Sites, Survey, and Ceramics: A GIS–based approach to modelling ancient settlement patterns in the Upper Mun River Valley, Northeast Thailand

by

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Statement on the Contribution of Others

Nature of assistance	**Contribution**
Initial design and resources	The Society and Environment Before Angkor project
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Research collaboration	Dr David J Welch Dr Stephen Murphy Naho Shimazu
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Abstract

This thesis focuses on analysing the development of settlement in the Upper Mun River Valley of northeast Thailand, from the eighteenth century BCE till the fourteenth century CE. It integrates pre-existing research with the results of a new series of satellite and pedestrian surveys - the first time such wide-spread intensive and systematic survey has been attempted within northeast Thailand. This research utilises the statistical capabilities of a Geographic Information System, to bring together the environmental, cultural, and socio-political landscapes of the prehistoric and historic Upper Mun River Valley.

The Upper Mun River Valley is situated upon a major tributary of the Mekong, at the heart of mainland Southeast Asia. This location is critical to the development of the region. Previous research within the Upper Mun River Valley has focused on excavation, reconnaissance survey, and the reconstruction of Angkor period temples. Key individual sites have revealed the region's complex, multi-period occupation sequence; stretching from early Neolithic agriculturalists, to the area's absorption into the Angkorian polity in the first millennium CE. There is, however, a lack of detailed, intensive survey to contextualise these remarkable individual sites within their local surrounds. This thesis systematically revealed the surface remains of over 100 prehistoric and historic sites, within a sample of four distinct landscape types (deep alluvial floodplains, upper alluvial floodplains, terraces, and uplands). The results

allowed us to reconstruct long-term settlement trends, in the context of environmental, cultural, and socio-political change. The Phon Songkhram Archaeological Survey [PSKAS] settlement pattern analysis has revealed the flexibility, strength, and resilience of Upper Mun River Valley communities. They maintained a complex relationship to the local landscape, most notably water features. Within the wider context of tropical Mainland Southeast Asia, the Upper Mun River Valley appears to be relatively localised, reactive, and internal in its development. This raises questions regarding the relationship between tropical resource abundance, or a lack thereof, and the need for an increase in complexity to ensure long-term sustainability. Such a trend could be further revealed, with intensive surveys, in comparable regions of Southeast Asia.

In conclusion, this thesis reveals the sheer wealth and variability of settlement with the Upper Mun River Valley, and purports that the river valleys of the environmentally challenging Khorat plateau experienced a settlement development trajectory unique within the region. Emerging from this thesis, key transitional sites identified during this project, will be examined further through planned future excavations. Moreover, it is hoped the success of the methods utilised in this thesis will prompt the use of systematic intensive survey techniques in future projects throughout Southeast Asia.

Contents

List of Tables

List of Figures

List of Abbreviations

ASTER	Advanced Spacebourne Thermal Emission and Reflection Radiometer
CIRCP	Chifeng International Collaborative Archaeological Research Project
GIS	Geographic Information System (mapping software)
KBAP	Khorat Basin Archaeological Project
K-S Test	Kolmogorov-Smirnov test
KSTUT	Kok Samrong-Takhli Undulating Terrain (project)
LIDAR	Light Detection and Ranging
m ASL	Meters above Mean Sea Level
PSKAS	Phon Songkhram Archaeological Survey (project)
UMRV	Upper Mun River Valley
UTM	Universal Transverse Mercator (cartographic datum)

Table of Conversions

1 mile = 1609 m

1 inch = 2.5 cm

1 ha = 10 000 m^2

“Settlement archaeology has much to offer the study of prehistoric and protohistoric societies in Southeast Asia. In applying this approach we have much to draw on from several years of theoretical and methodological development on the subject.”

-- Richard Wilen, 1982, p.79

“A high degree of independence reduces resilience … disruption (either upstream or downstream) in one sector cascades into impacts on the other sectors”

- Cutter et al., 2008, p. 604

1. Introduction

This dissertation will draw together pre-existing archaeological data and introduce new survey data to provide a fuller picture of prehistoric and historical settlements patterns in the Upper Mun River Valley (UMRV), northeast Thailand (eighteenth century BCE – fourteenth century CE). The primary research objective is to understand how communities lived within the changeable and relatively arid landscape of the Upper Mun River, which is critically placed at the centre of Mainland Southeast Asia, and is located along one of the major riverine highways of the region. This thesis aims, specifically, to study the relationship between settlement patterns and environmental, cultural, and socio-political factors. Regional and supra-regional comparisons will be drawn to the findings, with a focus on the rise of complex societies in Southeast Asia, and their relative sustainability.

To achieve this, this thesis will complete a comprehensive survey of sites in the UMRV using systematic, intensive pedestrian survey (hereafter referred to as the Phon Songkhram Archaeological Survey [PSKAS]). The spatial distribution of the newly recovered and pre-existing sites will be analysed in relation to a variety of environmental and cultural factors. Trends identified through this analysis will provide insight into the structure of communities in the UMRV, how they changed and developed over time, and their place in wider Mainland Southeast Asia.

The UMRV is located in the upper catchments of the Mun River – a tributary that extends west from the Mekong River towards central Thailand. Currently the UMRV is dry and salt-affected, with unpredictable seasonal rains. Furthermore, paleoenvironmental records suggest the region has been volatile and water-scarce for at least the last three millennia (Boyd, 2008). Despite environmental challenges, the location of the UMRV at the heart of the continent makes it critical to the development of wider Mainland Southeast Asia. It is an obvious route that connects the region from east to west, as well as to the Angkor heartland.

Over four decades of research has revealed a wealth of excavation and reconnaissance survey data in the UMRV, most notably the Origins of Angkor and Khorat Basin Archaeological Projects (Higham, 2012; Welch, 1985). However, the PSKAS is the first systematic, intensive pedestrian survey to be undertaken in the UMRV. It is also the first attempt to systematically search for sites in the 'uplands' of the UMRV, or to incorporate flat sites without encircling earthworks. Such an approach provides detailed snapshots of occupation, across large swaths of the UMRV landscape. During the course of pedestrian surveys some fifty-six artefact concentrations or "sites" were identified, fifty-three of which were previously unknown to researchers. Two thirds of these sites were considered shallow or flat without associated earthworks, so could not have been recovered using traditional reconnaissance survey techniques. A further 48 sites were also identified through satellite survey. This thesis has highlighted the potential of systematic, intensive, pedestrian survey and satellite survey to reveal the archaeology of northeast Thailand in great detail and with relative efficiency.

Analysis of resulting settlement patterns has revealed the flexibility, strength, and continuity of the UMRV prehistoric communities and their consistent re use of sites and their focus upon water management. The results indicate that by the mid sixth century CE structural changes had begun in the UMRV. Local communities became more integrated, with site sizes and types changing, and settlements shifting to higher, less fertile environs. However, it would appear these changes were only ever partially realised. Hence, communities remained decidedly local or sub-regional in size, and were irregular and flexible entering into the historic period. Communities continued to re-use, or be located near, prehistoric sites. Furthermore, the linear pattern of expansion suggests that communities tailored their growth to maintain access to water features, even in the highest elevations. These settlement trends appear to characteristic of occupation in the UMRV.

When comparisons are made between development in the UMRV and its neighbours in central Thailand, the Mekong Delta, and Tonlé Sap region, it is apparent that the UMRV did not experience a smooth or typical transition from prehistory to history. Rather, findings suggest the arid and unpredictable conditions of the Mun River system provided limited opportunities for the development of a large integrated polity, such as can be seen in central Thailand or the Mekong Delta. This is despite social, political, and environmental pressures to achieve a unified state. This late and somewhat limited integration, however, appears to have contributed to the longer-term resiliency of UMRV communities, and their ability to selectively adopt and integrate social, political, technological innovation. It is proposed here that there is a relationship between a lack of tropical resources and the need for an increase in complexity to ensure long-term sustainability. This is an area of research, however, that should be explored further.

The remainder of this introduction provides an overview of the rationale behind producing this thesis, and what it aims to achieve. A detailed outline of the structure of the thesis is also presented, along with potential limitations and how they were addressed.

1.2 The Research Agenda

The rationale behind instigating a new study of settlement patterns in the UMRV relates to three major points; timing, a lack of local-scale survey data, and a history of site selection bias.

This thesis is essentially a survey and settlement pattern study. However in its attempt to record and analyse intermediate-scale, ancient occupation of the UMRV, a broad range of disciplines are drawn upon, including archaeology, art history, spatial science, and paleoenvironmental reconstructions. Such a multidisciplinary approach is required to obtain archaeologically meaningful results from raw settlement pattern data. It is only recently that data has become available from these diverse fields; most notably paleoenvironmental studies (Boyd et al., 1999a; Boyd et al., 1999b; Boyd, 2008; Boyd & McGrath, 2001a; Boyd & McGrath, 2001b), art historical studies by Murphy (2010), excavations by the Origins of Angkor and Society and Environment Before Angkor projects (Boyd & Chang, 2012; Higham, 2012). Improvements in remote sensing data have also occurred, including access to high resolution satellite imagery. Therefore, it seems timely to re-evaluate settlement patterns in the region.

Further, there is an urgent need for intermediate-scale settlement data in the UMRV. Prehistoric burial remains and the construction of encircling earthworks in the UMRV, hint at local communities and large kin-based groups forming the dominant social unit during prehistory. This may even extend into the early historic period. However, there is no detailed information regarding inter-site connections and how the distribution of prehistoric and historic settlement patterns changed at a local level, with the exception of Pryce & Piggott's 2010 intensive pedestrian survey, which focused on evidence of metallurgy. This provides a stronger statistical base for the resulting data, and allows for study of 'communities' of the UMRV, a scale of research that lies between individual sites and the construction of polities. Communities were, perhaps, the most critical social unit during prehistoric and proto-historic times, and remain the foundation of modern northeast Thai populations. Providing this local-scale, 'community' data will be a major focus of this project.

Previous studies have purported that a two-tier, market centric prehistoric model formed the basis for the emergence of hierarchy or heterarchy in the UMRV (Chapter 3.2). Furthermore, the emergence of complex late Bronze Age and Early Iron Age burial rituals, and evidence of early animal domestication have led to the hypothesis that the UMRV experience a relatively early rise to urbanism (Chapter 3). The introduction of intermediate scale data, will allow us to test these controversies, examining how sites functioned and interacted, and at what stage, if at all, we see the beginnings of urbanism and hierarchical/heterarchical structures.

Finally, there is an archaeological bias towards researching large earthwork encircled mounds in the modern floodplains of the Mun River Valley (Eyre, 2010; Mudar, 1995; Wilen, 1982). These sites are increasingly being revealed, due to industrial and agricultural expansion in the UMRV. A limited number of research projects combined with the wealth of archaeological material in northeast Thailand, have led investigators to selectively choose these sorts of sites across the region for excavation. Interpretations of the cultural history of the UMRV, therefore, rely almost entirely upon comparisons between these individual excavations, often separated by significant distances. There is a need for surveys in the UMRV that can record settlement patterns within a range of landscapes, and without bias towards a particular site type. This will reveal how representative large excavated sites are of general occupation, or whether they are a more specialised or ceremonial site type. This thesis uses a systematic and intensive approach to studying settlement patterns that does not assume the nature or likely location of sites. This will prove or disprove the hypothesis that prehistoric sites are predominately large, earthwork encircled mounds, and historical sites temple complexes, located close to the Mun River and its tributaries.

1.3 Aims of the Thesis

The principle aim of the PSKAS is to record and analyse intermediate-scale prehistoric and historic settlement patterns in the UMRV (northeast Thailand), in relation to environmental, cultural, and socio-political changes.

In order to achieve this aim the project will:

1. Systematically and intensively record occupation within a range of landscapes of the UMRV.
2. Identify local environmental and cultural trends and analyse settlement patterns, with reference to available paleoenvironmental, archaeological, and historical data.
3. Analyse the nature of communities in the UMRV, how they changed and developed over time, and draw regional and supra-regional comparisons.

This will aid a discussion of how the development of communities in the UMRV fit within, or contribute to, theories of the rise of complex societies in Southeast Asia and their relative sustainability. The following hypotheses, drawn from relevant literature (see Chapters 4, 5, and 6) will been supported or unsupported.

1. Prehistoric sites in the UMRV are predominately large, earthwork encircled mounds, and historic sites large temple complexes. Both are located near to the Mun River System and its tributaries

2. There is a relatively early appearance of urbanism in the UMRV Southeast Asia during the late Bronze to early Iron Age, as evidenced by the complex burial rituals and domestication of water buffalo/ cattle

3. Two-tier and market-place community models, formed the basis for an emerging hierarchical or heterarchical system in the UMRV

1.5 Dating

There are a various, overlapping approaches to dating the prehistory and history of the UMRV, and of wider Mainland Southeast Asia (Barram, 2003; Brown, 1988; Higham & Higham, 2009). However, the PSKAS project has undertaken a specific approach to dating, which applied the categories; early prehistory, late prehistory, the pre-Angkor period, and Angkor period. These categories were best suited to the aim of the PSKAS project; to reveal long-term settlement patterns and trends of the UMRV. Furthermore the, early prehistoric, late prehistoric, pre-Angkor, and Angkor periods, could be "confidently" identified from surface artefact remains (Chapter 6.3.1).

1. **Early Prehistory (eighteenth century BCE – first century CE)**: Concordant with the Neolithic (eighteenth - tenth centuries BCE), Bronze Age (tenth - fifth centuries BCE), and the early Iron Age (fifth century BCE – first century CE) of the excavations of Noen U-Loke and Ban Non Wat (Higham et al., 2007; Higham & Kijngam, 2009; Chapter 4.1). Bronze and early Iron Age material was not considered separately for the PSKAS project, due to similarities in artefact characteristics (Chapter 6.3.1 for detail). Neolithic material was recovered in such small quantities during the PSKAS project, that they were not statistically viable. Rather, Neolithic sites were considered a subset, or case study, of early prehistory (Chapter 4.1). These provided a valuable insight into the initial occupation of the UMRV.

2. **Late Prehistory (first – mid sixth centuries CE)**: Late prehistory is a far narrower period than early prehistory, encompassing Iron Ages 3 and 4 from the excavation of Ban Non Wat (Higham & Kijngam, 2009) and Noen U-Loke

(Higham & Rispoli, 2014, p. 5). Late prehistory has primarily been identified through the presence of the "Phimai Black" ceramic tradition (Chapters 4.1 and 6.3.1). It also retains distinctive features of site organisation, including encircling earthworks or "moats".

3. **Pre-Angkor period (mid sixth – ninth centuries CE)**: Post-dating the late Iron Age but predating the spread of "Angkor-style" ceramics and temple complexes, the pre-Angkor period in the UMRV is characterised by the emergence of Indianised Post Gupta and Pala art styles (Chapter 4.2). The term *Indianised* here does not refers to the external take over or "civilising" of mainland Southeast Asia by India, but rather the selection, adaptation, and expression of elements of Indian religion, art, and political ideology (Evans et al., 2015; Murphy, 2010, p. 41). The pre-Angkor period largely overlaps the Khorat Basin Archaeological Project's Muang Sema period (sixth – tenth centuries CE), and the Origins of Angkor project's protohistorical or "Chenla" periods (mid sixth – early ninth centuries CE, Higham, 2012; Welch & McNeill, 1991).

4. **Angkor period (ninth – fourteenth centuries CE)**: The Angkor Empire was technically established with the 802 CE coronation of the first god-king Jayavarman II, in the Tonlé Sap basin of modern-day Cambodia, and continued until its collapse in the fourteenth century CE. Using the term "Angkor period" here, serves to link the UMRV occupation sequence to the tradition of Angkor-style ceramic, religious iconography, and epigraphic/inscriptional references associated with the Angkorian Empire, which rapidly spread across Southeast Asia. This period is clearly visible in archaeological assemblages. It is not

intended to suggest the UMRV was submersed or fully integrated into the Angkorian Empire during this period. The starting date, the ninth century CE, should be considered a guide, as there is an inconsistent and somewhat delayed spread of this characteristically "Angkor-style" material reaching the northeast of Thailand (Chapter 4.2). Hindu iconography, for example, did not become widespread in northeast Thailand, until the accession of King Rajendravarman II in 944 CE (Siribhadra & Moore, 1997, p. 31), and Mahayana Buddhist icons only appear from 1181 CE onwards (Crick, 2010).

In future studies, once further excavations in the region have been conducted, it is intended that this chronology could be refined.

1.6 Limitations

This project is to a large extent exploratory in its attempt to apply a more systematic and quantifiable approach to survey in northeast Thailand. Intensive pedestrian survey has never been conducted on a large scale in northeast Thailand before. As such, a number of the survey techniques required in-field adjustments during the initial 2012 season. Further refinements were made between subsequent survey seasons. The survey team also consisted of rotating volunteers, with varying levels of archaeological experience. There is a risk these factors could create some inconsistencies in recording between survey seasons, or between survey groups. Detailed recording forms and pre-survey training were used to minimise these risks.

1.4 Structure of the Thesis

This document is organised to facilitate a clear description of how prehistoric and historic settlement patterns in the UMRV were uncovered and analysed. It is presented as eight chapters, and five appendices (Table 1). In this introductory chapter the research questions are outlined, the aims and scope of my project are defined, along with potential limitations. In Chapter two, the location and setting of the study area is discussed in detail. Both paleoenvironmental and modern environmental landscapes are considered here. In Chapter three, a background to archaeological research within Mainland Southeast Asia broadly is presented. This is followed, in Chapter four, by a summary of prehistoric, protohistorical, and historical evidence of settlement in the UMRV, northeast Thailand. There is a focus upon the key sites: Ban Non Wat, Noen U-Loke, Non Ban Jak, Non Muang Kao, Phimai, Muang Sema, and Phon Songkhram.

In Chapter five, concepts of archaeological scale, sites, survey, and communities are examined and defined for the purposes of this thesis. This theoretical discussion is followed by an overview of methodology in Chapter six. Chapter seven examines new survey results by time period. Followed by the collation of all sources, including excavation, new survey, previous survey, and historical data, brought together to discuss the entire settlement sequence of the UMRV, in relation to periods of technological, environmental, and social change. In Chapter eight, socio-political organisation of the UMRV is discussed, in comparison with wider trends of tropical, Mainland Southeast Asia. Finally, in Chapter nine major findings are summarised, and future work is proposed. A series of appendices have also been included, containing examples of recording forms, photographs of unusual artefacts, and summary tables of all sites and diagnostic artefacts recorded. The complete database of all diagnostic artefacts is available upon request.

Table 1:

Chapter Organisation

Chapter	Content
1.Introduction	Introduction to the development of archaeology in Thailand, the research agenda, aims, structure, and limitations of the thesis.
2. The study area	A detailed overview of the geography, climate, soils, and vegetation of the study area.
3. Archaeological discipline in Southeast Asia	The development of the discipline of archaeology in Southeast Asia and implications for the study of ancient settlement patterns.
4. Evidence of settlement in the UMRV, Thailand	Prehistoric, protohistoric, and historic background to the study area, with particular reference to the sites of Ban Non Wat, Noen U-Loke, Non Ban Jak, Non Muang Kao, Phon Songkhram, Phimai, and Muang Sema.
5. Theoretical background	Review of archaeological survey techniques, concepts of scale, community, and settlement theories.
6. Methodology	Pre-survey design, fieldwork, and post-survey analysis are outlined, with justification for each method chosen.
7. Results	Initial survey results are presented, followed by results by time period (early prehistory, late prehistory, the pre-Angkor period, and the Angkor Period). Finally long-term trends for entire occupation sequence are outlined.
8. Mounds to monuments: Development in the UMRV	A discussion of the long-term development of the UMRV, with reference to two case studies: Noen U-Loke and Phon Songkhram. Comparisons are made with trends of Wider Mainland SEA, most notably the development of central Thailand and the Mekong Delta.
9. Conclusions and future work	Overview of the contributions made by this thesis and recommendations for future work.

2. The Study Area

The PSKAS is located on the Khorat Plateau, a flat landmass in the semi-arid tropics of northeast Thailand, which lies at the crossroads or several modern and ancient inland routes. It is integral to examine the ancient and modern landscapes of the UMRV, as ancient reconstructions of the geography, climate, soils, and vegetation inform a discussion of archaeological research in this region, and are important factors in when analysing settlement strategies. The modern landscape, on the other hand, provides information regarding post-depositional disturbance of archaeological sites in an area with several decades of intense agricultural activity.

2.1 Geography and Climate

Geography and climate, is the most significant environmental factor impacting on modern subsistence and settlement strategies in the UMRV, and one might assume (see Chapter 3.2), a critical factor to ancient settlements. This is, in part, due to the unpredictable semi-arid tropical climate of the Khorat Plateau, where the PSKAS study area is located, with its major riverine networks dominating the landscape in the absence of significant rises in elevation. Such riverine networks likely served as ancient trade routes, a major source of freshwater fish and shellfish, and a means of maintaining crops. Climate and the location of rivers, however, are not static, and ancient geography and climate cannot necessarily be interpreted from modern evidence.

The large landmass of Southeast Asia lies between the Indian and Pacific Oceans and is generally divided into mainland and island zones (Figure 1). A feature of mainland geography is the extensive river systems, which begin in the highlands of northeast India and northwest China, before winding into lowland areas of Southeast Asia. The Mekong River, for example, makes its way through China, Burma, Laos, Vietnam, Thailand, Cambodia, and Vietnam on its way to the South China Sea. These river systems produce vast fertile floodplains, valleys and deltas described as the lowlands (Higham, 2002). Within the lowland and highland zones of Mainland Southeast Asia there is significant homogeneity in climate, vegetation, and animal life, despite the significant number of modern nation states. Thus the modern nation state boundaries that divide Mainland Southeast Asia, such as that along the Mekong separating Thailand and Laos, are misleading in their fragmentation. Southeast Asian populations are far more overlapping and fluid than these boundaries would lead us to believe, with major rivers such as the Mekong, acting more to connect populations through trade and communication, than to divide. There are, however, natural divisions more relevant to an archaeological study. One such division is the large topographical region known as the Khorat Plateau, which lies at the heart of the lowlands of mainland Southeast Asia

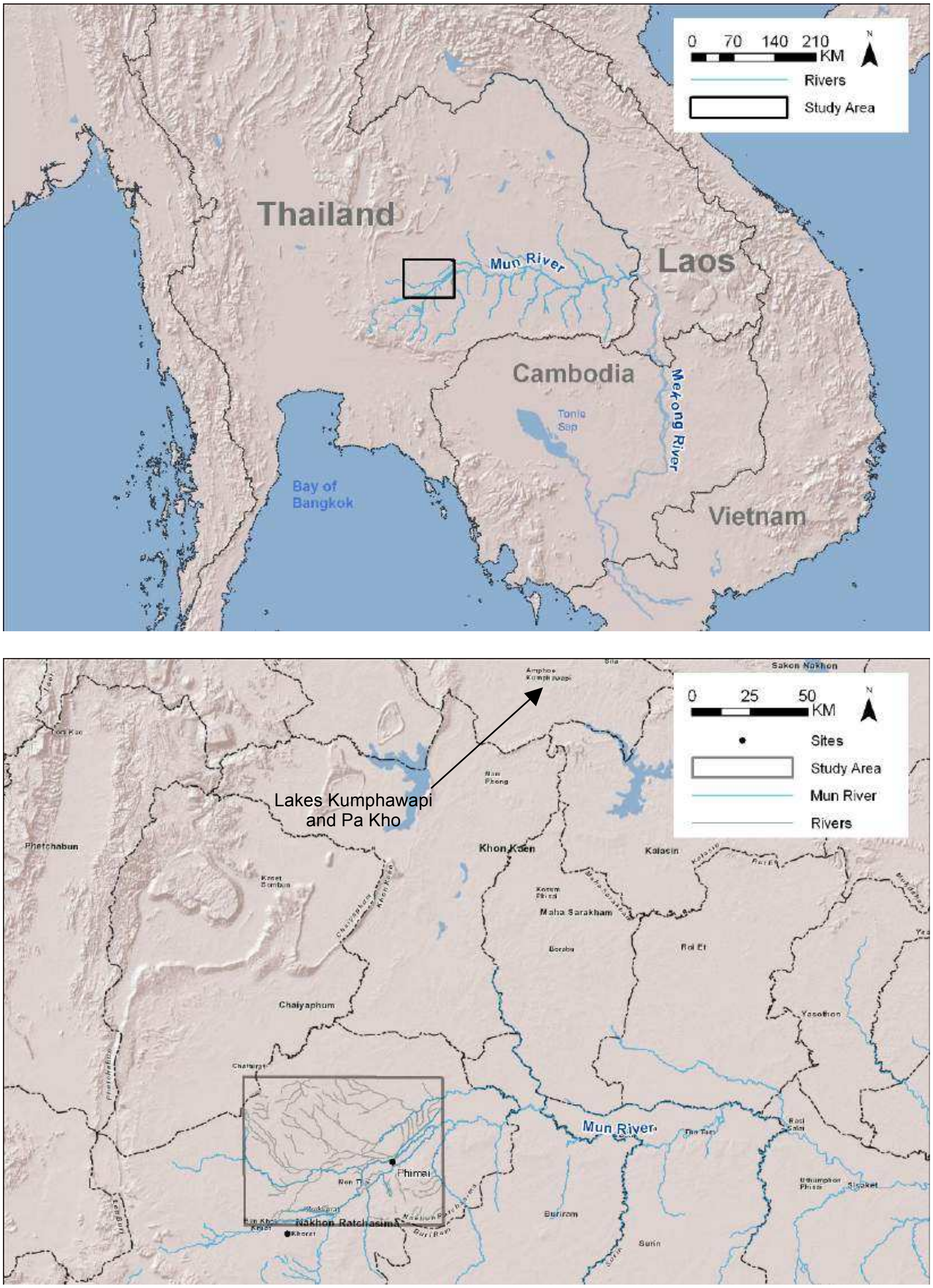

Figure 1. Location of the study area.

Khorat Plateau

The Khorat plateau is a saucer shaped basin bordered to the west by the Phetchabun and Dong Phraya Yen mountain ranges, to the south by the Dang Raek mountain range, and to the north and east by the Mekong River system (Figure 1). The Khorat Plateau predominately lies within northeast Thailand, but also incorporates lowland areas of Savannakhet and Vientiane Province, Lao PDR (Murphy, 2010, p. 126). Relief of the Khorat plateau is characteristically low lying and flat, with elevations in the order of 20 to 30 m (Löffler et al., 1984, p. 322). Elevations only rise approximately 100m for the Phu Phan Range running through the centre of the plateau, separating it into two drainage basins, Sakhon Nakhon in the north and Khorat in the South (Löffler et al., 1984, p. 322). The larger Khorat basin is fed by the meandering Mun River System and its major tributary the Chi River, to the north. The Mun River system runs east-to-west through the plateau, before flowing into the Mekong at the border of Thailand and Laos P. D. R.

The current climate and hydrology of the Khorat Plateau is a product of the terminal Holocene, only stabilising in the last six centuries. Prior to this stable modern period, paleoenvironmental studies from Lake Kumphawapi (Boyd et al., 1999a; Boyd, 2008; Chawchai et al., 2013) and Lake Pa Kho (Haque, 2012) in the Sakhon Nahkon Basin, indicate a series of major climatic shifts occurred (Figure 1). The Mainland Southeast Asian continent passed from the cooler/wetter conditions of the early Holocene, into the warmer/drier and more volatile mid-late Holocene period. The major climatic changes of the Holocene are summarised below:

1. **Fiftieth century BCE:** the Khorat Plateau appears to have been a "well-watered plain" with high levels of precipitation (Boyd, 2008, p. 20; Haque, 2012).

2. **Twentieth – fifth centuries BCE**: well-watered lakes and swamps disappearing, and large single channel rivers infilling (Boyd, 2008). Others place this aridity earlier, arguing for "severe dry" conditions by thirty-second century BCE (Chawchai et al., 2013) and fiftieth century BCE (Haque, 2012) respectively.

3. **Fifth century BCE– fourth century CE:** narrow multi-channel systems develop and cycles of wetness/dryness related to the strength of the summer monsoons begin (Boyd, 2008). Two key periods of dryness are the seventh – fifth centuries BCE and first – fourth centuries CE (Boyd, 2008; Chawchai et al., 2013). These periods were characterised by particularly unstable and unpredictable seasons.

4. **Fourth century CE onwards:** single-channel rivers fed by sheet-wash drainage formed and still continue today (Boyd, 2008; Haque, 2012).

Today, climate on the Khorat plateau is typically monsoonal; with dry, cool continental weather from November to February and a somewhat erratic rainy season with an average annual rainfall of 1379 mm falling predominately in July, August, and September (Thai Meteorological Department, 2005-2006).

PSKAS study area

The 500 km^2 study area that is the subject of this thesis is located in the central northern portion of the UMRV, within the southwest corner of the Khorat Plateau (Figure 1, Figure 2). The study area is located where the rich alluvial floodplains of the Mun River transition into dry terraced foothills, and approach the tributaries of the Chi River to the north. The study area has been divided into four landscape types: deep alluvial floodplains, upper alluvial floodplains, terraces (low, mid, high), and "uplands" (hill slopes above 200 m ASL). There is approximately a 100m rise in elevation (141 m ASL – 243 m ASL), from the lowest point of the alluvial floodplains beside Phimai on the Mun River, to the highest point of the sandstone hill slopes approaching Chatturat, in the northwest comer of the study area (Figure 2).

Modern drainage within the study area consists of several single-string rivers running northwest to southeast (Figure 2). Perhaps the most significant for this study are the Phon Songkhram and Huai Yai (also called Prasat River) rivers at the centre of the study area. The Phon Songkhram River continues on to join the Sa Thaet tributary some 12 km north of Phimai, which in turn joins the Mun 67 km downstream. The Huai Yai River is connected directly to the Mun at Phimai through a combination of artificial canals and natural stream networks.

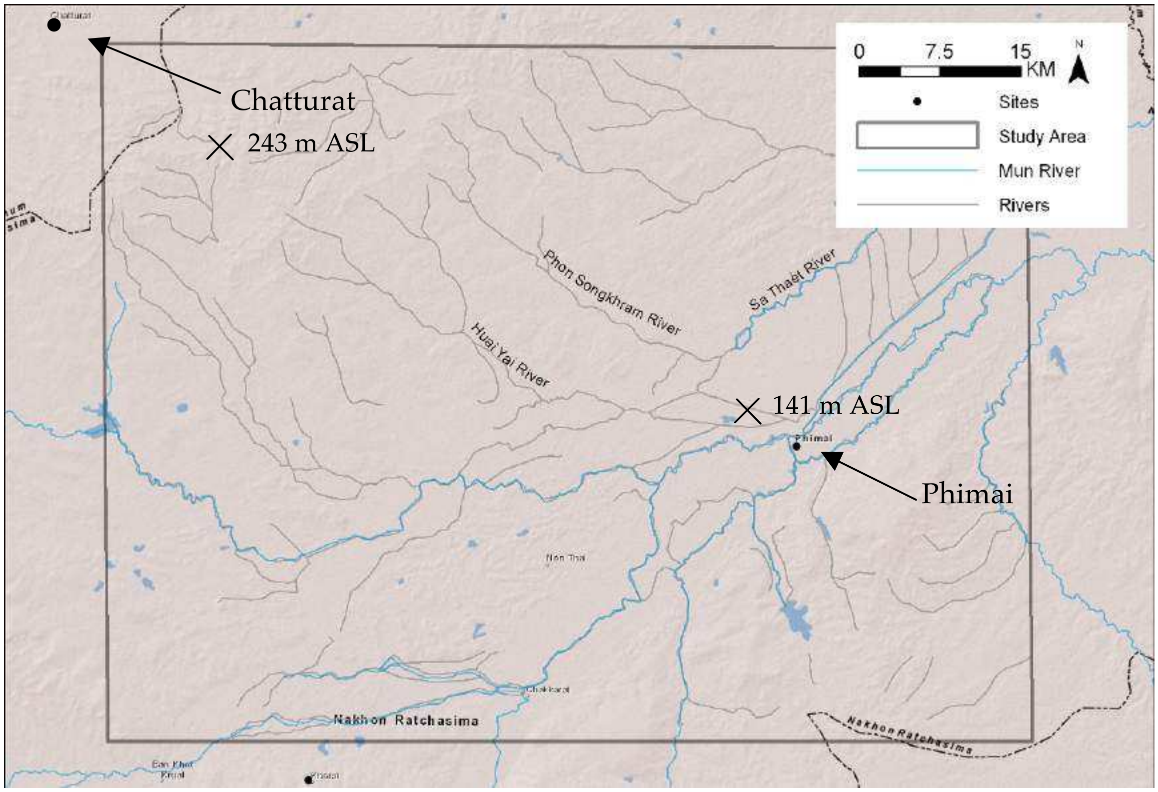

Figure 2. Modern river network in the study area.

The location of the study area, within the southwest portion of the Khorat Basin, could also be described as a gateway to northeast Thailand, with Mueang Nakhon Ratchasima as its entry point (Figure 3). This access is not just administrative. Significantly, the study area is significantly situated at a natural intersection of various natural routes. A major pass through the Phetchabun Ranges to the west of the study area, allows easy access to Chao Phraya basin and the inland connections of central Thailand. Following the Mun River to the East accesses the Mekong River, and low passes through the Annamite Range, towards the Vietnamese coast of the Southern China Sea. A gap in the Dang Raek mountain range to the southeast of the study area further links the UMRV to the riverine, and later road, network of the Tonlé Sap region. In particular, it connected the UMRV to the centre of the Angkor Empire, during the ninth to fourteenth centuries CE. This has implications for an analysis of settlement patterns, demonstrating the significance of the region to ancient and modern populations, and also the likely connection to trade routes and the flow of ideas, despite the distance from seaports.

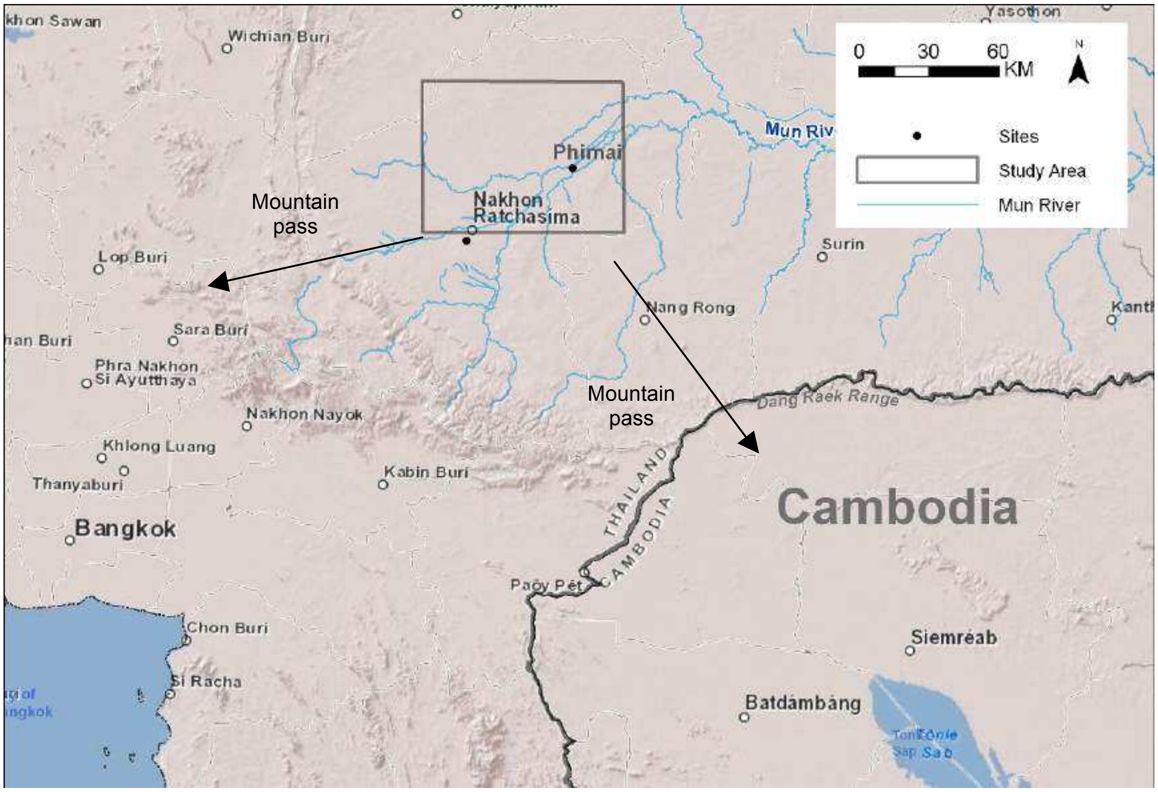

Figure 3. Mountain passes from the UMRV to central Thailand and northwest Cambodia.

2.2 Soils

Soils are a key environmental factor for ancient and early historic settlement strategies, due to their impact to agricultural practices and industrial activities. The proximity of Late Iron Age settlements to recent clays in the UMRV, for example, has been used to imply an intensification of wet-rice agriculture in the region (Chapter 3.2). The extended time frame of soil formation, typically formed over millennia, ensures that modern soil patterns contain the remains of their ancient counter-parts, and can provide a useful insight into prehistoric and early historic conditions. This chapter presents the soil profile of the UMRV more generally, and the PSKAS study area specifically.

The first national soil map series published by the Thailand Soil Delineate Division (1977-1980 CE, 1:100,000 scale) is still in used by scientists to describe the soil profile of Thailand (Higham, 1989; Welch, 1998). Its categories are based upon Moorman, Montrakun, and Panichapong's (1964) original description of the geomorphology of the basin. The soil profile was formed from extensive alluvial deposition events of the Mekong and its tributaries during the Pleistocene. The alluvial deposits record sedimentation in four phases, each separated by a period of erosion. These phases correlate to my division of the study area into floodplain, lower terrace, upper terrace, and high terrace environmental zones. The oldest, upper terrace oldest is characterised by Yasothan series red sandy soils, the middle terrace by Khorat and Udon series pale brown to yellow soils, the lower terrace by Roi Et series dark brown soils, and the alluvial floodplain are formed of fine clay and sand lenses (Moorman et al., 1964; Figure 4). The alluvial floodplain can be further divided into an underlying "old" alluvium, dating to the early to mid-late Holocene (McGrath & Boyd, 2001a), and up to 5m of "young" alluvium, built up over the last four millennia (Boonseneer, 1977; Boyd, 2008; Udomchoke, 1989). For further soil information see David Welch (1985, pp. 60-73).

Soil formation and pH within the Khorat Plateau has been influenced heavily by the underlying Mahasarakham formation, or "rock-salt formation". This formation is expressed on the surface as a series of large salt-dome outcrops emerging from the Talat Khae deposit (Dheeradilok, 1993; Welch, 1985, p. 43). The exposed rock salt is carried by rapidly rising ground and surface water into the lower floodplain of the Mun River

Valley during the wet-season (Wonsomsak, 1987). This briny salt-water then precipitates in the dry season onto the ground surface, generating a source of secondary salinisation. Although not a new phenomenon, soil salinisation has only recently reached "disastrous" levels (Iizuka et al., 2007). Post-1950's agricultural expansion into the uplands of the UMRV, has replaced deep-rooted trees with shallow-rooted crops and plantations, greatly increasing salinity transfer throughout the valley (Williamson et al., 1989, p. 153). This situation is not helped by large water reservoirs and ground water extraction for salt production.

