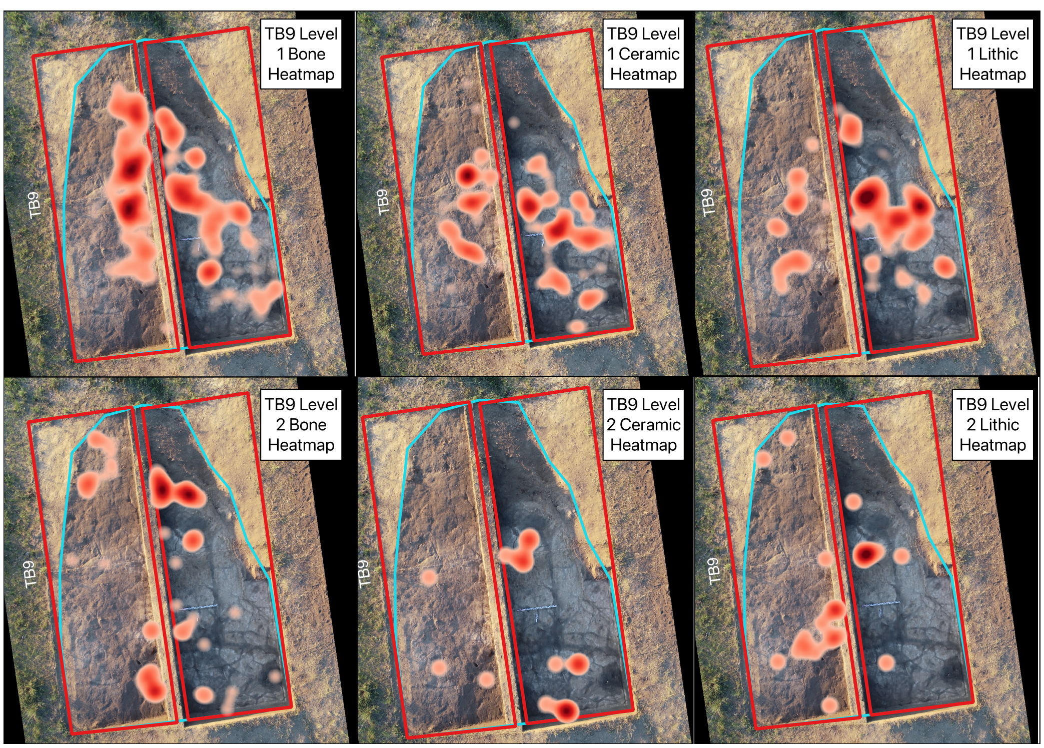

Figure 16: Illustrations of the heatmaps for TB9

5.3 Evaluating Patterning in TB12

The next question answered in this section is whether there is statistically significant clustering of artifacts in TB12. The results of a Ripley's K analysis indicate that there is clustering that occurs between 0.20 -0.40 m for Level 2 (Appendix: Figure 33), around 0.10 m for Level 2B (Appendix: Figure 34), and Level 2B floor (Appendix: Figure 35). After DBSCAN was run through R for all three levels to determine the location of said clusters, as well as being run through a chi-square test to determine any significances between cluster/artifact type combinations, it was found that two of the three levels contained insignificant differences between the clusters concerning proportions of bone, lithic and ceramic. The two levels were Level 2 ($\chi 2 = 6.65$, $df = 10$, $p = 0.76$) and Level 2B floor ($\chi 2 = 5.61$, $df = 4$, $p = 0.06$). Level 2 contained five clusters plus outliers (Cluster 0) but no significant standardized residuals, which means each cluster within the level contains an even distribution of all three material types (Figure 17). Level 2B floor contained one cluster plus outliers (Cluster 0), as well as several significant standardized residuals, with the outliers (Cluster 0) containing more ceramic than expected and Cluster 1 containing less ceramic than expected (Figure 17 and Table 6). Overall, this means that the amount of ceramic is insignificant but has more influence than the other two material types.

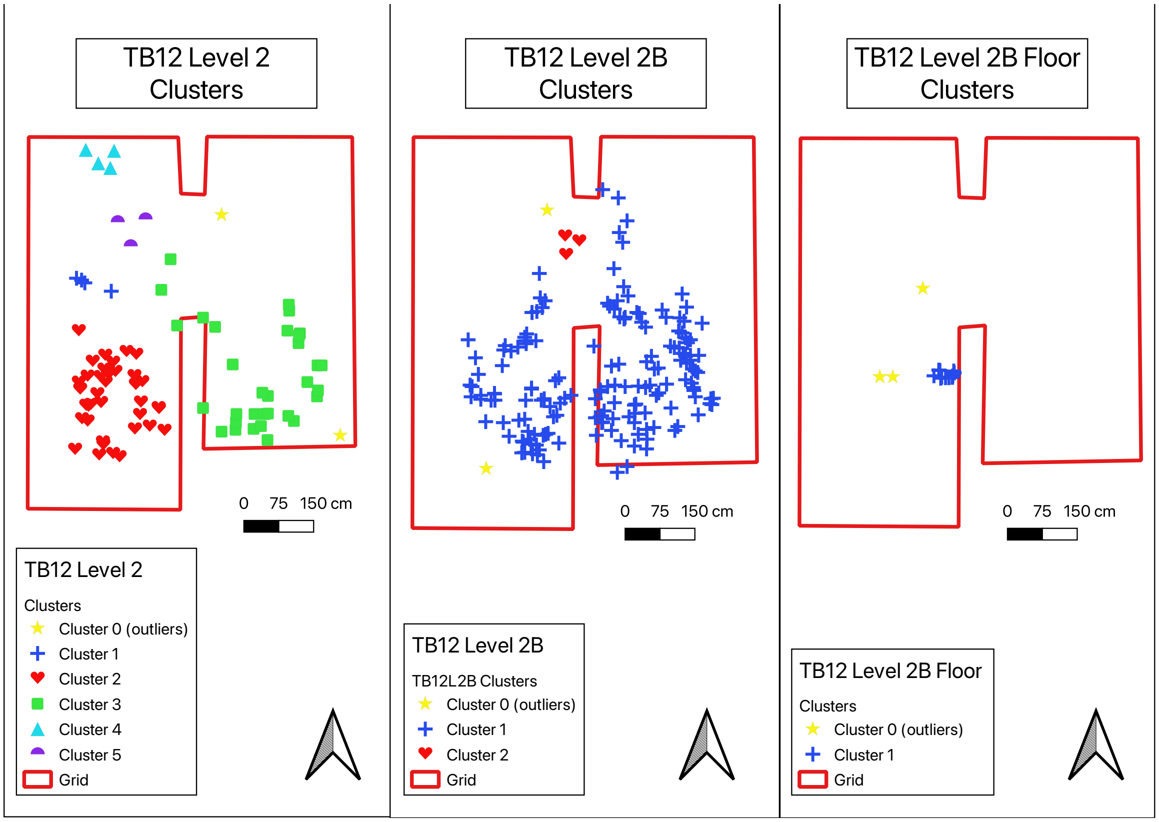

Figure 17: Illustrations showing clusters in TB12

Level 2B was the only level that held significance for TB12 (χ *2* = 11.83, *df* = 4, *p* = 0.019), and contained two clusters plus outliers (Cluster 0) (Figure 17). According to the significant standardized residuals, Cluster 1 contains more bone and less ceramic than expected, while Cluster 2 contains more ceramic than expected. Lithic material was insignificant for any cluster but was more evenly distributed than other artifact types.

Table 6: Significant Cluster/Artifact Type Observations for TB12

Unit	Level	Cluster	Material	Residual	Observation
TB12	2B	0 (Outliers)	Bone	2.14	Cluster 1 contains more bone than expected
TB12	2B	1	Ceramic	-1.93	Cluster 1 contains less ceramic than expected
TB12	2B	0 (Outliers)	Ceramic	2.91	Cluster 2 contains more ceramic than expected

Artifact scatter maps and Kernel Density Estimations (KDEs) were created for TB12 to identify artifact distributions, showing that the densest areas of bone were located toward the southern end, near where the ashy deposits had also been identified (Figure 18). For ceramic, Level 2 had a denser area of artifacts near the hearth, while located more NE for Level 2B (Figure 18). Lithic is like ceramic in that the densest areas are near the hearth for Level 2, while more NE for Levels 2B and 2B floor (Figure 18). When comparing the heatmaps for each of the three artifact types within the same level, it appears that the densest area of all three is located around the hearth for Level 2 (Figure 18). For Level 2B, the dense areas are more spread out, but in general, still located towards the southern end of the unit (Figure 18).

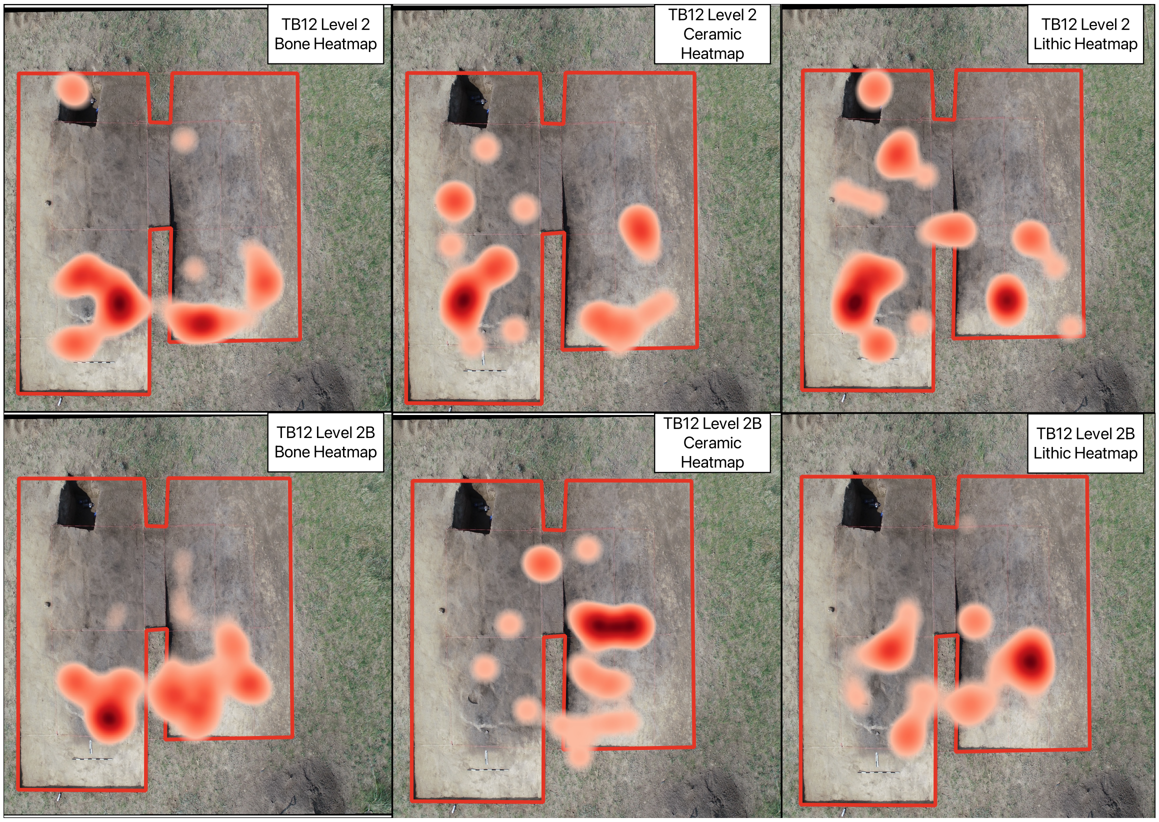

Figure 18: Illustrations of the heatmaps for TB12

After running a Chi-square test to observe the vertical variability for TB12, it was determined that the difference between the levels of TB12 with respect to proportions of bone, lithic, and ceramic is significant ($\chi\ 2 = 16.84$, $df = 4$, $p < 0.01$). Based on the significant standardized residuals, it can be determined that: 1) Level 2 contains more ceramic than expected; 2) Level 2B contains more bone and less ceramic than expected; and 3) Level 2BF contains less bone and more lithic than expected.

5.4 Evaluating Patterning in TB13

The next question answered in this section is whether there is statistically significant clustering of artifacts in TB13. The results of a Ripley's K analysis indicate that there is clustering, which occurs around 0.15 m for Level 1 (Appendix: Figure 36), 0.05 m for Level 2 (Appendix: Figure 37), 0.04 m for Level 2 floor (Appendix: Figure 38), and between 0.02-0.04 m for Levels 2B, 2C, and 2C floor (Appendix: Figures 39-41). DBSCAN was then run to determine the cluster locations, along with a chi-square test to answer the question of whether any clusters hold a significant proportion of any of the three artifact types and demonstrated that the only level that did not have a significant difference between clusters with respect to proportions of bone, lithic and ceramic is Level 2C ($\chi 2 = 18.76$, $df = 12$, $p = 0.09$). This level contains five clusters plus outliers (Cluster 0) and a few significant standardized residuals, even though it is not overall significant (Figure 19). These residuals show that Cluster 0 (outliers) contains less bone and more lithic than expected, and Cluster 2 contains more ceramic than expected (Table 7). Overall, this means that the amount of bone/lithic for Cluster 0 and ceramic for Cluster 2 is not significant but has more influence than the other material types for that specific cluster.