In addition to raised salinity levels, the cyclical flooding and drying of Mun River Valley soils, over millennia, has also led to a proliferation of iron, aluminium, and manganese rich soils within the Plateau (Dheeradilok, 1993; Löffler & Kubiniok, 1996, pp. 210-211). In this process of laterisation, elements rise with the wet-season water table, to create naturally iron- and aluminium-rich nodules, in the upper layers of river valley soil (Cawte & Boyd, 2010).

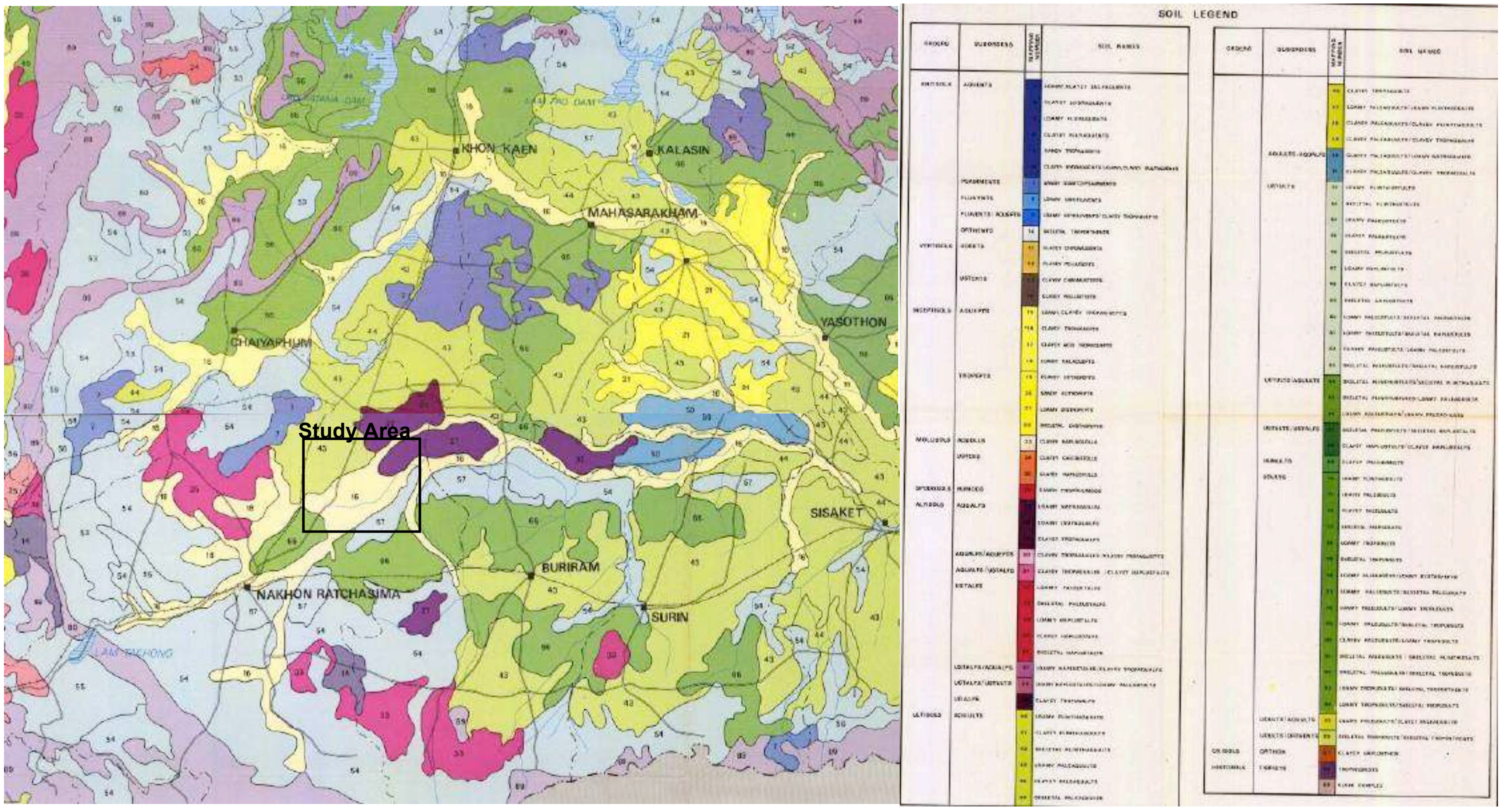

Figure 4. General soil map Khorat Basin with study area highlighted (after Vjarnsorn & Jongpakdee, 1979).

PSKAS study area

The modern soil distribution within the PSKAS study area is mixed, with large stretches of sandy loam, weathered regolith, old clays, smaller patches of highly saline soil, and more recent clays (Figure 5). Narrow tracts of alluvial complex soils can also be found bordering modern streams and river levees. Due to its proximity to the Mun River and its tributaries, the study area has a high proportion of "young" loam/sand/clay lenses in its alluvial floodplains and low terraces. The largest and most fertile stretch of recently deposited clay in the study area is located at Phimai (Figure 5). Spread over an area of approximately 1000 km^2, this clay was likely deposited in the late historical period, and today is the centre of an extensive wet-rice growing precinct (Vincent, 2003, p. 234; Welch, 1985, p. 66).

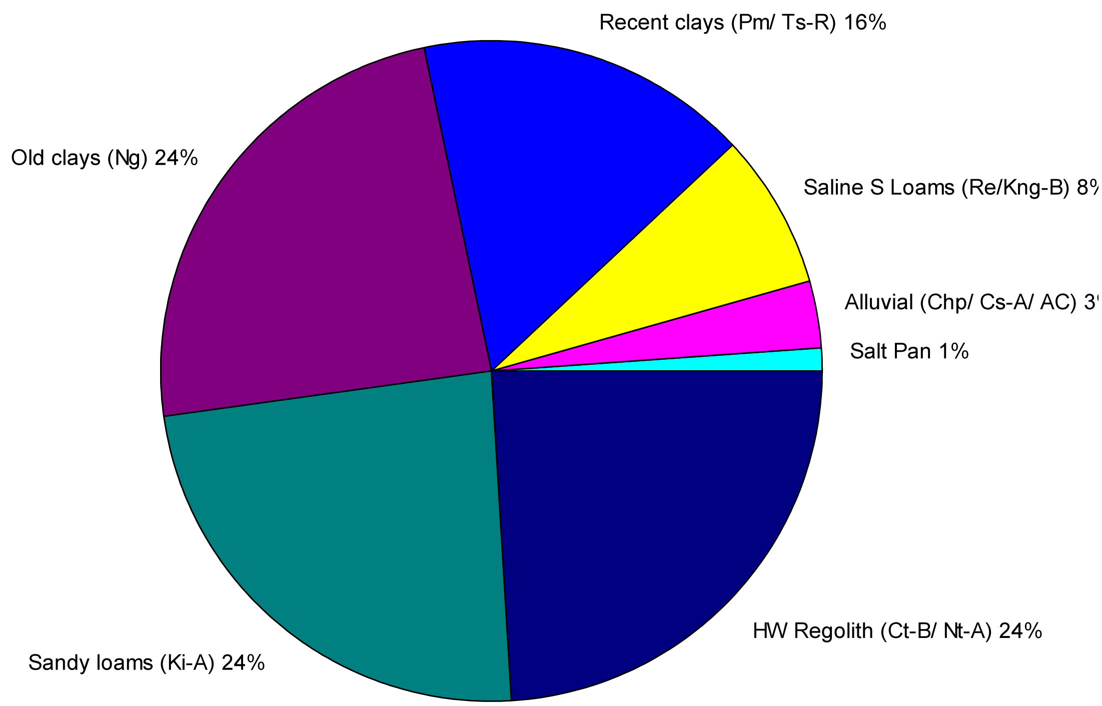

Figure 5. Modern soil profile within the study area

Higher elevations at the northwest corner of the study area offer far more challenging soils for farmers, with regolith sandstone worn down over the millennia into thin sandy topsoil (Figure 5). This topsoil is excessively drained and poorly suited to wet-rice agriculture. A network of artificial irrigation canals has been constructed in northeast Thailand in the last two decades, to combat unpredictable rains and supply farmers with water during the driest of seasons. This has allowed an increase in upland cash crops, such as sugar cane and cassava. The deforestation and ploughing associated with such crops have caused widespread soil erosion, and has depleted what nutrients remained in the largely sandy soils of upland northeast Thailand (Lorsirirat & Maita, 2006). Such sandy/ salty soil is then washed downstream towards the terraces and banks of the Mun River, where it has a detrimental effect on the paddy rice farmers of the lowlands.

With its preponderance of saline soils, and particularly shallow rock salts, the PSKAS study area is an excellent area to mine salt. High-resolution satellite imagery analysis suggests up to 14 percent of soils within the study area are affected by salt (Appendix A). Indeed, at the centre of this we find two major contemporary salt factories: the Phon Songkhram and Phimai salt factories.

The soil profile of the study area has remained unchanged for millennia, with the exception of modern clays, deposited in the early first millennium CE. As such it is a viable factor for comparison with ancient settlement distributions. Care should be taken not to draw conclusions from prehistoric settlement proximity to modern clay deposits.

2.3 Vegetation and Land Use

Ancient vegetation and land use is difficult to discern from modern data, particularly in the UMRV where vast and intense agricultural activity has changed the landscape considerably in the last five decades. Such modern land use data is not a valid factor in ancient settlement pattern studies. However, a map of modern land use and vegetation assists greatly in monitoring and understanding post depositional disturbance within the study areas, and bias in archaeological survey towards certain land types (such as villages, rice fields etc). It also serves to reveal the modern strategies used to survive and profit in the unpredictable UMRV landscape, and highlight the significance of the idea of resilience in the region.

The vegetation of Thailand is a mixture of deciduous and evergreen forest types, closely situated between Indo-Burmese, Indo-Chinese, and Malesian (Malay Peninsula/ Archipelago, New Guinea, and the Bismarck Archipelago) floristic regions (Maxwell, 2004). Pollen analysis and sediment sequences from Lake Kumphawapi in northeast Thailand give an indication of vegetation types naturally found on the Khorat Plateau (Boyd, 2007; Chawchai et al., 2013; Kealhofer, 1996). These vegetation types include savannah, dry deciduous forest, hill evergreen/ lower montane forest above 1000 Meters above Mean Sea Level (m ASL), pine woodland (200-1300 m ASL), dry semi-evergreen forest, and mixed deciduous forests (Penny, 1999; Smitinand, 1989). Following the post-World War Two agricultural expansion the percentage of forest-land in northeast Thailand has dropped considerably; from 42 percent in 1962 (Forest Resources Assessment, 2005), to 15 percent by 2001 (Food and Agriculture Organisation of the United Nations [FAO], 2004). Figures from 2010 suggest deforestation then stabilised at 15 percent (FAO, 2010). However, these figures are increasingly dominated by fast-growth plantations such as exotic eucalyptus, so it is likely that deforestation will continue.

PSKAS study area

The PSKAS study area has a modern land use profile typical of the wider Khorat Plateau (Figure 6). Step-wise classification of IKONOS satellite imagery from April of 2012 revealed that over 86 percent of the natural vegetation within the study area had been removed for wet-rice agriculture and cash-cropping (See Appendix G for method, Figure 6). The eight percent of remaining forest and scrub in the study area is comprised of isolated evergreen rainforest vegetation in the gullies, and along the banks of rivers, to pockets of dry deciduous scrub up on the terraces and hill slopes. This figure also includes collections of established trees encircling villages and stabilising wet-rice bunds, which inflate the forest/ scrub figures somewhat (J. Moloney, personal communication, December 1, 2014). The abundance and diversity of mammals, birds, herbs and mushrooms, once available to villagers as a diet supplement or a source of income, are now largely depleted (Lynam et al., 2006).

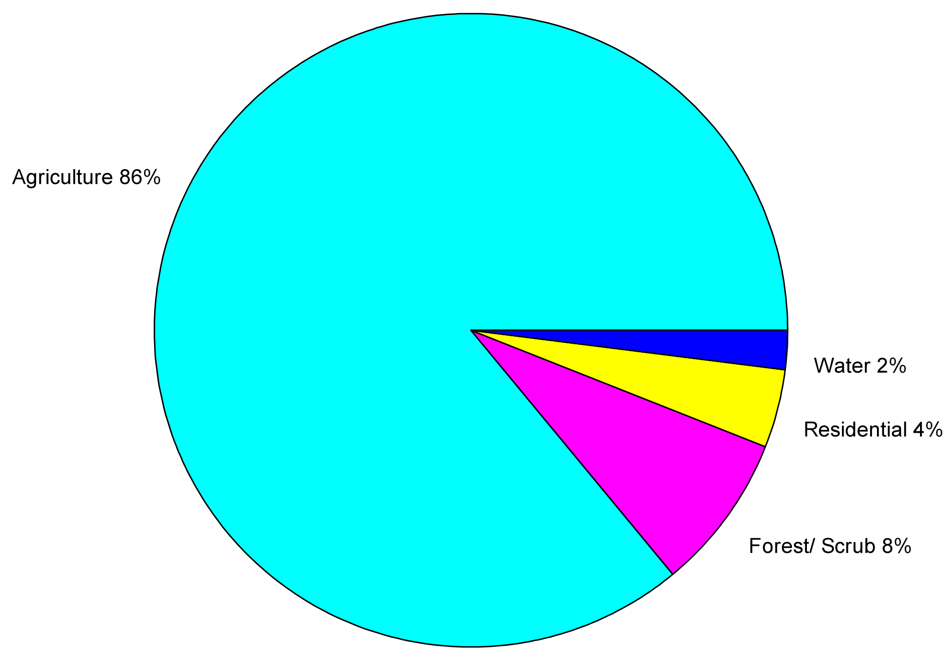

Figure 6. Modern land use profile in the study area.

Some sections of forest have been preserved for community use. The Phon Songkhram community forest at the heart of the study area has been set aside to retain some biodiversity, and for limited local village use. These community forests also serve a spiritual function. With the rise of tree ordination rituals in the late 1980s, a symbolic association between trees and Buddhism has developed (Delcore, 2004, p. 1). Furthermore, there is a long standing association between animism and trees in northeast Thailand and the adjacent mountains of Laos and Vietnam (Sponsel et al., 1998).

Aside from community forest reserves, the most recent regions of the study area to be deforested are the sparsely occupied uplands. Discussions with elderly residents of Bu Kwao village on the Khamin River during the PSKAS survey revealed that they were amongst the first to arrive in the early 1930's. These, then new residents, were greeted by dense forest and abundant wildlife, including regular sightings of deer, tigers, and elephants. It would seem that only decades ago the uplands/hill slopes of the study area contained a rich and diverse environment, with wild resources to supplement localised rice and sweet potato farming. This highlights how rapidly the landscape has changed in the last 80 years. Care must be taken in drawing conclusions from the distribution of sites by land use. Such vast agricultural activity is also certain to have impacted on the post-depositional disturbance of archaeological remains in a number of ways. Vegetation density and sub-surface agricultural disturbance will impact upon the likelihood of discovering a site – the vast ploughed agricultural areas could make site discovery easier, and reveal sub-surface early layers. However such ploughing will likely spread the remains of the site, and partially disturb the context and boundaries of a site. This is discussed in further detail below (Chapter 7.1).

2.4 Summary

This chapter has discussed the geography, climate, soils, and vegetation of the study area, both in the past and the present. The ancient UMRV landscape will form a key factor for the analysis of settlement strategies in this thesis. Modern environmental land use, allows us to understand the impact of post-depositional factors on the region, and will need to be monitored closely during the survey process.

Sandy, relatively arid, salt-affected, and with unpredictable rains, the semi-arid tropical study area is one of the more challenging environments within Thailand and Mainland Southeast Asia. Key natural assets are pockets of wet-rice suitable clay deposited during the late historic period, pervasive salt, lateritic soil rich in iron and aluminium deposits, and forest resources. Attempts to increase the short-term yield of these resources to meet modern demand include; the construction of dams and canals, slash and burn deforestation, deep salt extraction, and unrestricted fishing and hunting. This has dramatically altered the landscape of the UMRV over the last 80 years. Such extensive modern activity has implications for archaeological site disturbance, which need to be considered. Furthermore, the modern vegetation and land use, displays very little relationship with ancient land use, and cannot be used as proxy in analysis.

Prior to the modern period, paleoenvironmental records suggest that the region also had poor soils, was highly salt-affected, and experienced episodes of extreme drought. Ancient people faced many of the same issues as modern populations, yet managed to occupy and subsist in the region for over four millennia, without the aid of modern technology and industry. How ancient communities achieved this resilience is a key question for archaeologists.

There may be only limited time to answer this question. Following the agricultural revolution of the 1960's, northeast Thailand became one the largest producers of wet-rice worldwide. Furthermore, in the last decade a revolution in cassava plantation has opened up new, dry areas to agriculture. Unfortunately this industrialisation, to feed a growing international market, has led to the destruction of many archaeological sites. This is a destruction that continues today. It is increasingly urgent that the archaeology of UMRV is recorded, before a representative sample of ancient occupation no longer exists.

3. Archaeological Discipline in Southeast Asia

This chapter examines how theories of settlement within the UMRV of northeast Thailand have been heavily shaped by broader socio-political trends sweeping Mainland Southeast Asia, and the rather turbulent and fractured modern history of the region (Anderson, 1991; Glover, 2006; Trigger, 1984). This chapter provides a background to the evolution of Archaeology in Southeast Asia during the colonial period (1800 -1950s), the early modern period (1950s – 2000), and the recent modern period (2000 – 2016). An understanding of how the archaeological discipline has developed in the region exposes key gaps and controversies in the literature. These need to be addressed through more innovative and methodologically rigorous settlement pattern studies in the region. This thesis argues that these studies should include intermediate-scale data.

In the developing region of Mainland Southeast Asia the "background narrative" has impacted on archaeological discipline in a number of ways. Concepts and ideas, popular during particular periods of research, have been applied selectively, resulting in politically-laden terminology. Technical and socio-political constraints were placed on archaeological research, narrowing available fields and methods of research. Finally, as Lustick (1996) succinctly argues, "social scientists are bound to be more attracted to and convinced by accounts that accord with the expectations about events contained in the concepts they deploy and the theories they seek to test" (p. 606). Such a "historiographical" view has relevance for pre-historians as well as historians of Southeast Asia (Bentley, 2006). This relationship, however, is two-way: Archaeology is not only influenced by the development of modern history, but also appropriated to shape developing national identities and nation-state boundaries (Glover, 2006; Wood, 2011).

3.1 Re-imagining the "Glorious Past" of Indochina (1800 – 1950s)

Archaeological research in Southeast Asia during the eighteenth, nineteenth, and early twentieth centuries CE had both a political and an economical agenda, and was heavily shaped by the incursions of French and Dutch colonialists (Glover, 2006; Shoocongdej, 2011). European scholars brought with them an emphasis upon architectural features that featured Indic or Chinese symbolism, which ranked higher on the European/western developmental hierarchy. Centres or "cities" that contained these stylistic references included the river- and port-centred Cham, Dong Song, and Angkor civilisations of Vietnam and Cambodia. The contrast between these "lost" civilisations and the current populace, was used to suggest cultures required external stimulation, or would face decay and eventual collapse. Thus, clear parallels were drawn to the "benefits" of European colonisation in Southeast Asia, and colonisation and resource exploitation was legitimised (Anderson, 1991, pp. 181-182).

Cultural endowment of archaeological sites was often used by European colonialists to purport political and economic agendas. The ninth century CE Buddhist site of Borobudur, located in central java, is an excellent example. First discovered by British explorer Lieutenant Governor Sir Thomas Raffles in 1814, and later rebuilt and recorded during the Dutch occupation of the nineteenth century, Borobudur was used by the Dutch to emphasize the regions pre-Islamic past (Tanudirjo, 1995, pp. 62-70; Wood, 2011). Borobudur later became a major tourist attraction for the Republic of Indonesia, and a symbol of the Hindu Javanese cultural continuance in the region. In contrast, Islamic mosques and burial sites post-fifteenth century CE remained relatively under researched in Indonesia. Reid (1979; 2010) describes this process of down-playing Islamic involvement in nation-station construction as a form of "nationalist orthodoxy".

Such a nationalist orthodoxy has parallels to the French, and latter Khmer Rouge, appropriation of the Angkorian Empire in Cambodia. In the nineteenth century the ruling Cambodian dynasty claimed direct descent of the great rulers of the Angkorian Empires. However, it was the French research of the 1860's (Henri Mahout) and 1870's that spurred a re-imagining of the Angkorian Empire and Cambodia (Glover, 2014; Lyons & Papadopoulos, 2002). This re-imagining portrayed Angkor as a place that had became "noble" and "civilised" following Indianisation, but had since lost its "greatness", and is largely disconnected from the current Cambodian populace. This linked the Indochina space to French ideals of civilisation and cultivation, and implied the incursion of the French might once again lead the Cambodian people into a "glorious future" (Lysa, 1996). Such a contrast, between a former greatness and a current "decay", latter fuelled discontent in educated Cambodians during the 1960's, 70's, and 80's. Buoyed on a wave of increasing nationalism, and a post-war social and economic independence, Sihanouk and later Pol Pot returned to the French-constructed ideal of Angkor as the peak of attainment, and linked this with modern policy and achievements. The latter leader, Pol Pot, attempted to resurrect the Angkorian Empire in Cambodia through any means necessary, seeing the construction of such an empire as indicative of the ingenuity and strength of the "enslaved" Cambodian People, in spite of the repression of their foreign overlords/ external powers (Becker, 1998, p. 200; Wood, 2011, p. 41). Thus, the French interpretation of the symbolism of Angkor had been reversed.

Although never subject directly to colonisation by European powers, nationalism and politics have played a major role in the development of archaeology in Thailand. It was not until King Rama IV (Mongkut) in the mid-nineteenth century CE, began the process of transitioning from a Buddhist to a western calendar, that interest grew in the discipline of archaeology (Glover, 2006). Late nineteenth and early twentieth century archaeology was focused on art history, and typically practiced by "aristocratic, Western-educated Thais on the fringes of the royal clan" at institutions such as the Fine Arts University (Silpakorn) in Bangkok (Glover, 2014, p. 45; Higham, 1989, pp. 25-27). In many respects, the ancient Thai Kingdom was used by the royal clan to establish the "antiquity" of their royal claim. Establishing a long-lineage was particularly important given the pressure from neighbouring European colonists, who placed such significance in this cultural continuity and links to high-level development (Bernon & Lagirade, 1994; Krairiksk, 1991). In the 1830's, for example, King Rama IV discovered the 13th century CE Ramkhamhaeng inscription on a stone stele, then regarded to be the oldest example of Thai language and culture, and proof of connection to the Sukhothai kingdom. The authenticity of this national icon has since been questioned, with many scholars claiming the inscription dates from a later period (Glover, 2006; Peleggi, 2001).

3.2 Mounds, Moats, and Market-Places (1950s – 2000)

Interest in the prehistory of Southeast Asia was late in developing, partially as the region was considered an "archaeological backwater" with its metal age artefacts argued to be a product of diffusion from their more "civilised" neighbours (Bayard, 1980). Prehistoric inhabitants of Southeast Asia were considered "peripheral", and were seen as incapable of indigenously generated invention or progress (Coedes, 1968; Groslier, 1966). Clark (1971) summed up the antiquarian view in his outline of World Prehistory when he described the peoples of Southeast Asia, Indonesia, and the Philippines as not capable of a fully-developed "phase of technology" comparable with the other parts of the world, and as having a delayed use of stone tools well into the Christian era. Bronze and Iron artefacts, that appeared in Southeast Asia, Clark attributes to diffusion from neighbouring territories during the latter half of the first millennium CE. A perspective held by Coedès (1969) who writes "[i]t is interesting to note that even in prehistoric times, the autochthonous peoples of Indochina seem to have been lacking in creative writing genius and showed little aptitude for making progress without stimulus from outside" (p. 13).

In the 1950's this view of prehistory changed markedly. Large-scale aerial reconnaissance surveys were undertaken across Southeast Asia to reveal remnant archaeological features (Malleret, 1959a; Wilen, 1987; Williams-Hunt, 1950). Hundreds of large mounds, often encircled by a "moat" feature, were discovered across all surveyed regions, with concentrations in the Mun and Chi River Valleys of northeast Thailand. These mound and moat features indicated that complex settlement patterns, and by inference complex cultures, existed across Southeast Asia, outside of the coastal and river-junction complexes of Angkor, Funan, Champa, and Dvaravati. Terminology, such as small towns "defended" by moats and evidence of a "metropolis", first appeared in these reports, and was to have a lasting effect on future studies. In 1952 geographer Carl Sauer hypothesized that Southeast Asia was an early plant domestication site. This theory, however, was largely dismissed due to the prevailing picture of Southeast Asia as a "relict" region (Miksic, 1995, p. 49; Sauer, 1952). In the mid 1950's eminent British archaeologist Horace G. Quaritch-Wales excavated four "fortified" mounds located in northeast Thailand, and concluded two periods of occupation were present: a Dvaravati period (sixth – tenth centuries CE) leading into the "Khmer" or Angkor period (tenth – thirteenth centuries CE, Quaritch-Wales, 1957). Dating relied heavily on the presence of Iron in the lower layers, at that time believed to be a product of Indianisation. Re-interpretation of the sites excavated by Wales has since pushed the earliest date of occupation back into late prehistory (McNeill, 1997; Solheim, 1972)

Despite increasing evidence for a rich and largely undiscovered prehistory across Mainland Southeast Asia, only limited excavation of mound features were undertaken over the following two decades. In 1968 a series of excavations at large habitation mounds in the Chi River Basin of Thailand, including Non Nok Tha and Ban Chiang, renewed interest in these large prehistoric/ protohistoric features, and would return the focus to models of food production and economic development (Bayard, 1972; Bayard, 1980; Gorman, 1977; Higham, 1975; Solheim, 1972). These major excavations led to a series of pedestrian surveys in the Lake Kumphawapi region of Thailand by Higham and Parker (Higham & Parker, 1970; Table 2, Figure 1). The Lake Kumphawapi survey studied the Ban Chiang culture of northeast Thailand using a combination of aerial survey, local interviews, and limited directed transect survey (Kijngam et al., 1980). Kijngam and colleagues (1980) used patterns in moated site-size is used as a proxy for the development of hierarchy and political complexity. Results appear to indicate a two-tiered or "chiefdom-level" site hierarchy exists in the Kumphawapi area, with at least one large centre. Hierarchical organisation in this context refers to a linear, ranked “urban-driven” trajectory of social and economic development (Earle, 1978; Wright, 1984). This, Kijngam and colleagues argued, suggested the beginnings of state-level organisation in the region. However, Wilen (1982) criticised the settlement analysis presented by Kijngam and colleagues (1980), suggesting a reconnaissance/interview survey that focuses heavily on a single site type, in this case moated sites, is not statistically viable (also see Higham et al., 1982). Furthermore, there is little discussion of the proportion of “non-producers” within a site, an important indicator of a politically organised settlement system (Steponaitis, 1981; Wilen, 1982).

Table 2:

Archaeological Projects Discussed In-Text

Project	Location	Type	Results	Reference
Quaritch-Wales	Chi River Valley	Excavation	Excavation of four “moated” sites, including Muang Phet and Thamen Chai.	Quaritch-Wales, 1957
Solheim, Bayard & Gorman	Chi River Valley	Excavation	Excavation of several Hoabinhian and prehistoric sites, including Ban Chiang, Non Nok Tha, and Spirit Cave.	Bayard, 1970; Gorman & Charoenwongsa, 1976
Lake Kumphawapi	Ban Chiang region, northeast Thailand	Survey, Excavation	Survey recovered 30 sites, 17 prehistoric and 13 historic, at a density of 0.03 per km^2, with 76 percent of sites described as “mounded”.	Kijngam et al., 1980
KBAP I, KBAP II	Phimai Region, northeast Thailand	Survey, excavation	Survey identified 334 potential and 107 confirmed sites, at a density of 0.153 sites/ km^2.	McNeill & Welch, 1991; Welch, 1985
Lam Maleng Survey	Lam Maleng Valley, central Thailand	Survey	Survey identified 159 sites, at a density of 1.68 sites/ km^2.	Mudar, 1995
KSTUT	Upper Chao Phraya River Valley, central Thailand	Survey	Survey identified 25 open-air sites, at a density of 0.43 sites/ km^2.	Eyre, 2006; Eyre, 2010
Origins of Angkor	Mun River Valley	Excavation	Excavation of eight prehistoric and pre-Angkor sites, dating as early as the Neolithic, including Phimai, Ban Non Wat, and Noen U-Loke.	Higham, 2001; Higham, 2012.
Society and Environment Before Angkor	Mun River Valley	Excavation	Excavation of three prehistoric sites, Ban Non Wat, Nong Hua Raet, and Ban Salao, dating as early as the Neolithic.	Boyd & Chang. 2010
Khao Wong Prachan Valley Project	Khao Wong Prachan Valley, central Thailand	Survey	Survey and metallurgical analysis identified sherd carpet of Iron Age and (predominately) “Dvaravati” material.	Pryce et al., 2011

Two conclusions emerging from the Lake Kumphawapi survey would direct subsequent surveys in the region: that interview from local inhabitants was the most "profitable" way to find sites and that there is a strong correlation between sites and modern wet-rice agriculture (Kijngam et al., 1980, p. 10; Wilen, 1987). With regard to future surveys in the region, Kijngam and colleagues commented on the need for a "concentrated settlement pattern survey of these small (c. 0.6 - 5.2 ha) burial and settlement sites relative to the paleoenvironment" (Kijngam et al., 1980, p. 57). Although latter criticised for methodological inconsistencies, the Lake Kumphawapi project and later excavations in the Chi River Basin, signified a resurgent interest in the, largely prehistoric, habitation mounds of Southeast Asia. It also identified late prehistory as a significant formative period in Southeast Asia, worthy of further investigation.

In 1984 and 1989 the Khorat Basin Archaeological Project (KBAP I & KBAP II) applied many of the Lake Kumphawapi survey recommendations to complete a major survey near the Angkorian city of Phimai in northeast Thailand (Welch, 1985; Welch & McNeill, 1991; Table 2). The aim of the KBAP project was to "investigate the development of town centres which emerged in northeast Thailand during the late prehistoric Formative Period (ca. 600 B.C.-A.D. 600) and the early historic period (ca. A.D. 600-1300)" (Welch, 1985, p. v). Approximately 62 black and white aerial photographs (1: 42000 scale, taken in April 1954) were examined for evidence of large archaeological structures. These images covered approximately 16,000 km^2 of the Phimai region, overlapping much of the study area for this thesis (Figure 2). Welch (1985) indicated this method of survey was very successful, and is "confident that for all [environmental] zones the photographs permit the identification of the great majority of the habitation sites occupied from the late prehistoric period [onwards]" (p. 153). He noted, however, that such a technique relies heavily upon definitions of sites as large, "walled and moated" mounds (Welch, 1985, p. 143).

In addition to reconnaissance survey, the KBAP also conducted a systematic, intensive, pedestrian survey in 50 m transects of the 16 km^2 surrounding Ban Tamyae, and two non-systematic pedestrian surveys following the old alluvial channels between Ban Prasat - Ban Ya Kha and Ban Tha Luang - Non Ban Kham respectively (Welch, 1985). None of these three intensive surveys returned any archaeological surface material, beyond the sites already identified by aerial photography, which included Ban Prasat, Ban Ya Kha, Ban Tha Luang, Non Ban Kham, and Ban Tamyae. Key factors to consider are whether this absence of surface artefact material indicates that intensive surface survey is ineffectual in northeast Thailand, due to overwhelming post-depositional disturbance caused by annual flooding and intensive agriculture that has covered archaeological remains. Or, alternatively, that the major river floodplains simply did not contain a high density of pre-modern occupation relative to other sub-regions (Welch, 1985, p. 151). The findings from the KBAP survey largely appeared to confirm Higham and Parker's early conclusion that a two-tier hierarchy existed in northeast Thailand prior to Indianisation or historical influence, and that wet-rice agriculture was key to late prehistoric settlement patterns. Welch proposed that a temple and market-place structure was in place throughout the historical periods to regulate exchange networks, and that the origins of this lay in late prehistory (Welch, 1989). Such a model borrowed heavily from Wheatley's (1975) and Hall's (1985) use of Angkor ceremonial centres to redistribute wealth, with the competitive market network model proposed by Christie (1985). Although clearly the most systematic and wide-spread survey of Southeast Asia to date, this study, once again, was biased towards mounded features with encircling earthworks or "moats" large-enough to be visible from aerial photography. Furthermore, there are issues inherent in using models of thirteenth/ fourteenth century CE Angkor in the Tonlé Sap Basin, to direct analysis of first - fifth century CE northeast Thailand.

A rare example of an archaeological project not focusing solely on mounded features is the Lam Maleng and Kok Samrong-Takhli Undulating Terrain (KSTUT) surveys in central Thailand. Following criticism of earlier reconnaissance style surveys, including Lake Kumphawapi and the KBAP surveys, the Lam Maleng survey undertook a full-coverage regional-scale survey in artefact watersheds of the mid-upper terraces of the Lam Maleng Valley, central Thailand (Mudar, 1993; Mudar, 1995; Wilen, 1982; Wilen, 1987). In direct contrast to previous surveys, all of the prehistoric sites recovered from the Lam Maleng survey were non-mounded artefact concentrations, which tended to be located within the upper terraces on a variety of soil types (Mudar, 1999). Building on the findings of the Lam Maleng survey, the KSTUT survey targeted the eastern half of the Upper Chao Phraya River Valley, central Thailand (Eyre, 2006; Eyre, 2010). The KSTUT project also used tiered full-coverage survey. The findings of the Lam Maleng and KSTUT surveys suggest the type and number of sites recovered depends, at least partially, upon on the survey technique utilised. Furthermore, with the increase in site detail, numbers, and variety, the application of new socio-political concepts and frameworks became possible, most notably heterarchical models. Heterarchical models emphasize the development of multiple, discrete settlements simultaneously (Brumfiel, 1995; Mudar, 1995; O'Reilly, 2000; White & Eyre, 2010). Metal-age sites were found on land that differed considerably in agricultural potential, and appeared to be grouped into ceramic sub-regions. This, coupled with “residential-style” burials and consistent reuse of sites, is more indicative of a decentralised or heterarchical system. In the Upper Chao Phraya River Valley, for example, Onsuwan Eyre presented evidence for a dual approach to settlement organisation: an internally “loose” organisational structure, which emphasizes large village production centres of variable size, balanced by a more cohesive, external socioeconomic-driven identity (Eyre, 2010). It is difficult, however, to determine whether interpretations of hierarchy or heterarchy are revealing the socio-political reality of the place and time under study, or are instead a result of the systematic versus non-systematic approaches to survey.

With the advent of new laboratory techniques, and the increasing reliability of radiocarbon dating, in the 1990’s and early 2000’s, archaeological projects began to expand and incorporate large-scale excavations of mound features. The Origins Angkor Project was a multi-disciplinary project that studied archaeological features of the Mun River Valley, northeast Thailand, from the mid 1990’s to 2007 (Higham, 2002). The Origins of Angkor project used the results of the Lake Kumphawapi and KBAP surveys to focus upon eight mounded sites (Table 2). Excavations revealed a highly complex, and relatively “wealthy” series of occupation and burial mounds, which dated from the Neolithic Period or eighteenth century CE, till the “protohistoric” periods or sixth century CE (Higham, 1989). The findings from these excavations are discussed in further detail in Chapter 4.1. The focus was not only on the mounds themselves, but also in the earthworks that encircled them.

The defensive nature of mounds and encircling moat-like features has been a focus for investigators within Southeast Asia, since first discussed by Williams-Hunt in

1950. Defensive features, triggered by inter- and intra-community violence and competition over key resources, are an important indicator of two-tiered or chiefdom-level organisation (Carneiro, 1981; Earle, 1997; Redmond & Spencer, 2012; Spencer, 2000). However a lack of weaponry recovered in burial contexts, coupled with the shallow and irregular nature of many encircling earthworks cast doubt upon the defensiveness of mounded settlements in Southeast Asia, particularly in northeast Thailand (White, 1982, p. 45; White, 1988). Professor Bill Boyd's geoarchaeological analysis of these moat-like features has turned the focus from defence towards manipulation of the local environment. Boyd reconstructed fossil channel networks and excavated several prehistoric "moats", to suggest a feedback model for the relationship between climate, moats, and settlement (Boyd, 2008; Boyd et al., 1996; Boyd et al., 1999a; Boyd et al., 1999b; Boyd & McGrath, 2001a; Boyd & McGrath, 2001b; McGrath et al., 2008). This marks a shift in focus within Southeast more generally away from proving/disproving evidence of hierarchical development or urbanism, towards the role of the environment in settlement patterns both locally and on a broader scale.

Continuing this trend, the Society and Environment before Angkor project, conducted from 2007 to 2013, has gradually built a model of the archaeological landscape within UMRV, through excavations, survey, environmental and ethno-archaeological studies (Table 2). This includes further excavations at Ban Salao and Non Klang, which is a part of Nong Hua Raet village, as well as several new excavation pits at Ban Non Wat, which are orientated in an approximately east-west transect across the mound.

In summary, previous research in Thailand has focused, almost exclusively, on the large mounded habitation mounds that appear to proliferate flooding zones of Mainland Southeast Asia. Excavation of several of these mounds has revealed a complex pre-historic culture(s) that pre-dates Indianisation by millennia. Such archaeological evidence has been used to develop models of state-development, hierarchy, heterarchy, and urbanisation, and has ensured prehistory is unconsidered in equal measure with proto- and historical research. However, these studies of prehistory are rarely combined with an examination of the ensuing historical periods in northeast Thailand, and the supporting body of archaeological evidence remains within traditional survey and excavation processes. This is beginning to change as there is now a growing internal push within Southeast Asia to reflect upon the processes adopted within the region, what agendas have driven those processes, and how they might be improved upon (Shoocongdej, 2011). At the same time, new areas of methodological and technological innovation emerging from Central Thailand, Cambodia, and China present an opportunity to update our approach to settlement studies in northeast Thailand and really address the missing intermediate-scale settlement data.

3.3 Methodology and Innovation: Lessons from Central Thailand, Cambodia, and China (2000 - 2015)

In the last decade archaeological projects from central Thailand, Cambodia, and China have been subject to technical and methodological innovation, with surprising and often revealing results. These case studies are part of a wider trend in the discipline of archaeology within Southeast Asia, towards challenging traditional models and modes of archaeological research, and moving beyond disciplinary, political, and technological boundaries.

In Southeast Asia there have been few attempts at intensive pedestrian survey outside of traditional mound features. This is, in part, due to a perception that surface artefacts do not provide sufficient information regarding early or prehistoric periods of occupation. There may also be some hesitancy, due to the intensive and time-consuming nature of such a survey. The Khao Wong Prachan Valley project team, however, successfully conducted a highly intensive pedestrian survey in central Thailand, confirming the feasibility of such a technique. In 2011 Pryce and colleagues conducted a small scale (two km^2) intensive, systematic pedestrian survey at a fine resolution, with 10 m transects. This was conducted within the Khao Sai On region of the Khao Wong Prachan Valley, central Thailand. The project hoped to uncover the household-scale distribution of Iron Age metal-working activity and to test the usefulness of intensive pedestrian survey within Thailand. Pryce and colleagues (2011) noted that a range of material was recovered, including a large body of prehistoric artefacts. With regard to the usefulness of intensive pedestrian survey he argued strongly that:

> Unbroken and intensive survey coverage at some meaningful resolution in Southeast Asia is often feasible (excluding some very mountainous and/or jungle environments) and with geomorphological forethought (see, e.g., Ciarla and Natapintu 1992) can provide an unprecedented understanding of diachronic landscape usage. (Pryce et al., 2011, p. 63)

Although the Khao Wong Prachan Valley project was specifically an archaeo-metallurgical study, there is great potential for applying similar techniques to record and analyse intermediate-scale (local) and within-site occupation in northeast Thailand, and other regions of Mainland Southeast Asia. This could be particularly useful, if results can be coupled with new technology, and spatial analysis software.

In the Tonlé Sap region of modern-day Cambodia, traditional survey techniques have been integrated with new, remote technology, with great success. The Greater Angkor, and associated Light Detection and Ranging or LIDAR survey of Angkor, Phnom Kulen, and Koh Ker, are both international, multi-disciplinary projects led by researchers from Sydney and Monash Universities, in association with the Cambodian Authority for the Protection and Management of Angkor and the Region of Siem Reap or APSARA (Evans et al., 2013). They form a small but growing body of projects, centred in modern Cambodia, that are interested in how emerging spatial technologies might illuminate long-term settlement in Mainland Southeast Asia. Prior to 2012, the roads, cities, and temples of the Angkor Empire (ninth– fourteenth century CE) were largely obscured by dense forest, with examples outside of the modern city Siem Reap difficult to survey due to unexploded ordinance and land-mines. However, in 2012 airborne laser scanning using LIDAR technology, was used to map in significant detail (<1cm) the vast structures of the Khmer capital of Angkor. The results revealed a well-planned urban sprawl, with temple complexes, and the remains of large-scale hydrological projects which had, and in some cases continue to, transform the landscape (Evans et al., 2013).

Building on the study of the urban spaces found near major structures of the central temple complex, Miriam T. Stark and colleagues (Evans et al., 2013; Stark, Rachna, Piphal, & Carter, 2014 [IPPA conference presentation]) have undertaken intensive, systematic survey within the walled enclosure of Angkor Thom to determine whether "house-like" mounds, roads, and ponds visible in the LIDAR relate to occupation. Stark and colleagues found that occupation levels, as interpreted from surface ceramics, were lower then expected, and more in keeping with acolytes and visitors to the temple, rather then a densely occupied city (Stark, Rachna, Piphal, Carter, 2014). In an associated mapping project, Mitch Hendrickson studied the road system connecting the centre of Angkor Empire to its regional hubs (Hendrickson, 2007). Historical accounts, satellite imagery, and reconnaissance survey were combined to reveal a vast and complex road network. Far from being static, this road network emerged from requirements specific to each region, and changed to meet the needs of the empire over time (Hendrickson, 2010, pp. 493-494). This series of associated projects, based in the Tonlé Sap region of modern-day Cambodia have drawn attention to the potential of spatial technology and mapping to reveal, often quite nuanced, human-landscape interactions. It has further reinforced the difficulties of structural or walled "site" boundaries and how they may not reflect "everyday" occupation. It is clear that there was a more organic relationship between people and their local landscape than architecture/structures and historical documents would lead us to believe. Balancing historical research and archaeological survey, as well as traditional and non-traditional methodologies, is critical to understanding settlement trends.

The Chifeng International Collaborative Archaeological Research Project or CIRCP in the Yuncheng and Chifeng regions of southwest Inner Mongolia and northeast China is an excellent example of how this balance can be achieved. The CICRP was developed by the; Institute of Archaeology at the Chinese Academy of Social Sciences, the Inner Mongolia Institute of Archaeology, Jilin University, Hebrew University, the University of Pittsburg, and the University of Hawaii at Manoa (Drennan & Dai, 2010; Peterson & Drennan, 2005; Peterson et al., 2010). The Yuncheng and Chifeng portions of the CICRP survey covered 1500 km^2 and 1234 km^2 respectively, at a 50m resolution, providing detailed, medium-scale data on the spread of archaeological material of all periods across the northeast Chinese landscapes. In the tradition of pioneering "Field-by-Field" settlement pattern studies of the Valley of Oaxaca some 40 years earlier, the CICRP utilised a complete-coverage, site-less approach to recording. This generated a grid network of artefact densities, and avoided overly simplistic site definitions (Blanton et al., 1979; Kowalewski et al., 1989). The surveys revealed a fluid and complex picture of population growth and movement during the Neolithic and early Bronze Ages of northern China, with different sub-regions expanding at different rates, and with differing levels of socio-political complexity. The study revealed the tendency to view all archaeological trends within China from the perspective of, or in response to, the famous Yellow River Valley region, with its early historical texts and state complexes (Drennan & Dai, 2010). Such a top-down historical/ empire-state bias in China has obvious parallels to the archaeology of Mainland Southeast Asia, with its tendency to present prehistoric and pre-Angkor settlement as an inevitable trajectory leading to the development of the Angkor Empire. More regionally specific studies, such as those conducted by the CIRCP, can reveal complex and somewhat independent socio-political trajectories, as much a product of internal machinations as they are of external influences.

3.4 Summary

Mainland Southeast Asian archaeology is entering an era of technical and methodological innovation. In several key, developing regions there is a movement towards comparisons across nation-state boundaries, and more localised, community-focused research. We can no longer rely on selective excavation of a collection of large, visible archaeological mounds, located almost exclusively in the alluvial floodplains, that was the focus of much of the second half of the twentieth century. Nor can we neatly fit archaeological findings in to a Western-driven discourse on linear state-development or rely upon politically-laden terminology (Cowgill, 2004; Glover, 2006; p. 7; Miksic, 2000; Wheatley, 1983, p. 419).

However research of this nature has traditionally, and continues, to dominate the archaeological research focus of northeast Thailand. In order to move forward, a systematic approach to archaeological research is required in northeast Thailand. Inspiration has been drawn from Central Thailand, Cambodia, China and Vietnam. This includes an approach that:

- Integrates traditional survey and excavation techniques, with new spatial technologies and software.
- Encompasses both archaeological and art historical evidence.

- Maintains a careful balance between internal development and external influences, when interpreting settlement patterns.
- Is conscious of the histographical past of the region under investigation, and attempts to move beyond politically-laden terminology.

With these ideas in mind we now turn to closer consideration of what is currently known about the study region for this thesis – the prehistory and history of the Upper Mun River Valley.

4. Evidence of Settlement from the UMRV, Thailand

The previous chapter highlighted the large body of survey, excavation and art historical research, focused upon, or near northeast Thailand. What follows is a summary of the findings from that research, separated into prehistoric and protohistoric/ historic sections. From the eighteenth century BCE Neolithic agriculturalists of the UMRV terraces, through the technological breakthroughs and complex burials sequences of the Metal Ages and the inter-regional exchange of ideas and religious symbolism during the protohistoric period, until the political and economic incursions of the Angkorian Empire in the tenth to fourteenth centuries CE. The existence and cultural complexity of communities of the UMRV, and the key role they play in the wider region of Mainland Southeast Asia, has been revealed. However, there remain gaps in our knowledge in the region, which currently relies heavily on large burial and habitation mounds of the alluvial floodplains. We are yet to develop a complete picture of how settlement developed long-term in the UMRV, particularly during the elusive Neolithic period, and the centuries immediately prior to the spread of Angkor.

4.1 Prehistoric Evidence

The earliest permanent sedentary settlement of the UMRV, that we have evidence of so far, dates from the eighteenth to the fifteenth centuries BCE or the "Neolithic" period (Gorman, 1971). The Neolithic remains one of the least understood periods of northeast Thailand prehistory with so few published examples of sites (Glover, 1991, p. 352; Higham, 2012). This paucity of evidence partially derives from a reluctance to survey for pre-metal age sites. It is generally considered that the deeper the archaeological deposits are under present ground surface the less likely material will reach the notice of site surveyors (Higham & Kijngam, 1984). Rather, what information we have is derived from the excavation and survey of large, multi-period mounds, from which evidence of Neolithic settlements is uncovered in the basal layers.

Neolithic settlements excavated in northeast Thailand range in diameter from greater-than 400 m (Ban Chiang), through to 100 m (Non Nok Tha, Bubpha, 2003; Higham & Thosarat, 1998). Neolithic sites appear to have been small in size, particularly when compared to Neolithic sites from costal Vietnam, including Da But and Con Co Ngua (Bui Vinh, 1991; Higham & Kijngam, 2010). Furthermore, given their low sherd levels and shallow sediment build up, it is likely Neolithic sites sustained a low population density (White, Charoenwongsa, & Goodenough, 1982). Following an aerial photograph survey of mounded sites, Kijngam and colleagues (1980) concluded that Neolithic mounds were typically constructed in low alluvium terraces within river or stream floodplains or at the edge of shorelines or lakes. White (1982) has proposed that early settlements were deliberately located in gentle or "predictable" flood areas, as evidenced by the multiple, shallow flood lenses at the basal layers of several Neolithic sites; most notably Ban Na Di (Higham & Kijngam, 1984; Van Liere, 1980). Managing flooding, particularly with regards to burial, might also relate to the tendency for Neolithic burial mounds to be located upon slight, natural bedrock embankments or prominences. Mudar (1995), however, has critiqued the methods used to survey the Khorat Basin, arguing that Higham and colleagues' (1982) and Welch's (1985) survey of prehistoric sites was biased towards wet-rice suitable soils. In fact, when a systematic survey was applied to Lam Maleng, Central Thailand, Mudar (1993; 1995) uncovered a tendency for Early Period sites (twenty-fifth to fifth centuries BCE) to be located on upland areas, unsuitable for wet-rice cultivation (Mudar, 1995, p. 185).

What also must be considered is that Neolithic sites were active at a time when environmental conditions would have been considerably wetter and more humid, with a predicted sea level two to four metres above modern levels (Boyd, 2008). Several of the paleochannels, which are currently in-filled with alluvium clays and sand-fans, would have effectively been shallow swamps or embayments in the Neolithic. There would have been far fewer seasonal fluctuations, and estuarine and freshwater resources would have been more readily available; a fact supported by the prevalence of shell middens in the basal layers of almost all excavated Neolithic sites, most notably Ban Non Wat, Non Nok Tha, Khok Phanom Di, and Nong Nor (Higham, 2014, p. 8). The UMRV would have been a highly appealing location for early sedentary settlements.

Genetic and Isotope studies indicate Neolithic settlements contained a complex and varied population, with both migrant and local groups. Carbon, strontium, and oxygen isotope results collected from dental enamel from Ban Non Wat and Ban Chiang indicate a balanced diet of C_3 rice and C_4 meat/ marine resources in the early periods of occupation (twenty-first - ninth centuries BCE, Boyd & Chang, 2010; Bentley et al., 2011;

King et al., 2012). However, the strontium signature of Ban Chiang, versus the neighbouring Ban Chiang Eastern Soi occupation mound, appear to differ significantly with regard to variance. This led Bentley and colleagues (2011) to suggest Ban Chiang contained a migrant population, whereas the nearby mound of Ban Chiang East Soi constituted a pre-existing local population. There is also evidence of population variance within other sites. Intra-site variance of isotope signatures, implying inter-community groupings, is noted in Ban Lum Khao's early Bronze Age population (Bentley et al., 2009). Interestingly, an unusual and early collection of flexed burials from Ban Chiang (Bentley et al., 2010) and Ban Non Wat (King et al., 2013; Newton, 2013) both contained highly anomalous skeletal and dental pathologies, a markedly negative carbon isotopic signature indicative of a greater reliance on wild meat resources (King et al., 2013, p. 1687), and a strontium signature originating from "more open conditions, or higher altitudes" (Bentley et al., 2010, p. 876). These results appear to support Higham's (2009) interpretation of flexed burials in the earliest Neolithic layers of Ban Non Wat and Ban Chiang as the remains of hunter-gatherers co-existing with migrant agriculturalists.

It would appear that earliest sedentary or "Neolithic" settlements were low-density and varied in size, contained multiple population groups, and were predominately located upon naturally raised areas with easy access to marine and estuarine resources. However, these conclusions are derived from a single source; large multi-period mortuary sites in wet-rice suitable soils. We need more sites, identified by systematic survey, to verify patterns of Neolithic occupation in the UMRV.

The Metal Ages form the bulk of the prehistoric period, and encompass the spread of bronze and iron technology into the UMRV from the fifteenth century BCE till the mid sixth century CE. Once again the primary source of information is large multi-period habitation/burial mounds. However the Iron Age does contain production-focused sites, such as the salt processing sites Bo Phan Kan and Non Tung Pie Pone, and the Iron smelting site Ban Dong Phlong (Higham, 1977; Nitta, 1997).

Settlement studies have revealed a tendency for Bronze and Iron Age sites of the UMRV to be located close to modern and ancient water sources (Boyd, 2008). Kijngam and colleagues noted a significant number of surveyed sites in the Lake Kumphawapi region of the Chi River Valley were located within 1.7 km of modern water features (Kijngam et al., 1980, pp. 64-65). The KBAP survey in the Phimai region also recorded a preference for prehistoric sites to be located close to modern water sources (Welch, 1985). Welch argued that this revealed an overall preference for lower elevations where water features were more plentiful, with 0.12 moated prehistoric sites per km^2 in alluvial floodplains, 0.11 in the terraces, and 0.02 in the "uplands" (Welch, 1985). This tendency extended to both modern water features, and those contemporary with the Metal Ages. Boyd's geoarchaeological study of the UMRV, which included a reconstruction of pre-modern water networks, found that prehistoric sites clustered "within the approximately one-fifth of the floodplain in which the former rivers flowed" (Boyd, 2008, p. 13). Bill Boyd noted that during the early centuries of prehistory, run-off was high and near-by resources plentiful, and sites tended to be located in elevations at low risk of river flooding, likely on elevated banks next to large deep rivers (Boyd, 2008, p. 15). When environmental conditions became dryer and more volatile, from the mid fourth century BCE onwards, however, fossil channels were adapted to encircle mounded Iron Age sites, whist remaining connected with a larger fossil river network (Boyd, 2008, p. 13).

This focus on irrigation matches well with the placement of Metal Age sites on or near soils well-suited to wet-rice agriculture, slightly raised to allow for flooding events (Kijngam et al., 1980, pp. 64-65; Welch, 1985, pp. 320-321). Such positioning, coupled with the presence of rice in burial contexts and rice-farming implements, has led researchers to argue for an intensification of wet-rice production during the Metal Ages, culminating with a surplus by the terminal Iron Age (Bellwood, 2001; Glover & Higham, 1996; Higham, 1989; Higham & Tracy, 1998; Kealhofer, 2002). There are, however, questions over environmental bias towards wet-rice locations, when surveying the Phimai Region and Lake Kumphawapi regions (Eyre, 2010; Wilen, 1987). Furthermore, Christina Castillo's archaeobotanical study of the UMRV indicates intensive Indica wet-rice did not dominate until the terminal Iron Age or protohistoric periods (Castillo, 2011; Castillo et al., 2015). Rather, less intensive rain-fed Japonica rice and dryland millet farming was prominent during the early to mid Metal Ages (Castillo, 2011, p. 117).

Despite the length of the prehistoric era, and the changeable nature of local conditions during the early centuries CE, consistency of site location was a feature of UMRV settlement patterns, as was steady population growth, and expansion out from large occupation sites (McNeil & Welch, 1991). This is best exemplified by the site of Ban Non Wat.

Ban Non Wat

This site is the richest source of Neolithic and Metal Age information for the Upper Mun catchment (Figure 7). Located in upper alluvial floodplains, approximately 24 km northwest of Phimai, Ban Non Wat is a mid-sized mounded feature 300 m in diameter, five metres in height (above the current floodplain), and with at least three encircling water features. Excavations conducted east-to-west by the Origins of Angkor team from 2002-2007, and then by the Society and Environment Before Angkor team from 2007-2011 have revealed nearly 700 human burials stretching from eighteenth century BCE Neolithic settlers, to late Iron Age (sixth century CE).

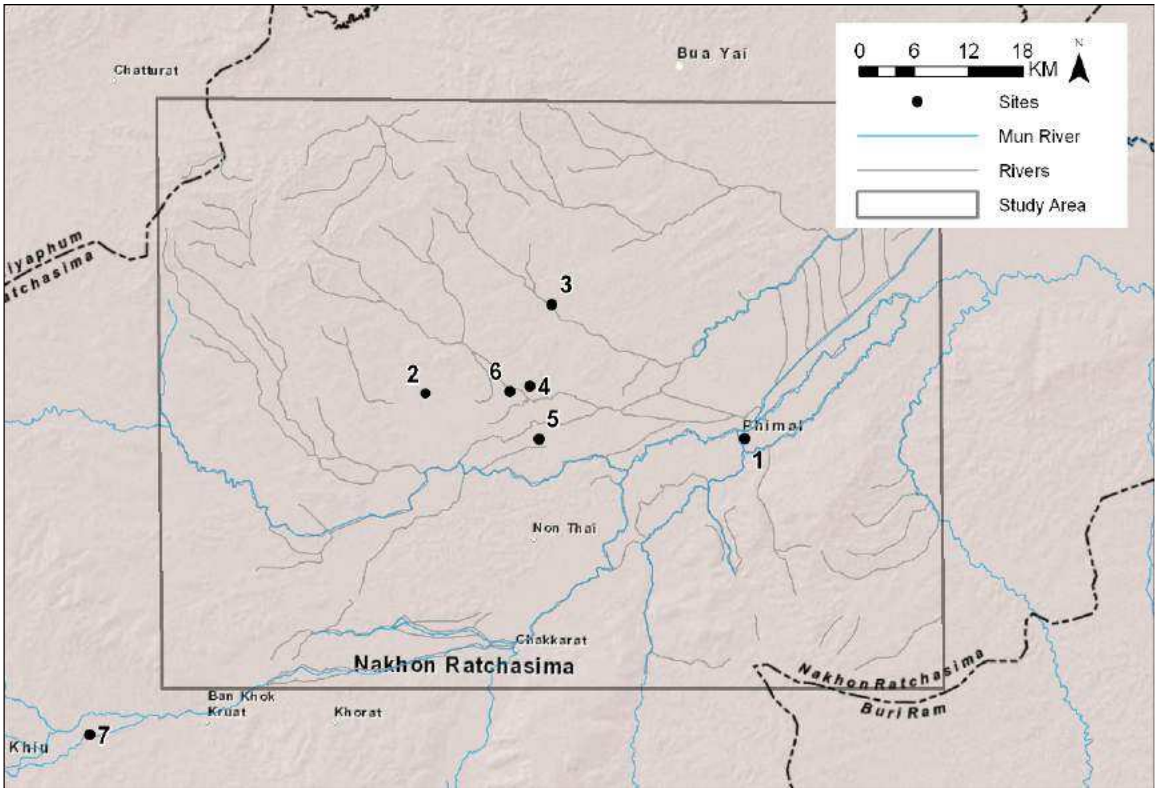

Figure 7. Major sites in the UMRV: 1. Phimai, 2. Non Ban Jak, 3. Phon Songkhram, 4. Ban Non Wat and Noen U-Loke, 5. Non Muang Kao, 6. Noen U-Loke, and 7. Muang Sema.

The prehistoric sequence of Ban Non Wat was highly complex, containing two Neolithic periods between the mid seventeenth and mid eleventh centuries BCE, five Bronze Age periods between the tenth and early fifth centuries BCE, and four Iron Age periods during the early fifth century BCE to the sixth century CE (Higham & Higham, 2009; Higham & Kijngam, 2009, p. 25).

Excavation of Ban Non Wat has revealed a stable and rapidly expanding early prehistoric community, with a complex, multi-period occupation sequence and extensive burials. The earliest evidence of occupation at Ban Non Wat is a substantial Neolithic burial and occupation sequence, built upon a natural prominence. This sequence contained fish and shellfish remains, mammal bones, complex ceramic vessels, shell beads, and stone adzes. Entering into the Bronze and Early Iron Ages the community expanded in size and wealth, with burials containing several "high status" items such as carnelian beads (Iron Age), bronze axes/adze, and numerous elaborately decorated ceramic vessels (Higham & Kijngam, 2009). During the early centuries CE iron-working floors began to appear, and encircling earthworks or "moats" were adjusted to match the changing channel network surrounding the site (Duke et al., 2011). This internal shift towards production was followed by a steady decrease in burial remains and evidence of domestic occupation during the late Iron Age, and (apparent) site abandonment entering into the terminal Iron Age.

Contemporary with the later centuries of occupation at Ban Non Wat is the burial and occupation mound of Noen U-Loke, located approximately two km to the southwest.

Noen U-Loke

Noen U-Loke is an oval-shaped mound, approximately 500 x 250 m in size, surrounded by multiple encircling earthworks. It is located marginally deeper within the modern alluvial floodplain than Ban Non Wat (Figure 7). Excavations by the Origin's of Angkor team from 1996-1998 have revealed a remarkably strong and complex series of mid-late Iron Age occupation and burial sequences (Higham et al., 2007; Tayles et al., 2007). These grew in significance even as Ban Non Wat was beginning its decline. At Noen U-Loke there was a notable increase in mortuary wealth in the late Iron Age or Phimai Black period (second – fourth centuries CE). This was demonstrated by the inclusion of grave goods, including fine bronze artefacts such as finger and toe rings, bangles, earrings and belts in large numbers, occasional gold and silver beads and earrings, and semiprecious stone beads and pendants (Solheim & Ayres, 1979; Welch, 1985, pp. 194 – 197; Welch & McNeill, 2004. For an overview of Iron Age materials see Higham, 2011 or Glover, 1991). Earlier, at the beginning of the Iron Age iron jewellery items were occasionally found, including bangles, *torcs* (neck rings), and *bimetallic* (bronze and iron) rings that were likely fastening pieces for belts or clothing. However, it appears these disappeared very quickly as bronze and other materials became more favoured for ornament (Chang, 2002).

Returning to the late Iron Age, it is then that new standardised, regional ceramic traditions, including the well known Phimai Black ceramics, appeared. Analogues of these appeared as far south as Phum Snay in northwest Cambodia and Si Mahosot in southeast Thailand, and as far west as Chansen in Central Thailand (Bronson & Dales, 1972, pp. 15-46; O'Reilly et al., 2006, p. 195; Pisnupong, 1992). Whether this wide distribution is the result of shared ideas, or the trade of pots from a few centralised production areas, is still unclear. Higham and colleagues (2014), however, noted that recent excavations at the site of Non Ban Jak, located some 9 km west of Noen U-Loke, were found to contain small kilns with Phimai Black ceramics in situ, suggesting local, village-level production. Archaeological material within the Non Ban Jak excavation square became steadily scarcer, during the mid sixth century CE or pre-Angkor period.

It would appear that the late Iron Age abundant display of mortuary wealth within Ban Non Wat and Noen U-Loke, is followed by a sudden decrease in grave good "wealth", and the apparent abandonment of the sites in the terminal Iron Age, and early pre-Angkor periods (Higham et al., 2007; O'Reilly, 2000). It is suggested by Talbot (2007) that competition within settlements might have become less important, negating the need for overt displays of wealth during mortuary rituals, and presumably other ritual events in the community. Furthermore, Higham (2012, p. 283) argues that the disappearance of nucleated "kin" burial plots or distinct clusters of burials, in Iron Ages three and four of Noen U-Loke, indicates the onset of higher-level hierarchical control. Alternatively, other researchers suggest the limited display of mortuary wealth during the terminal Iron Age is related to a local environment change, rendering certain sites less significant or attractive, rather than signifying a shift into higher levels of social stratification (Boyd et al., 1999a; O'Reilly, 2000, pp. 7-8). The abandonment of sites with large encircling ditches or "moats" in particular, has led Boyd (2008) to suggest that deforestation and a shift in hydrology would have been a significant factor. Boyd argues that constructed ditches were no longer sufficient to manage or compensate for a changing local environment. Where occupation continues, inhumation burials eventually disappear, rice in found in burial contexts, streak burnishing is replaced with incising, and iron agricultural tools and wheel-turned ceramics became common (Welch, 1998, p. 222). There is clearly a change in the nature of occupation following the terminal Iron Age. The excavation of the large, oval occupation mounds of Non Ban Jak and Non Muang Kao has illuminated the nature of this "new" occupation (Higham, 2012, pp. 272-277; Higham & Rispoli, 2014)

Non Ban Jak and Non Muang Kao

Non Ban Jak and Non Muang Kao are both large mounded sites, encircled by oval earthworks, and located in the upper alluvial floodplains of the UMRV (Figure 7). The excavation of the approximately highest points at these two sites has revealed the remains of plastered clay floors, wooden sleeper beams, and wattle and daub walls, suggesting a housing complex or "town" (Higham et al., 2007; Higham et al., 2014). In the case of Non Ban Jak, this complex overlays an earlier Phimai Black kiln and an iron ploughshare (Higham & Rispoli, 2014, p. 17). The disturbed upper 50 cm - 1 m of sediment at both of these sites includes evidence for pre-Angkor period ceramics, most notably stylised wave, impressed circle, and red painted designs (Figure 8).

Figure 8. Pre-Angkor period ceramics collected from the surface of Non Ban Jak.

Recently published dates indicate the latest phase of occupation at Non Ban Jak extends to the eighth and potentially ninth century CE (Higham et al., 2014). This suggests continuation of occupation, at least at some level, well into the pre-Angkor period (see Chapter 1.5 for a definition of pre-Angkor). It would appear that at these two sites we can see clear evidence of a transition from prehistory into the pre-Angkor periods. That is, sites that experienced significant changes in the nature of settlement, and have developed a focus on agricultural surplus.

Summary: Prehistory

A range of multi-disciplinary projects within the UMRV of Mainland Southeast Asia has revealed the regions rich and complex prehistory. Whilst these projects are indeed diverse, common points emerge:

- Earliest prehistoric, particularly Neolithic-period, sites appear to be modest settlements, with distinctive interment rituals and ceramic traditions, and a strong relationship to the fossil river network. However we need more sites to establish basic settlement distributions.

- The Bronze and Iron Ages (fifteenth century BCE– mid sixth century CE) are a time of burial complexity and wealth, trade relationships, technological advancement, and expansion from Neolithic centres. The standardised Phimai Black ceramic tradition develops, and some site complexes are abandoned, whilst others flourish.

How did these strong prehistoric centres, having developed over millennia with such consistency, transition to proto-history/ history? Were the large, wet-rice producing habitation mounds of late prehistory a breeding-ground for elites, trade networks, and ultimately state-like development?

4.2 Protohistorical and Historical Evidence

The protohistorical and historical periods of the UMRV span the mid sixth to fourteenth centuries CE. Evidence of this period derives from a variety of sources including excavation, Chinese dynastic records, Khmer and Sanskrit inscriptions detailing events by, or about, the ruling elites, architectural, and sculptural remains. There are publications that outline in great detail the historical records, inscriptions, and excavations of Mainland Southeast Asia (Talbot, 2003, p. 77; Vickery, 1998). As this study emphasises the local scale, in geographical terms, it will focus upon inscriptions recovered from within the UMRV, and those found elsewhere that reference the UMRV (Figure 9). These records describe two phenomenon; the local development of leaders within an increasingly cohesive regional identity, and the increasing external influence stylistically, politically, and economically of neighbouring polities.

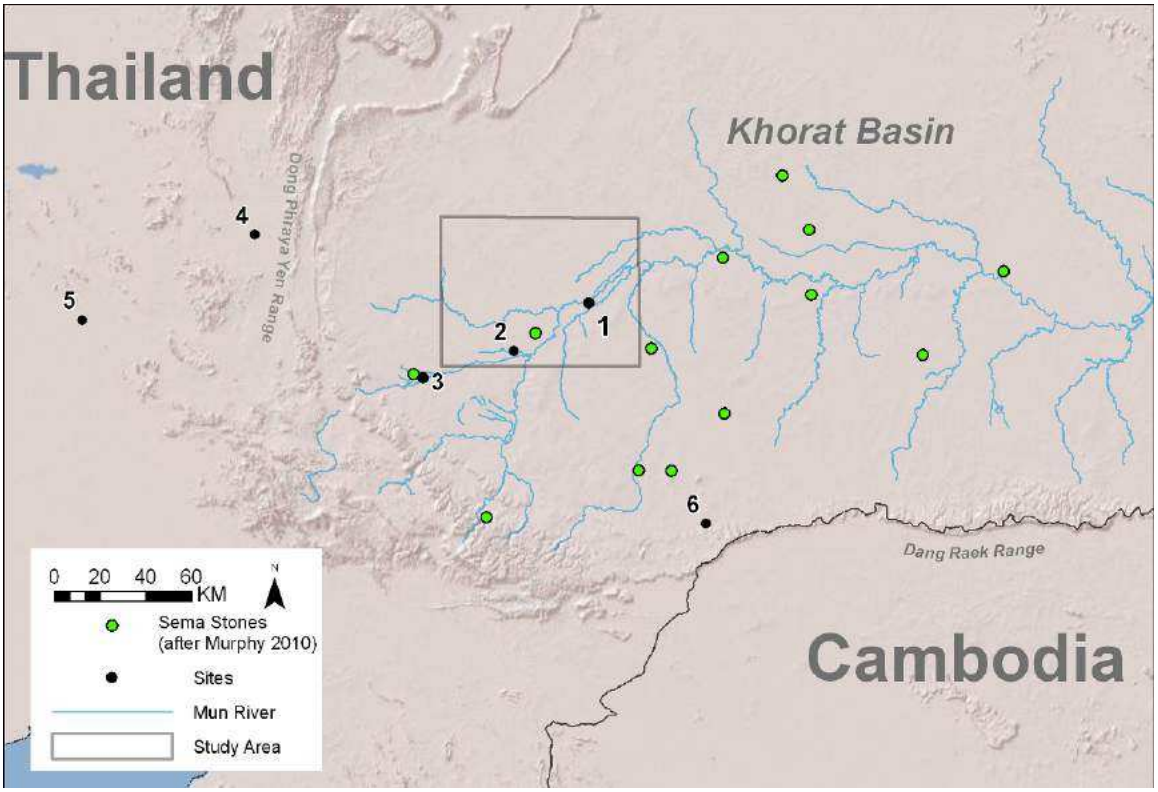

Figure 9. Location of historical sources mentioned in text: 1. Phimai, 2. Prasat Hin Phanom Wan, 3. Muang Sema, 4. Sri Thep, 5. Chansen, and 6. Khao Plai Bat.

Early inscriptions of the mid sixth centuries CE recovered from the UMRV describe invasions by southern Cambodian leaders, along tributaries of the Mekong, and principally the Mun River (Higham, 2012, p. 285; Jacques & Freeman, 1997, p. 57; Sedov, 1978, p. 113). These included a late sixth century CE Sanskrit inscription by Sitrasena (also spelt Citrasen), the brother of Bhavavarman I, within the Tham Pet Thong cave, near the present Thai-Cambodian border (Seidenfaden, 1922, p. 22). Sitrasena was the first ruler of Chenla, and ruled from 550 to 600 CE. Inscriptions attributed to Sitrasena are also found at Wat Sri Mueang Aem in Khon Kaen. These included the Pak Nam Mun Inscription One, the Pak Nam Mun Inscription Two, the Wat Supattanaram Inscription

One, and the Tham Phu Manai Inscription in Ubon Ratchathani (Inscriptions in Thailand Database accessed 2014).

Another such inscription, this time located at Phimai (K.1106), describes a military victory beyond the Dang Raek mountain range, presumably originating from the south (Figure 9). This has led researchers to suggest Chenla leaders Mahendravarman (mid-fifth – early sixth centuries CE), and later his son Isanavarman (early sixth century CE), invaded towns along the Mun River, appointing relatives to rule over the conquered territory (Higham, 2012, p. 285; Jacques & Freeman, 1997, p. 57; Talbot & Chutima, 2001, p. 179). However, a lack of subsequent inscriptions suggests the early invasion, and control of Mun River settlements was a brief event, without any long-term consolidation of governance over the area (Jacques & Freeman, 1997, p. 69; O'Reilly, 2007; Seidenfaden, 1922; Talbot & Chutima, 2001, p. 76). Vickery notes that the tenor of Isanavarman's inscriptions does not reflect direct rule, or control from south of the Dang Raek mountain range, rather,

> [l]ocal elites merely evoked his suzerainty while maintaining their own local authority…. Outside his core kingdom in Kompong Thom the records suggest rather autonomous local chiefs sometimes voluntarily acknowledging some kind of super-ordinate hierarchy, but not subject to direct rule by the suzerain. (1998, p. 337)

Whilst early inscriptional evidence describes invasions from the southeast, architectural and ceramic styles, and religious iconography of the fifth, sixth, and seventh centuries CE point to a growing influence and trade from the west. To the west of the UMRV was a powerful central Thai polity, originally described by contemporary

Chinese travellers as the “To-lo-po-ti” state, and later translated as “Dvaravati” by the Ayutthaya chronicles, “….krung thep dvaravati sri ayutthya…” (Beal, 1969, p. 200; Diskul, 1972, pp. 4-5;). The Dvaravati are thought to have been an ethnically Mon polity, or group of related polities, based in the Chao Phraya Basin, central Thailand, during the fifth to the eleventh centuries CE (Vallibhotama, 1986, p. 229). Unlike Funan and the later Chenla polities, Dvaravati predominantly utilises Buddhist, and to a lesser extent Brahmancial, iconography (Brown, 1996; Revire, 2014; Vallibhotama, 1986, p. 229). Features characteristic of this Dvaravati-Mon style include brick *stupas* or *chedis* (stepped hemispherical mounds), *ubosoth* (monastery), *sema stones* (Buddhist stone marker), and displays of Post Gupta and Pala Indian art styles of Indian origin (Murphy & Pongkasetkan, 2010; Revire, 2014; Talbot & Chutima, 2001, p. 182). Several sites located in the UMRV contain temples and monuments in the Dvaravati-Mon style, including Phimai and Muang Sema (Coedès, 1968; Hutterer, 1982; Murphy, 2013; Wheatley, 1979; Figure 9).

Higham and Rispoli (2014) have presented strong excavation-based evidence in support of the integration, or at least a regular trade relationship, between the central Thailand Dvaravati people and the UMRV, during the mid sixth centuries CE. This trade, Higham and Rispoli suggest, occurred via a pass in the Phetchabun mountain range. They further argue that similarities in exotic gold, glass, carnelian, and agate ornaments from mortuary contexts indicate elite exchange between the UMRV and Loburi province in central Thailand, during the late Iron Age. Higham and Rispoli posit an export-import relationship with regard to; the mining and consumption of copper base artefacts, the spread of ideas relating to iron smelting technology, the large-scale construction of encircling moats, and housing infrastructure. The question is whether this trade remained a mutually beneficial relationship between two distant, independent neighbours, or developed into an organised and integrated settlement system.

Murphy's (2010) analysis of Buddhist markers or *sema* stones supports the idea of independence, and a consequently weak relationship, between central Thailand and the UMRV, than that of neighbouring areas, including the Chi River System to the North. Murphy notes that the spatial distribution of sema stones across the Khorat plateau implies a limited Mahayana Buddhist tradition in the UMRV (Figure 9). There is a notable lack of notable lack of Buddhist boundary markers or sema stones, dating to the seventh to twelfth centuries CE, associated with the Mun River. What sema stones have been identified by the Fine Arts Department of Thailand and later Murphy, tend to be somewhat isolated and plain, and adhere closely to major water features of the Mun River system. In contrast, the Chi River to the north appears to have played a far greater role in the spread of Buddhist symbolism connected to the Dvaravati culture. Murphy suggests this indicates less of a Dvaravati influence in the UMRV and, indeed, a "much stronger Chenla and later Khmer influence in the region, which could have made its way here by following the Mekong River, originating from the area around Sambor Prei Kuk in present day Cambodia" (Murphy, 2010, p. 149).

Drawing on other evidence, finds of Buddhist bronzes suggest early communication and trade between the Upper Mun River Basin and neighbouring polities was diverse and complex in nature. In 1964, the Prakhon Chai hoard was discovered within a small seventh century brick temple, in Khao Plai Bat, Buriram province (Figure 9, Boisselier, 1967; Bunker, 2002; Illustrated London News, 1965; Lerner, 1984; Talbot, 2003). The hoard contained over 300 statues dating as far back as the sixth century CE. Statues tend to be isolated finds, whose portability makes their provenance difficult to ascertain (W. Clarke, personal communication, June 16, 2014.). However, the design of these statues varied greatly, incorporating a combination of Dvaravati, Mekong basin, and local traits.

This regional, and inter-regional, variability in religious iconography was supported by Srisakra Vallibhotama's 1982 settlement pattern survey (Vallibhotama, 1986). Vallibhotama noted that Buddhist wheels, figures of Buddha, and other Buddhist iconography, were more prevalent in the west of Thailand, while iconography associated with Hinduism, Vishnu and Shivaism was more prevalent in the east. The site of Sri Thep in the Pasak Valley, 175 kilometres west of Phimai, depicts "numerous [types of] Hindu gods, both large and small" (Vallibhotama, 1986, p. 231; Figure 9). This variation led Vallibhotama to argue for multiple Dvaravati regions in Thailand. One such regional power, described as Sri Canasa, was potentially based at Muang Sema, or nearby Sri Thep (Hanwong, 1991; Saraya, 1992).

Sri Canasa is mentioned on a stela (K.400) of the tenth century temple of Bo Ika near Muang Sema, with an inscription dated to 868 CE. It commemorated the gift of a gold linga and slaves by Ansadeva, who obtained them from an abandoned domain "outside Kambudesa [Cambodia]" (although this is also translated as "inside Kambudesa" by some, see Brown, 1996, p. 26). On the other side of the stela is a second inscription, dated to the seventh century, which describes gifts of labourers and buffalo to a Buddhist monastic compound, by the leader of Sri Canasa (Brown, 1996, pp. 25-26; Coedès, 1954, pp. 83-85). Sri Canasa is the only unified pre-Angkor period polity, which we have evidence for, based in northeast Thailand. However the location and size of Sri

Canasa, and whether it was independent or a component of a larger neighbouring power, remains a source of debate.