The difference between the clusters of TB13 Level 1 with respect to proportions of bone, lithic, and ceramic is significant ($\chi 2 = 16.01$, $df = 4$, $p < 0.01$), containing two clusters plus outliers (Cluster 0) (Figure 19). Based on the significant standardized residuals, Cluster 1 includes more bone and less lithic than expected, while Cluster 2 contains less bone and more lithic than expected (Table 7). None of the artifact types for Cluster 0 held significant values, meaning there was more even distribution of all three material types.

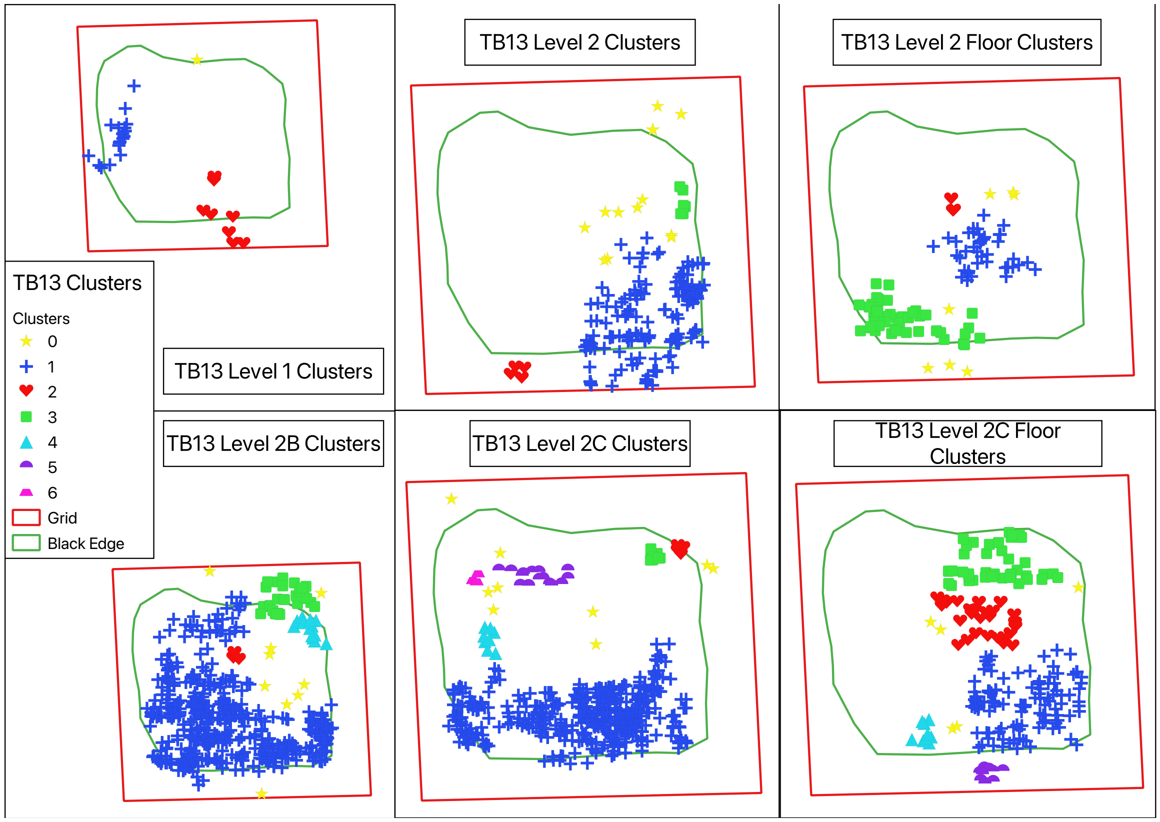

Figure 19: Illustrations showing clusters in TB13

The difference between the clusters of TB13 Level 2 with respect to proportions of bone, lithic, and ceramic is also significant ($\chi 2 = 13.90$, $df = 6$, $p = 0.03$), with three clusters plus outliers (Cluster 0) (Figure 19). After analyzing the standardized residuals, Cluster 0 (outliers) contains less bone, Cluster 1 contains more ceramic and less bone than expected, and Cluster 3 contains less bone and ceramic than expected (Table 7). Cluster 2 contained no significant residuals, meaning all three materials were distributed evenly based on the results.

The difference between the clusters of TB13 Level 2 Floor with respect to proportions of bone, lithic, and ceramic is significant ($\chi 2 = 21.78$, $df = 6$, $p < 0.01$) as well, creating three clusters plus outliers (Cluster 0) (Figure 19). Significant standardized residuals show that Cluster 1 contains more bone and less ceramic and lithic than expected, while Cluster 3 contains less bone and more ceramic and lithic than expected (Table 7). Clusters 0 (outliers) and 2 contain no significant values, representing even distributions of all three material types.

The difference between clusters of TB13 Level 2B with respect to proportions of bone, lithic, and ceramic is significant ($\chi\ 2 = 19.20$, $df = 8$, $p = 0.01$) and created four clusters plus outliers (Cluster 0) (Figure 19). Significant standardized residuals suggest that Cluster 0 (outliers) contains more lithic than expected, Cluster 1 contains more bone and less lithic than expected, and Cluster 4 contains less bone and more lithic than expected (Table 7). Clusters 2 and 3 contain no significant residuals, representing even distributions of all three material types.

The final level that demonstrated significance with the difference between clusters with respect to proportions of bone, lithic, and ceramic is TB13 Level 2C Floor ($\chi\ 2 = 62.10$, $df = 10$, $p < 0.01$). This level contained five clusters plus outliers (Cluster 0) (Figure 19). Significant standardized residuals from this level suggest the following: 1) Cluster 1 contains more ceramic than expected; 2) Cluster 2 contains both more bone and less lithic than expected; 3) Clusters 4 and 5 both contain less bone and more lithic than expected; and 4) Clusters 0 (outliers) and 3 contain no significant residuals, representing a relatively even distribution of all three material types (Table 7).

Table 7: Significant Cluster/Artifact Type Observations for TB13

Unit	Level	Cluster	Material	Residual	Observation
TB13	1	1	Bone	3.42	Cluster 1 contains more bone than expected
TB13	1	1	Lithic	-3.5	Cluster 1 contains less lithic than expected
TB13	1	2	Bone	-3.78	Cluster 2 contains less bone than expected
TB13	1	2	Lithic	3.82	Cluster 2 contains more lithic than expected
TB13	2	0 (outliers)	Bone	-2.05	Cluster 0 contains less bone than expected
TB13	2	1	Bone	1.94	Cluster 1 contains more bone than expected
TB13	2	1	Ceramic	-2.01	Cluster 1 contains less ceramic than expected
TB13	2	3	Bone	-2.07	Cluster 3 contains less bone than expected
TB13	2	3	Ceramic	1.94	Cluster 3 contains more ceramic than expected
TB13	2 Floor	1	Bone	4.20	Cluster 1 contains more bone than expected
TB13	2 Floor	1	Ceramic	-2.12	Cluster 1 contains less ceramic than expected
TB13	2 Floor	1	Lithic	-3.39	Cluster 1 contains less lithic than expected
TB13	2 Floor	3	Bone	-4.17	Cluster 3 contains less bone than expected
TB13	2 Floor	3	Ceramic	2.61	Cluster 3 contains less ceramic than expected

Table 8 (continued): Significant Cluster/Artifact Type Observations for TB13

Unit	Level	Cluster	Material	Residual	Observation
TB13	2 Floor	3	Lithic	3.02	Cluster 3 contains more lithic than expected
TB13	2B	0 (outliers)	Lithic	2.95	Cluster 0 contains more lithic than expected
TB13	2B	1	Bone	3.21	Cluster 1 contains more bone than expected
TB13	2B	1	Lithic	-3.36	Cluster 1 contains less lithic than expected
TB13	2B	4	Bone	-2.23	Cluster 4 contains less bone than expected
TB13	2B	4	Lithic	2.04	Cluster 4 contains more lithic than expected
TB13	2C Floor	1	Ceramic	2.06	Cluster 1 contains more ceramic than expected
TB13	2C Floor	2	Bone	3.06	Cluster 2 contains more bone than expected
TB13	2C Floor	2	Lithic	-2.92	Cluster 2 contains less lithic than expected
TB13	2C Floor	4	Bone	-3.61	Cluster 4 contains less bone than expected
TB13	2C Floor	4	Lithic	3.36	Cluster 4 contains more lithic than expected
TB13	2C Floor	5	Bone	-4.34	Cluster 5 contains less bone than expected
TB13	2C Floor	5	Lithic	5.84	Cluster 5 contains more lithic than expected

After running Kernel Density Estimations (KDEs) for TB13 to analyze artifact distributions, it appears that the denser clusters of bone are in the southern end, near the ashy deposits (Figure 20). The SE corner of the unit contains the bulk of ceramic (Figure 21) and lithic (Figure 22) material. When comparing the clay versus ceramic distributions, Level 2C appears to include most of the clay towards the southern end of the unit near the ashy deposits. In contrast, there is a more even distribution across the unit for Level 2 and 2B (Figure 23).