The presence of independent local chiefs or rulers from the late fifth centuries onwards, is further supported by scattered inscriptional evidence, primarily on sema stones (see Jacques, 1989 for a list of descriptions including K.404 in Chaiyaphum province, K.577 from Loburi province, and K.1082 from Yasothon province). Of particular note is an eighth century inscription (K.1000), located at Prasat Hin Phimai, which described a new, local king called Sauryavarman with Buddhist affiliations. Additionally, the Hin Khon stone marker inscriptions (K.388 and K.389) located near Muang Sema were written with a mix of Khmer and Mon scripts, and paired with a Sanskrit version. The inscriptions described how a Buddhist monk, identified as King Nrpendrahiphativarman, erected a Buddhist monastery and temple, to which he donated 10 pairs of cattle, gold and silver utensils, rice-fields, and betel nut trees. This inscription also referenced two other local leaders, including another Buddhist king, Sauryavarman; who is possibly the same person noted above, and who ruled in the Phimai region during the eighth century CE (Brown, 1996, p. 27; Talbot, 2003, p. 77). These inscriptions indicated a continued succession of local leaders with Sanskrit names, who paid homage to Buddhist deities, and ruled over a populace that primarily spoke local Mon-Khmer dialects (Bauer, 1991; Talbot, 2003, p. 76).

UMRV art historical evidence and ceramic/ artefact styles demonstrates remarkable similarities to the Dvaravati culture of central Thailand, and inscriptional evidence lends credence to the rise of local leaders. The development of economic, transport, and religious hubs, particularly from the eleventh century onwards, however, heavily references Mekong-based polities and the expanding Angkorian Empire. The Angkorian Empire, based in the Tonlé Sap Basin, officially began in 802 CE, when Jayavarman II appointed himself God-King upon sacred Mount Mahendraparvata (now known as Phnom Kulen). Evidence of Angkor-based incursions in the UMRV, however, are limited during the ninth and tenth centuries CE, as Jayavarman II, V, Yasovarman I, and Rajendravarman focused on consolidating their power internally. There are, however, a small collection of *prasats* (palaces or temples) in the early tenth century Koh Ker style, located along the northern edge of the Dang Raek mountain range, including Prasat Non Nu, Prasat Mueang Khaek, and Muang Gao. Located firmly within the UMRV we find Phanom Wan, a large multiple complex near Phimai dating from the ninth to the eleventh centuries CE (Maneenetr, 2007, pp. 2-3).

Suryavarman I (1010 – 1050 CE), was the first Angkor-based god-king to have a marked affect on the settlement patterns of the UMRV, including the introduction of rectangular moated and walled sites, large *barays* (water storage), and rectangular temple enclosures (Welch, 1998, p. 208). Suryavarman's policy of expansion, trade, and conquest led to the proliferation of fine imported wares and Khmer-style glazed vessels, into the UMRV in the tenth century CE (Hall, 1985; Welch, 1997). However, during the mid eleventh century CE, leaders Udayadityavarman II and Harshavaramn III moved their attention away from the UMRV, and Angkor influence upon the Khorat plateau waned.

From the late eleventh century CE onwards Khmer attention returned to the UMRV, as the Mahidhapura dynasty (Jayavarman VI – Suryavaman II) established a power base north of the Dang Raek mountain range (Dagens, 2004, p. 30; Hendrickson, 2007, pp. 196-197). Thus, the provincial capital of Phimai (*Vimayapura*) was constructed, and the route connecting Phimai to Angkor Wat established. This "northwest" route was a physical manifestation of the empire reaching out politically and economically, across mainland Southeast Asia (Hendrickson, 2010). Under Jayavarman VII in the twelfth century CE this coincided with the construction of seventeen rest-houses or *Arogayasala* (hospital sites) along the northwest road network, a relatively scarce collection of Brahmanic and Buddhist temple complexes (including Ta Prom and Phanom Rung) in the UMRV, and the refurbishment of provincial centre of Phimai as a Mahayana Buddhist sanctuary (Maneenetr, 2007, p. 2). Hall (1985, pp. 136-138) argues the primary function of such complexes was to manage local commodities, in the UMRV this involved salt, iron, and forestry resources, and to collect and redistribute taxes on behalf of the Angkorian Empire. A movement toward the collection and production of these resources is supported by survey data from the KBAP and Lake Kumphawapi projects, which reported a twelfth century increase in site numbers in the terraced zones and "uplands", where such resources concentrate (Kijngam et al., 1980; Welch, 1985). The salt of northeast Thailand, in particular, was highly prized. Thirteenth century CE Chinese explorer Zhou Daguan remarked that although sea salt was available to the Khmer, the "taste of mountain salt" was highly prized (Pelliot, 1902 [1296-7], p. 170). Welch argued for a fermented fish exchange network, along this northwest route; with fish from the Tonlé Sap exchanged for salt from near Phimai, and the two supplying salt or fermented fish for distribution across Mainland Southeast Asia (Welch, 1998, pp. 214-216). This theory is aided by the presence of several brick-Khmer kilns lining the route, which may be evidence of salt processing.

Thus the documentary, statuary, and architectural evidence, indicates that as we enter the historic period UMRV was at the crossroads of several inland exchange and communication routes, bringing to the area an influx of architectural styles and technologies, trade items, and cultural practices. These overland connections integrated the UMRV with central and upper northeast Thailand, northwest as far as northeast India and Bangladesh, through to Laos and Vietnam to the north and east, and of course to Cambodia and the Mekong Delta to the south. As with the rest of Southeast Asia, these wide-spread overland routes articulated with maritime trade, allowing items and concepts to pass into the UMRV from as far afield as India, China, the Middle East, and Venice (Murphy, 2010; Stark & Allen, 1998, pp. 163-174). The difference in the UMRV is that these connections were not likely to be direct, but mediated by coastal communities and polities.

The rapid and wide-spread uptake of external ideas could be interpreted, as evidence the UMRV of northeast Thailand was absorbed into or under the political influence of these potentially mediating neighbouring polities, with the UMRV controlled from large riverine outposts, such as Phimai and Muang Sema (Higham, 2012; Welch, 1998). However, when interpreting documentary evidence consideration must be given to its purpose and source (Stahl, 1993; Wylie, 1985, pp. 100-101). Renfrew points out that common art or styles do not necessarily imply direct influence of a unified state (Renfrew, 1975; Renfrew & Cherry, 1986).

The visibility and permanence of monuments and structures from, or related to, Indianised, Chinese, and Mekong Basin sources in the UMRV appears to favour an interpretation of this period as sudden and introduced, as opposed to a gradual, indigenous development (Stark & Allen, 1998, p. 166). However, common artistic and architectural traditions can be a product of multiple interactions between peer polities (McNeill & Welch, 1991). In the UMRV, an increasing trade of ideas between central and northeast Thailand, could have facilitated the adoption of Dvaravati, Chenla, or Funan techniques and styles by local, or regional, rulers. Recalling the inscriptional evidence above, such autonomous local leaders are referenced several times. They are described as being based at a number of large moated sites. These regional and local leaders may have gradually coalesced into the single large regional power, such as the polity described as Sri Canasa. If this was the case, then it occurred well before clear evidence is seen of the spread of Angkor-style monuments and ceramics across the UMRV, imposed from the southeast by Suryavarman I and his successors, from the tenth century CE onwards.

The archaeological and historical evidence points to the changing nature of occupation in the UMRV; from strong regional Iron Age identity in the first to mid sixth centuries CE, to religious and trade crossroads in the mid-sixth to ninth centuries CE, and finally to a strategic social, economic, and political hub from the tenth century onwards. Whether or not a unified polity eventually emerged in the region, this evidence does confirm the UMRV understood and played a role in the socio-political machinations developing within Mainland Southeast Asia during the fifth to fourteenth centuries CE. This history is perhaps best illustrated by looking more closely at two key sites, Phimai and Muang Sema.

Located along the banks of the Mun River, Prasat Hin Phimai is the central, Angkor period sanctuary of a large moated settlement. The modern town of Phimai surrounds the site with the central sanctuary preserved as an historic park. Structures within and around the historic park were restored and excavated during a series of projects from 1954 to 1971, led by UNESCO, the Fine Arts Department of Thailand, Silpakorn University, and Peacock. An excavation was carried out in the central sanctuary of Prasat Hin Phimai in 1998, as part of the Origins of Angkor Project (Bronson, 1979; Talbot & Janthed, 2002, p. 183; Welch, 1985). The late prehistoric and historic sequences of Phimai indicate that it has remained a prominent site on the route between the Khorat Plateau and the Chao Phraya Delta for at least the last 2000 years (Bronson, 1979, p. 327). Excavations have uncovered a pre-Angkor brick structure that underlies the reconstructed eleventh century CE Angkor-style central sanctuary. The earlier "square sump [*un puisard carre*]" shaped temple, made of finger-marked bricks, is similar to an example found underlying an Angkor-period sanctuary at nearby Prasat Phanom Wan, and has been radiocarbon dated to the seventh to ninth centuries CE (Buranrak, 2000; Pichard, 1976, p. 22; Talbot & Janthed, 2001, p. 188). Ceramics contemporary with the construction of the brick temple are cord-marked or incised fine earthenware and include carinated pots. These ceramics are immediately followed by the wheel-formed, thin, well-fired, orange or pink earthenware, often with an incised shoulder, typical of the pan-regional, standardised Dvaravati tradition of the sixth centuries CE (Bronson, 1976; Indrawooth, 1985). Phimai Black and red-slipped cord-marked ceramics were recovered from layers underlying the brick temple, and appeared to be characteristically Iron Age (fifth century BCE – third century CE, Welch & McNeill, 1988). Similar ceramics were recovered from the adjacent site of Ban Suai, where a significant Iron Age occupation mound was revealed, which countless sherds of Phimai Black ceramics. The Ban Suai mound lies in close proximity to the Angkor period town (Higham, 2011, p. 104; Solheim & Ayres, 1979; Welch, 1985, pp. 130-132).

Thus, the archaeological evidence from Phimai suggests occupation in the Late Bronze or Early Iron Age associated with the strong regional Phimai Black ceramic tradition. Prasat Hin Phimai, particularly the central complex, potentially acted as a point of consolidation for these neighbouring late prehistoric villages, including Ban Suai, entering into the Historic era. By the pre-Angkor period (mid sixth – ninth centuries CE) Phimai had developed into a relatively modest centre, but was redeveloped extensively, reusing some pre-existing materials, during the reign of Jayavarman VII (eleventh century CE). The result is the significant Angkor temple complex evident today.

Excavations at the significant site of Muang Sema, some 65 km southwest of Phimai, also revealed a large ninth/tenth century CE ceremonial centre that developed from a modest late Iron Age settlement (Fine Arts Department of Thailand, 1959, pp. 223-225; Welch, 1998, p. 224). The site was originally a moated late prehistoric mound (fifth to sixth centuries CE), from which a strongly Buddhist community appears to have emerged during the seventh to ninth centuries CE (Wangsuk, 2000, p. 209). This is followed by a decidedly Angkor phase of occupation at Muang Sema, from the ninth to the tenth centuries CE, when a second, much larger enclosing wall was built, along with a central Khmer-style temple. Buddhist monuments and buildings were increasingly constructed outside of the boundary of the site complex, including a large reclining Buddha and Wheel-of-Law southwest of the enclosing wall. These episodes of construction exemplify the gradual shift in the nature of settlement, away from something contained or easily defended by earthwork structures, and towards a more sprawling urban centre with greater religious symbolism. Murphy describes this as a "cognitive change" in the concept of a site, likely influenced by the introduction of Dvaravati culture and Buddhist faith from central Thailand (Murphy, 2013). Murphy also points out that a large residential population would be needed in order to produce a surplus of rice capable of sustaining a Buddhist monastery, such as that found at Muang Sema. Given the environmental conditions of the UMRV, religious sites would be limited to locations near large, wet-rice producing populations, on the relatively fertile alluvial floodplain. An exception to this is mountainous sites of "forest monasticism" described by Murphy (2013, p. 301). Here we can see the likely limits imposed by the aridity of the UMRV, on religious and socio-political development.

4.3 Summary

This chapter has presented an archaeological and historical background for the UMRV. Surveys, excavations and historical studies have revealed a complex occupation sequence stretching from Neolithic settlers of the eighteenth century BCE, to the Angkorian Empire of the fourteenth century CE. Three patterns emerge from this consideration of this archaeological body of research:

- Settlement patterns maintain a strong and complex relationship with landscape of UMRV; most notably water features, soils, access to salt and iron, and elevations. We need to record and analyse the development of settlements over time, in the landscape of the UMRV.
- There are relatively few examples of Neolithic period sites, and those bridging the fifth to ninth centuries CE. More research on these two elusive time periods is needed.

- The socio-political transition from prehistory to history appears unusual and complex in the UMRV, and requires further investigation, with consideration of both historical and archaeological evidence.

- We need to examine the significance of physical, spiritual, and cultural landscapes, as well as the role of kin-ship ties and communities. This not only has relevance to ancient patterns of settlement, but is also significant to the current communities of Mainland Southeast Asia.

A large and exciting body of information has emerged from previous archaeological and art historical projects, revealing the significance of the UMRV both regionally and within the wider context of Mainland Southeast Asia. Intermediate-scale data, however, is needed to inform models of occupation in the UMRV, and to draw together individual sites and periods of occupation. Such data requires collection in a systematic and unbiased manner, incorporating a range of sources, with careful reference to the large body of survey and settlement theory. Once a body of data has been collected we can then move on to consider how that data is interpreted, and how will this be developed into a model of 'community' and 'settlement' in the UMRV?

5. Defining Settlement and Community

This thesis will record and analyse intermediate-scale prehistoric and historic settlement patterns in the UMRV of northeast Thailand, in relation to environmental, cultural, and socio-political changes. This will address several key questions that have emerged from the body of archaeological literature; when the UMRV transitioned to urbanism, the structure of ancient communities, and the nature and placement of sites and settlement. Once this data has been collected, how do we interpret the results? In this chapter current models of sites and communities are examined to identify the most appropriate and effective models for this study.

5.1 Site, Scale, and Settlements

What constitutes an archaeological survey and what survey techniques might be successful in northeast Thailand?

The Merriam-Webster dictionary (Survey [Def. 1-4], 2013) describes the term "survey" as the process of appraising, delineating, or querying a person, tract of land, or concept, in order to collect data for the critical "analysis of some aspect of a group or area". Within archaeology the term survey more commonly refers to the study of the placement of sites or settlement within the wider landscape (Banning, 2002; Markofsky, 2010). A survey has two primary uses; as an exploratory technique for uncovering new sites, and as a directional device for targeting information regarding a particular hypothesis or archaeological sub-set (Banning, 2002). A directional survey might be undertaken to analyse the material culture associated with an excavated site, to sample regional and sub-regional distributions of archaeological material, or to refine survey techniques. Its application to archaeological projects has evolved considerably, from an aside to excavation, to an established archaeological technique in its own right.

Early archaeological surveys predominately served as a means of uncovering a suitable site for excavation (Ammerman, 1981; Cole & Deuel, 1937; Fisher, 1930). Such was the disregard for archaeological survey as an independent research process, that Ruppé (1966, p. 313) felt compelled to "defend" it as an important means of "critically" and "directionally" eliciting and analysing data. Ruppé was a proponent of the 1960's new wave of archaeological theorists, who attempted to differentiate survey, which is directed, from reconnaissance, which is purely exploratory (Binford, 1964; Ruppé, 1966). New archaeologists maintained that if a probabilistic, systematic survey design was utilised, archaeological surveys had the potential to uncover new remains, and verify existing sites in an unbiased and representative way (Binford, 1964). However, critics of the new approach to survey argued such a structured design could potentially miss highly clustered or unique finds (see discussion of the *Teotihuacan Problem* by Flannery, 1976; Read, 1977; Schiffer, Sullivan, & Klinger, 1978). Furthermore, it is argues that such a method is only useful and cost-effective in good field conditions, when sampling a widespread and abundant population (Shiffer et al., 1978).

The impact of field methods and location on a survey's effectiveness was later quantified as "obtrusiveness". This factor is defined as; the probability of discovery given a particular survey technique and surface visibility, the degree to which sites cluster, and how wide-spread the artefacts are (Read, 1986; Shiffer et al., 1978; Wandsnider & Camilli, 1992). The less clustered, dense, and more obtrusive the surface artefacts are, the smaller a "representative" sampling area can be.

In response to the optimism of "new" archaeological approaches to survey, the focus then shifted back to a critical evaluation of the limits of survey. There were concerns the search for elegant design had overridden "quality control" (Cowgill, 1986; Cowgill, 1990). It was suggested methodologically ugly techniques, such as interview-directed survey and purposeful sampling, might in some cases provide the most effective results (Aikens, 1978; Plog, 1978; Shiffer et al., 1978). Nance (1987) pointed out the distinction between making direct measurements and comments on the archaeological record, and indirect comments on the past (i.e. occupation spans, see Wandsnider & Camilli, 1992). Often the quality of the indirect observations is contingent upon the "validity" of the direct measurements. Direct measurements have; a *precision* – the detail in which artefacts are recorded, *reliability* – the degree to which results are replicable, and *accuracy* – deviation between actual and observed measurements. Indirect observations, however, are likely to consist of interpretations of occupation span, habitation centres, and regional socio-complexity. This cautious and rather dissociated view is summarised by Michael B. Shiffer and colleagues' definition of survey as, "the application of a set of techniques for varying the discovery probability of archaeological materials in order to estimate parameters of the regional archaeological record" (Shiffer et al., 1978, p. 2). It also introduces the increasingly diverse concept of a "site", as the product of an archaeological survey. Furthermore, it reiterates the assumption we make that archaeological evidence of settlement is at least partially representative of human occupation in the past (Dunnell & Dancy, 1983; Taylor, 2000).

Increasingly, surveys have been conducted independently of excavation, and a number of the criticisms levelled at survey techniques have been resolved (Wandsnider & Camilli, 1992). The suggestion that surface collections are disturbed, and have less integrity than buried remains (Hope-Simpson, 1983; Hope-Simpson, 1984), has been superseded by the recognition that all buried remains were once on the surface, and subject to the same forces (Cherry, 1984; Dunnell & Dancy, 1983). A direct relationship between surface and subsurface material, also known as surface-subsurface isomorphism, is demonstrated in several studies (Bevan & Conolly, 2004, pp. 123-138; Binford et al., 1970; Dunnell & Dancy, 1983). This relationship is particularly strong when methods are systematic, sites are shallow, and slope is negligible (Bevan & Conolly, 2006; Redman & Jo Watson, 1970, pp. 279-291).

The focus has now returned, however, to uncovering "substantive" or "meaningful" results using surface survey, despite its limitations (Ammerman, 1981). Wandsnider and Camilli (1992) succinctly summarise the benefits of survey as:

> (1) they are logistically and economically easier to obtain…; (2) they afford a regional perspective on prehistoric activities…; and (3) archaeological deposits are not necessarily destroyed by the documentation process and results, theoretically, can be replicated. (p. 169)

Conducting survey independent of excavation, therefore, is a worthwhile endeavour, where it can elicit or target archaeologically "meaningful" results, and is conducted in an environment with suitable conditions, namely relatively flat, shallow/disturbed sites and using systematic methods. Once results are obtained and verified, the question remains how do we interpret them?

The study of a "site", the unit of analysis for archaeological survey, has emerged as one of the most hotly debated issues within archaeological survey design, and interpretation (Burger, 2002; Dunnell, 1992; Dunnell & Dancey, 1983; Ebert, 1992; Ebert & Kohler, 1988; Foley, 1981; Isaac & Harris, 1975; Wandsnider & Camilli, 1992; Shott, 1995). As early as 1953, Gordon R. Willey asked the question " 'What is a site?'. Where is the line drawn separating site from site for the practical purposes of archaeological survey?" (p. 8). Traditional approaches delineate a site based upon marked geophysical or physical structures, most notable mounds or buildings, coupled with a high concentration of artefacts. This is the favoured approach for organisations that operate under time/ financial constraints, or for research that aims to cover a wide-study area, such as an entire region. This has also been a favoured technique applied within the UMRV (Chapter 3.2).

However this site concept has been described as overly reductionist, in its attempt to convert isolated, high concentrations of artefacts into individual points on a map (Dunnell, 1992). As an advocate of site-less survey, Dunnell argued the boundaries of a site are arbitrary interpretations, whereas artefacts have clear "bounded" margins, which can be quantitatively assessed (Binford, 1992; Dunnell & Dancy, 1983). The issue with site-less survey is that the artefacts have to be arranged for analysis purposes, and this reintroduces the issues of defined boundaries (Holdaway et al., 1998, p. 2).

Archaeological contexts with concentrated, obvious sites, particularly those located in hostile environments, might be more suited to an “offsite” or “non-site” approach to survey. This may highlight “less permanent traces of human activity”, which fall outside of traditional site boundaries (Bintliff & Snodgrass, 1988, p. 506). Such an approach provides a greater understanding of inter-site dynamics and different site types. However, this approach still retains the concept of a site, allowing easier integration into existing records and representation. Alcock and Cherry (1994), on the other hand, express concern that the “sherd carpet”, given its low-density and exposure to the elements, constitutes off-site material, and is highly susceptible to taphonomic disturbances. Markofsky (2013, pp. 254-257) provides a concise summary of arguments regarding off-site archaeological survey.

In 1992 James I. Ebert introduced the concept of distributional archaeology, as an approach to survey, which views archaeological material as a continuous grid of artefact density values. This approach avoids site boundaries and discreet entities that can bias statistical analysis. Further, it negates the excessive expenditure or post-survey amalgamation issues of a site-less approach. It is particularly useful for regional or community studies of long-term occupation sequences (Holdaway et al., 1998; Peterson & Drennan, 2005). This can be the only option where much of the archaeological material has been subject to post-depositional disturbance. The pervasive agriculture of east and Southeast Asia is a pertinent example of this disturbance, and ensures a distributional approach is perhaps the only means of intermediate-scale survey applicable to the UMRV. Distribution surveys can be statistically analysed as a continuous landscape, using statistical programs, which are directly integrated with environmental data. The distributional approach has seen regular use in: the

Mediterranean (Given et al., 1999; Renfrew, 1982), Europe (Wilkinson, 2000), the Americas (Balkansky et al., 2000; Berlin, 1951; Cherry et al., 1991; Feinman & Nicholas, 1996), and China (Peterson & Drennan, 2005). Despite the region's obvious suitability, there have been limited attempts to apply a distributional approach to a Southeast Asian context (Eyre, 2006). Examples of note include the 2009 survey by the Lopburi Regional Archaeology Project in Khao Sai On, Central Thailand (Pryce & Piggott, 2010), and the 1979 Bais Anthropological Project survey. The latter project applied probabilistic sampling of artefact distributions to the southeast Negros region, Philippines (Hutterer & McDonald, 1979).

The issue with distributional modelling of archaeological material is that continuous, distributional models are derived from the natural sciences; where some degree of gradual homogeneity can be assumed. Therefore the transition between two sampling points is assumed to be a gradual trend. However, archaeological material is not a smooth, gradual, natural deposition. Rather, it is "patchy" and is subject to all the unpredictable complexities and patterns of human behaviour (Ebert & Kholer, 1988; Isaac & Harris, 1975). As such, distributional analysis is perhaps more suited to understanding local trends of archaeological material, or as a complementary technique to uncovering smaller sites, which may be missed by traditional survey techniques and excavation (Pryce & Piggott, 2010).

Interpreting results using an effective unit of analysis appears to depend almost entirely upon the scale of settlement under investigation. In fact, spatial scale is perhaps the most important component of survey, as it impacts upon all elements of design and analysis (Jones & Taylor, 2009). Lock and Molyneaux (2006) describe scale as "a slippery concept, one that is sometimes easy to define but often difficult to grasp … there is much equivocation about scale, as it is at the same time a concept, a lived experience and an analytical framework" (p. 1). Lock and Molyneaux have highlighted the two central issues of scale: scale as a concept and scale as a unit of measurement. The first issue questions the very idea and existence of scale. To what extent is scale a construct of its observer? This debate centres upon the tension between individual and global scales of landscape perception (Hu, 2011; Trifkovic, 2006). The "archaeology of practice" asserts that space and/or landscapes, only accrue meaning in relation to people, bodies, and movements (Barrat, 1994). However, Hodder (1999) and Trifkovic (2006) reassert the need to reconnect the "non-discursive" actions of the individual, within an external contextual framework. Thus scale theory enters the archaeological discourse on Agency versus Structuralism, a debate that has been extensively published (Bapty & Yates, 1990; Barrett, 1994; Hodder & Hutson, 2003; Kristiansen, 2004). It is, however, worth noting that archaeologist's perceptions of past social, cultural, or economic systems might differ considerably from past inhabitants concepts of their own landscape.

A second, more practical approach to scale, assumes both society and nature adhere to inherent, independent units. It questions what unit is most appropriate, and how using different unit measurements might affect archaeological results. Bounded units of analysis are necessary to code archaeological data derived from survey. All units must have a fixed and clearly defined "grain", "extent", and "duration" of temporal and spatial scale, in order to be analysed (Dunnell, 1971, pp. 145-209). However, units are essentially abstractions within an archaeological landscape, which has developed and changed along a continuous scale, across space and time (Lock & Molyneux, 2006). In practice, definitions of bounded units, such as sites, artefacts, regions, and time periods, are often inconsistent, particularly when conducting regional and local surveys concurrently (Crumley, 1995). In response, Crumley (1995) suggests an "effective scale" exists, which he describes as "the scale at which pattern is recognised and meaning inferred" (p. 2). It may also be described as the spatial range at which a phenomenon can be reliably recorded and understood (Wandsnider, 1998, p. 89). Marquardt (1992, p. 107) suggests sifting through levels of scale until the effective scale is uncovered. However, the scales deemed effective by archaeologists, tend towards the readily available macro (regional analysis) or micro (intensive site analysis), with little consideration of the more allusive intermediate scales (Caraher et al., 2006; Kolb & Snead, 1997; Markofsky, 2010, p. 72). The intermediate-scales, often overlooked in archaeological research, range from inter-site analysis to local or community analysis, and finally sub-regional analysis. Such a scale is important, as everyone belongs to a community, and has done so since earliest prehistoric societies (Kolb & Snead, 1997). The local structures so crucial to trade, defence, social, and investment in technology in these societies, can also play a major role in settlement trajectories within a region (Feinman, 1995). Often it is only after studying the intermediate-scale that wider settlement strategy makes sense. However, an intermediate scale is perhaps the most conceptually difficult to record, as it requires a unit of analysis more refined than sites as points, but not as detailed as excavation. The site cluster, defined as a group of geographically proximate sites, is often used as a measure for this scale (Nash, 2009; Orton, 2000). At a micro-scale, high-frequency, changeable, and localised environmental processes often set the parameters for cultural responses (Fisher & Feinman, 2005). There is a strong and measurable interplay between the environment and cultural/socio-political responses at this scale, which may then be applied to larger scales of analysis, including regional and pan-regional studies (Van Der Leeuw, 2004). However, a project would have to be designed to specifically to understand this scale.

This thesis will target the missing intermediate scale of settlement data within the UMRV of northeast Thailand. It will search for the structuring of communities and inter-site interaction. All elements of survey and post-processing procedures will be tailored to target this scale. Systematic, intensive pedestrian survey across samples of different landscapes will provide the high intensity needed for local scale research, as well as covering a range of UMRV landscapes. The raw unit of analysis will be surface artefact clusters. Concentrations of these clusters, or "sites", will be determined during post-survey processing using a distance-intensity function. It is the location of sites that will provide environmental information, the collections within sites that provide cultural information, and connections between sites that provides socio-political information. It is hypothesized that the introduction of rigorous, intermediate-scale archaeological data will reveal more variety and irregularity in site types and location, and will also show the significance of local community interaction to settlement patterns in the UMRV.

5.2 Community Definitions

Once archaeologically "meaningful" information has been recorded and analysed as a series of sites, how then are findings related to the study of ancient communities? Arriving at such analysis first requires an understanding of the myriad of community definitions. The term "community" is laden with geographical, psychological, and archaeological connotations. Nevertheless, this is the term most often used in studies of an intermediate scale, and is therefore a critical concept. How do we define a community and how does a community define itself? Are there ways to measure a community using the archaeological record?

Perhaps the most common definition of a community in archaeology is a physical or geographic one. The modern political boundaries of Thailand, for example, separate the country into villages, sub-districts, districts, and provinces. The boundaries for these sub-sections are often irregular, as the major rivers or environmental features are used as a natural point of division. Such divisions also serve economic as well as administrative purposes; allowing a viable subsistence structure, which thus provides wide-spread access to key resources (Kolb & Snead, 1997, p. 611). Kantner (2008) defines the physical remains of community as "[s]paces for which meaningful relationships can be defined between past human behaviour, the material signatures people left behind, and/or the varied and dynamic physical and social contexts in which human activity occurred" (p. 41).

Communities modify the natural landscape, through both residential and industrial-scale construction, to suit their needs and establish their identity. The cultural landscape archaeologists study is a spatial or geographic expression of community, described by Hollinghead (1948) as "sociogeographic". The boundaries and spaces created by the social, political and economic communities have been extensively studied, as they are often archaeologically visible. However, defining ancient communities in purely geographic, political, or economic models is problematic. Archaeology tends to view history as a series of static events, over perhaps a few decades. A well-defined, physical community boundary suits this view. Realistically, however, community boundaries are the results of hundreds or even thousands of years of social, religious, political, and cultural influences, at an individual, local, and supra-local scale. Furthermore, they encompass a psychological sense of "togetherness", which can not entirely be defined in sociogeographic terms.

There is a resurgent interest in defining spatial complexity using psychological terms, and analysing how those psychological concepts might manifest themselves in the physical world (Mannino, 2011; Uzzell et al., 2002). Past work by Mannino and Snyder (2011; Mannino et al., 2011) reinforces the interaction of the physical and psychological in influencing behaviour. This is a concept not theoretically distant from Agency approach or *Mentalities* (Iggers, 2005). However, psychological elements of settlement patterns focus less on the perception of the individual, within a wider regional and supra-regional landscape, than on a unique shared identity. This identity is comprised of a sense of membership and belonging; a feeling that an individual makes a difference in the community and that the community is significant to its members. Further, there is a sense that the community can meet the needs of its members, and maintains a shared emotional connection between those who have common experiences and a history together (Mannino, 2011). Obst, Smith, and Zinkiewicz (2002) also argue that a fifth component exists; which is that of consciously identifying with a particular community. By viewing the group psyche as an independent entity, psychological concepts of complexity incorporate elements of Structuralism, rather then a purely individual agency.

Evidence of psychological structuralism has been found to manifest in the physical landscape, through commitment to sustainable environmental behaviours that benefit the community landscape or "place identity", and the symbolic/structural reinforcement of self-image that community provides (Epstein, 1983; Korpela, 1989). If this self-image is threatened by external or environmental change, this can lead to an attack on the self and social upheaval may eventuate (Uzzell et al., 2002). In this sense the number and type of social linkages appear to be associated with the strength of a society.

If community is such a complex and spatially boundless concept, how do archaeologists record it? Both psychological and geographical elements of a community are somewhat addressed by the daily interaction approach of Peterson and Drennan (2005). Peterson and Drennan modelled community patterns from the Hongshan Period (forty-fifth – thirtieth centuries BCE) in the Chifeng region of eastern Inner Mongolia, North China. They modelled daily activity interaction at a household level, including hunting, gathering, collecting water, and daily interaction zones for each individual site. Sites with overlapping zones of a 24-hour buffer interact on a daily basis, and are considered a small community. Peterson and Drennan thus argue, this may be scaled up to larger-scale community analysis, or even regional analysis, using the smoothing function to increase the buffer size. This form of analysis would be well suited to the intermediate, intensive survey findings of this thesis. However, care must be taken not to define social linkages solely by distance-interaction assumptions. It must be remembered that community is a complex mix of social, geographical, economic, and psychological features.

In many ways psychological concepts of space do not fit well within the boundaries of spatial data. Affiliation is linked to an emotional bond that crosses spatial boundaries and may have multiple overlapping types. For example, a village agriculturalist may consider himself: a member of his village community, a member of the river valley agriculturalists, a member of the young unwed men of the village, a member of his blood relation group, and a member of a friendship group. It is perhaps best to visualise psychological levels of spatial data of society as a series of processes, not boundaries. It could be represented spatially as a series of interrelated, dynamic networks, which overlap and have both a shared and individual component. Such multitudinous, interrelated connections have parallels to heterarchical organisational structures applied in archaeology (Crumley, 1995; White, 1995). The presence of such overlapping community structures will be considered in this thesis.

A more complex approach to modelling community linkages is to create a network of artefact attributes. Mills and colleagues' (2013) study of social networks, in the late pre-Hispanic southwest United States, is an excellent example of using the similarity and dissimilarity of artefacts to model communities over time. Some 800, 000 decorated artefacts from site collections were compared using an index of similarity. This index recorded proportions of similarly decorated ceramic wares between individual sites. Links between similar artefact collections were then used as a proxy for communication and social interaction. The resulting network highlighted changes in network density and centrality over long periods of time, shedding light on the nature of migration, and technological change in the twelfth to the fifteenth centuries CE. Interestingly, this study also explored the resilience of social networks. "Resilience" here refers to the ways in which complex societies resist collapse or entropic fragmentation (Barnes et al., 2012, p. 2). In an operational sense, it is a measure of the degree to which a society can absorb sudden "disturbances". These disturbances appear to be an inherent to a complex-chaotic system, and its ability to remain functional (Folke, 2007; Redman, 2005, p. 72). Resilience should not be confused with resistance, which refers to the ability of a system to maintain as-designed features/function, despite pressure to change (Barnes et al., 2012, p. 2).

Returning to the study of pre-Hispanic southwest United States by Mills and colleagues (2012), it is apparent the fragmented, intermediate sized communities to the north were more resilient and thus persisted, and indeed still exists today. Whereas, the much larger and better-connected southern communities, grew rapidly, before collapsing in the fifteenth century CE. Thus too many linkages, stretched over a large area, over-stressed a system and led to its collapse. Particularly in civilisations where centrality and connectiveness is expressed as large-scale civil works, including road and irrigation networks (Stark, 2006b; Tainter, 2014). It is perhaps the smaller, semi-independent communities that continued long-term, maintaining the flexibility to survive periods of environmental change. It is hypothesised here that the presence of small, resilient, semi-independent, but not isolated, communities, are critical to the millennia of continuous occupation in the UMRV.

5.4 Summary

This chapter has presented a series of methodological and theoretical frameworks, which will be used to guide the study of local prehistoric and historic settlement patterns in the UMRV, northeast Thailand. Although the concepts presented above are diverse, they all relate to the complex subject of archaeological settlement patterns and how best to interpret and model their relationship with the environmental, cultural, and socio-political landscape. This thesis will target intermediate or "local" scale data through intensive pedestrian survey, using surface artefact concentrations as raw data. “Site” boundaries will be determined post-survey by through distance-intensity grouping of artefact scatters, and will be examined for environmental, cultural and socio-political trends, including evidence of “community”. For the purposes of this thesis a community is defined as a combination of physical proximity, along with more intangible elements. Essentially, this thesis adopts a definition of community as a construct of shared cultural attributes strengthened by physical proximity and by the number of linkages between its individual parts. Communities are reflected in human-human relationships, and the interdependence between groups, when facing external challenges, such as environmental change. This definition of community will be analysed in this thesis through examining common cultural markers, such as ceramic and burial traditions, and the ability to undertake regular physical contact. There will not be a focus on pan-regional trade, as this aspect could not be understood by an intermediate-scale of investigation undertaken in this thesis. Rather, the focus is upon intermediate-scale communities that supported each other on a daily or weekly basis, given the environmental challenges of subsisting on the semi-arid, tropical Khorat plateau. The ‘resilience’ of the UMRV, or lack thereof, will be discussed, relative to neighbouring regions.

6. Methods and Materials

The primary data sources for this thesis were a 200 km^2 reconnaissance driving survey and a 50 km^2 systematic, intensive, pedestrian survey. These surveys were completed over three field seasons (2012 - 2014), during the dry-season months of January, February, and March. All surveys were located within the alluvial flood plains, terraces, and uplands of the UMRV, northeast Thailand. The process of collecting this primary data occurred in three major stages: pre-survey preparation, field-based survey, and post-survey statistical analysis. These three processes are outlined sequentially below, with attention given to the rationale in undertaking each method.

6.1 Pre-Survey

Pre-survey preparation, completed from 2011 to 2012, consisted of gathering mapping resources, classifying the landscape of the UMRV, and refining the survey design. This was a critical period, which provided invaluable information on the study area, and established the framework for later fieldwork.

6.1.1 Compiling Aerial Images and Early Maps

Two thematic maps and one geo-referenced aerial photo mosaic of the study area were obtained.

1. A **1958** 2-AMS Edition, 1: 250 000 scale, thematic map published by the U. S. Army Map Service. Features on the map, including mounds, were digitised from; the Thailand Royal Survey Department 1: 25,000 and 1: 50 000 maps (1953 - 54 & 1937 - 55), Siam Hunting Aero Surveys aerial photographs 1: 36 000 (1952), and Indochina and Thailand AMS 1: 250 000 (1954).

2. A **1983** 1-RTSD Edition, 1: 50 000 scale Amphoe Khong, Thailand thematic map, compiled by the Royal Thai Survey Department, Bangkok.

3. A **2009** 0.5m resolution orthophoto mosaic of Phon Songkhram sub-district and surrounds.

These maps and aerial images were primarily used as a reference guide during field survey, and for digitising existing rivers and villages post-survey. They also provided information regarding changes in land use since 1954. These reflected the significant deforestation and industrialisation of the landscape, following the post-war cash cropping boom of the 1950's and 60's (Vityakon et al., 2004).

6.1.2 Nakhon Ratchasima Rajabhat University Thematic Maps

Nakhon Ratchasima Rajabhat University's GIS department, under their current Memorandum of Understanding with James Cook University, provided a series of shapefile data layers of Phon Songkhram sub-district and its surrounding area. Particularly useful for this project were the roads, represented as lines, village, sub-district, and soil formation shapefiles, presented as polygons.

6.1.3 Known Sites

Known archaeological sites within the UMRV were compiled from the Fine Arts Department database, and digitised from various research publications (Higham, 1989; Higham, 2012; Welch, 1985). Survey boundaries were outlined in correspondence with both Welch (1985) and Heffernan (2010). The result is a collection of over 20 excavated sites, 106 confirmed sites, and over 300 potential sites located within the survey area. It should be noted that this figure only includes published sites. A number of archaeological features and sites, known to either the Fine Arts Department of Thailand or foreign researchers, are yet to be published or entered into government databases. Discussions with the relevant archaeologists and institutions, and access to unpublished field notes, have assisted with filling some of these gaps.

6.1.4 IKONOS Imagery

High-resolution IKONOS satellite imagery of the 20km^2 surrounding Phon Songkhram sub-district was purchased to undertake classification of land use, soil salinisation, and ground surface visibility. The methodology is described in Appendix A.

6.1.5 ASTER Elevation Models

A mid-level resolution digital elevation model was obtained, to understand the environmental context of the study area, and to analyse the relationship between elevation, environmental zones, and the survey results. A 30m horizontal and one-meter vertical resolution Advanced Spacebourne Thermal Emission and Reflection Radiometer (ASTER) map of the Khorat basin, provided by Nakhon Ratchasima Rajabhat University, GIS department, was used to generate a basic understanding of the elevation profiles and the slope of the survey area.

6.2 Field Methods

The fieldwork stage was completed over three successive field seasons, from 2012 to 2014, during the dry-season months of January, February, and March. It combined two survey strategies, intended to partially overlap and complement each other: reconnaissance associated with a 200 km^2 satellite survey and a 50 km^2 systematic, intensive, pedestrian survey.

6.2.1 Pedestrian Survey

Three months prior to the first field season of January 2012 an intensive survey strategy was developed. The initial aim of the survey was to rigorously record intermediate-scale settlement data, which could then be used to record and analyse the prehistoric and historic occupation of the UMRV.

It was difficult to obtain a method for an intensive survey from previous research in Thailand. There have been very few documented attempts at systematic, intensive, pedestrian survey, most notably the KSTUT and Khao Sai metallurgy studies, and only one within northeast Thailand, the KBAP study (see Chapter 3.2 for details). International projects were therefore, turned to for inspiration (Chapter 3.3). Early designs for the survey were based upon the systematic, intensive, pedestrian survey methodology of the 12-year CICRP project (Peterson & Drennan, 2005).

A semi-random, sub-regional sampling distribution was chosen as this would allow "representative" sections of the landscape to be surveyed in great detail. Survey areas of 15 – 19 km^2 in size were then chosen randomly within each landscape type, namely the uplands, low-mid terraces, and alluvial floodplains (Chapter 2.1). Allowances had to be made for rivers and political borders, creating a somewhat irregular survey area. Within each survey area four adjacent field walking groups, spaced 50 m apart, walked east-west transects, which correlated with WGS84 UTM Zone 48N Datum. The average diameter of alluvial floodplains and terraced sites of all periods from the northeast and central Thailand is approximately 300 m, with the average diameter derived from the KBAP I & II survey of northeast Thailand 278.69 m (Welch, 1985, p. 306), and excavated sites from within Phon Songkhram sub-district 325.71 m (Higham & Kijngam, 2009; Higham et al., 2007; On-site inspection by PSKAS team in 2012). The average diameter for sites recorded during the KSTUT in central Thailand was 345.40 m (Eyre, 2006, p. 381), with site areas ranging between 0.0004 km^2 for Wat Pho Koi and 0.915 km^2 for Chansen (Eyre, 2006). Thus, a 50m separation between transects was sufficient to cover a reasonable area, and map a range of archaeological concentrations, in detail, given the personnel and time constraints of the project. Note, this is consistent with CICRP transect spacings, which ranged between 25 m and 100 m (Peterson & Drennan, 2005).

Prior to the initial survey, there was concern voiced by members of the PSKAS team, that forest and ground cover within the higher elevations, was denser than that encountered in northeast China. This would then prohibit the discovery of archaeological remains, or be too dense to facilitate walking in parallel straight-line transects. Photographs and satellite images from the study area indicated the low-mid level scrub/forest cover, and agricultural structures, would be likely to necessitate occasional deviation from the line by 20 to 50 m (Figure 10). Fifty metre spacing would, therefore, be appropriate to absorb this. The only area where transect deviation may differ, is upon the large salt factory ponds at the centre of the study area, where pedestrian access was unknown.

Figure 10. Landscape challenges of northeast Thailand (clockwise): forest patches, canals, residential structures, and plantations.

The survey team was based at the research centre at Ban Non Wat, Phon Songkhram sub-district, northeast Thailand. Each survey transect team would consist of at least one native English speaker, typically an Earthwatch volunteer or researcher, and one local Thai guide. In the weeks preceding the first field season a reference atlas was created containing satellite images of the study area. This was then overlaid with an artificial 50 m grid correlated to the universal coordinate system or *datum* (UTM WGS 84′ 48N datum; Figure 11). Prior to the initial survey, each 50 m by 50 m grid square was given an individual, sequential code or "Grid Square ID" (alphanumeric grid reference) that indicated its northerly (1, 2, 3, 4, 5…) and easterly (A, B, C, D…) location. This was the key to organising all field photographic and paper recordings, and later linking together the database structure. It is hereafter referred to as the grid square.

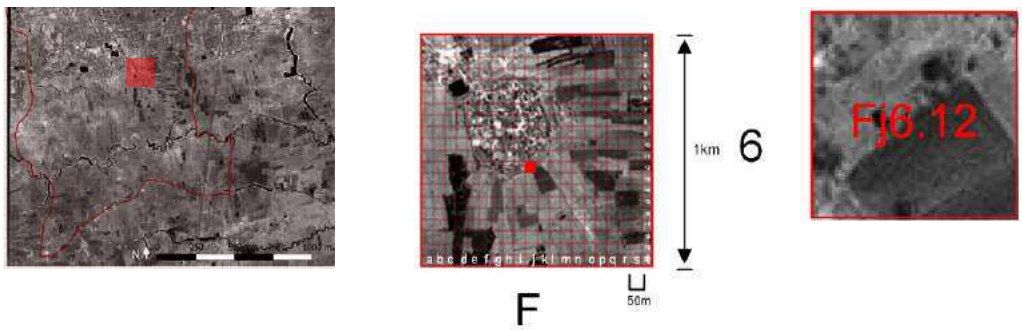

Figure 11. Survey grid layout with superimposed 50x50 m grid squares and grid square ID.

Artefact concentrations were recorded using a grid square recording form, and extensive photographs were taken with the aid of photographic recording template (Appendix B). Two crucial components of the grid square recording form were the "Artefact Density" and "Artefact Info" sections. The Artefact Density section recorded the density of artefacts per m^2. The density recording, for each superimposed grid square, generated a continuous surface grid of artefact concentrations. The Artefact Info section, in concert with photographs, allowed a count of diagnostic artefacts for each relevant period. This could then be used to derive the percentage of artefact density for each time period within each grid square, and across the survey area as a whole.

Two days (January 3rd - 4th 2012) of pre-survey reconnaissance of known sites within the study area, allowed the survey design to be further refined. It was noted that the level of diagnostic artefacts above known site complexes, tended towards extremes; either greater than 150 or less than three artefacts per m^2. The degree of general background artefact scatter across the landscape appeared negligible. Consequently, the minimum number of artefacts for recording was set to three or more diagnostic or un-diagnostic artefacts. Given how clearly they could be placed into broad diagnostic categories, upon visual inspection, it was decided that artefacts would not be collected. Intensive record keeping was used to sufficiently date artefact collections to the time periods under investigation. A collection-less approach has the benefit of not destroying the surface archaeological record, thus allowing for re-survey of areas at a later date, if the methodology should change significantly, or an error in recording occurs.

The artefact recording method was divided into two, due to the high variation in artefact density within known sites. If between three and 20 artefacts were found within a grid square, then all artefacts would be recorded, including diagnostic and un-diagnostic examples. If it was apparent the number of artefacts would exceed 20, a one metre circular or *dog-leash* method would be applied, and all artefacts within recorded. Focusing only on recording diagnostic examples was avoided. This can introduce observer bias, particularly given the varied archaeological experience of volunteers (Davis et al., 1997; Van Leusen, 2002, pp. 4-6).

It quickly became apparent during pre-survey reconnaissance, that the concrete foundations and roads of the large established villages would prove the most challenging obstacle to transect survey. This, therefore, required the integration of a separate, more opportunistic approach. It was decided that village housing plots, which varied between 100 and 300 m^2 in size, would be individually searched for artefacts once permission had been given by the land owner (Figure 12). This provided an opportunity to discuss the PSKAS project with local residents and village headmen/ women, and to gather ethnographic information regarding nearby sites and landscape disturbance history. Despite their time consuming nature, these discussions proved invaluable sources of information for reconnaissance surveys in subsequent seasons, and also generated community support and enthusiasm for the project.

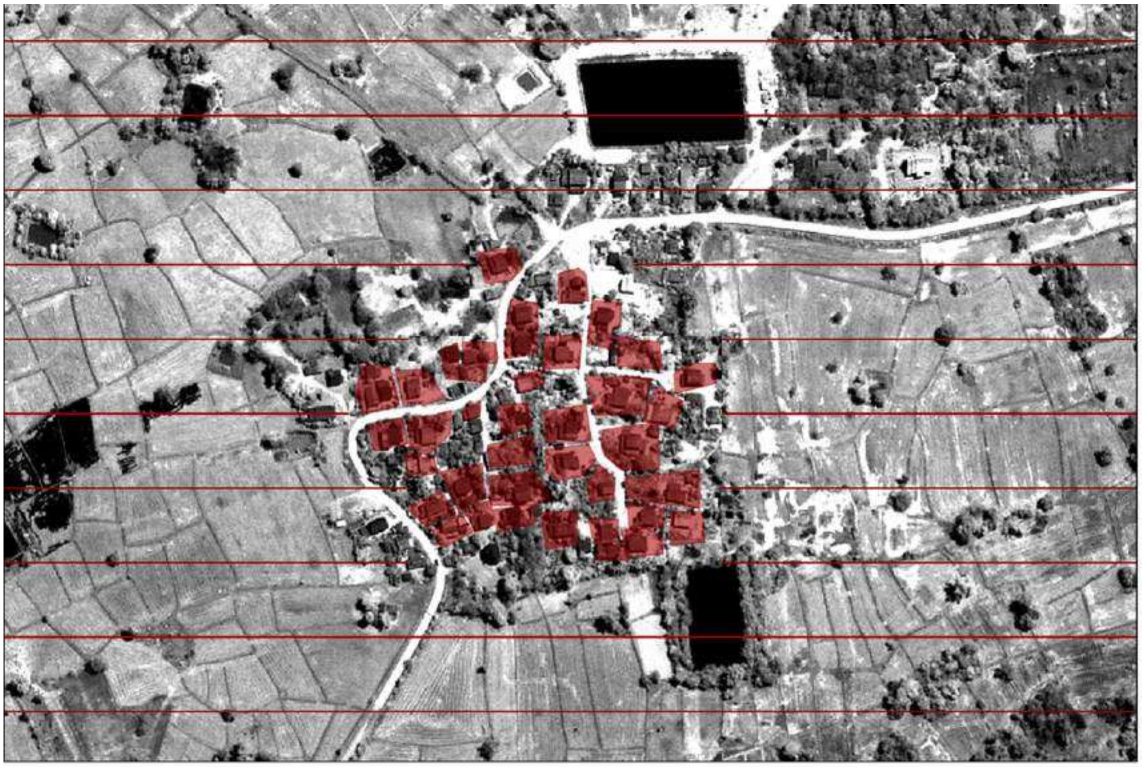

Figure 12. Two-stage survey of a large village: 50 m transects outside and house plot survey within the village.

During post-survey analysis, within-village concentrations were then integrated into the general survey grid network. The average density of artefacts from all housing plot samples, taken within each grid square, was used to determine its value. If no housing plot samples were available within a grid square, the value was the mean of all four surrounding grid squares. This created artificially smoothed artefact concentrations within inaccessible villages, but filled "holes" in the data, which could have caused significant problems during statistical analysis.

The process of conducting the systematic, intensive pedestrian survey in the field took 47 days to complete and covered a total of 50 km^2 (Figure 13). It was comprised of three sections: survey area A in the uplands, survey area B in the low-mid terraces, and survey area C in the upper alluvial floodplains. Survey area D in the deep alluvial floodplains was later added from the KBAP field journals (D. Welch, personal communication, April 17, 2014).

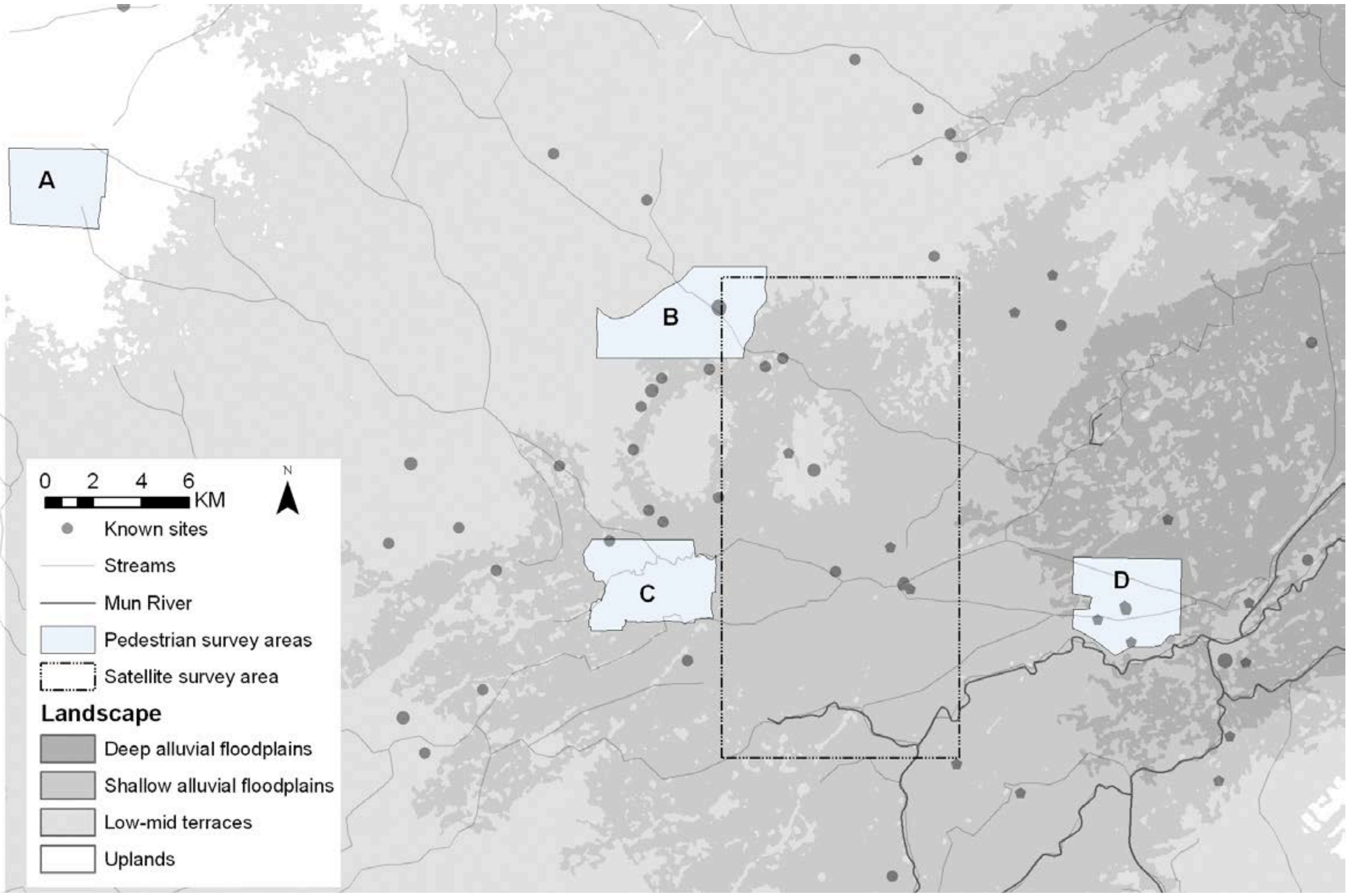

Figure 13. PSKAS pedestrian and satellite survey areas.

The initial section, survey area B, was completed in the 2012 field season over a 16 day period. The author and 10 volunteers surveyed 19.88 km^2 using 50m-interval pedestrian transects. The survey was conducted in mid-January, during the dry season, but following the rice harvest. Initially an area within the alluvial floodplains was chosen, as it encompassed the well-documented Ban Non Wat and Noen U-Loke sites (Higham & Kijngam, 2009; Higham et al., 2007). However, unseasonable rain had flooded many of the rice fields, and the survey was forced to move 6.5km north, to an area of low-mid terraced land between Ban Salao and Ban Phon Songkhram.

Four adjacent groups of field walkers, spaced 50 m apart, walked from the Ban Suang to Ban Khok Pra Hom road, running north-to-south through the centre of the survey area, to the eastern edge of the sub-district, and then back again. Each group contained a local Thai guide, an English speaker, and someone trained in recognising and recording artefacts (Figure 14). All field groups followed east to west parallel transects, maintaining a constant UTM northing reading on the Garmin Etrex GPS. Utilising the road as a beginning and end point, greatly aided the logistics of the exercise, facilitated transport to and from the drop off points, and provided a clear goal for field walkers.

Figure 14: Researchers and volunteers recording artefacts in the 2012 season (photographs by Wilbert Yee and author, reproduced with permission).

The Phon Songkhram salt factory proved a major challenge during the 2012 field season. Covering an area of 2.15 km^2, the salt factory was rumoured to have contained Neolithic and early Bronze Age site mounds, prior to the construction of the salt factory. It also, potentially, contained evidence of prehistoric salt production (A.Yankowski, personal communication, January 5, 2012). It was, therefore, important to include it in the pedestrian survey, despite the logistical difficulties. Permission to survey the salt factory was sought and obtained from the on-site manager, under the condition that the salt ponds were not polluted or disturbed. The salt ponds consisted of a series of large, rectangular, shallow pools, between 25 and 50m north-south, containing hyper-saline water. The original soil had been scraped out of each pond and used to make bordering raised bunds of two - four metres in width. Field walkers navigated the raised bunds, attempting to stay as close to their original transect as possible (Figure 15). The visibility of artefacts was increased by the excavation of the ponds, exposing and dumping a variety of prehistoric and historic material onto the bunds (Figure 15). However, ground visibility was also limited by the physical obstruction of the pond water. Furthermore, diagnostic ceramic patterns and finishes were heavily affected by salt corrosion. This corrosion led to a reliance on material and vessel form for dating artefacts, rather then decoration and finish.

Figure 15: Recording artefacts in the modern Phon Songkhram salt factory (photographs by author).

The 2013 January and February season was sufficiently dry to attempt a pedestrian survey within the southern or alluvial floodplain third of Phon Songkhram sub-district. Over 21 days a further 17.39 km^2 were surveyed, reaching from the southern banks of the Huai Yai River to the northern edge of Noen U-Loke (Figure 13: Survey area C). The survey methodology was consistent with that of 2012 survey area B, described above.

The alluvial floodplain section of the pedestrian survey presented many physical challenges. There were no passable roads within this section of the sub-district. What dirt roads did exist were muddy and likely to bog vehicles. Teams were often required to walk for up to an hour to reach the survey starting point. From late-January to early-February the rice paddy fields were between harvesting and replanting for the new season, so the ground surface consisted of baked clay mud, dry brush/long grass, and freshly ploughed earth. The heat, uneven terrain, and snakes, made this section of the survey particularly difficult. Individual's ensured visual contact was maintained with one other survey team at all times, and proceeded at a careful pace. Navigating the many agricultural canals and tributaries feeding into the Mun River, also slowed progress considerably. It proved far more time-efficient to wade across shallow rivers as a group, and then reform into transects, rather then search for a bridge.

The 2014 survey consisted of a 12.75 km^2 section of uplands, located approximately 21 km northwest of survey area B, within Sa Chaeng sub-district, Kham Sakaesaeng district, Nakhon Ratchasima, Thailand (Figure 13: Survey area A). This area was selected as it was the closest section to the 2012-2013 surveyed areas to rise above 250 m ASL. The site formed a natural hill slope rising from a tributary of the Huai Yai River. Once again the methodology was consistent with that of the previous two seasons, however the field season was conducted in early March, rather than January-February, due to research permit restrictions.

6.2.2 Satellite Image Survey

Satellite and aerial image survey is a prospection technique that examines both the visible and electromagnetic spectrum, for evidence of exposed archaeological structures, or man-made variation in the landscape (Masini & Lasaponara, 2006). Given the long history of aerial and reconnaissance survey in Southeast Asia (Chapter 3), it appeared to be a well-established and successful technique, suitable for comparisons with the findings of the PSKAS systematic intensive pedestrian survey.

Two months prior to the initial field season, high-resolution satellite imagery was searched for archaeological features within 200 km^2. This was area directly east of, and including, Phon Songkhram sub-district. The eastern 43 km^2 was surveyed using Spot imagery, at a resolution of 2.5 m resolution, and the western 157 km^2 DigitalGlobe imagery with a resolution of 0.5 m. Each one kilometre UTM projection grid unit was visually inspected for potential archaeological sites. This included but was not limited to; large features with circular, sandy, salty or moat-like attributes, and geometric structures associated with pre-modern temple and/or water control complexes.

Potential sites were verified or "ground-truthed" by the author, independent archaeologist Jitlada Innanchai, and two local villagers in January 2013. A discussion with the village headman ascertained, whether any artefacts had been found within the village, whether the site had been studied by previous archaeological projects, or the Fine Arts Department of Thailand. A general background to the age and history of the village was also provided. In addition, permission was sought for a brief visual inspection of roads, wells, canal cuts, or natural deposits that had been upturned for cassava or potato plantation. It became apparent during the PSKAS satellite survey that fine ceramic examples, mortar and pestles, and burial remains, were often remanded to the local *wat* (Buddhist temple) or school for storage, display, and religious ceremony. A practice also noted by Welch (1985, p. 145), during reconnaissance for the KBAP survey.

6.3 Post-Survey Methods

Post-survey methods involved; identifying and dating diagnostic artefacts from both the pedestrian survey and satellite survey and entering data into a GIS file database. This allowed the distribution of occupation in the study area over time to be established. Statistical tests were used to study the environmental, cultural, and socio-political trends of occupation.

6.3.1 Diagnostic Artefacts

Following each field season, the first post-survey process applied to the gathered data was to identify diagnostic artefacts, from both the pedestrian survey and satellite survey. Separating artefacts into diagnostic groups post-survey discouraged volunteers from making a judgment call on which artefacts were "old" or "significant" enough to record. Separation of the artefacts into temporal categories involved examining the photographs, recording forms, and notes from each individual artefact scatter, and entering the findings in the diagnostic artefact database. The database recorded the:

1. *Form*: for ceramic vessels this included rims, bases, and shoulders forming a unique profile. For non-pottery artefacts, form constituted a description of type, such as "brick", "adze", and "spindle whorl". The most common form recovered was blocks, both brick and laterite, with 43 examples. This was followed by vessel type one, with 23 examples.

2. *Finish*: The finish referred to wide-spread surface treatment. Common examples included red-slip, glazed, and *buff* (no treatment). More discrete

surface treatments, such as painted designs and burnishing, were considered surface decoration

3. *Fabric*: The fabric of an artefact refers to the raw material construction material. In the case of ceramics, fabrics included earthenware, stoneware, and porcelain. For non-pottery artefacts common fabrics, for example, included basalt, chert, fired clay, and bone. The paste or temper is not considered in this investigation due to collection constraints. However, this may be conducted in future studies.

4. *Decoration*: The decoration was considered a key diagnostic category, as it is the particularly useful for identifying small diagnostic sherds. For the purposes of the PSKAS project, decoration referred to restricted or isolated alterations of a vessel. Unlike form, finish, and fabric, a recovered PSKAS artefact may have several decorations. These included patterns such as cord-marking, incised circles, stamps, and manufacturing marks. They also included raised bands or appliqué, and painted designs.

5. *Manufacturing*: For ceramics this most often referred to wheel-scars, paddle-and-anvil marks, or a stand impression. However, in the case of stone, bone, and metal objects, it also referred to evidence of working, reworking, and ground surfaces.

Those artefacts that exhibited "sufficient diagnostic characteristics", for the purposes of this project three or more, could be confidently placed into temporal categories. Two types of artefacts emerged; category one, temporally diagnostic artefacts, and category two, those of interest to the investigator but not temporally diagnostic. Both are stored on the artefact attribute database. Those artefacts without any diagnostic features and not of particular interest to the investigator were not stored on the database. These two categories will now be examined in more detail, and by time period.

There are many shared or repeated attributes in ceramic design within the early prehistoric period. The easiest distinction between ceramics of the Neolithic, Bronze, and early Iron Ages are a combination of vessel form, tempers and clay types (Sarjeant, 2006; Sarjeant, 2010). However, these features are difficult to discern when recovering predominately small artefact fragments, in a field situation. In general, the diagnostic qualities able to be attributed to early prehistory are; paddle–and-anvil marked earthenware with cord-marking, a red slip, and in some cases a burnished or painted design (Table 3, Figure 16). Of particular note was impressed and incised Neolithic stoneware, clearly discernable, in the survey assemblage.

Table 3:

Early Prehistoric Artefact Attributes

Ceramic attributes	**Early prehistory (eighteenth century BCE – first century CE)**		
	Neolithic	Bronze Age	Early Iron Age
Form types	V-T1 (pedestal base with large flaring rim, and inverted lip) V-T2 (oval body, constricted neck, everted rim) V-T3 (round body, short straight/ simple rim) B-T1 (open bowl with round bottom and straight rim, with/without pedestal)	V-T2 V-T3 V-T4 (Round body, short everted rim) B-T1 T-section bangles	V-T4 V-T5 (round body, vertical neck, everted rim, and flat lip) V-T6 (large, egg-shaped vessel) B-T1 Bell
Surface decoration	ICS & IMP, CM on the body, CBM on the body, Red-painted ware, Black-painted ware, APP central cordon with IMP, IMP rice-design, ICS net pattern, ICS lines (random)	CM, CBM, Red-painted ware, R&B, APP central cordon with IMP	CM, CBM, R&B, APP central cordon with IMP
Fabrics/ pastes	Earthenware: Very hard, grey paste with quartz and rice-chaff temper.	Earthenware: Untempered or non-fibre tempers (quartz, sand, or grog) local clays	Earthenware: Non-fibre tempers (quartz, sand, or grog) local clays Fibre tempers
Finish	Red-slipped, tan-slipped, buff, mottled red/black-slipped	Red-slipped	Tan-slipped, red-slipped, tan-to-black slipped

Note. ICS = incised, ICS & IMP = incised and impressed, APP = appliqué, B&WHP = blue and white hand painted design, IUP = iron-under painted design, CM = cord-marking, CBM = comb-marking, SM = stamp-marking, R&B = red slipped and burnished, GL = glaze, V-T = Vessel Type, B-T1 = bowl type 1.

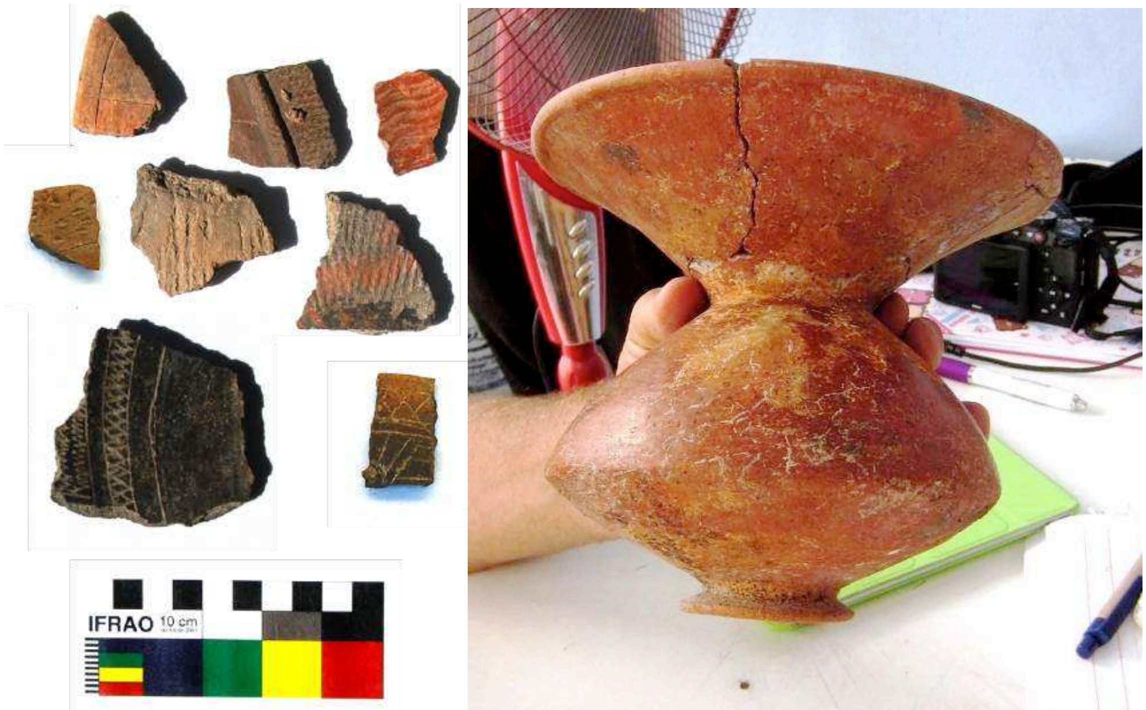

Figure 16. Early prehistoric ceramic examples from Ban Non Wat including Neolithic ceramics (left) and a Bronze Age Type 2 Vessel (right; photographs by the author, 2013).

There were also several category two artefacts, that is, those associated with occupation in early prehistory and of interest to investigators, but not considered temporally diagnostic. Stone tools were often found within the study area, including whetstones, grinding stones, and flakes. The majority of all stone adzes from Ban Non Wat, both shouldered and unshouldered examples, were found within an early prehistoric context, with numbers peaking in the Neolithic (Tessa Boer-Mah, 2008). Spindle whorls are also commonly recovered from early prehistoric contexts, and conical rollers were an artefact only found in the middle Bronze Age at Ban Non Wat (Higham et al., 2009; Kolb, 2012, p. 6; Sarjeant, 2006). Clay pellets are found throughout the entire occupation sequence of Ban Non Wat, located in the UMRV. However the density of clay pellets is generally concentrated in the early layers, particularly the Bronze Age and Neolithic (Higham & Kijngam, 2009, p. 244; G. Stenhouse, personal communication, November 20, 2014). Worked animal bone tools at Ban Non Wat and Noen U-Loke are primarily Neolithic and Bronze Age (Stenhouse, 2010, p. 75). However animal bone tools should not be confused with animal bone personal ornaments. Finally, human remains are commonly associated with early prehistoric contexts, as the historic and modern population of Thailand primarily practices cremation (Higham, 2002).

Late prehistory signalled the wide-spread, and highly standardised, introduction of the ceramic style known as Phimai Black (Solheim & Ayres, 1979; Welch, 1985; Welch & McNeill, 2004; Table 4, Figure 17). Phimai black is distinctive, with its high firing temperatures and organic temper resulting in thin, black earthenware. It is commonly associated with streak burnishing and incised circles or lines. Shallow bowls became common during late prehistory, as did paddle-and-anvil earthenware, with the beginnings of an everted, pronounced lip. This lip is also a feature of the pre-Angkor period, however it is only found on wheel-turned vessels.

Table 4:

Late Prehistoric Artefact Attributes

Ceramic attribute	Late prehistory (first-mid sixth centuries CE)
Form types	V-T2
	V-T4 (rounded lip)
	V-T5 (rounded lip)
	V-T7 (u-shaped body, everted rim, and rounded lip)
	V-T8 (flaring body, rounded shoulder, straight neck, straight rim, and straight/everted lip)
	B-T1
	B-T2 (open bowl with inverted rim and pedestal)
	B-T3 (open bowl with lip and ridge)
	B-T4 (everted bowl, with flat bottom, and straight/everted rim)
	Bell
Surface decoration	CBM, SM, IMP half-moon, IMP circles, ICS net pattern, burnishing, streak burnishing
Fabrics/ pastes	Fine quartz and sand tempered earthenware with laterite inclusions.
	Very rough fibre-tempered, fire-fired earthenware (junkware)
Finish	Tan, black, red, or combination slip, BTT, RTB, Buff
Evidence of manufacturing technique	Paddle-anvil marks

Note. ICS = incised, ICS & IMP = incised and impressed, APP = appliqué, B&WHP = blue and white hand painted design, IUP = iron-under painted design, CM = cord-marking, CBM = comb-marking, SM = stamp-marking, R&B = red slipped and burnished, GL = glaze, V-T1 = vessel - type 1, B-T1 = bowl type 1.

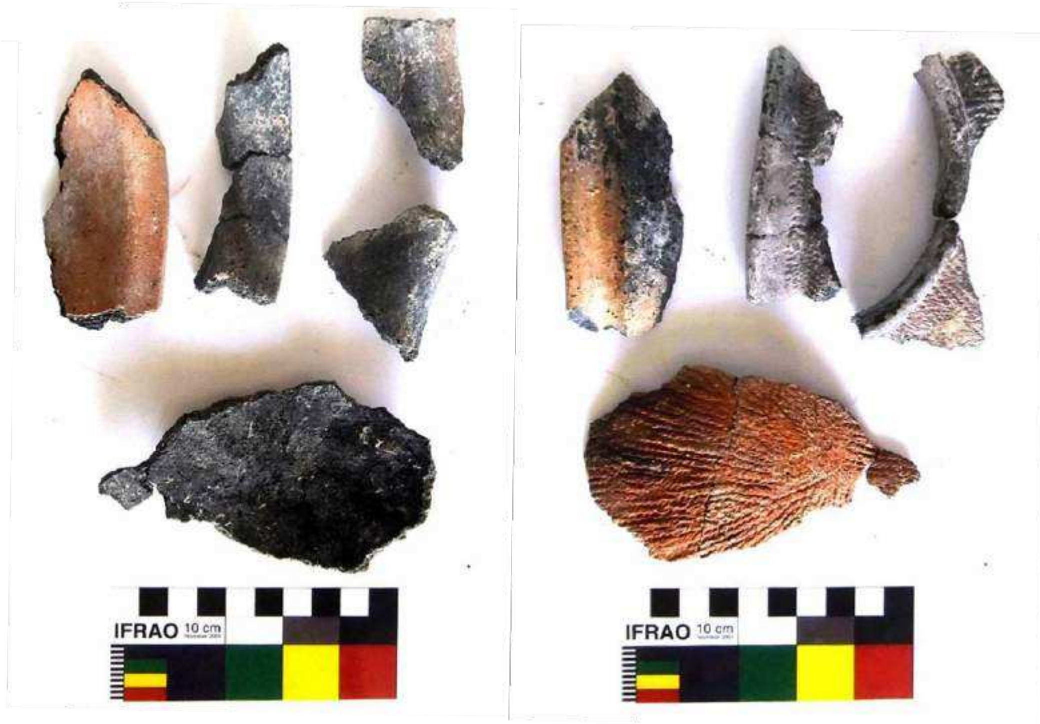

Figure 17. Phimai Black ceramics from Ban Non Wat (photograph by the author, 2013).

With regard to category two artefacts, the density of animal bone personal ornaments increases sharply in the late prehistoric of the UMRV, during the first to mid sixth century CE (Stenhouse, 2010). Indeed, carnelian beads and blank blocks were a feature of late Iron Age burial in the UMRV, as were decorative bronze objects; most notably bells, bangles, and spears.

Thus, we turn to the pre-Angkor period. Whilst there is overlap between the terminal Iron Age and pre-Angkor ceramic styles, particularly in the sixth century, the latter has some distinct attributes (Table 5). Wheel-turned earthenware, often thin, buff, and with red-painted designs, emerged for the first time in the mid sixth century CE, as did finger-marked bricks and Mahāyāna Buddhist figures and styles. Indic vessels, including animalistic lime pots, kendi, and dish-on-stand also emerged at this time (Chakrabongse & Rooney, 2013). In rare cases, contemporary trade wares have been found in northeast Thailand, including ninth century turquoise Persian ceramics and Yue, Changsha, and Xing Chinese wares (Scott, 2002). Another distinctive pre-Angkor ceramic, described in detail by Indrawooth (1985), is the "carinated vessel". Here Indrawooth refers to an earthenware vessel with a band of appliqué around the shoulder or neck, often decorated with small impressions, and a band of red paint.

Table 5:

Pre-Angkor Artefact Attributes

Ceramic attributes	**Pre-Angkor period (mid sixth – ninth centuries CE)**
Form types	Lotus bud lid Finger-marked bricks and stucco Spouted vessel (kendi) LJ-T8 (with multiple lips) Carinated vessels Dish-on-stand
Surface decoration	CBM, SM, IMP half-moon, IMP circles, ICS zig-zag, red-painted ware, APP central cordon with IMP, IMP triangles, ICS net pattern, ICS diagonal lines, ICS parallel lines (deep), burnishing
Fabrics/ pastes	Low-fired earthenware; predominately beige rice-husk tempered, also cream/white grog tempered ware Very rough fibre-tempered, fire-fired earthenware (junkware)
Finish	Buff, white-transparent GL, green-transparent GL, black slip
Evidence of manufacturing technique	Wheel scars

Note. ICS = incised, ICS & IMP = incised and impressed, APP = appliqué, B&WHP = blue and white hand painted design, IUP = iron-under painted design, CM = cord-marking, CBM = comb-marking, SM = stamp-marking, R&B = red slipped and burnished, GL = glaze, V-T1 = vessel - type 1, B-T1 = bowl type 1.

A rather enigmatic type of ceramic to emerge from the survey is described as "junkware" (Figure 18). Junkware is thick, rough earthenware, with many organic inclusions. Its crude construction suggests junkware may be a semi-temporary, large storage vessel for salt, fermented fish, or other goods. Examples from excavation, although commonly discarded due to a lack of surface treatment or decoration, appear to emerge in the late sixth century CE (viewed by the author at Non Ban Jak in 2014). This indicates production occurred on the cusp of the late prehistoric and pre-Angkor periods. For the purposes of this survey junkware has been placed in the pre-Angkor period.

Figure 18. Example of Junkware ceramic sherd, approximately one inch thick, with coarse fibre temper (photograph by the author, 2013).

It is difficult to find category two artefacts, or specialty items, which might relate to the pre-Angkor period, as excavations of this period in the UMRV have been scarce. One item commonly found within a pre-Angkor period context is *skin rubbers* (a ceramic, incised paddle; Higham & Kijngam, 2009). Evidence of large-scale iron production is common during this period, as were iron artefacts, including ploughshares, sickles, and spears. Also characteristic of the pre-Angkor period is Buddhist boundary markers or sema stones (Murphy, 2010). These stones may or may not contain carvings and inscriptions.

The Angkor period contains the most varied and distinctive artefacts in northeast Thailand (Table 6). Stoneware with a thick glazed finish was introduced, and bases and shoulders became adorned with bands of appliqués and geometric, incised designs (Brown, 1981; Groslier, 1981; Chakrabongse & Rooney, 2013). The wave motif, bordered by parallel incised or raised lines, became particularly prominent during the Angkor period (Figure 19). Chinese trade ware, identified by Naho Shimizu, also appeared in the UMRV during the Angkor period. Examples included; celadon ware, greenish-white Qingbai ware, and early blue-on-white Ming ware (ninth - fourteenth centuries CE) (Dupoizat, 2008; Tai, 2012).

Table 6:

Angkor Artefact Attributes

Ceramic attributes	Angkor period (ninth – fourteenth centuries CE)
Form types	Lime pot Lotus bud top B-T1 Box and cover Spouted vessel (kendi) V-T9 (large jar on pedestal base, with constricted neck, everted rim, multiple lips) Lenticular pot Bottle V-T10 (storage jar with flat base, straight rim, and rounded lip) Laterite/ sandstone blocks Mahayana Buddhist statutes/monuments Dish Pedestal bowl
Surface decoration	ICS zig-zag, ICS waves, APP waves, band of APP, ICS parallel lines, B&WHP, IUP, animalistic design, 3 ICS vertical lines, geometric shoulder design, APP lines, stepped, large holes
Fabrics/ pastes	Stoneware, white ware, sandstone, laterite
Finish	Crazed celadon GL, honey GL, brown GL, green GL, BGG, apple-green GL, black GL, olive GL, brown-and-green GL
Evidence of manufacturing technique	Wheel scars, stand scars

Note. ICS = incised, ICS & IMP = incised and impressed, APP = appliqué, B&WHP = blue and white hand painted design, IUP = iron-under painted design, CM = cord-marking, CBM = comb-marking, SM = stamp-marking, R&B = red slipped and burnished, GL = glaze, V-T1 = vessel - type 1, B-T1 = bowl type 1.