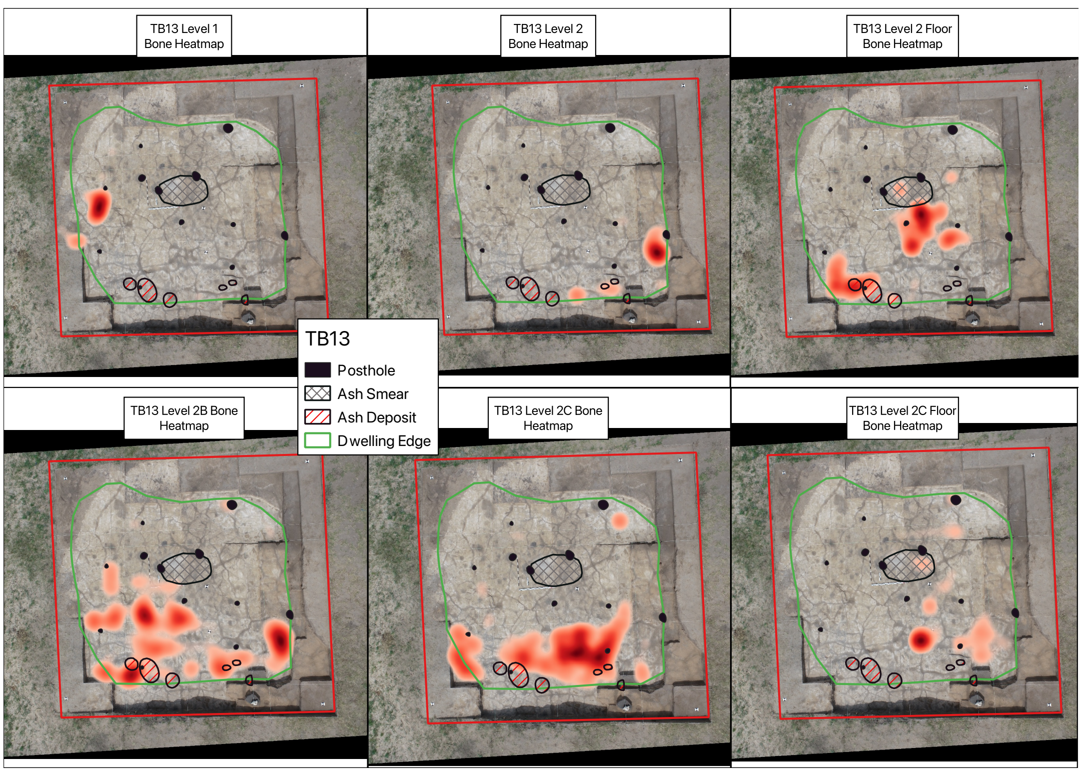

Figure 20: Illustrations of Bone Heatmaps for TB13

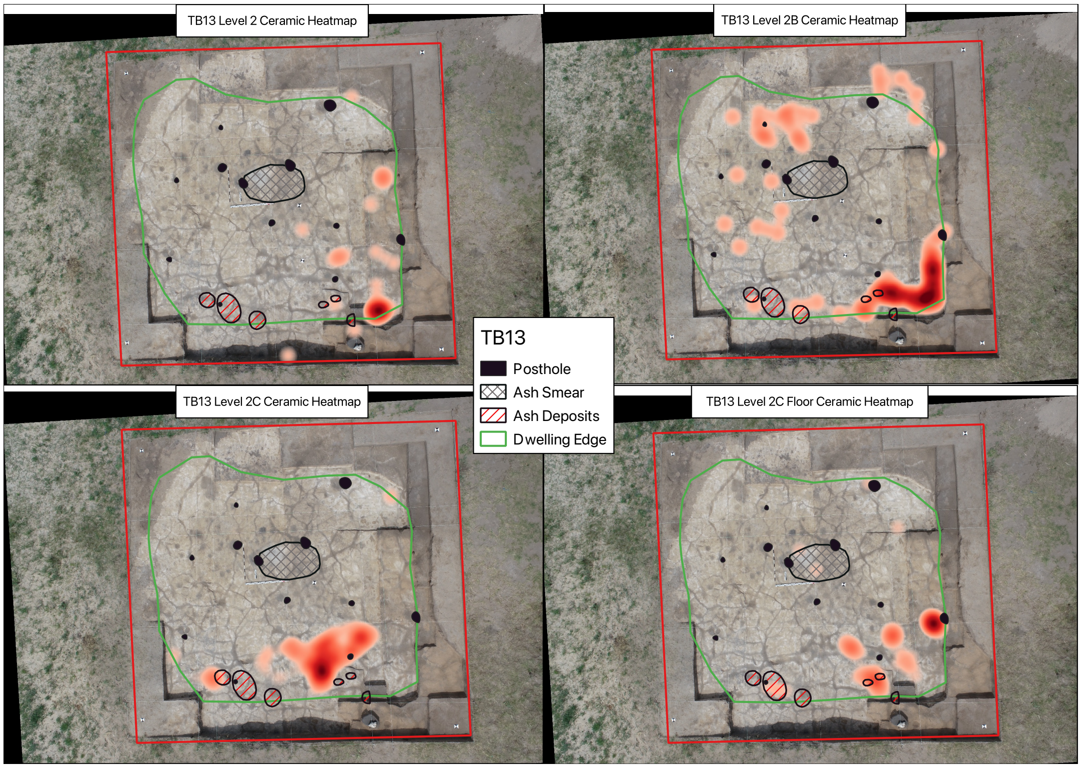

Figure 21: Illustrations of Ceramic Heatmaps for TB13

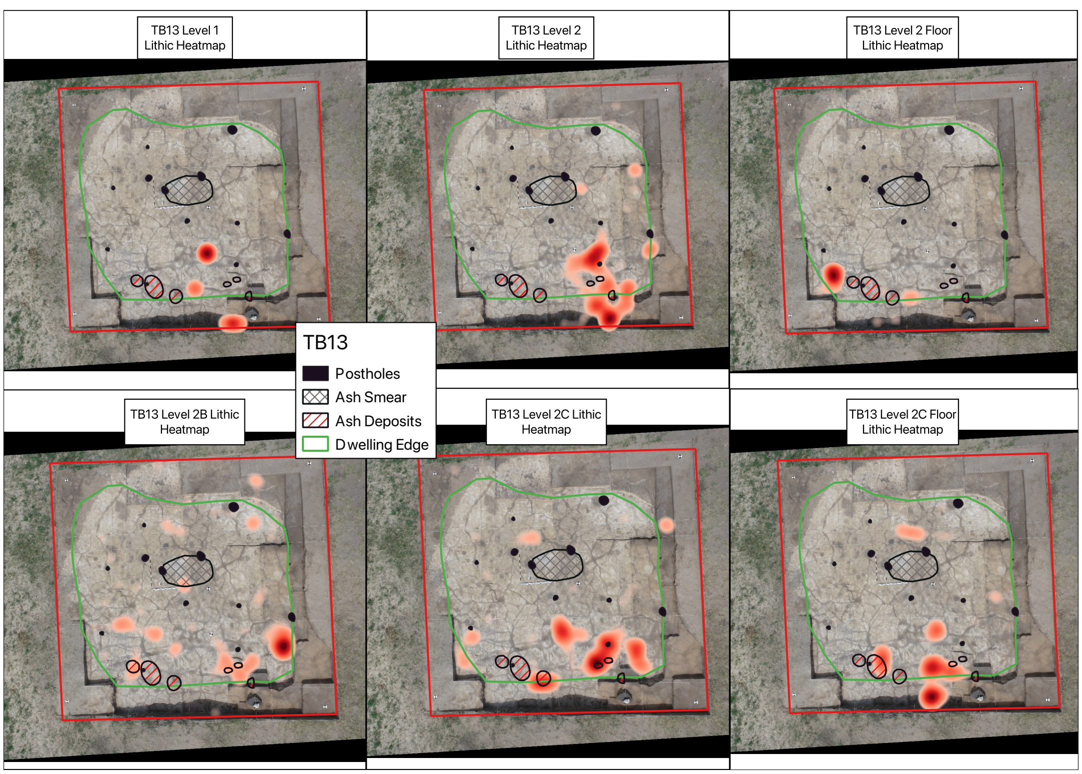

Figure 22: Illustrations of Lithic Heatmaps for TB13

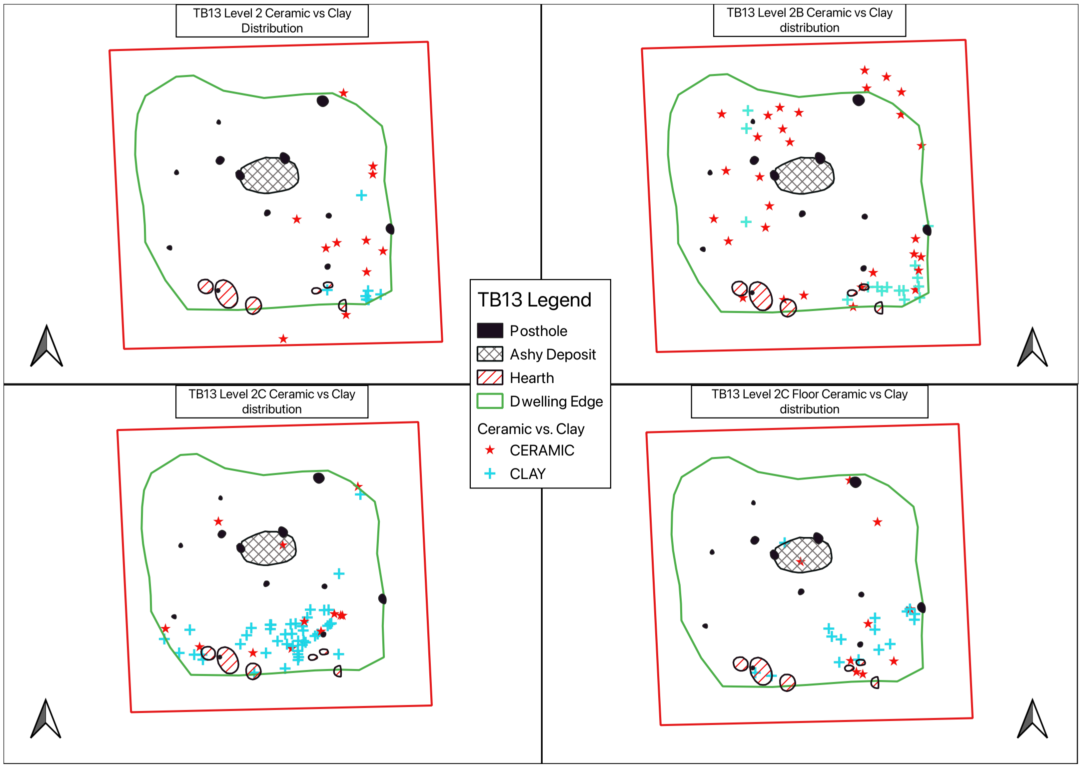

Figure 23: Illustrations of Ceramic Versus Clay Artifact Scatters for TB13

When comparing artifact distributions across each level, it appears that all three materials are clustered in the SE corner of the unit for Level 1 clustered towards both the hearth and ashy deposits for Level 2, clustered again in the SE unit for Level 2 floor, a more even distribution but still a concentration towards the southern end with the ashy deposits for both Levels 2B and 2C, and more clustering in the SE corner for Level 2C floor.

The Chi-square test for vertical variability determined that the difference between the levels of TB13 with respect to proportions of bone, lithic, and ceramic is significant ($\chi 2 = 56.65$, $df = 10$, $p < 0.01$). Significant standardized residuals reveal that: 1) Level 2 contains less bone and more lithic than expected; 2) Level 2B contains more bone and less lithic than expected; 3) Level 2C contains less lithic than expected; and 4) Level 2C floor contains less bone and more lithic than expected.

5.5 Evaluating Patterning in TB14

The next question answered in this section is whether there is statistically significant clustering of artifacts in TB14. The results of a Ripley's K analysis indicate that there is clustering, which occurs around 0.2 m for Level 2 and Level 2B (Appendix: Figures 42-43), 0.3 m for Level 2C (Appendix: Figure 44), and .04 m for Level 2C floor (Appendix: Figure 45). DBSCAN was run to determine the clusters' location, and a Chi-Square test was used to determine if any clusters held a significant amount of an artifact type. Like TB9, the results must be used cautiously as the baulk left unexcavated at the unit's center can cause sampling errors. Clustering in three of the four levels was not significant; the only one that was is TB14 Level 2C ($\chi^2 = 43.23$, $df = 28$, $p = 0.03$). This level contained 14 clusters plus outliers (Cluster 0) (Figure 25). The standardized residuals for this level show that Cluster 2 contains more ceramic than expected, Cluster 4 contains less bone than expected, and Cluster 5 contains less bone and more ceramic than expected. Clusters 0 (outliers), 1, 3, 6, and 8 to 14 contain no significant residuals, representing an even distribution of all three material types among these clusters (Table 8).

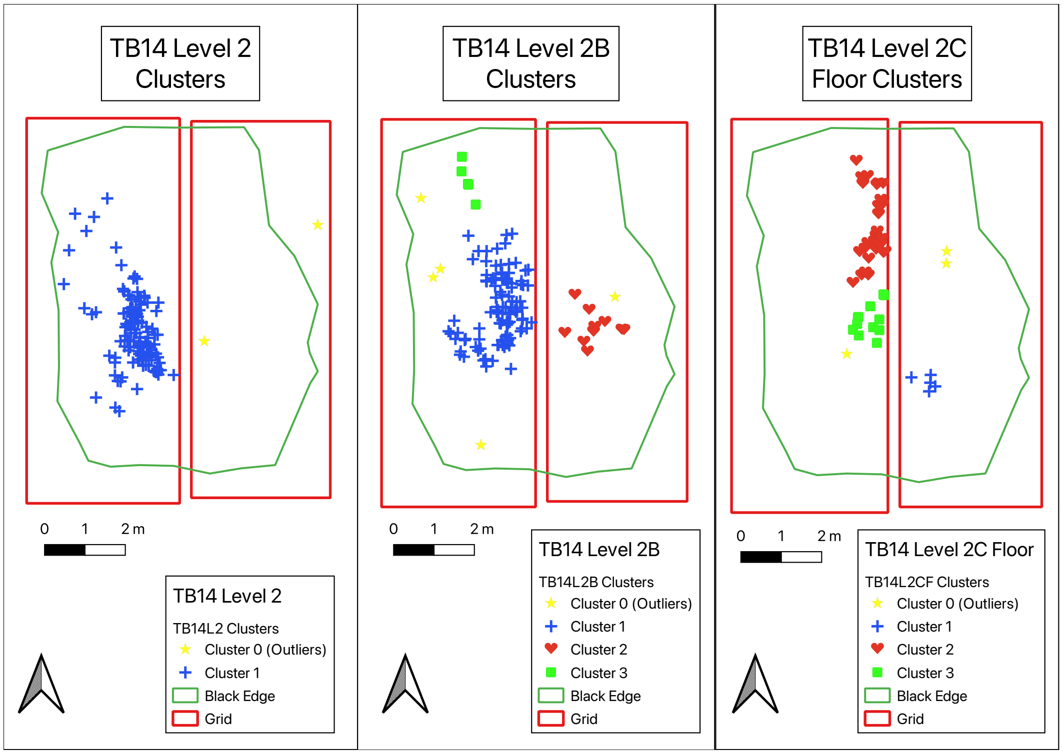

Figure 24: Illustrations Showing Clusters in TB14 Levels 2, 2b, and 2Cfloor

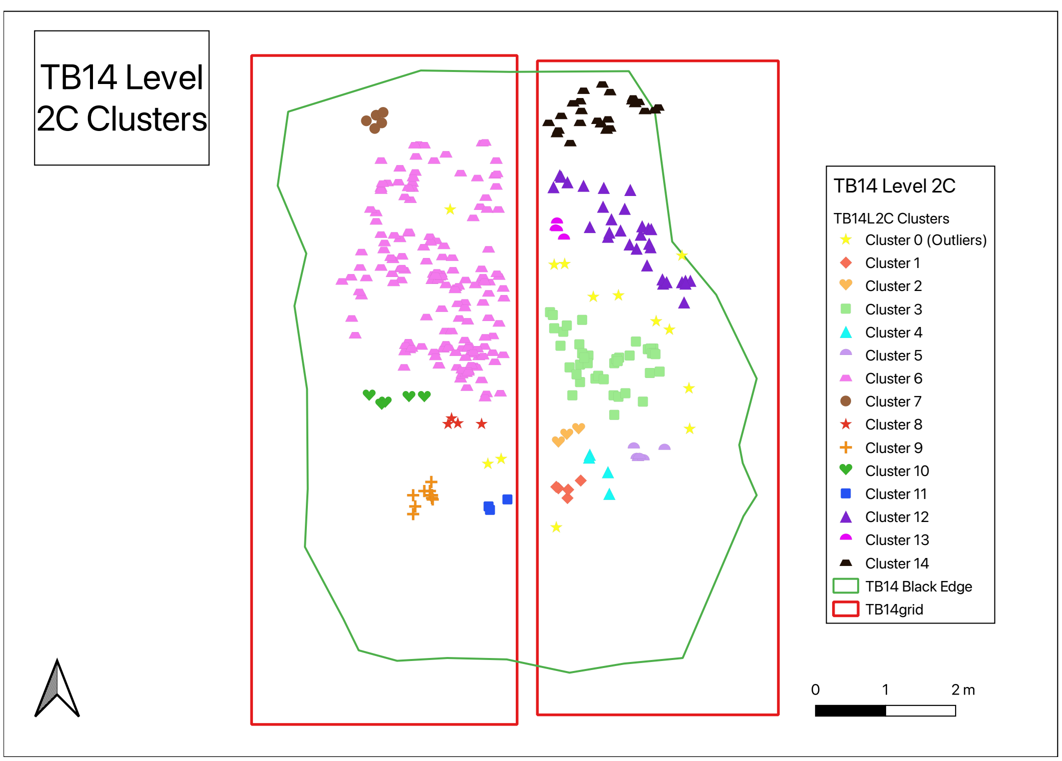

Figure 25: Illustration Showing Clusters in TB14 Level 2C

The three levels that were not significant between the clusters with respect to proportions of bone, lithic and ceramic are: 1) TB14 Level 2 (χ *2* = 1.27, *df* = 2, *p* = 0.53), containing 1 cluster plus outliers (Cluster 0); 2) TB14 Level 2B (χ *2* = 7.64, *df* = 6, *p* = 0.27) which contains 3 clusters plus outliers (Cluster 0); and 3) TB14 Level 2C Floor (χ *2* = 3.85, *df* = 6, *p* = 0.70) also with 3 clusters plus outliers (Figure 24). Both Level 2 and Level 2C floor did not contain significant standardized residuals, so all clusters for each level contain an even distribution of all three material types. Level 2B did contain a few significant residuals, even though the overall result was not significant; Cluster 1 contains a bit less bone than expected, and Cluster 2 contains a bit more bone than expected. Overall, this means that the amount of bone is insignificant but has more influence than the other two material types.