Figure 19. Angkor period ceramics, with a Type 10 Vessel (left) and a sandstone lotus (right; photograph by the author, 2012).

Category two artefacts are limited, as most collections from the Angkor period are highly diagnostic, and can be confidently placed in category one. However items potentially associated with Angkor period temples and their rituals included; pestle and mortar, featureless sandstone carvings, and isolated laterite blocks (Figure 19). Substantial structures constructed of laterite and sandstone, most notably monuments and temples, were considered temporally diagnostic. Isolated blocks, however, fell under category two, due to their propensity to be moved and reused as garden features. The remains of old canals, ponds, and diverted rivers are also commonly associated with the Angkor period. Without excavation, however, their date of construction cannot be confirmed.

Any late historic (fourteenth century CE - today) artefacts recorded during the PSKAS were later removed from the collection. Modern pots and water jars are usually concrete and mass-produced within northeast Thailand, and are therefore easily discernable. However, a small number of earthenware ceramics are still produced using traditional techniques by individual artists. Often the artist will stamp the rim with their design and generally the clay will be of a quality unmatched in ancient ceramics. These modern ceramics may be clearly discerned from ancient earthenware. An abbreviated summary of diagnostic artefacts is included in Appendix C, and the complete artefact attribute database is available from the author upon request.

6.3.2 Units of Analysis

Each individual category one or diagnostic artefact was assigned a grid square identification number linking it to the artefact scatter it originated from. The number of diagnostic artefacts then populated the "Grid Square Database", thereby providing a density map of artefacts per period (early prehistory, late prehistory, pre-Angkor, and Angkor). This network of grid squares, with densities of diagnostic artefacts as attributes, constituted the first unit of analysis. An example of grid squares can be seen in Figure 20. Grid squares are particularly useful for understanding survey collection processes, and potential landscape bias (explored in Chapter 7.1).

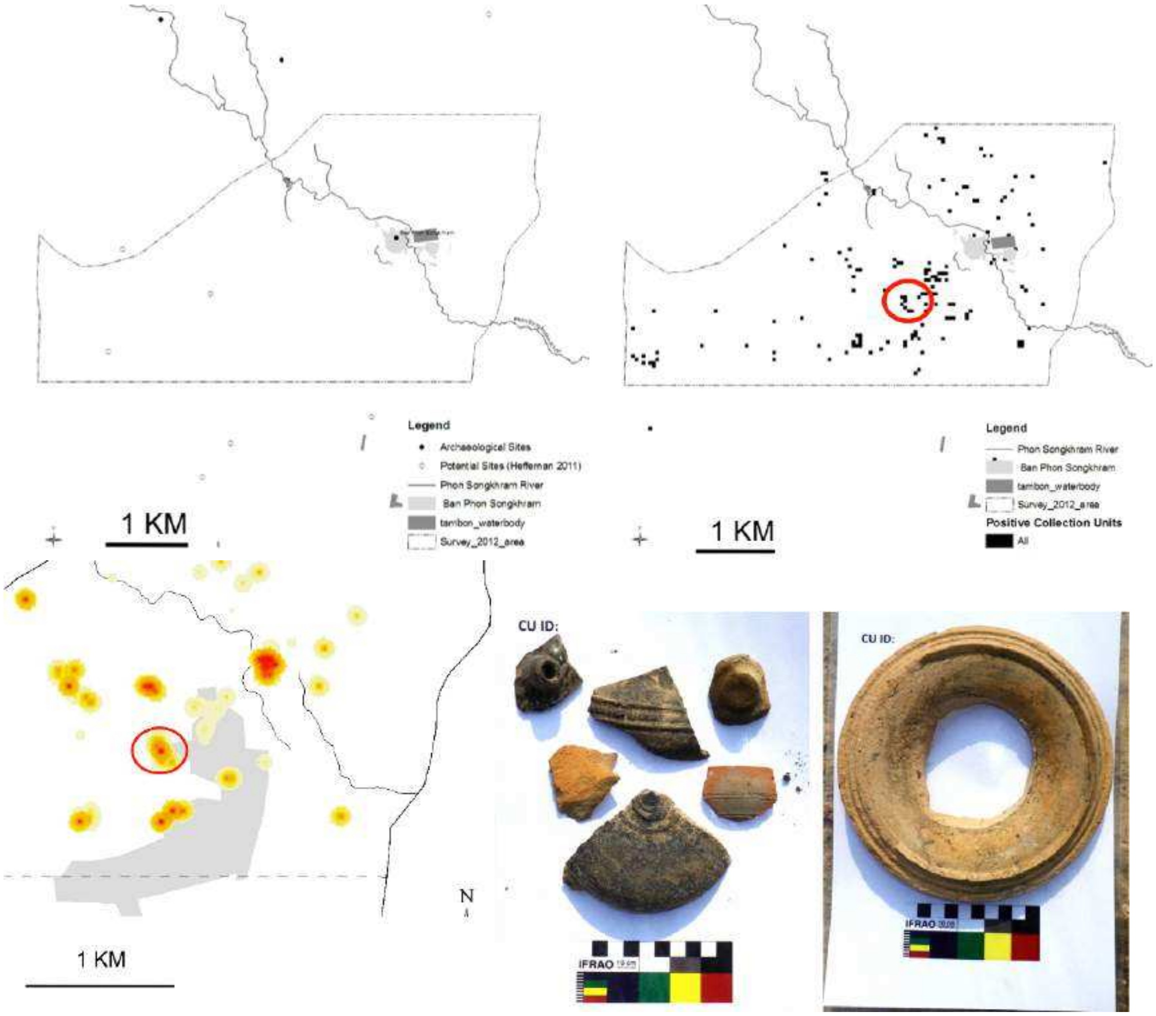

Figure 20. Survey area B with site 28 highlighted: Before pedestrian survey (top left), with grid squares containing diagnostic artefacts as black squares (top right), with distance-intensity mapping to define concentrations of artefact scatters or “sites” (bottom).

The second unit of analysis, more suited to archaeological investigation, refers to "sites" (Chapter 5.1). As the focus of this study is inter-site, rather than intra-site settlement patterns, an arbitrarily grouped measure of events or contexts is needed to undertake studies of archaeological significance (Evans et al., 2015). For the purposes of this thesis, site boundaries were defined as a product of the artefact density and the distance between grid squares (Chapter 5.1, Figure 20). A boundary was created, therefore, when 200 m away from a grid square containing four or more diagnostic artefacts. This figure then rose, based upon the number of diagnostic artefacts. For example, for five diagnostic artefacts the site boundary expanded to 225 m. Distance from a single grid square, however, was capped at 500 m. Grid squares containing less than or equal to four diagnostic artefacts were discarded, due to their potential for movement during annual inundation and agricultural earthworks. This method of visualisation relies on the assumption that the size, in area, of a site, is directly related to the density of its surface artefacts. It also assumes the centres of sites contain the highest density of artefacts (Note, there is local excavation evidence to support this second assumption, see Chapter 4.1). An example of how grid squares are designated as sites can be found in Figure 20.

6.3.3 Statistical Analysis

As is the case with most settlement studies, the results of this thesis are both qualitative and quantitative. The latter results require expression using statistics, which this section will outline in detail.

The semi-random collection of survey areas for the PSKAS project represented a significant statistical challenge for this thesis. How could the project test for relationships between these sites and various independent factors, given that a random stratified sample may be biased towards particular values? For example, it would be misleading if all four survey areas happened to be located on clay-based soils, when the study area clearly contained a variety of soil types. The impact of the sampling distribution on independent values, thus, needs to be tested first. To address this, the "control" (all survey areas) was compared to the "population" (entire UMRV), and major discrepancies are highlighted (Chapter 7.1). If the survey areas are not significantly skewed, sites themselves can then be subject to analysis.

Testing Independent Values

One of the initial goals of this survey was to examine the relationship between environmental and cultural features, and the location of sites. Using GIS software the relationship between site location and either continuous or categorical variables may be examined.

Categorical variables, such as soil or land use, were extracted from the site location and tested for significant trends. Chi-squared is a goodness of fit test, which examines the likelihood that deviations between the actual sample, and the expected sample, are the result of chance or due to other factors (Baxter, 2003). To test the significance of categorical independent variables, such as soils and land use, the chi-squared test was applied. The chi-squared test, however, is only suitable where the expected distribution of sites ("Exp"), given the sample size ("N"), is greater than five in all categories. To make this possible soil and land use were gathered into a series of categories based on similar characteristics. For example, scrub and forest were combined, as were recent clay soils Phimai and Tung Samrit.

Where sample size was still too low or the distribution of results highly uneven, the randomisation test, with 10, 000 repetitions, was utilised. The randomisation test is a non-parametric test which does not require a normal distribution. As archaeological site patterns are rarely normally distributed in the landscape, due to a variety of cultural and economic factors, this is a useful test for settlement data. It randomly examines all possible variations of the results given the sample size ("N"), generating a test statistic. It is the difference between this *test-statistic* (sampling distribution with parametric tests), and the actual distribution, that decides the significance value. Whilst the flexibility of the test makes it well suited to settlement studies, its results are often vague. Thus, targeting which factor is causing settlement trends can be difficult to interpret (Lunneborg, 2000).

Examining the significance of continuous independent variables, such as flow accumulation and elevation was a significant challenge, particularly given the semi-random distribution of the survey areas. Identifying significance primarily consisted of comparing plotted trend lines, the mean, standard deviation, and range. Obvious deviations from the control and population plots were examined using the Kolmogorov-Smirnov Test. The Kolmogorov-Smirnov, or K-S test, is a non-parametric and distribution free test. The two-sample K-S test determines the probability that two sample datasets are drawn from the same parent population, given their cumulative distributions. In this project the two datasets were the observed statistics, and 5000 random points from within the survey area used as the "control". If the resulting p-value is significantly low, less than or equal to 0.05, it is unlikely that the two datasets have derived from the same parent population. Therefore the survey sites were not considered randomly distributed with respect to an independent variable.

Distance from a discrete entity requires conversion from a vector to a raster format before analysis. For example, to discover whether sites are located unexpectedly close to modern rivers, a continuous *Euclidean* (as-the-crow-flies) distance raster from rivers in the survey areas must first be created. The output can then also be analysed as a continuous variable, using descriptive statistics and two-sample K-S test described above.

Spatial Distribution and Clustering

A further component of settlement pattern studies is the examination of site size, site clustering, and the distance-relationship between sites. This can provide you with an understanding of socio-political trends.

The rank-size rule, or Zipf's Law, states that, the size of a site in a settlement hierarchy will equal the size of the largest site divided by the original site rank (Reed, 2002; Woldenburg & Berry, 1967; Zipf, 1949). Settlement systems that conform to the rank size rule, and display a straight line when plotted on a log-normal graph, are said to adhere to central place theory. Modern US cities tend to conform well to the central place rule. Cities and towns, for example, double in relative size with each category increase, from small town to major capital city (Gabaix, 1999). Rank-size trend lines that appear convex are said to have multiple similar sized settlements, indicating poor integration, and potentially many settlement systems. If the rank-size trend line is concave, however, settlement patterns are dominated by their largest site. This indicates economic competition is low, and/or the large sites differentially interact with neighbouring settlement systems.

Central spatial tendencies are another graphical portrayal of a point pattern, in this case a site scatter through space. It displays the mean centre of all site locations, and a directional eclipse that constitutes a single standard distance of both x and y values, covering approximately 68 percent of all sites. These two factors establish the centre of a site distribution, the degree of clustering in a distribution, and it's predominate directionality (Allen, 2009; Environmental Systems Research Institute, 2011; Mitchell, 2009).

A more targeted study of site clustering is provided by Clark and Evan's nearest neighbour statistic (Illian et al., 2008; Pinder et al., 1979). Nearest neighbour compares the observed mean distance between actual sites, to the expected mean distance between sites ("N") if they were randomly distributed across the study area. This then produces a z-score that indicates clustering, z-score less than zero, or dispersal, z-score less than zero. The expected mean distance is a product of the number of sites by the size of the enclosing boundary. When "edge effects" are corrected for, nearest neighbour becomes a useful tool for identifying clustering at a single scale of analysis. However, as Bevan and Conolly argue (2006), and Peterson and Drennan (2005) clearly demonstrate, the nearest neighbour statistic is highly sensitive to boundary and scale. It may miss larger or smaller scale spatial patterns, and tends to provide a rather oversimplified result (Bevan & Conolly, 2006). Given its limitations, nearest neighbour was used in this thesis as a relative measure of clustering, between landscape types and time periods. Both fixed survey boundaries and minimum enclosing boundaries were used.

6.4 Summary

The PSKAS project was originally intended to be an exploratory approach, to test the merit of systematic intensive pedestrian survey within northeast Thailand. Once its merits had been established and new sites uncovered, the PSKAS project quickly grew to encompass both the localised intensive survey of surface artefacts, and the use of satellite imagery to map the broader collection of sites within the UMRV landscape. A systematic approach to survey allowed for the integration of both these techniques into a GIS framework, and the application of a series of statistical analyses. The following chapter will present the results of these processes, with a view to recording and analysing intermediate-scale settlement within the UMRV, in relation to environmental, cultural, and socio-political factors.

7. Results

This project represents the first attempt at intermediate-scale, intensive, pedestrian survey in the UMRV, and the most detailed and widespread attempt within Thailand. Therefore, the first step was to review the overall raw results of the survey and to identify any potential bias. The first section of this results chapter analysis the overall artifact assemblage, and the process of survey itself. The survey techniques applied here are evaluated and found to be both intensive and rich in archaeological information. This is followed by the presentation of the results of the early prehistoric, late prehistoric, pre-Angkor, and Angkor period survey data. Trends relating to environmental, cultural, and socio-political factors are analysed. Finally, long-term trends within the UMRV, across all four time periods, are considered.

7.1 Assessment of Overall Results

This chapter represents an evaluation of the survey techniques applied and a presentation of the raw assemblage recovered. It analyses whether the PSKAS survey encompassed a representative sample of the landscape of the UMRV, as modelled in Chapter 2. Or whether the results were skewed towards a particular modern land use and surface visibility.

The **PSKAS systematic, intensive, pedestrian survey** team consisted of four groups surveying 50 km^2 over six weeks, at an average of 270 m^2 coverage per group per day. A team total of 22, 000 artefacts was recorded, with approximately five percent categorised as temporally diagnostic, and a further 0.8 percent of interest to archaeologists but not temporally diagnostic (Table 7). This amounted to 6.34 grid squares containing diagnostic artefacts per day, or 1.19 sites per day. This technique was highly intensive. However, the PSKAS survey excelled with regard to the type and detail of information recovered. Earthwork encircled sites or large mounds, visible from aerial photographs or satellite imagery, constituted only nine percent of all sites recorded using systematic, pedestrian survey, and 35 percent of all sites recorded using satellite survey. Significantly more site types have been recorded, many of which are undetectable to aerial survey. Examples included small, shallow production sites, small collapsed stupas, shell middens, and areas of intermittent or short-lived occupation. For a complete description of all site types see Appendix C.

Table 7:

PSKAS Grid Squares

Survey unit	Area (km^2)	No. grid squares total	No. grid squares containing diagnostic artefacts	No. grid squares/ km^2	No. diagnostic artefacts	No. diagnostic artefacts/ grid square
A	12.75	5100	34	2.67	98	2.88
B	19.88	7952	150	7.55	504	3.36
C	17.39	6956	104	5.98	411	3.95
D	15.60	6240	10	0.64	40*	4*
Total	65.62	26248	298	4.54	1053	3.53

Note. * = Estimate based on KBAP field diaries and field inspection in 2012 (D. Welch, personal communication, April 17, 2014).

The intensive nature of the survey also revealed how areas of occupational intensity may fluctuate and shift within a site. The fixed edge of the mound or encircling earthworks can be misleading, as occupation was highly fluid and changeable in the UMRV. Such micro shifts were not enough, however, to threaten the cohesion of a site, as it is still clearly the same site from a regional perspective. However, isolated excavation squares may not encompass the entire occupation sequence of a site, and intensive survey is still, therefore, essential. This phenomenon is explored further in Chapter 8.1, with reference to examples Phon Songkhram and Noen U-Loke.

The results from within each survey area (A, B, C, and D), and by implication within different landscape types, varied greatly (Table 7). Survey area A, located in the dry, sandy hill slopes, returned a relatively modest collection of surface artefacts, concentrated near a corridor of vegetation passing through the centre of the survey area. Artefacts were primarily Angkor period, with a smaller collection of pre-Angkor ceramics. Survey area B, on the other hand, recorded a much higher number of artefacts, clustered in greater density. Located on the low to mid terraces of the Mun River Valley, artefacts in survey area B were well spread throughout the landscape, with a notable concentration in the Phon Songkhram salt factory. Artefacts consisted of primarily late prehistoric to Angkor period pieces, with an isolated Neolithic sherd also recovered. Survey area C, in the modern wet-rice precinct of the upper alluvial floodplains, also recorded a large collection of surface artefacts. Artefacts appeared more concentrated in the alluvial floodplains, adhering well to site boundaries, including the large Noen U-Loke mound, and a collection of small circular sites, which stretched in a linear fashion from the southwest corner of the survey area, towards Non Kham in the centre. Artefacts encompassed all periods, from the Neolithic to the Angkor period. Finally, survey area D, as interpreted from Welch's original (1985) findings, is located deep in the clay-rich alluvial floodplains near Phimai, and contained a single site (Ban Tamyae). Welch (1985) notes that Ban Tamyae was heavily concentrated with late prehistoric and historic period surface artefacts.

The high-resolution **PSKAS satellite survey** recovered 48 sites at an average of 0.24 sites per km^2 (Table 8, Figure 21). The survey technique was highly efficient, surveying an average of 16.67 km^2 per group per day. Site types varied from large, earthwork encircled mounds, such as site 81 visible in Figure 22, to small shell middens and production sites. The latter tended to be visible as pale salty and/or sandy, irregular shaped, patches in the landscape (Figure 23). Such features have only become visible with the latest high-resolution satellite imagery. There was a notable tendency for mounded and non-mounded sites to follow a linear pattern, such as the string of pre-Angkor period sites apparent in Figure 23.

Table 8:

Comparison of Survey Techniques in UMRV

Survey	Type	Efficiency (km^2 per group per day)	Date of fieldwork (Imagery)	Site density (sites per km^2)	Coverage (km^2)	Transect spacing/ Intensity (m)
PSKAS	Systematic, intensive pedestrian survey	0.27	2011-14 (NA)	1.19	50	50
PSKAS	Satellite survey	16.67	2013 (2012)	0.24	200	200
KBAP	Aerial and transect survey	No field survey conducted	1989 (1954)	0.15	700	300
KBAP	Reconnaissance survey	14.29	1979-80 (1950s – 1980)	0.08	300	1000

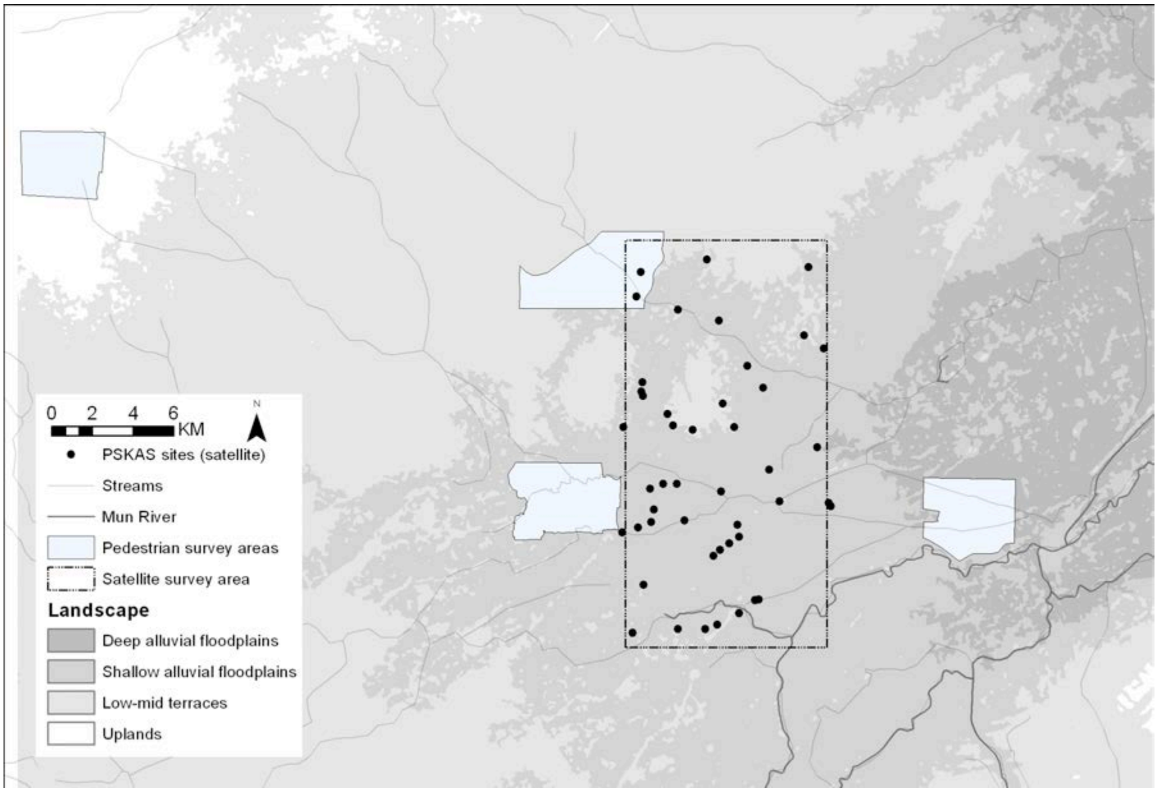

Figure 21: Sites recovered during PSKAS satellite survey.

Figure 22: Prehistoric and historic site 81, with mound and encircling earthworks.

Figure 23: String of partially destroyed pre-Angkor sites 96-99, visible as a line of white features from bottom left-hand corner to top right-hand corner of image.

Potential Bias

Findings have been heavily impacted by the survey technique utilised, particularly its coverage intensity. When pedestrian and survey techniques within the UMRV are compared, the impact of survey intensity on the number of sites recovered can be clearly seen (Table 8). The PSKAS satellite survey had a poor coverage intensity of 200 m, when compared to PSKAS intensive pedestrian survey, which utilised 50 m transects. Consequently a lower density of sites was recovered from the PSKAS satellite survey, of 0.22 sites per km^2, when compared to the pedestrian survey results, at 1.19 sites per km^2. The more intensive the survey, the more likely archaeological sites may be revealed. This trend continued when the PSKAS satellite survey results were compared with the lower resolution KBAP aerial survey, with a coverage intensity estimated at 300 m (Table 8). The latter recorded a somewhat lower site density of 0.15 sites per km^2.

Results suggested coverage intensity had a recordable impact on survey finds. It seems that increasing the coverage intensity lowered the survey efficiency, and increased the likelihood the survey sample was not representative of the region, or had a bias towards a particular landscape type (Table 8). Clearly there is a balance to be achieved between coverage, intensity, and survey efficiency.

When elevation values are examined from the four survey areas (A, B, C, D), the distribution appears to be generally representative of the wider UMRV. The mean differs by 0.27 m ASL and standard deviation by 8.18 m ASL (Table 9). Clearly the absence of survey areas containing 171-208 m ASL must be taken into account and should be addressed in future studies.

Table 9:

Elevation Profile of Study Area and UMRV

Sample boundary	Number of sample points	Range (m ASL)	Mean (m ASL)	Standard Deviation (m)
Within all survey areas	5000	141-179, 208-243	165.61	29.15
UMRV	5000	123-262	165.88	20.97

Soils within the UMRV of Thailand tend to be a mixture of alluvial clays, sandy loams, and regolith sands, and our survey areas generally followed this profile (Vjarnsorn & Jongpakdee, 1979; Chapter 2.2). However, the soil profile of the northern banks of the Mun differs from the southern banks somewhat, due to the drainage of the Mun River system. In the study area there is a higher proportion of sandy loams along the southern banks of the Mun River, as compared with higher proportion of clays and alluvial complex, along the northern banks of the Mun River. A similar trend can be seen in the Chi River system, north of the Mun. Given that the PSKAS study area is North of the Mun River, the survey and study areas lack the large expanse of sandy loam (Satuk, Warin, and Yasothon series) so prevalent south of the Mun River. The PSKAS study area has a much higher proportion of Phimai and Alluvial Complex soils. Hence the study area and survey areas can only be said to be representative of the soils of the northern UMRV.

Land use, on the other hand, is relatively uniform across the northern and southern portions of the UMRV, and is well represented in the study area (Chapter 2.3). There is a higher than expected percentage of industrial land use, due to the ponds of the Phon Songkhram salt factory at the centre of survey area B. This rises from less than one percent of the study area to approximately three percent of the study area.

The second potential bias relates to the visibility of the original or natural ground surface, and the artefacts located upon that surface. The term "natural ground surface" here refers to the original soil in its original setting. It should be noted that movement of a matter of meters, for bund construction of agricultural practices, is considered in situ given the scale and resolution of the survey. However, movement beyond 25 m is considered introduced and/ or artificial. As such, modern imported soils for agriculture or housing foundations will receive a poor natural-ground-surface-visibility rating. The visibility rating refers to the percentage visible to a pedestrian surveyor, and may include obscuring vegetation.

The results from a series of randomly collected points within the survey area indicate that the surface visibility of the natural soil can vary markedly within a matter of meters in the UMRV. It is, however, predominantly good, with 50 to 80 percent visible ground surface, or excellent with greater then 80 percent visible ground surface (Table 10). It is, of course, impossible to recover artefacts from zero visibility areas, such as water bodies, concreted areas, or imported/ artificial soils. However as these categories constitute less than three percent of the total study area, they are unlikely to have an impact on results. The excellent visibility of cassava plantations of survey area A, lifted ground surface visibility for agricultural sites. Furthermore, the excellent visibility between and around the Phon Songkhram salt factory, lifted natural-ground-surface-visibility for the industrial land use category as a whole.

Table 10:

Land use and Natural-Ground-Surface-Visibility Pivot Table of Randomly-Generated Sample Points within All Survey Areas

Natural ground surface visibility	Agricultural	Forest/ scrub	Industrial	Residential	Unknown	Unused	Total
Excellent (>80%)	52	1	33	12	2	6	106
Good (50-80%)	49	1	25	18	10	13	116
Fair (30-50%)	44	2	0	7	5	6	64
Poor (<30%)	34	1	1	2	1	0	39
Total	179	5	59	39	18	25	325

Within the salt factory of survey area B, localised shifting of surface artefacts may have exceeded 200 m, thereby destabilising site boundaries, and thus leading to the spread and fragmentation of sites. This area, however, contained one of the most prolific and complex collections of archaeological material within survey area B, so could not be removed from the survey area. To mitigate small-scale movement of artefacts, careful consideration of original site boundaries, using pre-salt factory records, was required. In contrast, modern post-deposition disturbance of survey areas C and D is almost exclusively related to intensive wet-rice farming. Slight mounds associated with archaeological sediment are often circumvented during ploughing, as heavy duty machinery would be required to remove the volume of soil.

As might be expected, diagnostic artefacts were generally recovered from grid squares with a natural-ground-surface-visibility exceeding 50 percent, with a lesser number from fair, or poor, natural-ground-surface-visibility. This trend, however, reflects the overall composition of the UMRV landscape, with its propensity for well-cleared agricultural land. There is a concern, however, that early prehistoric grid squares may be particularly susceptible to natural-ground-surface-visibility, given their relative depth under the soil (Kijngam et al., 1980; Welch, 1985). Both “dense” (greater than one diagnostic artefact) and “sparse” (greater than five diagnostic artefacts) early prehistoric grid squares show no significant relationship with regard to the visibility of the natural ground surface (Table 11).

Table 11:

Natural-Ground-Surface-Visibility by Early Prehistoric Grid Squares and Number of Diagnostic Artefacts (>1, >5)

Natural-ground-surface-visibility	All surveyed areas (>1 diagnostic artefacts)		All surveyed areas (>5 diagnostic artefacts)	
	Exp	*Obs*	*Exp*	*Obs*
Excellent	18.9	18	4.2	5
Good	20.7	28	4.6	7
Fair	11.4	8	2.6	1
Poor	7.0	4	1.6	0
Randomisation p-value (10000 Reps)	**0.122**		**0.131**	
Chi-Squared p-value	**0.178**		**0.263**	

Note. Five grid squares did not or were unable to have ground surface visibility recorded. Exp = Expected value; Obs = Observed value.

The degree of natural soil visibility, and vegetation impacting such visibility, appears to have had negligible impact on the whether artefacts were seen by surveyors, or the number of artefacts recovered. Dense artefact collections associated with large sites, appeared to be so concentrated and widespread, that they were unlikely to have been lost beneath ground cover, particularly given regular ploughing and bund construction in the region.

Summary

A surface artefact survey can only hope to record a fraction of the sub-surface record (Chapter 5.1). The effectiveness of a survey, however, depends upon how well suited a given technique is to eliciting targeted information. The PSKAS project sought to locate "sites", and approximate site boundaries, within the local landscape of the UMRV. Intensity was selected over coverage, relying on sub-regional sampling to further inform the distribution. It appears that natural-ground-surface-visibility, soils, and modern land use did not significantly affect survey results, and sites were clearly visible in the results. However all results should be cautiously interpreted, as there was some fragmentation of sites within the modern salt factories, and mid-upper level elevations were poorly represented.

The survey results may now be examined, with the sites separated into their five temporal categories: early prehistory, late prehistory, the pre-Angkor period, and the Angkor period. For each time period the site statistics need to be examined, including land use, soil, rank-size, central spatial tendencies, and clustering.

7.2 Early Prehistory (eighteenth century BCE – first century CE)

7.2.1 Results

There were 33 early prehistoric sites recorded in all survey areas. This included four Neolithic sites and one isolated Neolithic artefact (Table 12).

Table 12:

Early Prehistoric Site Number, Size, and Density

Survey area	Number of sites	Density of sites per km^2	Average area of sites (m^2)
A	0	0.00	NA
B	22	1.18	9724.88
C	10	0.63	26697.35
D	1	0.06	63425.80
Total	33	0.50	16495.35

Early prehistoric sites tended to cluster between 152 and 162 m ASL (mean ± 1 standard deviation), where the alluvial floodplains transition into the low terraces of the Mun River system (Table 13). No early prehistoric sites were recovered above 167 m ASL. The Kolmogorov-Smirnov test (K-S test) indicated that this elevation distribution was highly significant (Table 14, K-S statistic = 0.350, p-value = 0.001). The four Neolithic sites were located at the centre of the early prehistoric elevation distribution, with a range of 151 to 156 m ASL. However, their numbers were too low for a confident test of significance.

Table 13:

Elevation Statistics of Early Prehistoric, Neolithic Sites, and 5000 Random Points distributed throughout All Survey Areas (Control)

Sample	Number	Range (m ASL)	Mean (m ASL)	Standard deviation (m)
Early prehistoric sites	33	148-167	156.70	4.88
Neolithic sites	4	151-154	152.5	1.29
Control	5000	141-179, 208-243	165.61	29.15

Table 14:

K-S Test for Elevation Results: 33 Early Prehistoric Sites versus 5000 Random Points distributed throughout All Survey Areas (Control)

Test	Value
K-S statistic	0.350
P-value (2-tail)	**0.001**

Early prehistoric sites appeared to be located closer than expected, to the fossil channels digitised by Bill Boyd (1999a) (Table 15). However, it should be noted that the K-S test indicated this trend is not statistically significant (K-S statistic = 0.273, p-value = 0.061). In contrast, early prehistoric sites appeared to be randomly located, with regard to both flow accumulation and modern, perennial rivers (Table 16, Table 17, & Table 18).

Table 15:

Distance of Early Prehistoric Sites from Distinct and Indistinct Fossil Channels

Unit of analysis	Number	Range (m ASL)	Mean (m ASL)	Standard deviation (m)
Early prehistoric sites	33	0 - 1024	229.75	222.57
Neolithic sites	4	0 – 416	137.29	164.17
Control	5000	0 – 1630	415.12	374.69

Note. Fossil features digitised after Boyd, McGrath, & Higham, 1999a.

Table 16:

Distance of Early Prehistoric Sites from Perennial and Intermittent Streams Modelled using Flow Accumulation

Unit of analysis	Number	Range (m ASL)	Mean (m ASL)	Standard deviation (m)
Early prehistoric sites	33	0 - 949	348.94	216.83
Neolithic sites	4	90 - 404	241.98	111.00
Control	5000	0 – 1451	387.28	291.04

Table 17:

Distance of Early Prehistoric Sites from Modern, Perennial Rivers

Unit of Analysis	Number	Range (m ASL)	Mean (m ASL)	Standard deviation (m)
Early prehistoric sites	33	46 - 2295	610.15	505.44
Neolithic sites	4	46 - 461	333.36	175.06
Control	5000	0 – 2504	631.77	520.60

Table 18:

K-S Test for Water-Distance Results: 33 Early Prehistoric Sites versus 5000 Random Points distributed throughout All Survey Areas (Control)

Test	Fossil channels	Flow accumulation	Modern rivers
K-S statistic	0.230	0.132	0.086
P-value (2-tail)	0.061	0.620	0.970

A comparison of proportions, between modern land use and early prehistoric sites, revealed more sites were located on residential land (four sites), than might be expected if the spatial patterning were random (one site) (Table 19). This was statistically significant (p-value < 0.01) within survey areas B, C, and all combined survey areas.

Table 19:

Land Use for Early Prehistoric Sites

Land use	Survey area A		Survey area B		Survey area C		Survey area D		All Survey areas	
	Exp	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*
Agricultural	0	0	16	11	10	8	1	0	27	19
Forest/ scrub	0	0	3	2	0	0	0	0	3	2
Residential	0	0	1	1	0	2	0	1	1	4
Salt factory	0	0	1	8	0	0	0	0	1	8
Water	0	0	1	0	0	0	0	0	1	0
Randomisation (10000 Reps) p-value	NA		**<0.00001**		**0.003**		0.095		**<0.00001**	

Note. The modern land use was derived from a stepwise classification of IKONOs 2012 multi-spectral imagery: Exp = Expected value; Obs = Observed value.

There were more sites (23 sites), within all survey areas, located on old alluvium Kula Ronghai (Ki-A), and weathered regolith type Chatturat/ Non Thai (Ct-B/ Nt-A) soils, than might be expected if the sample was randomly distributed (16 sites) (Table 20). This was significant at a 95 percent level. In contrast, there is a noticeable lack of sites located on Roi Et (Re-H) and Nam Phong (Ng) soil types.

Table 20:

Soil for Early Prehistoric Sites

Soil	Survey area A		Survey area B		Survey area C		Survey area D		All survey areas	
	Exp	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*
Ki-A	0	0	7	9	1	1	0	1	8	11
Re-H	0	0	0	0	0	0	0	0	2	0
Salt pan	0	0	1	1	0	0	0	0	0	1
Kng-B	0	0	0	0	0	0	0	0	0	0
Ct-B/ Nt-A	0	0	14	12	0	0	0	0	8	12
Ng	0	0	0	0	0	0	0	0	8	0
Chp/Cs-A/ AC	0	0	0	0	1	2	0	0	1	2
Pm/ Tsr-A	0	0	0	0	8	7	1	0	5	7
Randomisation (10000 Reps) p-value	NA		0.785		0.541		0.471		**0.041**	

Note. Exp = Expected value; Obs = Observed value.

The early prehistoric rank-size curve is highly convex, indicating there was low integration of sites, and/or multiple settlement systems within the survey area (Johnson, 1981; Figure 24).

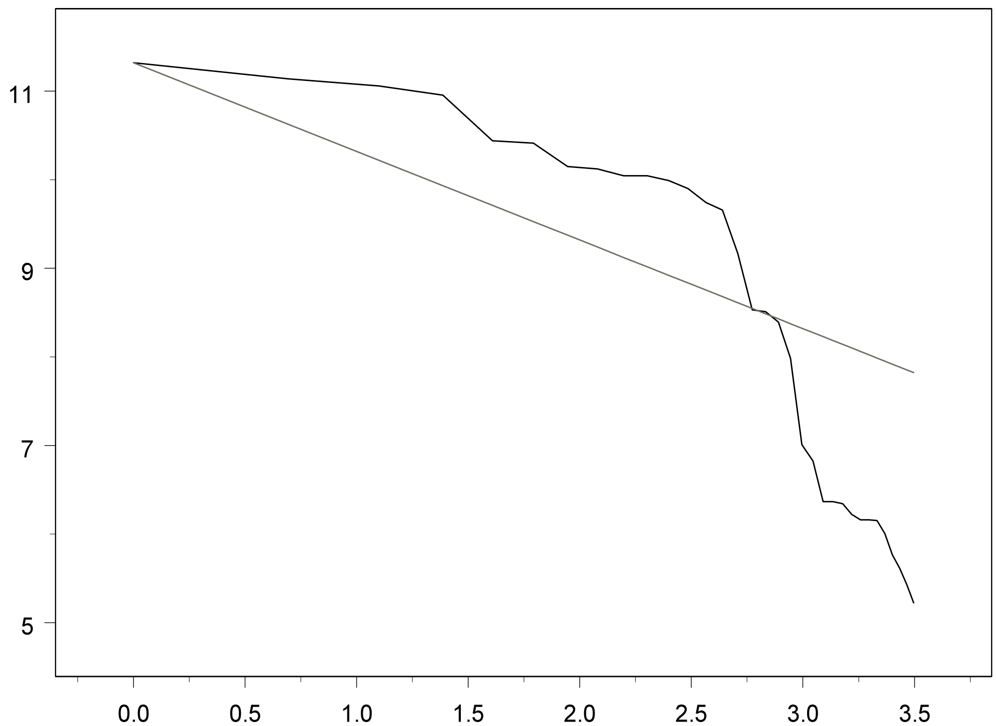

Figure 24. Early prehistoric rank-size curve: X-axis is log (rank) and y-axis is log (site area). The straight line represents a fully integrated settlement system.

Both *local* (within individual survey boundaries) and *combined* (all survey areas combined) central spatial tendencies were examined (Figure 25). Local ellipses (circular outlines of clusters) appeared to be well spread, and slightly angled along the direction of the Mun River in a northeast to southwest direction. The regional ellipse had a mean centre in the low terraces and upper alluvial floodplains, and weak directionality given the survey parameters.

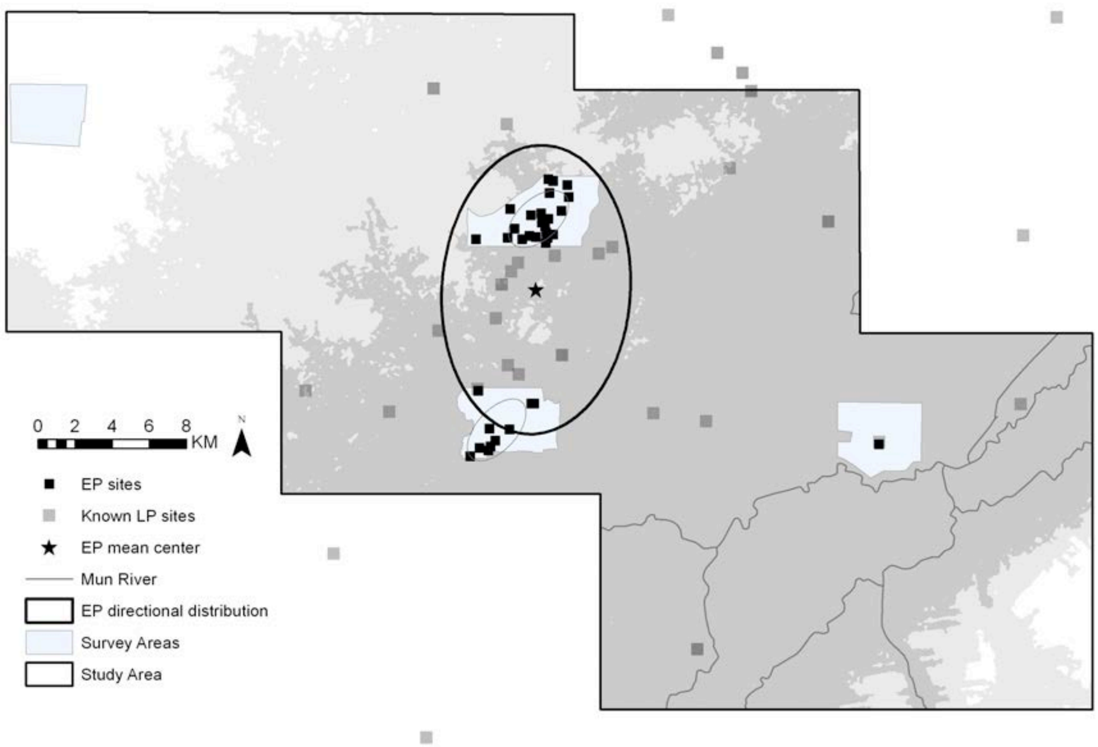

Figure 25. Early prehistoric central spatial tendencies.

The nearest neighbour results, presented in Table 21, indicated random distancing of sites within survey areas B and C. This occurred, whether minimum enclosing rectangles, or boundary constraints, were used. A four-part sampling distribution has a general tendency for clustering, particularly when examined within a single rectangle. Therefore site clustering of all PSKAS survey areas was regarded as a relative measure, to be compared to other time periods.

Table 21:

Early Prehistory Nearest Neighbour Results

Site pattern theme		Expected mean distance (m)	Observed mean distance (m)	Nearest neighbour ratio	Z-score	P-value
Survey area A	Boundary constraints	NA	NA	NA	NA	NA
	Minimum enclosing rectangle		NA	NA	NA	NA
Survey area B	Boundary constraints	533.02	476.73	1.12	1.06	0.290
	Minimum enclosing rectangle		410.41	1.30	2.68	**0.007**
Survey area C	Boundary constraints	614.85	689.20	0.89	0.65	0.514
	Minimum enclosing rectangle		523.11	1.18	1.06	0.289
Survey area D	Boundary constraints	NA	NA	NA	NA	NA
	Minimum enclosing rectangle		NA	NA	NA	NA
All survey areas	Boundary constraints	1107.97	2752.41	0.40	-6.57	**<0.001**

Distribution of Neolithic Sites

Noen U-Loke is one of five locations where Neolithic ceramics were recovered during the PSKAS pedestrian survey, which included four sites and one isolated find (Figure 26, Figure 27). All Neolithic sites were small, shallow, and not associated with encircling earthworks. Three of the five Neolithic sites were associated with human remains. Three of the sites were occupied into late prehistory. Of interest was a large collection of stone tools in survey area B, located between two major Late Holocene rivers (Figure 27,

Appendix C). This stone tool assemblage was located beside the only Neolithic artefact recovered in the low-mid terraces.

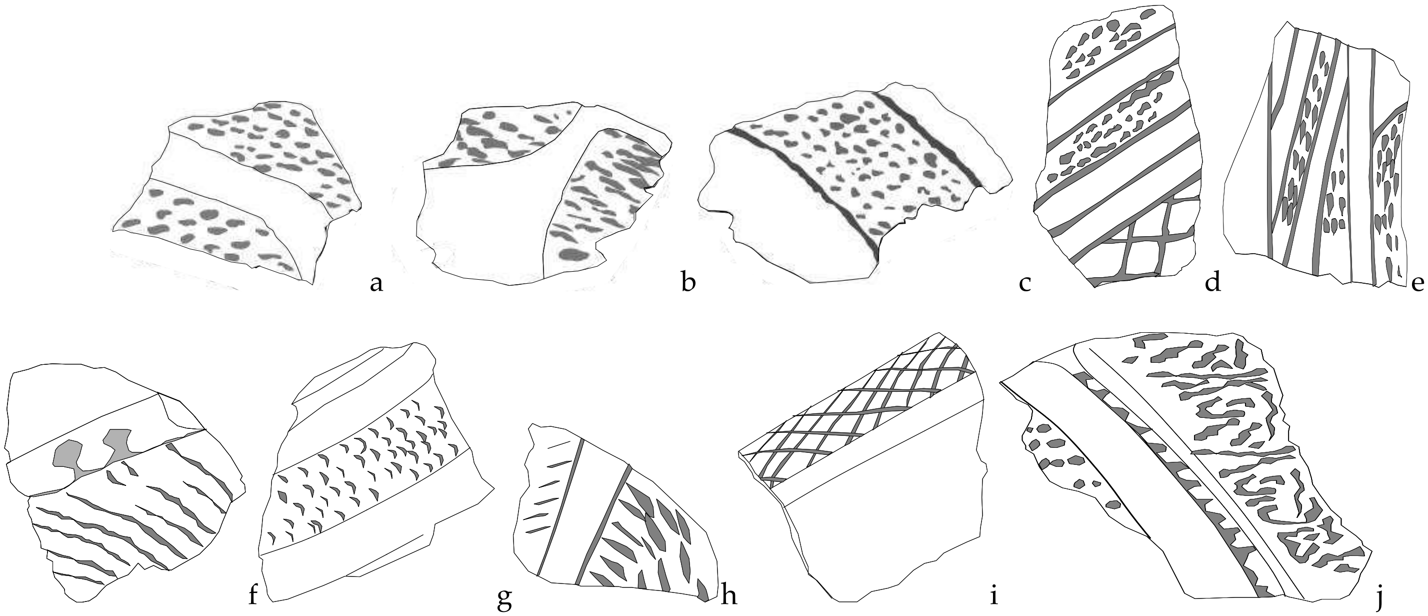

Figure 26. Examples of incised and impressed Neolithic sherds found during pedestrian survey: A-b at the southern edge of site 17, near the outer moats of Noen U-Loke, survey area C: C-j at 0.5-2m deep well cutting at site 20, along the Huai Yai River, survey area C.

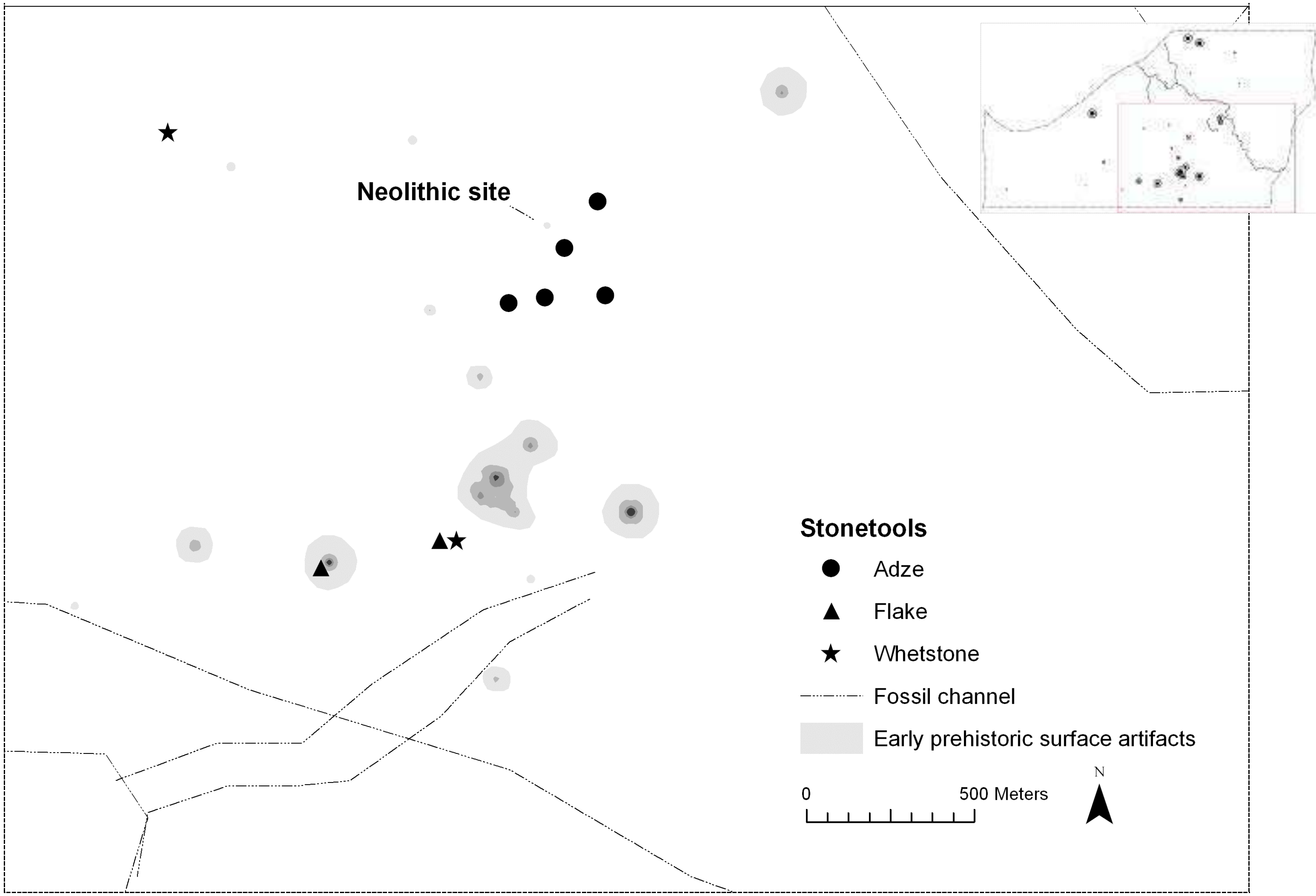

Figure 27. The distribution of stone tools in survey area B, with early prehistoric sites and fossil channels.

7.2.2 Discussion

Excavations to-date within the UMRV of northeast Thailand have suggested that early prehistoric, particularly Neolithic settlements, were low-density and varied in size, and maintained a strong relationship with water features (Chapter 4.1). The PSKAS results have further revealed the distribution of these small, irregularly-sized communities, which appear to be built upon their Neolithic predecessors, and are clustered in the most resource-rich environments of the UMRV.

Neolithic sites form the earliest evidence of sedentary settlement in the UMRV. However, a settlement study of Neolithic sites has not previously been attempted due to a lack of recorded sites. Even when all published examples of Neolithic sites from Thailand are considered, site numbers remain very low, with between one and three sites per river valley (Higham, 2010, p. 201). During the course of the PSKAS project five new Neolithic sites were identified. All were located in alluvial floodplain and low terraces, at a relatively low density of 0.06 sites per km^2. Site placement appeared to be carefully considered; the distance between Neolithic sites varied from 500 m to two kilometres, and two of the five sites were located on raised ridges or prominences. Neolithic diagnostic artefacts from the low-mid terraces were associated with a large collection of adzes, flakes, and whetstones. It was also noted that this assemblage was located between two large Late Holocene rivers. These rivers were contemporary with the Neolithic period (Boyd & Habberfield-Short, 2007).

Such a normally distributed and narrow elevation profile appears to have been a feature of early prehistoric sites more generally. Early prehistoric sites were located no lower than 142 m ASL and no higher than 168 m ASL. The density of early prehistoric sites per km^2 and average site size maintained an inverse relationship. There were relatively fewer sites as the alluvial floodplains were approached, however, what sites remained were larger and contained a greater density of surface artefacts. These trends are consistent with regional investigations of the KBAP survey, which indicate prehistoric sites were located at the transition of low terraces to alluvial floodplains (Welch & McNeill, 1991). As post-depositional disturbance was negligible in the UMRV uplands, the absence of early prehistoric sites in upper elevations cannot be attributed to ground visibility (Chapter 7.1). It is highly likely, therefore, there were no early prehistoric settlements of any significant size in elevations above 167 m ASL. This may reflect cultural and/or economic preference by early settlers, and warrants further consideration.

The early prehistoric period occurred during the transition of a wetter/ cooler climate, towards a more volatile and seasonal late Holocene climate (Chapter 2.1). Shadows in aerial and satellite images are the remains of the fossil river system from this transitional period (Boyd et al., 1999a). PSKAS results indicated a positive relationship existed between early prehistoric sites and these fossil drainage shadows. This, however, did not reach statistical significance ($p < 0.05$). In total, 73 percent of early prehistoric sites were located within 300m of a fossil river network. This was particularly evident for the four Neolithic period sites, which were located relatively close to both the fossil river network and modern flow accumulation, with a mean distance of 137 m and 242 m respectively. In contrast, there appears to be no relationship between early prehistoric or Neolithic sites and modern drainage.

This relationship with drainage lines is also reflected in a preference for early prehistoric sites to be located upon natural ridges still visible in the digital elevation model. This relationship was particularly evident during the Neolithic and early Bronze Age period. Such a relationship is consistent with excavation findings from both the Origins of Angkor and Society and Environment Before Angkor projects (Boyd et al., 1999b; Chapter 4.1). These natural ridges may have aided flood management, provided a naturally defensive position, or, alternatively, created a land bridge into flooded areas of cultural significance.

The strong relationship between drainage patterns, landforms, and early prehistoric sites, is also reflected in soil types. There was a notable absence of early prehistoric sites within washed sandstone deposit soils, such as the poorly drained Roi Et (Re-H) and well drained Nam Phong (Ng) series. Results were significantly (p-value ≤ 0.05) skewed towards the old alluvium Kula Ronghai (Ki-A) and regolith Chatturat/ Non Thai (Ct/ Nt) soils. This result is consistent with excavation evidence (published in Boyd & Habber-Smith, 2007), for early prehistoric sites to be located on old alluvium soils.

Such a result is, perhaps, expected given these are the soils contemporary with early prehistory. Within the study area, both soil series were associated with the large fossil river channels, created during the late Holocene, and contemporary with Neolithic and early Bronze Age occupation. Kula Ronghai soil infilled the original fossil channels, and Chatturat/ Non Thai soils form slightly raised and undulating terraces running alongside the channels. The preference for these soils reinforces the significance of proximity to the fossil channel network. Unexpectedly, there were also a substantial number of early prehistoric sites located within Phimai/ Thung Samrit young alluvium soils, deposited during the late historic period. However Boyd's geoarchaeological analysis of Noen U-Loke and its surrounds indicates that sites were originally constructed on raised areas of old alluvium, which were then later, inter-fingered with up to 5m of young alluvium, including Phimai/ Thung Samrit soil types. So this trend is, somewhat, misleading.

Elevation, soil, and drainage all indicate a preference for early prehistoric sites to be located within the upper edges of the current floodplain. This was an area that contained the largest and most densely clustered collection of fossil channels and rich old alluvium soils, during the early prehistoric era. This strong relationship between water access or management, and early sedentary settlements of the UMRV continues when we examine the spatial distribution of sites. Previous studies have presented early prehistoric settlement in the UMRV as scattered, irregular in distribution, and modest in scale (Chapter 4.1). The PSKAS results supported this trend; with rank-size curves, and nearest neighbour results indicating a low integration of sites, with potentially multiple settlement systems, and an irregular pattern of placement. Highly complex interment rituals, discovered during the Origins of Angkor and Society and Environment Before Angkor excavations, hint at a complex, multi-layered society during early prehistory. However, the PSKAS project found little evidence of organisation at a supra-local scale, beyond a preference for proximity to fossil river channels and fertile environs, creating linear distributions of sites. Little evidence of local specialisation was found during the early prehistoric period, with artefact types well distributed throughout all sites. There was, however, a concentration of stone tools in survey area B (Figure 27). Regionally, spatial trends revealed during the PSKAS were much stronger, and showed a strong preference for following the course of the Mun River System and its tributaries, in a northeast to southwest orientation.

Summary

The first sedentary settlements in the UMRV, during the Neolithic (eighteenth – tenth centuries BCE), were located almost exclusively on raised areas of old alluvium that protruded into the modern alluvial floodplain. Such sites continued to be occupied well into the Bronze Age, when the population increased from 0.06 to 0.5 sites per km^2, and began to spread in a linear fashion along fossil river networks. Settlement remained poorly integrated throughout early prehistory, with independent centres irregularly placed near naturally advantageous positions. Our results confirm that early prehistoric sites maintained a focus on the Mun River and its fossil tributaries, and the resources it provided.

7.3 Late Prehistory (first – mid sixth centuries CE)

7.3.1 Results

There were 15 late prehistoric sites at an average density of 0.23 sites per km^2 (Table 22).

Table 22:

Late Prehistoric Site Number, Size, and Density

Survey area	Number of sites	Density of sites per km^2	Average area of sites (m^2)
A	0	0.00	-
B	6	0.32	7886.02
C	8	0.50	33066.95
D	1	0.06	59080.00
Total	15	0.23	24782.78

Late prehistoric sites had a tendency to cluster between 149.5 and 158.5 m ASL (mean ± 1 standard deviation), at the transition from alluvial floodplain to low terraces of the Mun River system (Table 23). No late prehistoric sites were recovered above 164 m ASL. The K-S test indicated late prehistoric sites did not significantly differ with regard to elevation (Table 24). This result, however, may have been influenced by low site numbers.

Table 23:

Elevation Statistics of Late Prehistory and 5000 Random Points distributed throughout All Survey Areas (Control)

Sample	**Number**	**Range (m ASL)**	**Mean (m ASL)**	**Standard deviation (m)**
Late prehistoric sites	15	149-164	154.00	4.50
Control	5000	123-262	165.88	20.97

Table 24:

K-S Test for Elevation Results: 15 Late Prehistoric Sites versus 5000 Random Points distributed throughout All Survey Areas (Control)

Test	**Value**
K-S statistic	0.334
P-value (2-tail)	0.071

Late prehistoric sites were located significantly close to modern rivers (K-S statistic = 0.360, p-value = 0.041), and were randomly distributed with respect to both fossil channels and flow accumulation (Table 25, Table 26, & Table 27).

Table 25:

Distance of Late Prehistoric sites from Distinct and Indistinct Fossil Channels

Unit of analysis	Number	Range (m ASL)	Mean (m ASL)	Standard deviation (m)
Late prehistoric sites	15	0 - 1069	325.19	372.73
Control	5000	0 – 1630	415.12	374.69

Note. Fossil features digitised after Boyd, McGrath, & Higham, 1999a.

Table 26:

Distance of Late Prehistoric Sites from Perennial and Intermittent Streams, Modelled using Flow Accumulation

Unit of analysis	Number	Range (m ASL)	Mean (m ASL)	Standard deviation (m)
Late prehistoric sites	15	42 - 908	330.02	224.90
Control	5000	0 – 1451	387.28	291.04

Table 27:

Distance of Late Prehistoric Sites from Modern Perennial Rivers

Unit of analysis	Number	Range (m ASL)	Mean (m ASL)	Standard deviation (m)
Late prehistoric sites	15	46 - 846	285.33	251.73
Control	5000	0 – 2504	631.77	520.60

A comparison of proportions, between modern land use and late prehistoric sites, revealed sites in survey areas C and D were significantly skewed towards forest and residential zones, at a 0.01 confidence level (Table 28).

Table 28:

Land Use of Late Prehistoric Sites

Land use	Survey area A		Survey area B		Survey area C		Survey area D		All survey areas	
	Exp	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*
Agricultural	0	0	4	5	8	7	1	0	13	12
Forest/ scrub	0	0	1	0	0	1	0	0	1	1
Residential	0	0	0	1	0	0	0	1	1	2
Salt factory	0	0	1	0	0	0	0	0	0	0
Water	0	0	0	0	0	0	0	0	0	0
Randomisation (10000 Reps)	NA		0.243		**<0.001**		**<0.001**		0.858	

Note. The modern land use was derived from a stepwise classification of IKONOs 2012 multi-spectral imagery (Appendix A). Exp = Expected values; Obs = Observed value.

Sites within all survey areas had an overall tendency for old alluvium Kula Ronghai (Ki-A) and Phimai/Thung Samrit (Pm/ Tsr-A) soils ($p < 0.01$) (Table 29).

Table 29:

Soils for Late Prehistoric Sites

Soil	Survey area A		Survey area B		Survey area C		Survey area D		All survey areas	
	Exp	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*
Ki-A	0	0	2	4	1	1	0	1	4	6
Re-H	0	0	0	0	0	0	0	0	1	0
Salt pan	0	0	0	0	0	0	0	0	0	0
Kng-B	0	0	0	0	0	0	0	0	0	0
Ct-B/ Nt-A	0	0	4	2	0	0	0	0	4	2
Ng	0	0	0	0	0	0	0	0	4	0
Chp/Cs-A/ AC	0	0	0	0	1	0	0	0	0	0
Pm/ Tsr-A	0	0	0	0	6	7	1	0	2	7
Randomisation (10000 Reps)	NA		0.190		0.843		<0.001		0.001	

Note. Exp = Expected value; Obs = Observed value.

Late prehistoric rank-size curves were convex for the upper ranges of site sizes. This indicated a collection of mid-sized settlements, which range in size from 0.33 to 0.99 km^2 (Figure 28). The rapid reduction in the number of sites, when site size dropped below $100m^2$, is characteristic of most rank-sized distributions, and does not, therefore, indicate convexity (Johnson, 1981, p. 109).

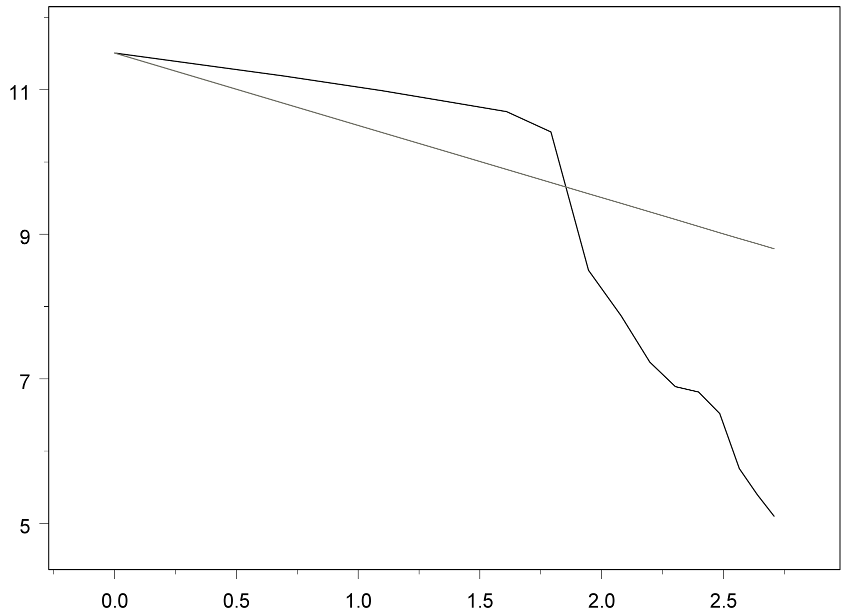

Figure 28. Late prehistoric rank-size curve, x-axis is log (rank) and y-axis is log (site area).

Both the local and combined results were examined for the central spatial tendencies of their late prehistoric sites (Figure 29). Local ellipses appeared linear, and were generally angled along channel features emerging from the Mun River valley. A regional ellipse was concentrated in the low terraces and upper alluvial floodplains.

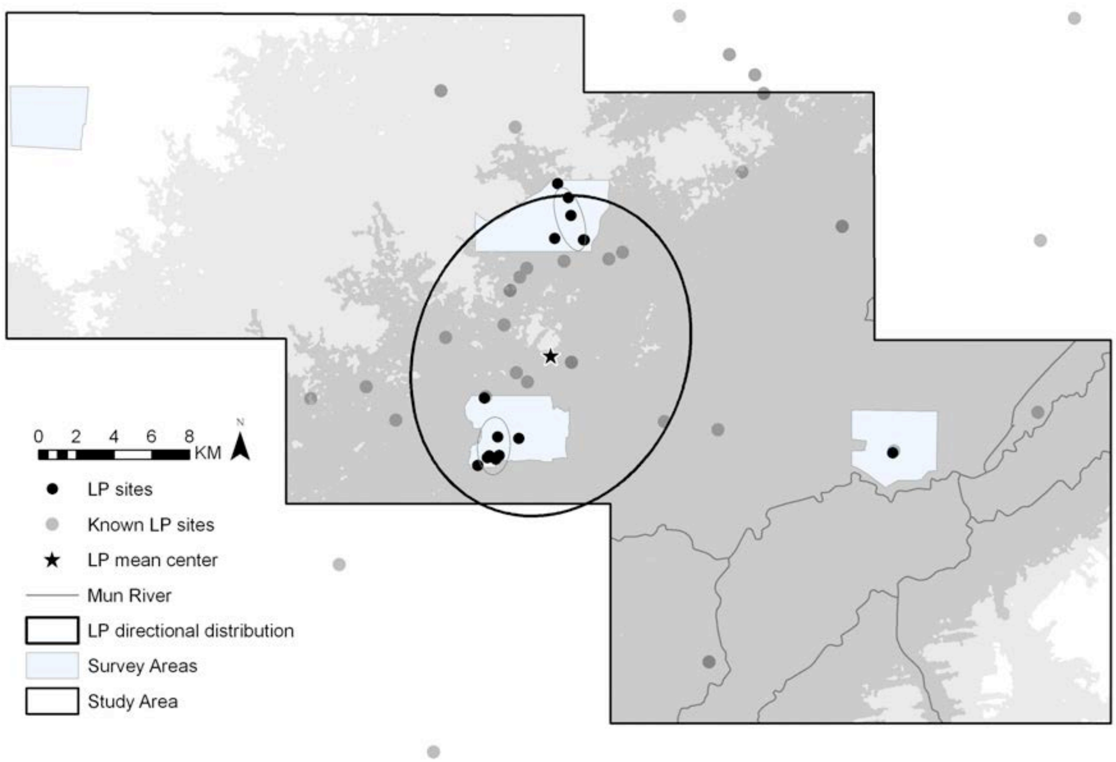

Figure 29. Late prehistoric central spatial tendencies.

When examining the nearest neighbour results, the linear nature of local features ensured that results differed considerably, depending on the boundary constraints. When the minimum enclosing rectangle was applied, the results were slightly clustered. However, when fixed survey areas were used as boundary constraints, results were significantly dispersed (Table 30). As was noted for early prehistoric results, site clustering of all survey areas is a relative measure to be compared to other time periods.

Table 30:

Late Prehistoric Nearest Neighbour Results

Site pattern theme		Expected mean distance	Observed mean distance	Nearest neighbour ratio	Z-score	P-value
Survey area A	Boundary constraints	NA	NA	NA	NA	NA
	Minimum enclosing rectangle		NA	NA	NA	NA
Survey area B	Boundary constraints	732.54	434.89	1.69	3.21	**0.001**
	Minimum enclosing rectangle		912.87	0.80	-0.93	0.355
Survey area C	Boundary constraints	713.41	474.38	1.50	2.73	**0.006**
	Minimum enclosing rectangle		770.552	0.93	-0.40	0.69
Survey area D	Boundary constraints	NA	NA	NA	NA	NA
	Minimum enclosing rectangle		NA	NA	NA	NA
All survey areas	Minimum enclosing rectangle	1994.68	4082.48	0.49	-3.79	**<0.001**

When late prehistoric settlement patterns were compared to the saline soil map, K-S failed to indicate a relationship existed between late prehistoric sites and highly saline soil (Tables 31, Table 32).

Table 31:

Distance of Late Prehistoric Sites from Saline Soil and Salt Outcrops

Unit of analysis	Number	Range (m ASL)	Mean (m ASL)	Standard deviation (m)
Sites	15	0- 900	312.39	243.75
Control within all survey areas	26278	0 - 1665.08	379.72	300.45

Table 32:

K-S Test Salt-Distance Results: 15 Late Prehistoric Sites versus 5000 Random Points distributed throughout All Survey Areas (Control)

Significance Tests	**P-value**
K-S statistic	0.159
P-value (2-tail)	0.843

7.3.2 Discussion

Previous excavations and survey would suggest settlement of the late prehistoric period (first – mid sixth centuries CE), was dominated by large, earthwork encircled, burial-focused mounds in the alluvial floodplains and low terraces (Chapter 4.1). These mounds showed evidence of population increases and the beginnings of a two-tier hierarchy. Results for the PSKAS project supported the concentration of late prehistoric settlement in the alluvial floodplains, and the focus upon water management. Whilst local centres appeared to have aggregated in the alluvial floodplains, the PSKAS project recovered little evidence of regional intensification, organisation, or industrialised-scale resource use.

The PSKAS results indicated that late prehistoric occupation was concentrated in the modern alluvial floodplains, with 53.33 percent of sites, and to a lesser extent, the low terraces, with 40 percent of sites. Late prehistoric sites tended to be located between 153.5 – 159.5 m ASL (mean ± one standard deviation). This trend was consistent with early prehistoric findings, indeed 11 of the 15 late prehistoric sites contained evidence of earlier occupation. The further the modern alluvial floodplains are entered, the larger and denser late prehistoric sites tended to become. The largest and most isolated site, Ban Tamyae, was located deep in the floodplains of survey area D (Welch, 1985). These relatively large alluvial floodplain sites, often with encircling earthworks, appear to be a feature of late prehistory in the UMRV. With their position above the modern flood zone, these sites have often been reused as village mounds by modern populations. Such reuse accounts for the significantly high number of late prehistoric sites found in residential areas, and the scrub surrounding villages.

The PSKAS project results revealed a strong relationship between late prehistoric sites and soil type. This included notable absence of late prehistoric sites within colluvium-deposit soils, such as Chatturat/ Non Thai (Ct/Nt), and the washed-deposit Nam Phong (Ng) series. Results showed a significant over-representation of sites within old alluvium Kula Ronghai (Ki-A) and recent alluvium Phimai/ Thung Samrit (Pm/ Tsr-A) soils. This was a trend consistent with excavation evidence, which links late prehistoric or Iron Age occupation and wet-rice suitable clay soils (published in Boyd & Habberfield-Short, 2007). However, the PSKAS survey did not find an unexpectedly high number of sites in sandy and lateritic terrace soils (Roi Et), or an unexpectedly low number of sites in Phimai soils, noted by Welch and McNeill (1991, p. 217). Furthermore, the relationship with saline soils was poor. These findings do not support an association between intense resource production and late prehistoric occupation clusters.

A strong relationship between late prehistory and salt deposits was not identified by the PSKAS results. This was perhaps surprising, given archaeological evidence that salt was a critical resource during this period (Yankowski & Kerdsap, 2013). The PSKAS survey proposes that the abundance of salt in this region, and its increasingly easy household production during late prehistory, ensured that dramatic settlement changes were not required (Chapter 2.2, Appendix A). Salt does concentrate in particular pockets of the UMRV. However the close association between saline soil, and ancient and modern drainage, ensured that salts were carried and spread into the upper floodplains, middle terraces, and low terraces. Perhaps movement to access these resources was not required, at least not during late prehistory. Potentially, the same could be said of lateritic deposits (Cawte, 2006). However, further research is required to confirm this.

Many have suggested two or even three-tier hierarchies developed as early as the fifth century BCE or Iron Age in the UMRV (Higham, 2012; Higham & Rispoli, 2014; Welch, 1985). The PSKAS project, however, found little evidence for a regional pattern or structure in late prehistoric site distributions, beyond a general adherence to the edges of the Mun river valley channel. The local settlement distributions were primarily linear features, which followed channels emerging from the alluvial floodplains. Phimai Black ceramics were well-spread across all site types, this supported a lack of social stratification and/or localised production. The standardised nature of the Phimai Black tradition, however, does support regional interconnectiveness, as least in terms of communication and trade.

Summary

Late prehistoric (first – mid sixth centuries CE) sites showed a similar pattern of distribution to early prehistoric communities. A strong continuation of settlement patterns was evident during late prehistory, as sites in the alluvial floodplains tended to aggregate and increase in density. These sites used encircling earthworks as a feature of their expansion, shifting and altering to best utilise the narrow, volatile fossil channels developing in the UMRV (Boyd et al., 1999a; Boyd, 2008). There is little evidence of regional integration or social stratification, during late prehistory. However, there is growing evidence of linkages between sites, and greater variation in site size. This indicates strong, and increasingly interconnected, local communities.

7.4 Pre-Angkor (mid sixth – ninth centuries CE)

7.4.1 Results

Twenty-seven pre-Angkor period sites were recovered during the PSKAS survey, at an average density of 0.41 sites per km^2 (Table 33).

Table 33:

Pre-Angkor Site Number, Size, and Density

Survey area	Number of sites	Density of sites per km^2	Average area of sites (m^2)
A	2	0.13	16648.25
B	14	0.75	9724.53
C	10	0.625	24128.48
D	1	0.06*	49732.80*
Total	27	0.41	17053.98

Pre-Angkor period sites were found in a wide range of elevations, which included a presence in the upper terraces and uplands (Table 34). The K-S test indicated that it is highly unlikely that pre-Angkor sites were randomly distributed with regard to elevation (Table 35).

Table 34:

Elevation Statistics of Pre-Angkor Sites and 5000 Random Points distributed throughout All Survey Areas (Control)

Sample	**Number**	**Range (m ASL)**	**Mean (m ASL)**	**Standard deviation (m)**
Pre-Angkor sites	27	149-218	160.63	16.74
Control	5000	123-262	165.88	20.97

Table 35:

K-S Test for Elevation Results: 27 Pre-Angkor Sites versus 5000 Random Points distributed throughout All Survey Area (Control)

Test	**Value**
K-S statistic	0.334
P-value (2-tail)	**0.005**

There was no significant relationship between water features and pre-Angkor period sites ($p > 0.05$) (Tables 36, Table 37, & Table 38).

Table 36:

Distance of Pre-Angkor Sites from Distinct and Indistinct Fossil Channels

Unit of analysis	Number	Range (m ASL)	Mean (m ASL)	Standard deviation (m)
Pre-Angkor sites	27	0 - 1047	297.34	264.17
Control	5000	0 – 1630	415.12	374.69

Note. Fossil features digitised after Boyd, McGrath, & Higham, 1999a.

Table 37:

Distance of Pre-Angkor Sites from Perennial and Intermittent Streams, Modelled using Flow Accumulation

Unit of analysis	Number	Range (m ASL)	Mean (m ASL)	Standard deviation (m)
Pre-Angkor sites	27	0 - 905	344.57	192.56
Control	5000	0 – 1451	387.28	291.04

Table 38:

Distance of Pre-Angkor Sites from Modern Perennial Rivers

Unit of analysis	Number	Range (m ASL)	Mean (m ASL)	Standard deviation (m)
Pre-Angkor sites	27	0 - 2268	551.23	540.78
Control	5000	0 – 2504	631.77	520.60

A comparison of proportions between modern land use and pre-Angkor period sites, revealed a slight over representation of residential land (Table 39). This, however, did not reach statistical significance ($p > 0.05$).

Table 39:

Land Use of Pre-Angkor Sites

Land use	Survey area A		Survey area B		Survey area C		Survey area D		All survey areas	
	Exp	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*
Agricultural	2	2	10	12	10	10	1	0	23	24
Forest/ scrub	0	0	1	0	0	0	0	0	2	0
Residential	0	0	1	2	0	0	0	1	1	3
Salt factory	0	0	1	0	0	0	0	0	1	0
Water	0	0	1	0	0	0	0	0	0	0
Randomisation (10000 Reps)	1		0.337		1		**<0.001**		0.066	

Note. The modern land use was derived from a stepwise classification of IKONOs 2012 multi-spectral imagery. Exp = Expected values; Obs = Observed value.

Pre-Angkor sites generally followed expected soil proportions, except for survey areas C and D, which had a significant ($p \leq 0.05$) tendency to be located in old alluvium Kula Ronghai (Ki-A) soil, rather then the younger alluviums soils (for example Pm/Tsr-A or Chp/Cs-A/ AC, Table 40).

Table 40:

Soils for Pre-Angkor Sites

Soil	Survey area A		Survey area B		Survey area C		Survey area D		All survey areas	
	Exp	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*
Ki-A	0	0	5	4	1	3	0	1	6	8
Re-H	0	0	0	0	0	0	0	0	2	0
Salt pan	0	0	0	0	0	0	0	0	0	0
Kng-B	0	0	0	0	0	0	0	0	0	0
Ct-B/ Nt-A	0	0	9	10	0	0	0	0	7	10
Ng	2	2	0	0	0	0	0	0	6	2
Chp/Cs-A/ AC	0	0	0	0	1	0	0	0	1	0
Pm/ Tsr-A	0	0	0	0	8	7	1	0	5	7
Randomisation (10000 Reps)	1		0.782		**0.005**		**<0.001**		0.133	

The pre-Angkor period rank-size curve was marginally convex. This indicated low integration of sites, and/or multiple settlement systems (Johnson, 1981; Figure 30). Muang Sema is located outside of the PSKAS study area, however as it may represent the largest rank of site size in UMRV, missed due to survey limitations or bias, it was considered in a second rank-size curve. When the distribution was adjusted for this largest recorded pre-Angkor period site in northeast Thailand, Muang Sema at 1.44 km^2 in size, the large-medium sized sites within the survey approached log-normal (Figure 30).

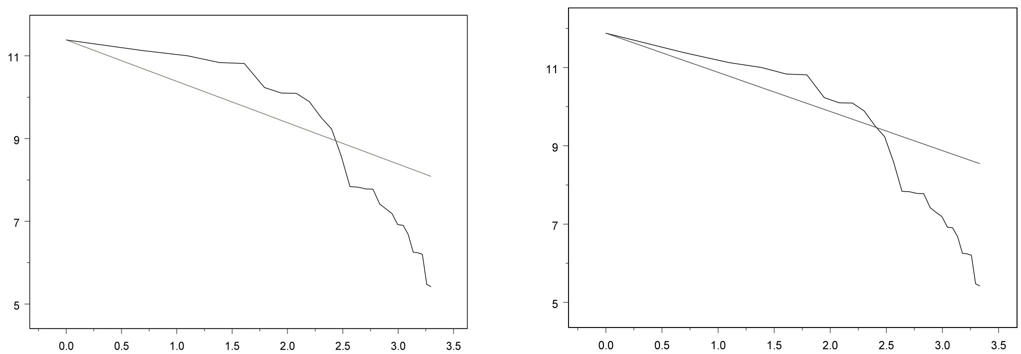

Figure 30. Pre-Angkor rank-size curves with rank (x-axis) and site area (y-axis): Original (left), Muang Sema added (right).