Table 9: Significant Cluster/Artifact Type Observations for TB14

Unit	Level	Cluster	Material	Residual	Observation
TB14	2C	2	Ceramic	2.32	Cluster 2 contains more ceramic than expected
TB14	2C	4	Bone	-2.30	Cluster 4 contains less bone than expected
TB14	2C	5	Bone	-2.00	Cluster 5 contains less bone than expected
TB14	2C	5	Ceramic	3.30	Cluster 5 contains more ceramic than expected
TB14	2C	7	Bone	1.97	Cluster 7 contains more bone than expected

Kernel Density Estimations (KDEs) were run to analyze artifact distributions for TB14. After analysis, it appears that both when comparing the distribution of a single artifact type between the levels and when comparing each of the three artifact types for a single level, artifacts are clustered toward the central-right portion of the dwelling, except for Level 2C (Figures 26-28). Level 2C shows a much larger distribution of artifacts across the unit, with less clustering near the center (Figures 26-28).

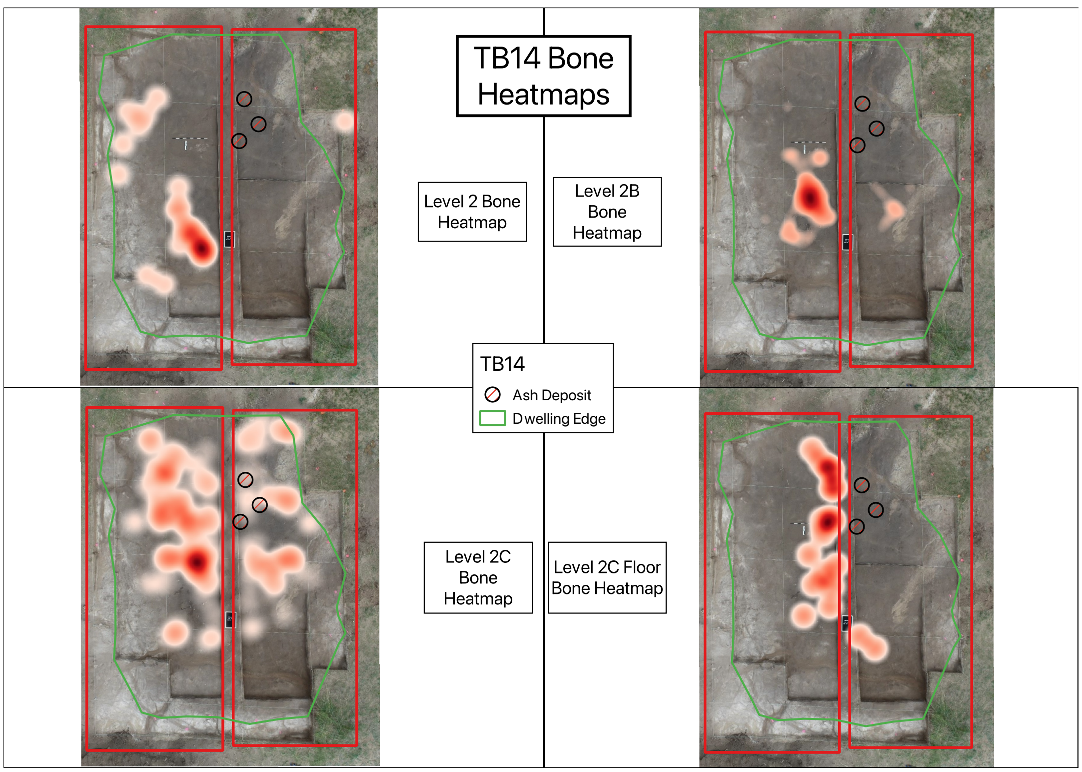

Figure 26: Illustrations of Bone Heatmaps for TB14

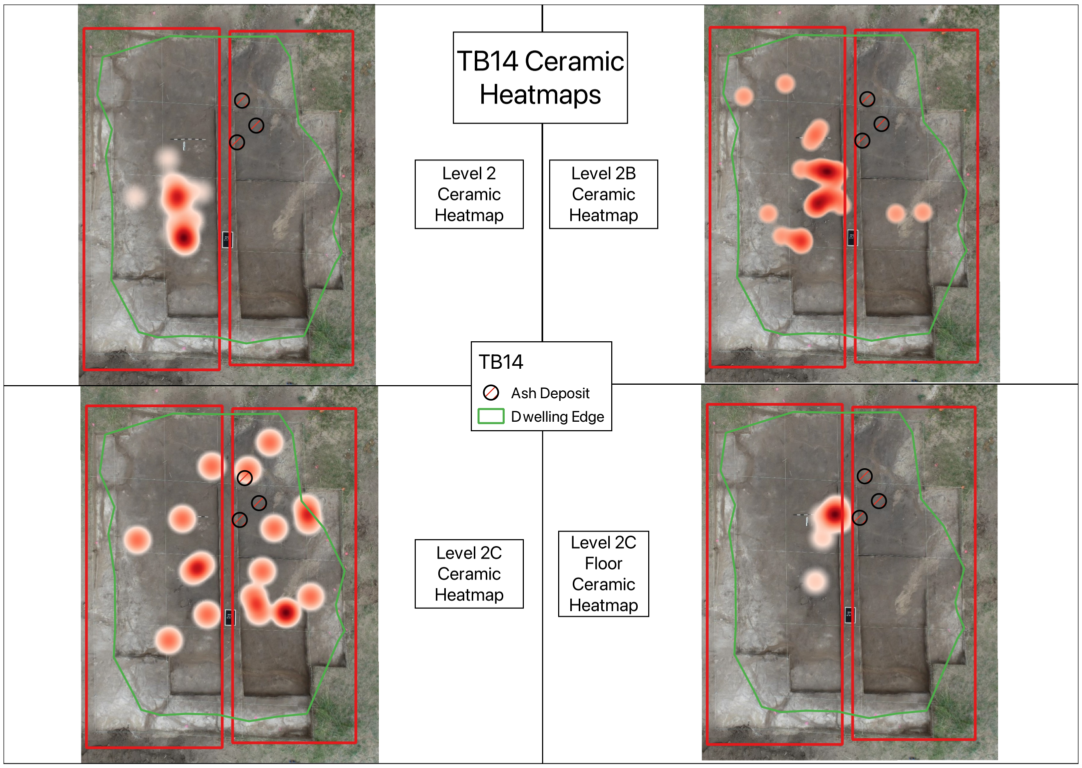

Figure 27: Illustrations of Ceramic Heatmaps for TB14

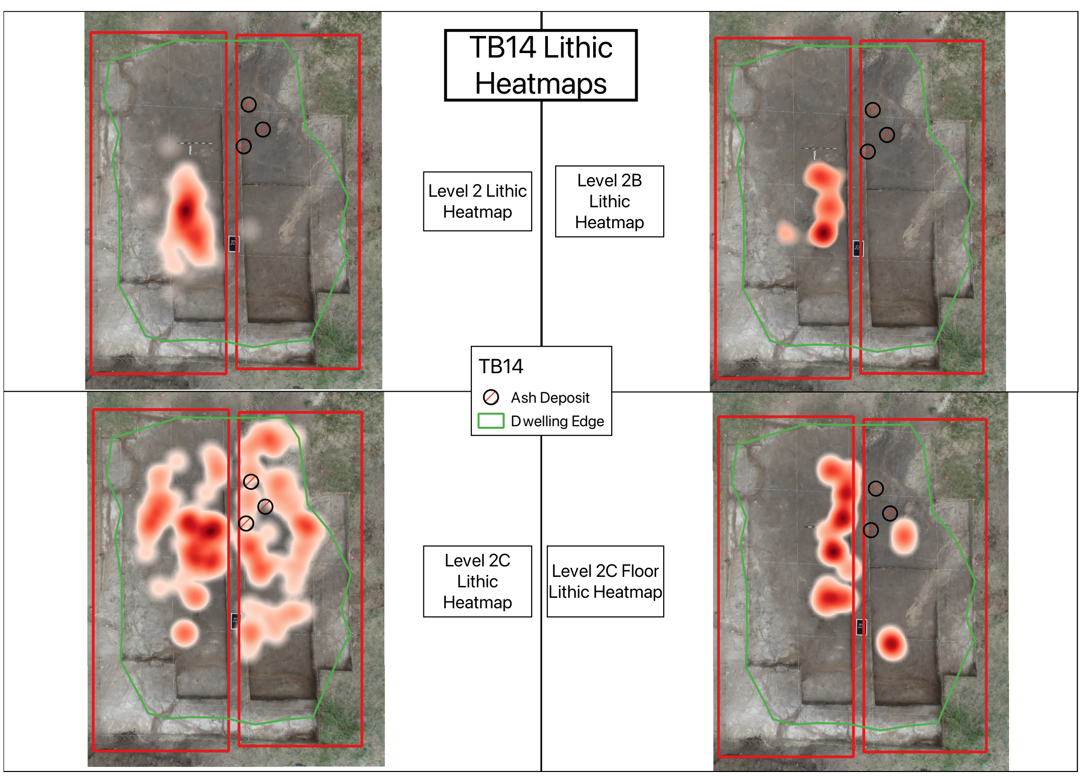

Figure 28: Illustrations of lithic Heatmaps for TB14

The Chi-square test for vertical variability for TB14 showed a significant difference between the levels with respect to proportions of bone, lithic, and ceramic ($\chi 2 = 84.39$, $df = 6$, $p < 0.01$). Based on significant standardized residuals, it is observed that: 1) Level 2 contains less bone, more ceramic, and more lithic than expected; 2) Level 2B contains less bone and more lithic than expected; and 3) Level 2C contains more bone, less ceramic, and less lithic than expected.

Chapter 6: Discussion and Conclusion

6.1 Introduction

The main goal of this thesis is to understand what artifact distributions can reveal about site formation processes, particularly the nature of artifact deposits within each dwelling and how this relates to the use, abandonment, and post-abandonment treatment of each, including how inhabitants managed household waste disposal. This analysis, in turn, has the potential to provide insight into the question outlined in Chapter 2: do the units/dwellings at Tamsagbulag represent seasonal or full sedentism? In other words, analyzing these datasets across several excavated units can give insight into how intensively the site was occupied, for example, on a more seasonal or year-round basis.

6.2 Discussion, Interpretation of Key Findings

6.2.1 TB2

TB2 appears most likely to have been used for either one or multiple episodes as a midden. There is only one major cluster on the northern end of the blackened soils and Ripley's K and DBSCAN show similar artifact composition for both levels: mostly bone, with little ceramic and lithic (Bone made up 85% of Cluster 1 for Level 1, and 73% of Cluster 1 for Level 1B). A similar pattern is seen in both the artifact scatter maps and KDEs, with the densest areas of artifacts located in a north-central location of the blackened soil area. It does not appear this was a dwelling since the artifacts are concentrated in the middle, and both levels are similar in structure and content. TB2 can be identified as a midden because of what Needham and Spence (1997) described as the two main factors that can help identify middens; (1) the repetitive deposits of similar character (in this case two similar deposits, primarily composed of bone, on top of one another), and (2) structural evidence for the episodic way in which deposits build up.

6.2.2 TB9

TB9 differs from TB2 as the two exposed levels appear to have different distributions/clustering, and overall, more artifacts cover a larger area. TB9 Level 1 has two main clusters, one on either side of the baulk. These clusters are likely artifacts of excavation baulk placement and can be interpreted as one continuous cluster. Based on the original chi-square test run, both sides have a similar distribution of artifacts; however, bone is most abundant (66% for Cluster 1 and 50% for Cluster 2). Based on the artifact distribution maps and KDEs for both levels, Level 1 has significantly more artifacts (N = 484) than Level 2 (N = 87), with little organization/patterning for any of the three artifact types.

TB9 Level 2's cluster distribution is distinct, as even though the baulk is still noticeable, there are unique clusters within each side of the unit. Clusters 1 and 2 both contain a large amount of bone (75% and 93%, respectively), whereas the distribution of artifact types is more even in clusters 3 (31.25% bone, 37.5% lithic, 31.25% ceramic) and 4 (45.2% bone, 38.7% lithic, 16.1% ceramic). Cluster 5 contains a substantial proportion of ceramic sherds (62.5%). The artifact distribution maps and KDEs suggest different data to Level 1, as most of the artifacts appear to be pushed away from the outline of the dwelling in the southeastern portion of the unit.

Based on the observations above, I have concluded that this unit may have been a dwelling during its first iteration, as there are fewer artifact scatters within the possible dwelling outline. They appear clustered, indicating more individual deposits such as possible work areas or dumping/sweeping piles directly outside the unit. As the level above contains a significantly larger number of artifacts and no apparent clustering, this dwelling may have been turned into a dump site once the original dwelling was abandoned.

6.2.3 TB12

All three levels of TB12 that were analyzed contain a similar pattern of clusters. The most significant cluster for Level 2 appears to be Cluster 2, in the southeastern quadrant of the excavation, where there is a denser concentration of artifacts surrounding a possible hearth or ashy deposit. This cluster contains a relatively undifferentiated proportion of artifact types (Bone = 38%, Ceramics = 27%, Lithics = 35%), which may suggest the hearth/ashy deposit was the main working area for this dwelling, or that material was later pushed to or deposited at the edges of the hearth/ashy deposit and towards the southern and eastern walls of the dwelling. The remaining Level 2 clusters have no clear pattern but are distinctly visible (see Figure 5.7). All clusters contain even distributions of the three artifact types, suggesting an undifferentiated dumping deposit, perhaps with each cluster being a distinct dumping event. The KDEs generated for Level 2 support the idea that, despite multiple clusters, the densest area of deposition was around the hearth.

Level 2B is similar to the level above in that most artifacts appear to have been pushed towards the southern end of the dwelling. The KDEs show a lack of real patterning to the types of artifacts, with each evenly distributed. Level 2B Floor does not contain many artifacts, with only one small cluster that includes most lithic artifacts. The fact that there is not much trash/debris left over could suggest that the residents were living longer here and regularly cleaning the floor. The high proportion of lithics within this deposit indicates that the inhabitants were working with lithics within the house.

I propose that TB12 was used as a seasonally inhabited dwelling. Levels 2 and 2B suggest longer-term use since the larger clusters are within the southern end of the dwelling, suggesting a possible sweeping episode. Overall, the similar spatial distribution of artifacts between Level 2B and Level 2 could have been formed through prolonged use and *in situ* deposition across work areas, particularly around the hearth, or by cleaning/sweeping episodes aimed at redepositing refuse towards the southern walls of the dwelling.

6.2.4 TB13

TB13 contains more levels and was assigned based on observed changes in sediment compaction during excavation, with each level delineated by a thin layer of more compacted soils. Level 1 contains two main clusters, primarily bone (92%) and lithics (62%). This could suggest two distinct work areas within the dwelling while it was inhabited or two separate post-abandonment dumping episodes. TB13 was on a slight slope, so Cluster 1 could have been deposited through erosion. This is where site formation processes are critical as all three aspects of LaMotta and Schiffer's (1999) model (1. Habitation, 2. Abandonment, 3. Post-Abandonment) could have influenced how/why the artifacts ended up where they did.

Level 2 contains one major cluster in the SE corner of the dwelling (i.e., Cluster 1), with a majority of it consisting of bone (60%) and lithics (30%). This cluster is also located near several smaller ash deposits, showing a similar pattern to TB12. As at TB12, there are several possible explanations: intensive use and deposition of material around the hearths; sweeping of household debris towards the southern wall; or post-abandonment dumping. Level 2 Floor is similar to Level 2 in that the two major clusters of artifacts are located near the hearths/ashy deposits, albeit in this case, the large ash stain towards the center and the smaller ashy deposits in the SW corner. The high density of material and substantially sized fragments of large ungulate bone tend to counter the idea of waste from *in situ* activities around a hearth. They are more consistent with a pattern in waste management associated with sweeping (LaMotta and Schiffer 1999).

Level 2B appears less patterned. There is a major cluster spanning the unit's western half and southeastern corner, with two smaller clusters in the NE corner. The dwelling walls' location is unclear, so these smaller clusters (Clusters 3 and 4) are not necessarily inside the original dwelling. Site inhabitants could have swept debris into the NE corner of the house or been dumping refuse on an outside corner of the dwelling, or it could be explained by post-abandonment dumping. The KDEs show that the densest areas of all three artifact types are located in the S/SE corner of the dwelling. Level 2C appears similar, and the level's major cluster (Cluster 1) is located at the southern end of the unit near the hearths/ashy deposits. The KDEs suggest that the densest areas of each artifact type are all located in the southern half of the unit. The pattern appears slightly different on the Level 2C Floor, with most artifacts clustered in the eastern portion. This could be due to how excavations were conducted; this area was the only section excavated in 2022, and there may not have been an L2C recorded in 2021. The heat maps also suggest that while the densest areas of ceramic and bone are in the SE corner of the unit, the lithics appear to be closer to the south-central portion of the unit.

Based on both the observations above, it appears this dwelling was inhabited seasonally as well, but for a more extended amount of time than TB9 and TB12, and that there may have been multiple sweeping episodes over time, as Levels 1 and 2Floor are more suggestive of sweeping either towards a specific area or ashy areas of the dwelling.

6.2.5 TB14

TB14 Level 2 contains one main cluster on the western side of the dwelling, with a majority of the artifacts being lithics (~62%). There may be fewer artifacts on the eastern side as the dwelling was under a roadway, and the east side appears to have been more heavily affected by erosion. Level 2B seems like Level 2 in that one major cluster on the western side has a similar makeup (~62% lithics).

Level 2C is quite different in its distribution of clusters. There are 14 identified clusters, and they take up a much larger area of the dwelling than the other levels. A closer look at the clusters reveals that many are small, containing only a few artifacts. The clusters also show an even distribution of artifact types, suggesting a lack of any sweeping/cleaning episodes. Level 2C floor is more like 2 and 2B, with many artifacts in the central-western portion of the dwelling. The KDEs for TB14 reflect a similar pattern, with each of the three artifact types' densest clusters located closest to the central right portion of the unit, except for Level 2C, where the densities of all three material types are more evenly distributed throughout the unit.

Based on the observations above, this dwelling may have been first used (Level 2C Floor) as a longer-term shelter, as the densest areas of artifacts are closer to the center, suggesting sweeping. The second iteration (Level 2C) is quite different, with the artifacts being much more dispersed and no real pattern, suggesting a possible shorter-term occupation with no real need to sweep/clean. The last two iterations, represented by Levels 2 and 2B, appear like the very first iteration, suggesting possible sweeping episodes. Overall, it is difficult to hypothesize the living iterations for this dwelling, so the analysis above is just observations rather than interpretations.

6.3 Site Use and Seasonality

Most Tamsagbulag dwellings show signs of sweeping and possibly dumping, mainly within the dwellings, suggesting that inhabitants had sweeping areas. This could be because moving large amounts of garbage in or out of the dwelling was difficult, depending on the entrance configuration. As expressed in Chapter 3 when comparing seasonal versus full sedentism, lower levels of sedentism (such as winter encampments) may reflect accumulation of sweeping/waste within dwellings utilized for extended periods of time, but with only one occupation period. This pattern can be seen in each unit identified as a dwelling, such as with TB12's densest areas of artifacts located towards the southern end, TB13 demonstrating sweeping towards the ashy/hearth areas, and TB14's ashy areas accumulated with artifacts towards the center of the dwelling. Like Keatley Creek in British Columbia, semi-subterranean pit dwellings are most used in the winter months to keep warm, especially in the form of both hearths and sheer body heat. There is evidence of hearth/ash deposits within many of the dwellings, clearly showing there were internal hearths. Based on the evidence and analyses conducted, it appears likely that the site of

Tamsagbulag was used during the winter months, and either visited yearly or every couple of years.

6.4 Limitations and Recommendations for Future Research

One limitation of this thesis was the array of different coordinate systems due to the differing machines/techniques utilized during each excavation year. A better understanding of the coordinate systems used during each excavation year, along with more thorough excavations of future dwellings, would allow for a whole site plan to be developed using GIS technology, where spatial analyses could be run on the site's overall layout. This would allow future researchers to see what patterns may exist with the dwellings' setup to answer questions based on seasonality and sedentism, as site structure is another common trait analyzed when determining sedentism (Kelly 1992; Rafferty 1985).

Another limitation was that only excavated artifacts *in situ* were documented and used in this analysis. Many artifacts were also identified for each unit level when screening and placed into their bags, but have yet to be analyzed. It has been found elsewhere that studying artifact distributions in volumetric densities (artifacts per cubic meter) and areal densities (artifacts per square meter) can be beneficial for studying waste disposal/abandonment patterns at archaeological sites (Hardy-Smith and Edwards 2004). Areal densities can give more realistic impressions of actual quantities of materials present. In contrast, volumetric densities can be beneficial for comparing other sites and contexts (Hardy-Smith and Edwards 2004).

Future research should include the analysis of faunal remains to have a more detailed account of the types of animals utilized at Tamsagbulag, as this can better indicate which seasons the dwellings were occupied and can further help determine the degree of sedentism at the site (Rafferty 1985). Micromorphological analyses of the deposits would be beneficial for future research, as they can help identify things such as the composition and reworking of areas within a dwelling, such as hearth deposits, and whether they were trampled, swept, dumped, or something else (Conard et al. 2010). Understanding how the dwellings were covered is another crucial aspect that should be studied further as roofs can add another layer to the spatial analysis to take into consideration especially after abandonment, as collapsed roofs, activity areas that may potentially take place on roofs, and possible waste thrown onto the roof from cleaning out pit dwelling interiors can all add to the floor assemblages (Hayden 2005: 40).

6.5 Significance and Concluding Remarks

This research is significant as there are few studies about early settlement patterns of hunter-gatherer groups in Mongolia, with the site of Tamsagbulag being the only known pre-Iron Age sedentary settlement in Mongolia. If this is a sedentary site relying on big game, this would be a unique case, as most sedentary hunter-gatherers rely heavily on plant foods and/or small prey such as fish (Stiner et al. 2000). This research at Tamsagbulag contributes new data to the expanding body of research on the complexity of hunter-gatherers and may support the growing body of literature that objects to the notion that all hunter-gatherers are highly mobile. Studying early settlement patterns at sites such as Tamsagbulag could also provide more insight into how these early communities were organized, how they interacted, and potential hierarchies and specialization within the community.

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Appendix A: Ripley's K Results

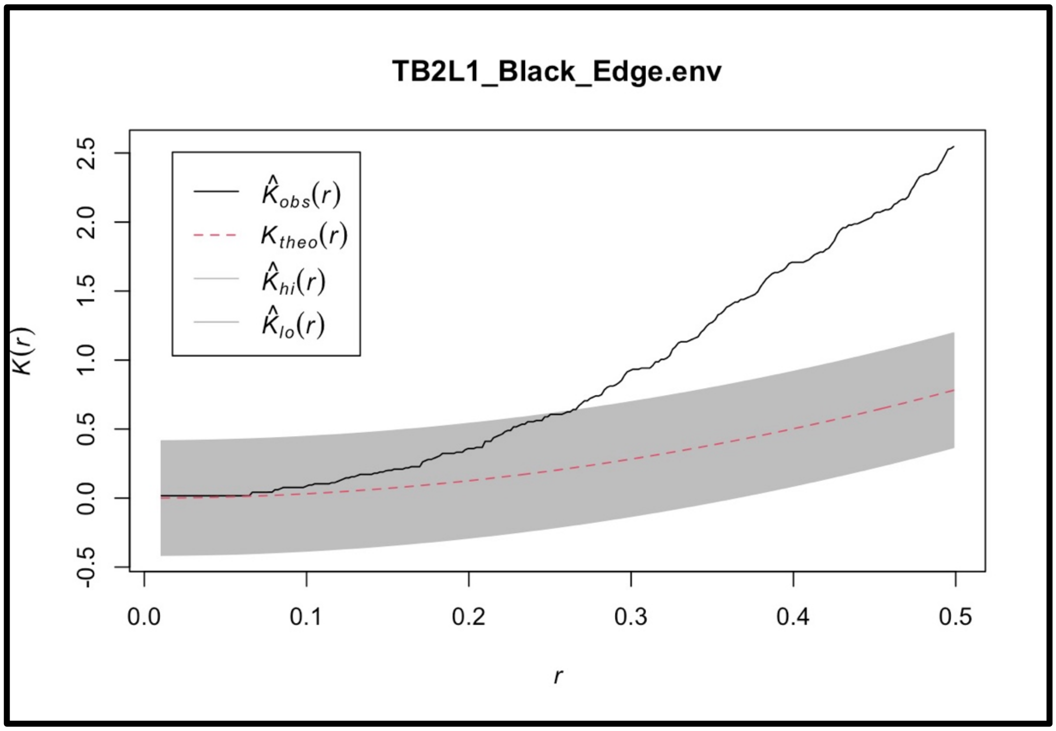

Figure 29: Ripley's K for TB2 Level 1

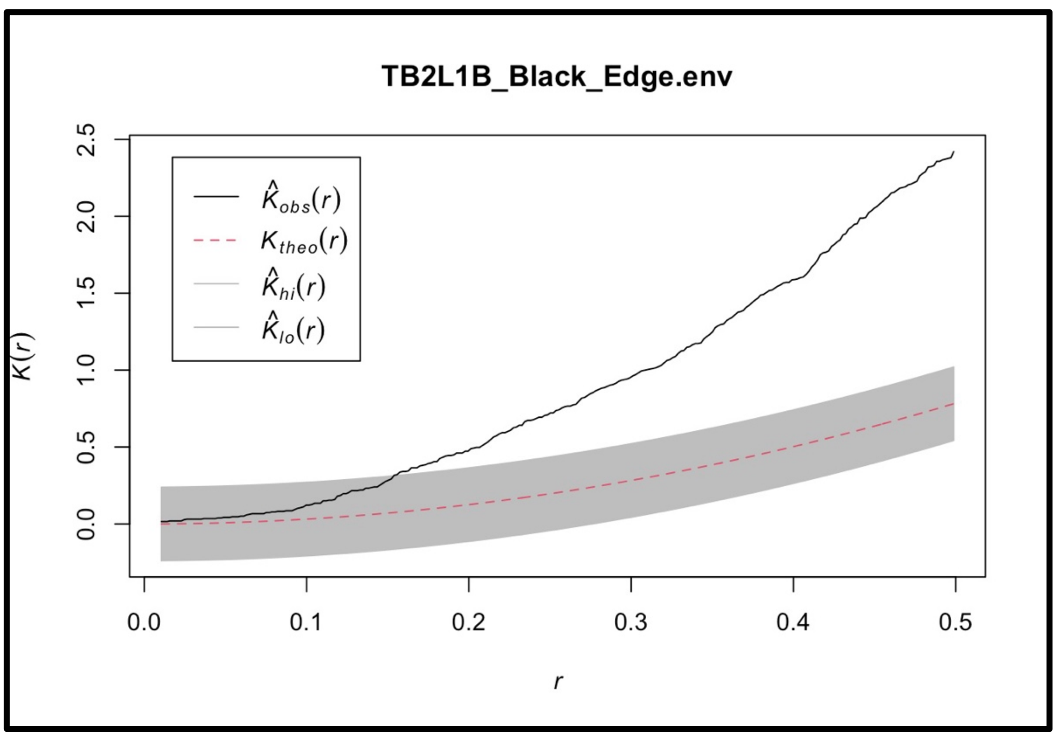

Figure 30: Ripley's K for TB2 Level 1B

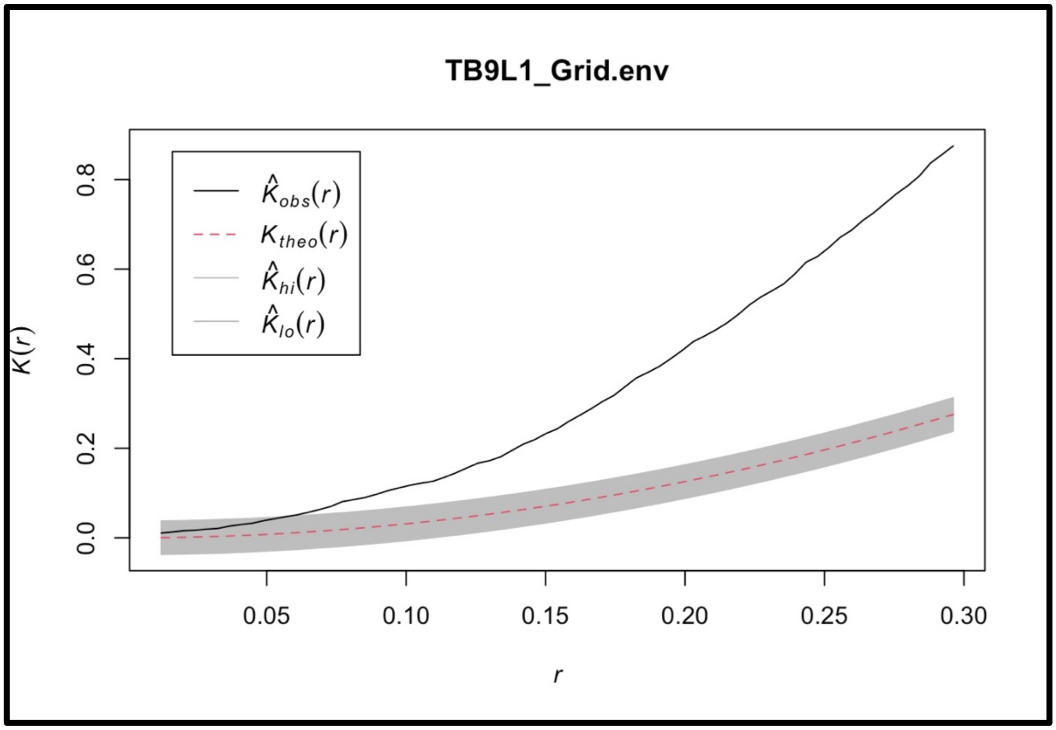

Figure 31: Ripley's K for TB9 Level 1

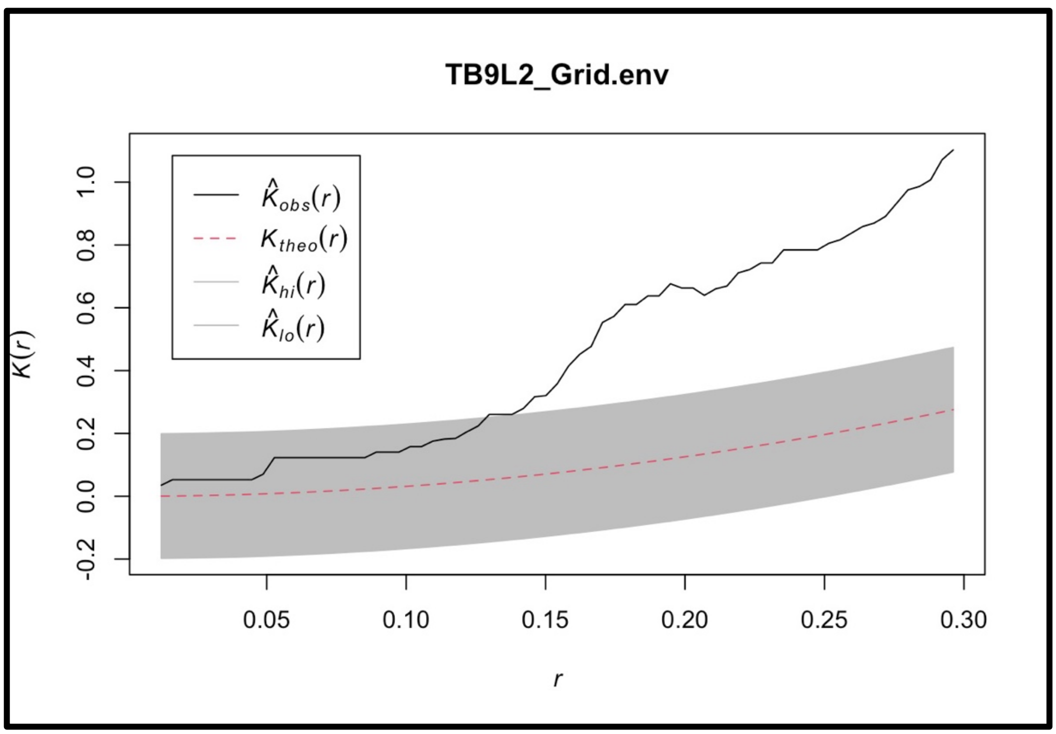

Figure 32: Ripley's K for TB9 Level 2

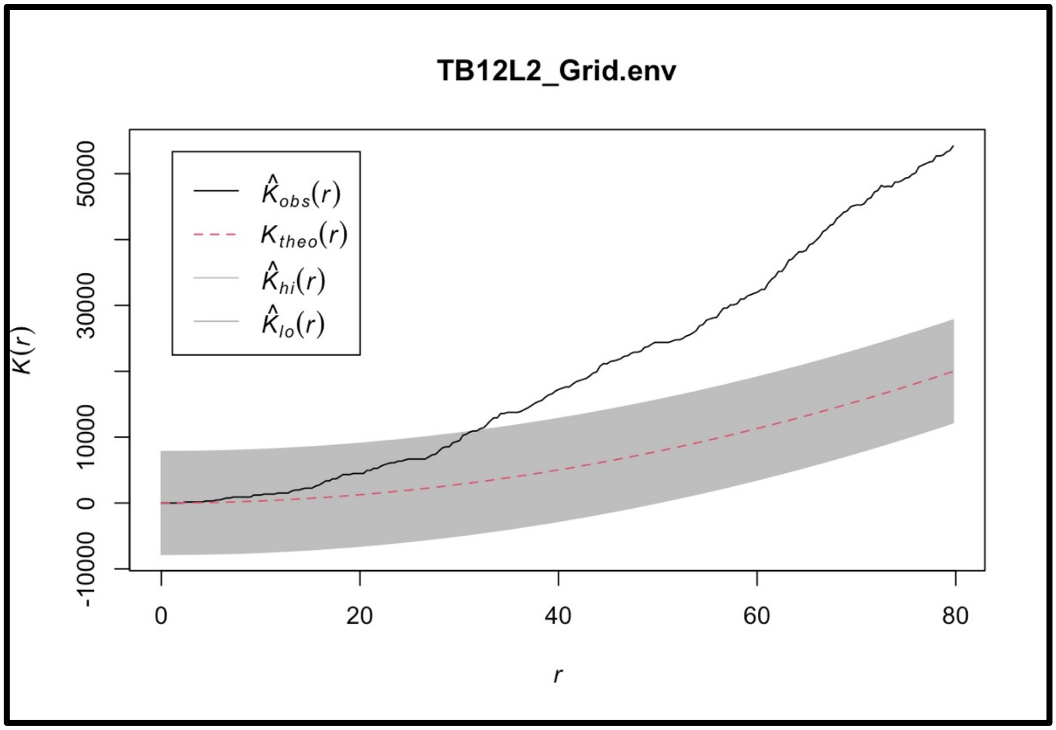

Figure 33: Ripley's K for TB12 Level 2

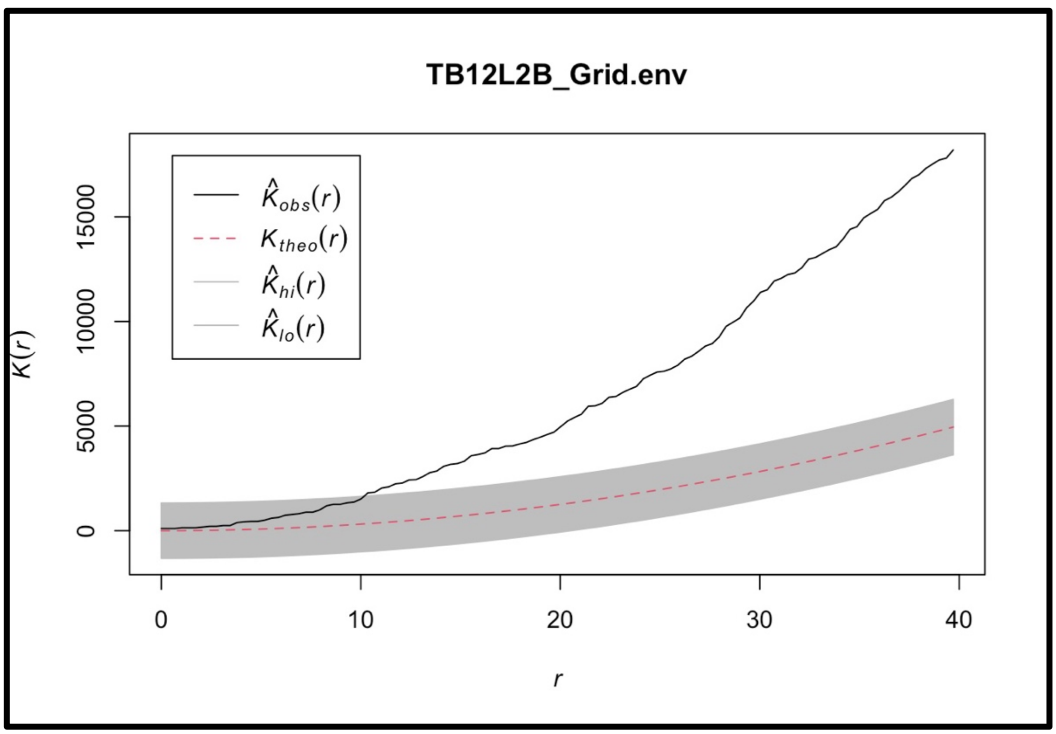

Figure 34: Ripley's K for TB12 Level 2B

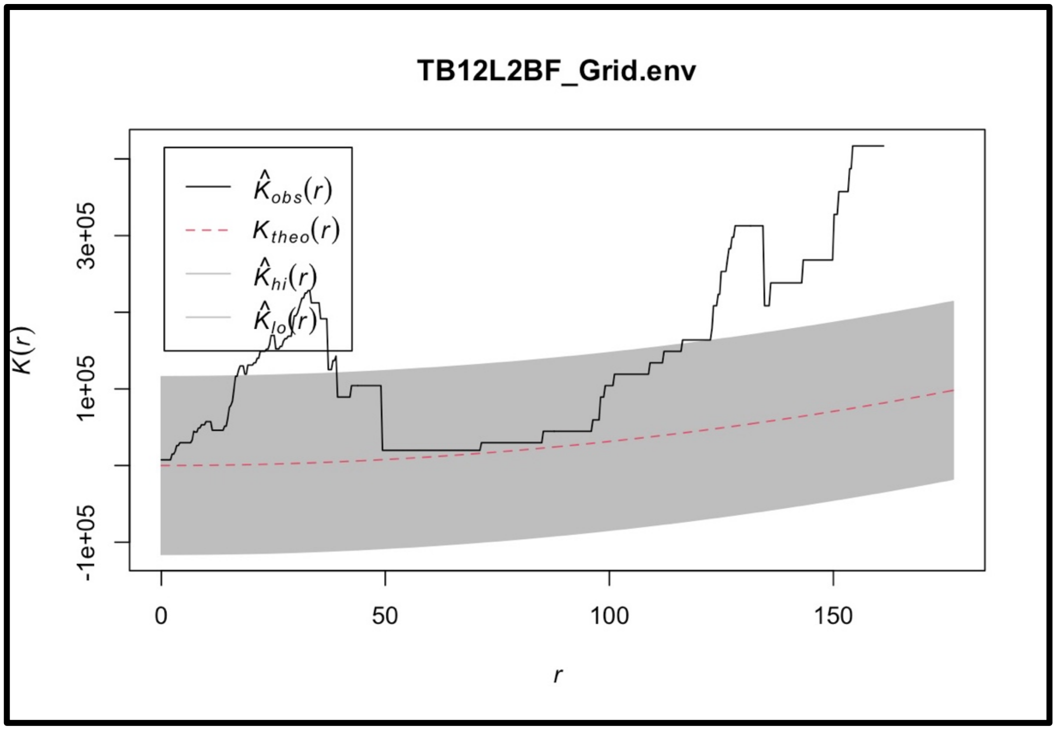

Figure 35: Ripley's K for TB12 Level 2B Floor

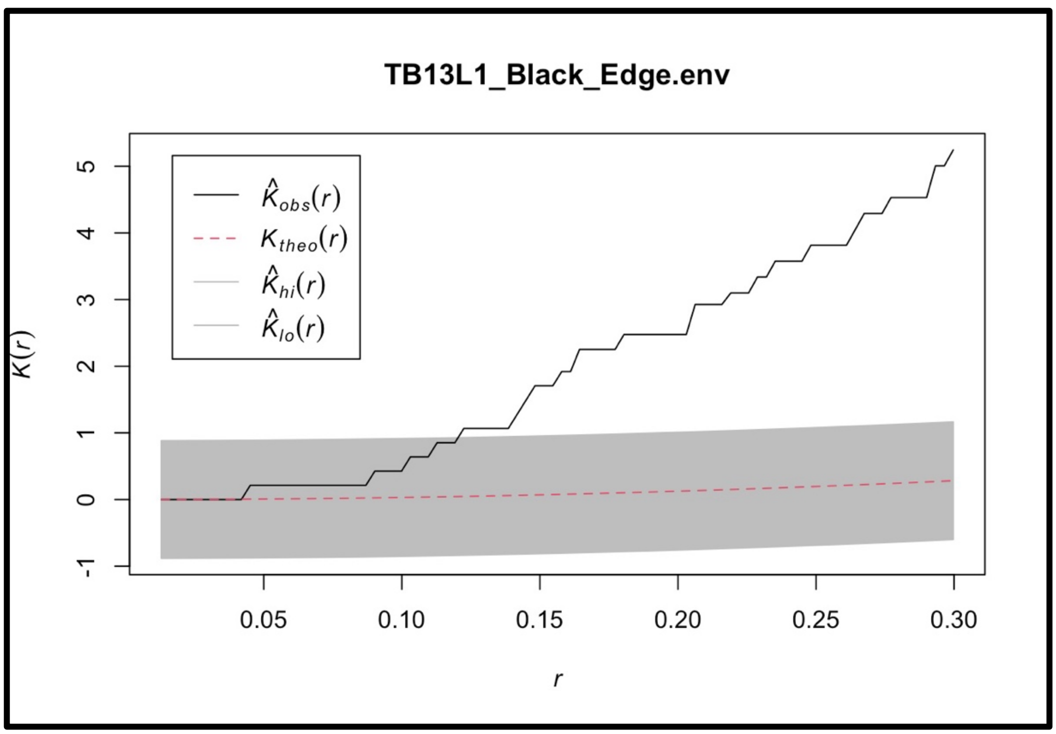

Figure 36: Ripley's K for TB12 Level 1

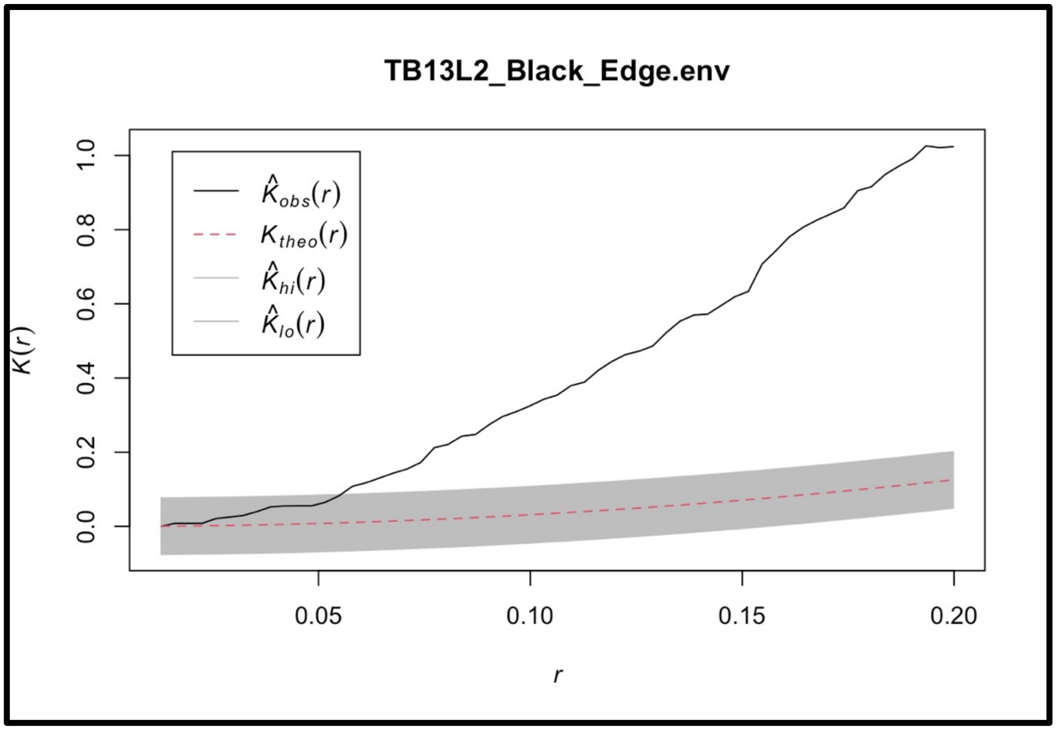

Figure 37: Ripley's K for TB13 Level 2

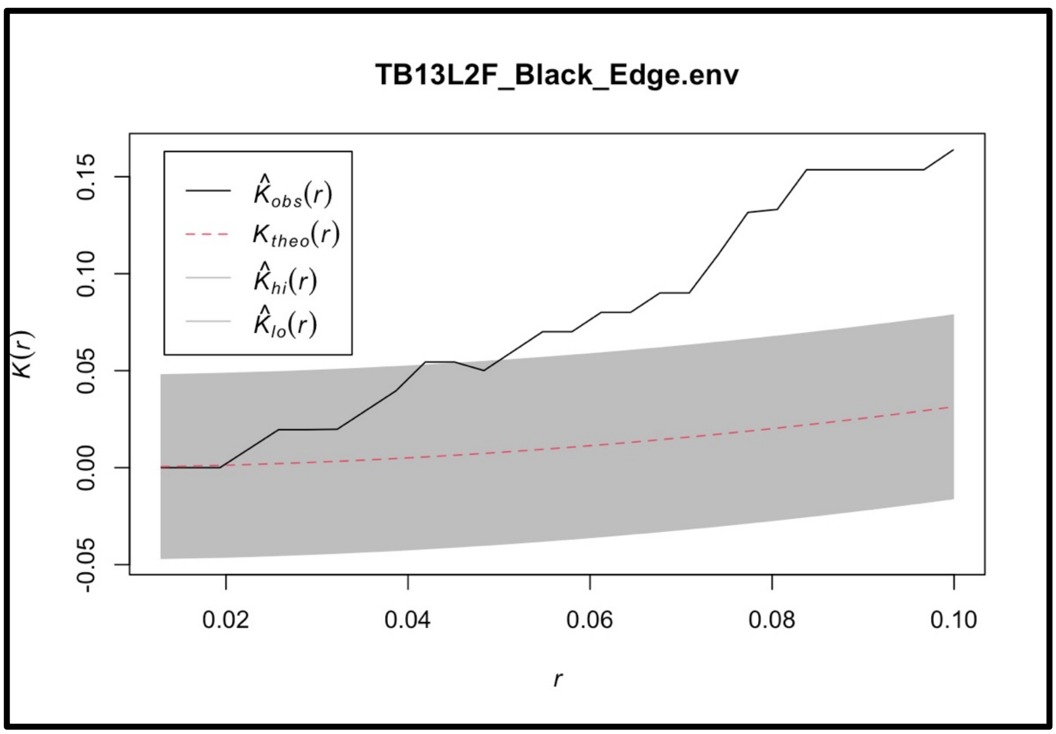

Figure 38: Ripley's K for TB13 Level 2 Floor

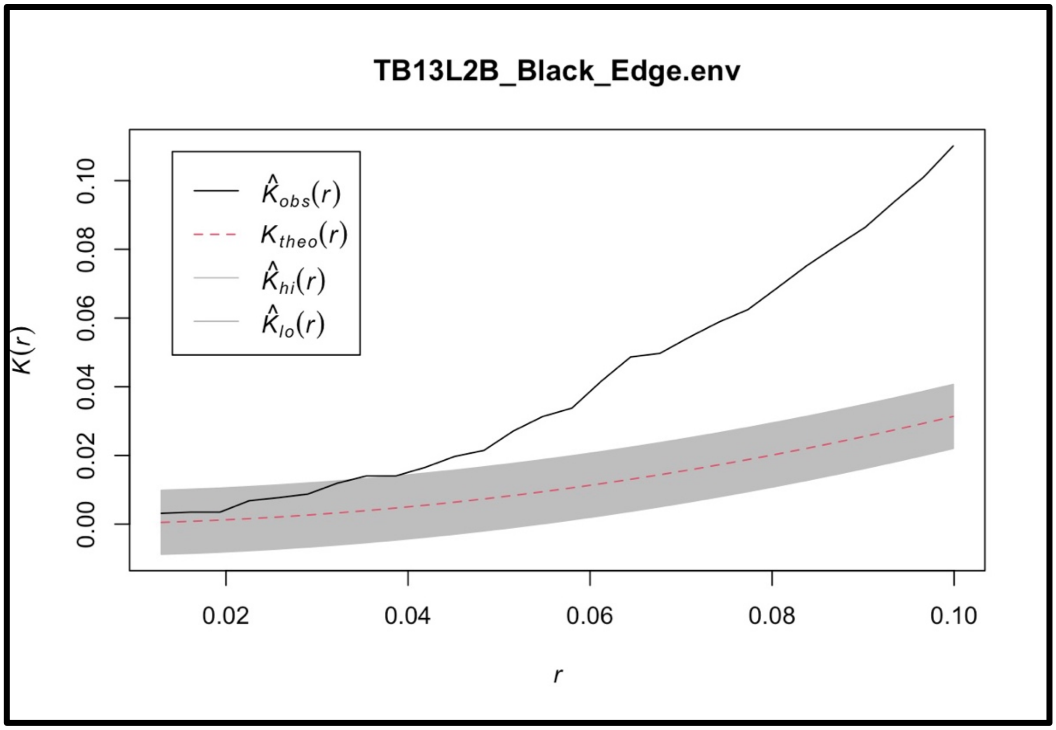

Figure 39: Ripley's K for TB13 Level 2B

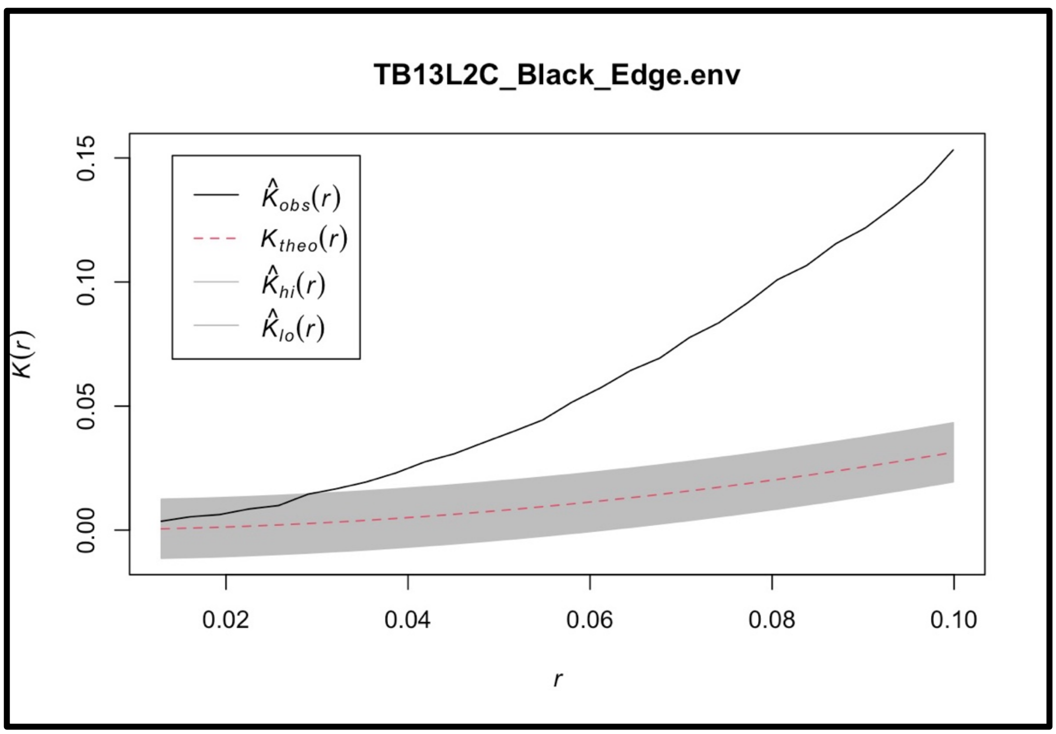

Figure 40: Ripley's K for TB13 Level 2C

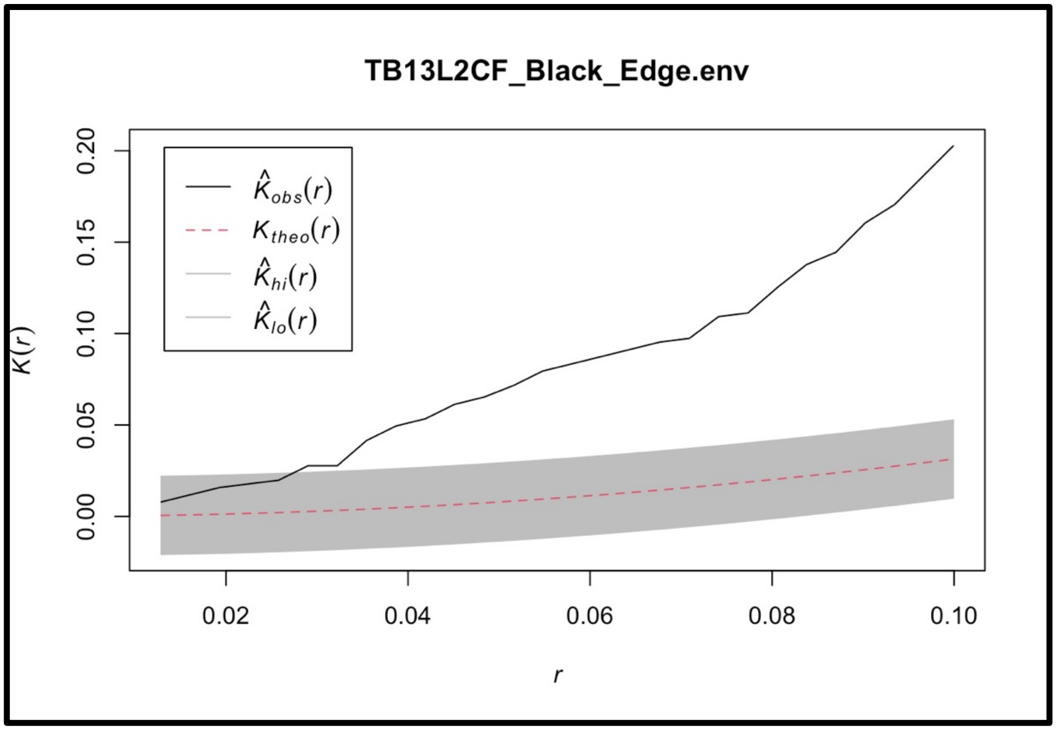

Figure 41: Ripley's K for TB13 Level 2C Floor

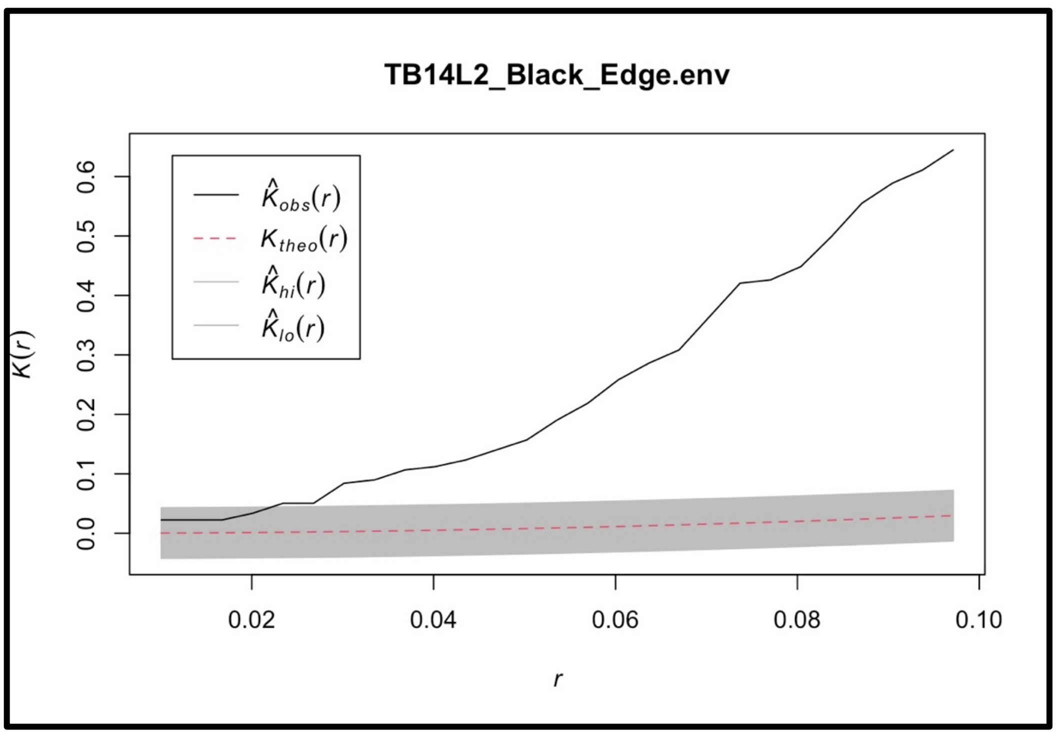

Figure 42: Ripley's K for TB14 Level 2

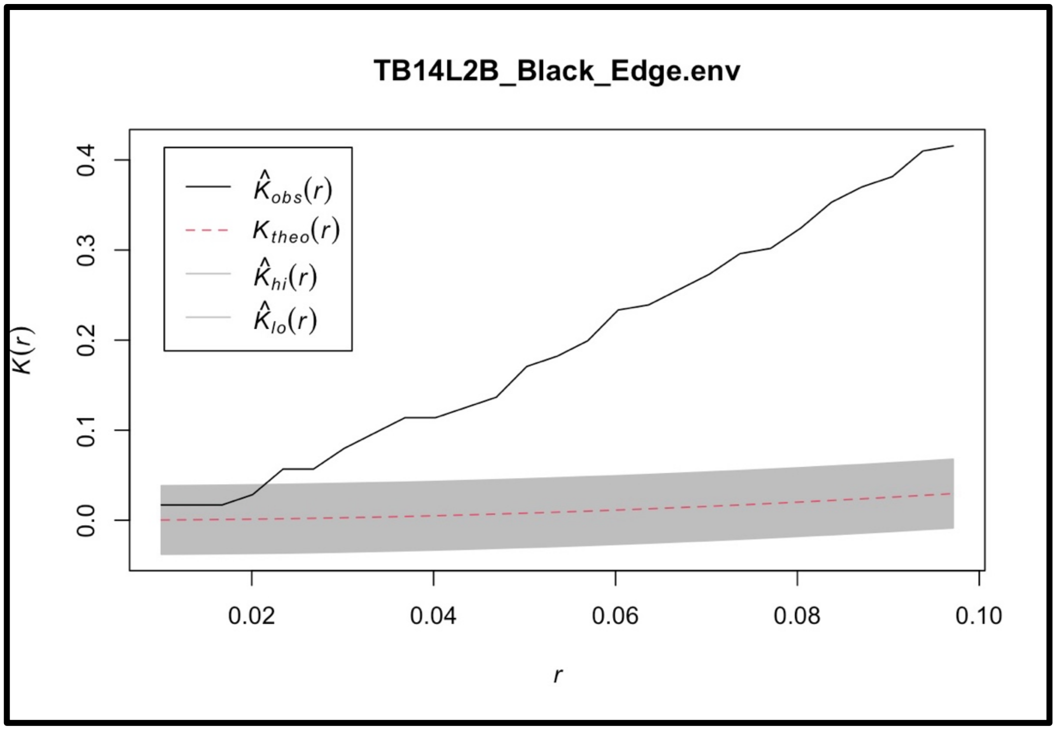

Figure 43: Ripley's K for TB14 Level 2B

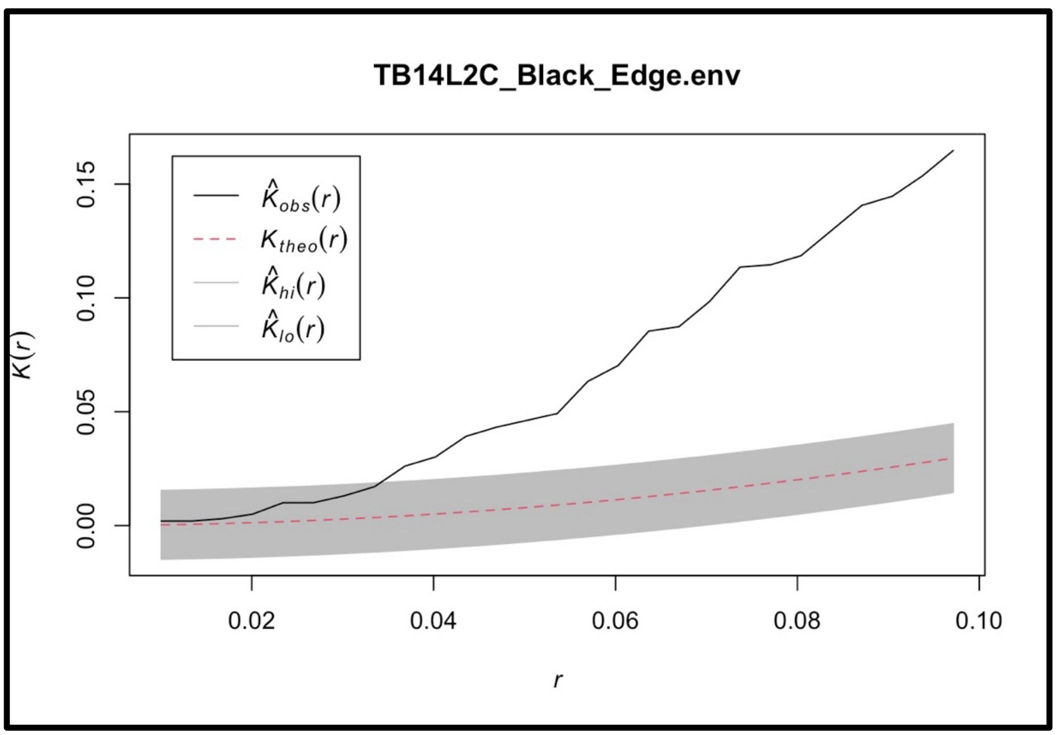

Figure 44: Ripley's K for TB14 Level 2C

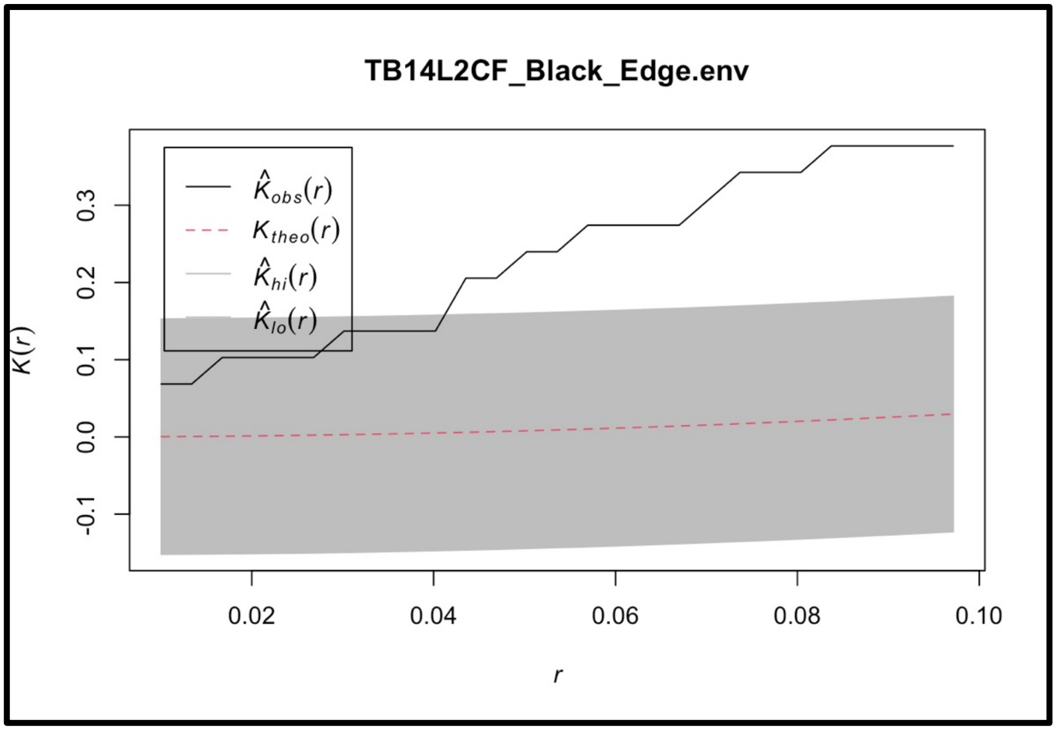

Figure 45: Ripley's K for TB14 Level 2C Floor