The local and combined results were examined for the central spatial tendencies of their pre-Angkor period sites (Figure 31). The local distribution tended to be linear in nature. Regionally, pre-Angkor period sites were generally distributed northwest to southeast. They were orientated towards Phimai, and early routes through the Dang Raek mountain range, bordering northwest Cambodia. The regional distribution was difficult to compare with known sites, however, as there were so few documented examples in the area.

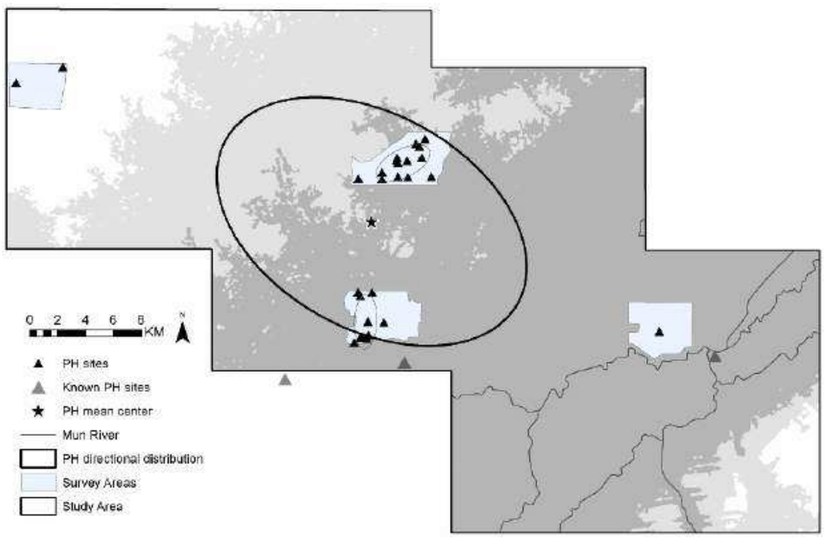

Figure 31. Pre-Angkor central spatial tendencies.

In terms of the Nearest Neighbour statistic, pre-Angkor period sites showed a rising z-score. This indicated an increasingly even distribution of points, transitioning from the alluvial floodplains of survey area C, towards the uplands of survey area A (Table 41). This occurred regardless of whether a minimum inclosing rectangle, or fixed survey area, was applied.

Table 41:

Pre-Angkor Nearest Neighbour Results

Site pattern theme		Expected mean distance	Observed mean distance	Nearest neighbour ratio	Z-score	P-value
Survey area A	Boundary constraints	3543.59	29.76	119.06	319.40	**<0.001**
	Minimum enclosing rectangle		1274.76	2.78	4.82	**<0.001**
Survey area B	Boundary constraints	634.34	503.95	1.26	1.85	0.064
	Minimum enclosing rectangle		597.61	1.06	0.44	0.660
Survey area C	Boundary constraints	505.31	431.07	1.17	1.04	0.300
	Minimum enclosing rectangle		689.20	0.73	-1.61	0.110
Survey area D	Boundary constraints	NA	NA	NA	NA	NA
	Minimum enclosing rectangle		NA	NA	NA	NA
All survey areas	Boundary constraints	1512.04	3042.90	0.50	-5.00	**<0.001**

The settlement patterns and saline soil map were compared (Table 42). The K-S test indicated pre-Angkor period sites did not maintain a relationship with saline soil (Table 43).

Table 42:

Distance of Pre-Angkor Sites from Saline Soil and Salt Outcrops

Unit of analysis	Number	Range (m ASL)	Mean (m ASL)	Standard deviation (m)
Sites	27	0 – 1012.42	346.84	249.40
Control within all survey areas	5000	0 - 1665.08	379.72	300.45

Table 43:

K-S Test Salt-Distance Results: 27 Pre-Angkor sites versus 5000 Random Points distributed throughout All Survey Areas (Control)

Test	**Value**
K-S statistic	0.089
P-value (2-tail)	0.984

The spread of pre-Angkor period structures and inscriptions across the study area is presented in Figure 32. Note; this is a combination of PSKAS systematic intensive pedestrian and satellite survey results, as well as known structures and sema stones (Chapter 4.2).

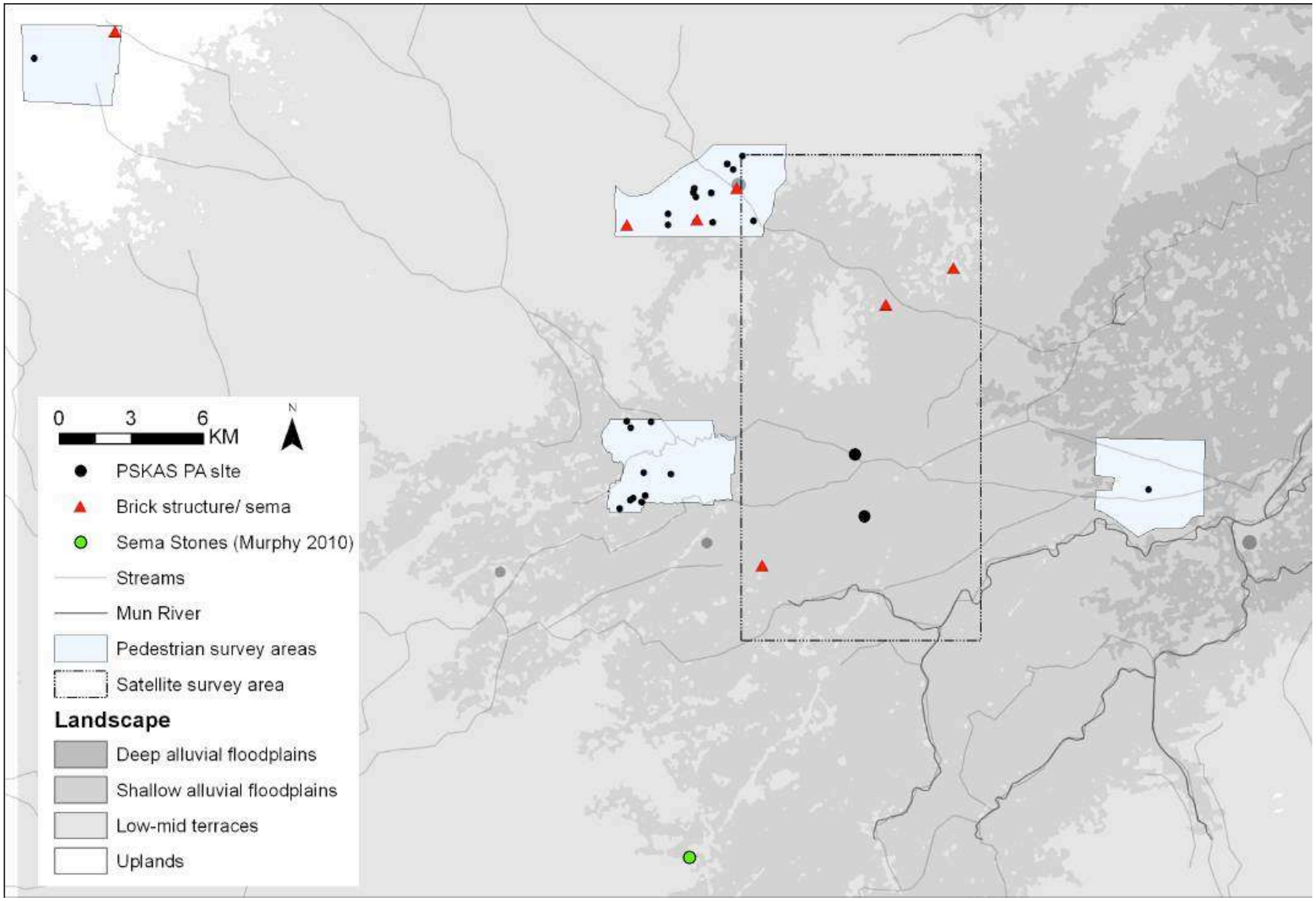

Figure 32. Pre-Angkor period sites with brick structures, including temples and monuments, and sema stones.

7.4.2 Discussion

Relatively little is known about the pre-Angkor period (mid sixth – ninth centuries CE) in the UMRV (Chapter 4.2). Early historical texts and rare excavations present a confusing picture. There appears to have been the reuse of prehistoric sites, causing a lack of regional integration in regional site patterns. This supports consistency in settlement patterns transitioning from prehistory to history. On the other hand, there were significant alterations in ceramic traditions and interment ritual, along with the expression of new religious and socio-political ideas. These may all indicate a change in settlement strategy or cultural shift. The PSKAS results did support a reduction in site size, a shift into higher elevations, and the development of a strong riverine trade network. However the placement of art historical evidence, primarily monuments, sema stones, and inscriptions, within the PSKAS study area, appeared to indicate art-historical features were more for display to external parties, rather than a reflection of internal administration or management by a centralised authority.

A reduction in site size and occupational intensity appear to be characteristic of the pre-Angkor period, and were noted by previous regional surveys (Welch, 1985). The PSKAS survey noted a 31 percent drop in average site size to 0.017 km^2 (17053.98 m^2), and a concurrent reduction in average within-site artefact density (18.23 sherds per m^2). There is the potential this reduction in site size was caused by the appearance of small, satellite settlements and/or intermittent occupation (Welch, 1989). Such smaller satellite settlements may have related to production and maintenance, or functioned as religious/administrative centres. Interestingly Phon Songkhram town in survey area B, which contains a pre-Angkor brick structure and Angkor period temple, was surrounded by a number of very small settlements. These are potentially associated with salt production, the maintenance of the temple, or they may have been intensive farming outposts.

Pre-Angkor sites were concentrated in the low-mid terraces, with 52 percent of sites, and upper alluvial floodplains, with 37 percent of sites. The elevation range of sites, however, was relatively varied (149 - 218 m ASL). For the first time sites were recovered in the uplands of survey area A, at a relatively low site density of 0.13 sites per km^2. Such a spread into higher elevations, particularly with the construction of new sites, was also noted by the KBAP survey (Welch & McNeill, 1991, p. 220). The PSKAS survey's clustering results indicated new upland sites were more evenly distributed then partially reused lower elevation sites, which retained much of their prehistoric patterning. Sites in the uplands, however, tended to be located near the headwaters of Mun River tributaries, following their course into the uplands. Thus, the focus on drainage lines remains a consistent feature of settlement transitioning from prehistory to history.

Survey area A, for example, is located at the meeting point of the Khamin River, a tributary of the Mun, and the Luek River, a tributary of the Chi system. There also appeared to have been the shadow of a previous channel, potentially Late Holocene in date, which originally connected the two tributaries. This created a relatively fertile corridor, in an otherwise dry and agriculturally marginal area. It is along this corridor that the PSKAS survey located two large, dense artefact scatters. These scatters were previously large mounds; site 2 (Non Noi) and site 4. The former, Non Noi, had been destroyed by cane sugar plantations in the modern era, and its artefacts consequently scattered near the banks of the Kut Ta Dam River. However, members of nearby village reported Non Noi was originally a small mound with an Angkor period temple (recorded by the PSKAS team in 2014). Artefacts recovered from Non Noi during the PSKAS survey were characteristic of an established pre-Angkor and Angkor period occupation mound. Site 4, on the other hand, was located on the peak of a hill, with views over the Bahn Kut Ngong River Valley to the north. Given its positioning and type of artefacts, it was concluded that this site was likely to have contained an eighth to twelfth century CE temple, or monument. A more extensive survey of the site and its immediate surrounds would further refine this conclusion. This would reveal the relationship and pattern of occupation connecting the two nearest major pre-Angkor towns of the Mun and Chi River Systems: Ban Kut Ngong to the north and Ban Nohn Sung to the south.

It is unlikely the shift into higher elevations during the pre-Angkor period, was directly related to the need to be closer to salt outcrops, also known as salt domes, and intense salt production. PSKAS results indicated the location of sites maintained no discernable relationship with salt deposits. Indeed, on average pre-Angkor period sites were located further away from salt deposits, than their late prehistoric counterparts.

Rather than saline soils, the PSKAS results favoured Chatturat and Non Thai soils. This trend, however, did not reach statistical significance. This is in contrast to the KBAP project findings (Welch, 1985), that Muang Sema period sites (sixth – tenth centuries CE) had a tendency to be located on Roi Et and Kula Ronghai soil types. The number of sites found in regolith formation soils is, perhaps, reflective of the PSKAS survey covering a wider range of landscapes. This included systematically exploring the uplands, which were not included in the KBAP survey.

There is ample evidence that by the pre-Angkor period several socio-political and religious influences had reached the UMRV, and local leaders were displaying their power through inscriptions, monuments, temples, and portable statues (Chapter 4.2). There is, however, a paucity of historical evidence for a single unified polity in the UMRV, such as can be seen in central Thailand or the Mekong Delta. This lack of unity was supported by the PSKAS survey results, where sites appeared to be only partially integrated, and in the alluvial floodplains and terraces, retained much of their irregular prehistoric spatial distribution. Such poor integration, however, could have been influenced by the PSKAS sampling distribution, if the survey area did not cover the largest type of site within this settlement system. It seems likely a small and well-spread collection of very large pre-Angkor centres existed outside of the PSKAS survey area. The largest recorded pre-Angkor site in northeast Thailand, for example, is Muang Fa Daet, in the Chi River Basin at 1.71 km^2. Muang Sema, only 65 km southwest of the study area, had a rectangular-moated occupation mound approximately 1.44 km^2 in size (Higham, 1989, p. 284). However, a large proportion of the Muang Sema complex, particularly the monastery site, dates to the ninth and tenth centuries, within the Angkor Period (Wangsuk, 2000, p. 209). Even when Muang Sema was used as the largest site size in rank-size calculations, however, integration remained incomplete. There was too large a collection of mid-sized sites in the alluvial floodplains, to allow for integrated site ranking. If leaders were developing in the pre-Angkor period of the UMRV, their territory appears to have remained local, and the centres of power evenly positioned relative to each other.

A feature of pre-Angkor period settlement in the Mekong delta that did support a new, integrated settlement system was the use of brick temples and monuments with religious iconography, and Buddhist boundary stones. The PSKAS pedestrian and satellite survey recovered a spread of brick stupas and monuments throughout the survey area, which was clearly located either side of major river courses (Figure 33). These were evenly spaced, and found both with occupation sites, and in isolation. The brick stupas and monuments could be viewed as a display of power, or a route marker, which targeted those travelling on the riverine network, using the architectural language, widely understood by mainland Southeast Asian leaders at the time. This is congruent with "localisation" theory, which Rispoli and colleagues describe as a; "dynamic cultural process in which elements of a distinct exotic culture are independently selected, elaborated upon and manipulated to fit the needs of a receptive local culture" (2013, p. 150). It is proposed, that not only were elements of incoming Dvaravati and Mekong Delta ideas selectively chosen for local reuse, but that they were then reflected back at the original sources, and used to communicate and/ or manipulate encroaching neighbouring polities. Such displays present a picture of trade and socio-political relevancy, unity, and prominence, which is not borne out in the archaeological record of residential occupation.

Summary

In a region known for its continuity of settlement, the pre-Angkor period of the UMRV marked some of the more radical changes in settlement patterns and culture. These changes were, however, built upon the strong foundations of late prehistoric centres. Late prehistoric, alluvial floodplain mounds in wet-rice suitable soils, including moated examples, expanded during the pre-Angkor period. The remainder of the pre-

Angkor population constructed new, smaller settlements, within the terraced and upland regions of the UMRV. These proceeded to spread into previously unsettled areas of dense, dry forest in the hilly uplands. Landscape features, including soil and elevation, no longer dominated preferred site location. However, settlements still adhered closely to the modern rivers, and fertile corridors generated by ancient rivers. Displays of power, in the form of monuments, temples, and sema stones, remained particularly close to these riverine corridors. This perhaps reflects the river ways new use as an inter-regional route. There was a separation developing here, however, between art historical displays/ religious symbolism, and residential evidence of occupation. Such a divide was also occurring within sites, as local populations separated somewhat from religious centres. Despite this division, religious and socio-political communities were increasingly dependent upon their local centres, as the demand for rice (and presumably other basic resources) would have risen markedly (Murphy, 2010).

7.5 Angkor Period (ninth – fourteenth centuries CE)

7.5.1 Results

There were 25 Angkor period sites, at an average density of 0.38 sites per km^2 (Table 44).

Table 44:

Angkor Site Number, Size, and Density

Survey area	Number of sites	Density of sites per km^2	Average area of sites (m^2)
A	7	0.55	18195.61
B	15	0.75	10807.80
C	3	0.17	27029.33
D	0	0	0
Total	25	0.38	14822.97

Angkor period sites were found in a wide range of elevations, with a strong presence in the upper terraces and uplands (Table 45). The K-S test indicated that it was highly unlikely that Angkor-period sites were randomly distributed with regard to elevation (Table 46).

Table 45:

Elevation Statistics of Angkor SItes versus 5000 Random Points distributed throughout All Survey Areas (Control)

Sample	Number	Range (m ASL)	Mean (m ASL)	Standard deviation (m)
Angkor sites	25	150-225	175.48	27.34
Control	5000	123-262	165.88	20.97

Table 46:

K-S Test for Elevation Results: 25 Angkor Sites versus 5000 Random Points distributed throughout All Survey Areas (Control)

Test	Value
K-S statistic	0.461
P-value (2-tail)	0.000

Tables 47, 48, and 49 show the distance between Angkor period sites and various water features. Distances from Angkor period sites to fossil streams (K-S statistic = 0.159, p-value = 0.555), flow accumulation (K-S statistic = 0.240, p-value = 0.112), and modern rivers (K-S statistic = 0.085, p-value = 0.994) were not statistically significant.

Table 47:

Distance of Angkor Sites from Distinct and Indistinct Fossil Channels

Unit of analysis	Number	Range (m ASL)	Mean (m ASL)	Standard deviation (m)
Angkor sites	25	16 - 1028	359.29	276.44
Control	5000	0 – 1630	415.12	374.69

Note. Fossil features digitised after Boyd, McGrath, & Higham, 1999a.

Table 48:

Distance of Angkor Sites from Perennial and Intermittent Streams, Modelled using Flow Accumulation

Unit of analysis	Number	Range (m ASL)	Mean (m ASL)	Standard deviation (m)
Angkor Sites	25	30 - 596	308.24	164.19
Control	5000	0 – 1451	387.28	291.04

Table 49:

Distance of Angkor Sites from Modern Perennial Rivers

Unit of analysis	Number	Range (m ASL)	Mean (m ASL)	Standard deviation (m)
Angkor Sites	25	0 - 2267	631.03	546.63
Control	5000	0 – 2504	631.77	520.60

A comparison of proportions between modern land use and Angkor period sites, revealed a higher than expected number of sites, located in the salt factory and residential zones of survey area B. This trend, however, did not reach statistical significance (p .0.05) (Table 50).

Table 50:

Land Use for Angkor Sites

Land use	**Survey area A**		**Survey area B**		**Survey area C**		**Survey area D**		**All survey areas**	
	Exp	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*
Agricultural	7	7	11	10	3	3	0	0	22	20
Forest/ scrub	0	0	2	0	0	0	0	0	2	0
Residential	0	0	1	2	0	0	0	0	1	2
Salt factory	0	0	1	3	0	0	0	0	0	3
Water	0	0	0	0	0	0	0	0	0	0
Randomisation (10000 Reps)	1.000		0.064		1.000		NA		0.167	

Note. The modern land use was derived from a stepwise classification of IKONOs 2012 multi-spectral imagery. Exp = Expected values; Obs = Observed value.

A greater than expected number of Angkor period sites, within survey areas A and C, were located on old alluvium Kula Ronghai (Ki-A) and weathered regolith formation of Chatturat/ Non Thai (Ct-B/ Nt-A) soils (Table 51). This was significant at a 0.01 confidence level.

Table 51:

Soils for Angkor Sites

Soil	Survey area A		Survey area B		Survey area C		Survey area D		All survey areas	
	Exp	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*	*Exp*	*Obs*
Ki-A	0	0	5	7	0	1	0	0	6	8
Re-H	0	0	0	0	0	0	0	0	2	0
Salt pan	0	0	1	0	0	0	0	0	0	0
Kng-B	0	0	0	0	0	0	0	0	0	0
Ct-B/ Nt-A	0	1	9	8	0	0	0	0	6	9
Ng	7	6	0	0	0	0	0	0	6	6
Chp/Cs-A/ AC	0	0	0	0	0	0	0	0	1	0
Pm/ Tsr-A	0	0	0	0	3	2	0	0	4	2
Randomisation (10000 Reps)	**<0.001**		0.351		**<0.001**		NA		0.276	

The Angkor period rank-size curve was slightly convex. This indicated a partial integration of sites, and/or multiple settlement systems (Johnson, 1981; Figure 33).

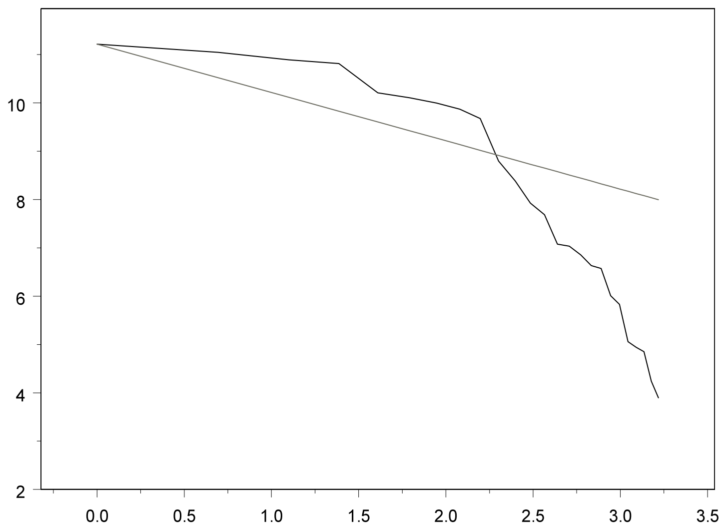

Figure 33. Angkor rank-size curves: X-axis is log (rank) and y-axis is log (site area).

Both the local and combined results were examined for the central spatial tendencies of their Angkor period sites (Figure 34). The local distribution within upper elevations of the Mun River Valley tended to be linear in nature. The regional ellipse generally angled southeast, towards Phimai and the road to Angkor. However, mean centre was located quite high, in the mid-upper terraces of the study area.

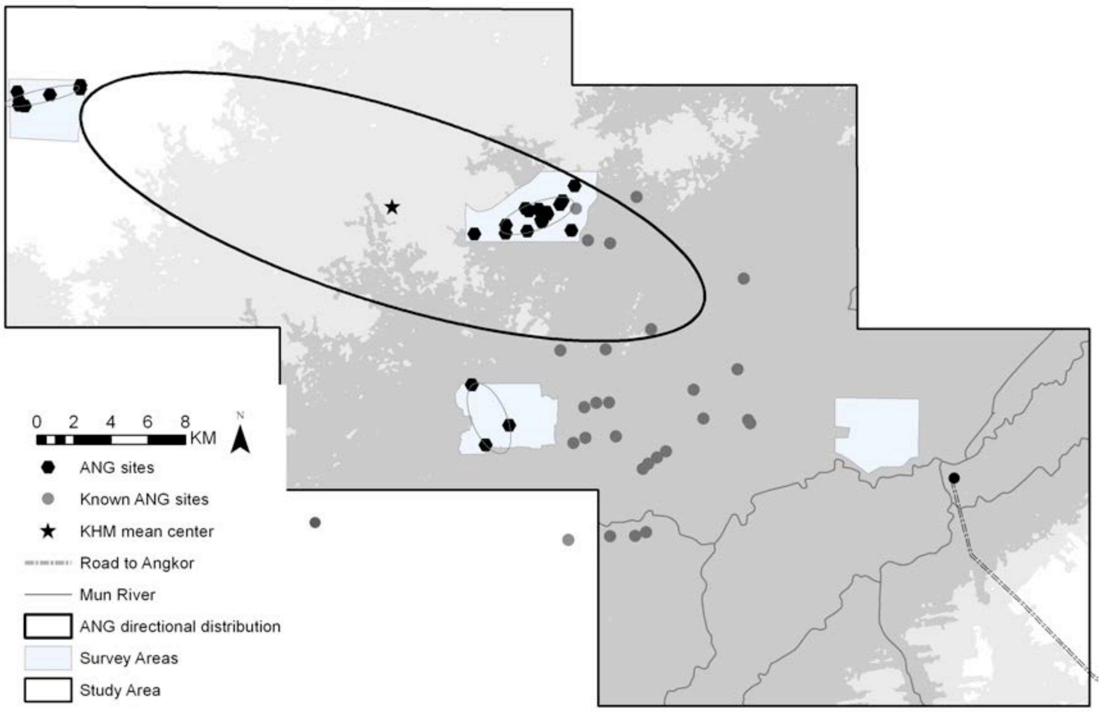

Figure 34. Angkor central spatial tendencies.

With regard to the Nearest Neighbour statistic, Angkor period sites showed a rising z-score as the lower elevations were approached. Upland and high terrace sites, located in survey areas A and B, were slightly clustered, and low terrace and alluvial floodplain sites were well dispersed (Table 52). This trend became highly dispersed when a minimum enclosing rectangle was used as the boundary. This reflects the linear nature of local site distributions. The overall Nearest Neighbour score was highly clustered.

Table 52:

Angkor Nearest Neighbour Results

Site pattern theme		Observed mean distance	Expected mean distance	Nearest neighbour ratio	Z-score	P-value
Survey area A	Boundary constraints	450.11	676.13	0.67	-1.69	0.091
	Minimum enclosing rectangle		312.04	1.44	2.24	**0.025**
Survey area B	Boundary constraints	528.06	577.35	0.92	-0.63	0.527
	Minimum enclosing rectangle		458.34	1.52	1.13	0.260
Survey area C	Boundary constraints	2096.28	1258.31	1.67	2.22	**0.027**
	Minimum enclosing rectangle		640.14	3.28	7.54	**<0.001**
Survey area D	Boundary constraints	NA	NA	NA	NA	NA
	Minimum enclosing rectangle		NA	NA	NA	NA
All survey areas	Boundary constraints	694.42	2119.77	0.33	-6.432	**<0.001**

Local routes

Figures 35 and 36 show the location of laterite blocks, and material associated with Angkor period temple construction. Note the east-to-west string of laterite blocks with associated patches of occupation. These blocks branch off the Phon Songkhram River in the southeast corner of the survey area.

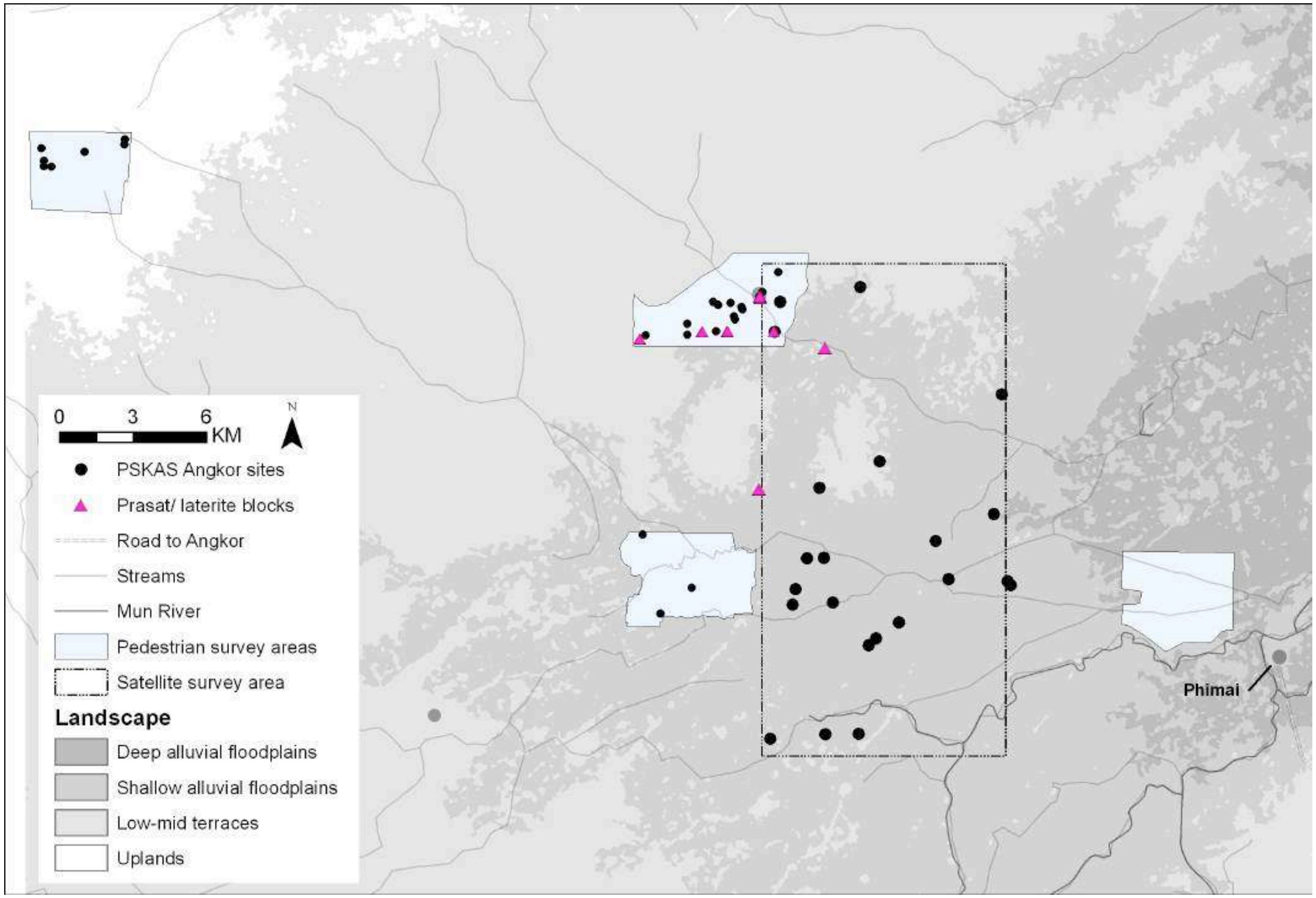

Figure 35. Angkor sites with Prasat and laterite blocks.

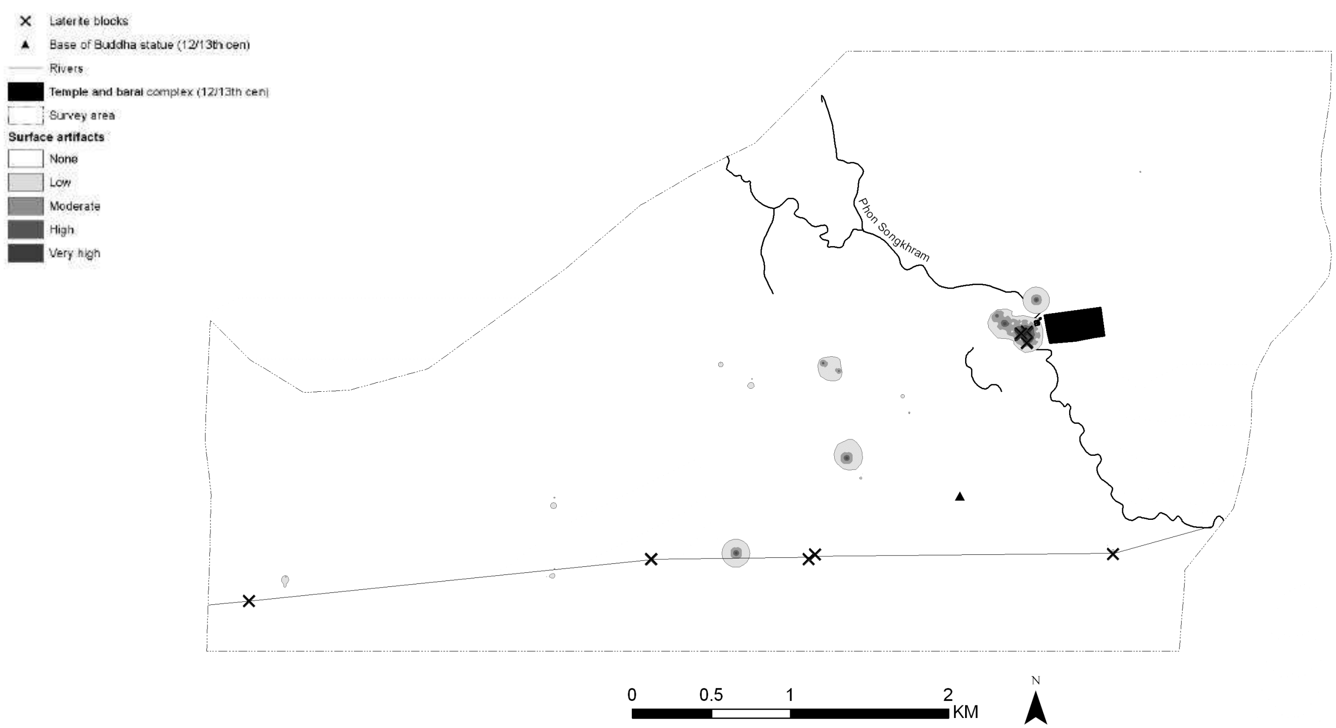

Figure 36. Enlarged view of trail of laterite blocks in survey area B.

7.5.2 Discussion

During the Angkor period (ninth – fourteenth centuries CE), Angkor-style artefacts and architecture pervaded the UMRV. Extensive pan-regional road and irrigation networks were constructed, and historical references to the UMRV in the cities of Angkor became commonplace (Chapter 4.2). These factors all appear to support the UMRV changing beyond recognition, and forming the "hinterland" of the Mekong-based Angkorian Empire. Analysing Angkor period settlement using PSKAS results should be approached with caution, as in many respects, a local-scale study cannot encompass the connections of what has become a regional and pan-regional settlement system. However, the PSKAS results did reveal: an integration of pre-existing riverine and new overland routes, further standardisation and integration of settlement, and the construction of temples and monuments which had a significant impact on settlement patterns.

During the Angkor period occupation levels appeared to decrease in the alluvial floodplains. This trend was also noted by David Welch and Judith McNeill (1991, p. 213) in the KBAP survey. The PSKAS survey has revealed that the aggregation and dominance of a small collection of large sites in the alluvial floodplains caused a decline in the number of Angkor period sites. Thus, the reduction in site numbers does not reflect a drop in overall population. It is likely major alluvial floodplain centres, such as Phimai, maintained a large and dense population. Their isolation potentially reflected land ownership by local leaders, and the development of intensive wet-rice precincts. Such precincts may have been controlled by local leaders or local temple administration, which initially provided the resources to clear and plant the agricultural land (Chapter 4.2).

In contrast, the number of sites in the upper elevations increased during the Angkor period, with the uplands and middle terraces containing 88 percent of all sites. An increase in occupation in the agriculturally marginal uplands may relate to two factors:

1. Settlement areas would have been made more viable by the development of marginal land using the capital and servants of new temples bestowed to loyal followers of the ruler of the Angkorian Empire (Welch, 1998, p. 70).
2. An improvement in irrigation techniques, including construction of canals and *barays* (large ponds), would have allowed for greater exploitation of the higher elevations.

These upland sites, although numerous, were small is size and low in density, and as such would not have sustained the intensity of occupation of the alluvial floodplains centres.

The PSKAS project revealed a noticeable number of Angkor period sites overlaying modern villages. Re-use of Angkor period occupation mounds by modern villages is logical, given the similar environmental conditions and short separation between the two periods. It is not just sites within the survey area, however, that continue to be occupied today. Indeed, many modern roads overlay their Angkorian equivalents, and proximity to the large Angkor period complex of Phimai, remains a community focal point. In the case of Phon Songkhram in survey area B, the modern village still utilises the Angkor period water management systems, including canals and a large baray (Chapters 4.2 and 8.1).

During the Angkor period, site size, landscape, and soils became more evenly occupied, forming a distribution more typical of a well organised and integrated system. The standardisation of sites during the Angkor period is reflected in the rank-size curve, which is observed to straighten. It is noted however, that reused small to medium sized occupation sites maintained an irregularity, which prevented complete log-normal rank-size distribution.

When ceremonial sites were examined in isolation, the results conformed well to Hall's model of the economic organisation of Angkorian regional centres (Hall, 1975; Hall, 1979; Hall, 1985). Interestingly, there was a collection of medium-sized sites between one and two km south of Phon Songkhram temple. These contained an abundance of imported and very fine ceramics and a late twelfth to early thirteenth century CE Buddha statue base. Given its location at the junction of an overland road and the Phon Songkhram River route, this may have been a market place, or secondary administrative/ ceremonial centre linked to Phon Songkhram temple.

During the Angkor period there was a complex relationship between site placement and road/ riverine routes. From a regional perspective, several large administrative or ceremonial complexes appeared in the alluvial floodplains. These branched away from Phimai in a northwest-southeast direction. Such examples were located close to the Mun River and its tributaries. A string of laterite blocks in survey area B, suggested an overland road branching off the tributary of Phon Songkhram. The “road” passed beside the occupation of the modern salt factory, with its trade items, and continued in an east to west direction. Small to medium sized settlements followed this overland route. Thus, a shift in priorities feature in the Angkor period, where trade and communication appeared to have been just as influential on settlement patterns, as managing water resources and developing a wet-rice surplus.

Summary

During the Angkor period (ninth – fourteenth centuries CE) sites standardised somewhat and were increasingly found in higher elevations. Irrigation and road networks became critical to settlement patterns, particularly with regard to ceremonial and trade centres. Furthermore, the integration of long-established sites and riverine networks could truly be seen by the Angkor period, with new temples, roads, and land ownership systems all connecting the local strategies to a wider pan-regional community.

7.6 Combined Periods (eighteenth century BCE – fourteenth century CE)

7.6.1 Results

As a result of systematic, intensive pedestrian survey 56 sites were recovered, at an average density of 1.19 sites per km^2. Thirty-one percent of these sites contained more than one period of occupation. Figure 37 shows the density of sites, and landscape type, for each time period. The site density was adjusted for the length of each time period, to account for differential periods of deposition. This was necessary as the early prehistoric period spanned at least eighteen and a half centuries, whilst the pre-Angkor period encompassed only three centuries. The results indicated site density doubled with each temporal period from early prehistory to the pre-Angkor period, where it peaked at 0.41 sites per km^2, before halving during the Angkor period. This sharp increase then drop, reflected occupation trends in the upper alluvial floodplains and low-mid terraces. In contrast, occupation in the uplands grew steadily throughout all time periods, and the low alluvial floodplains remained low, with isolated examples of occupation.

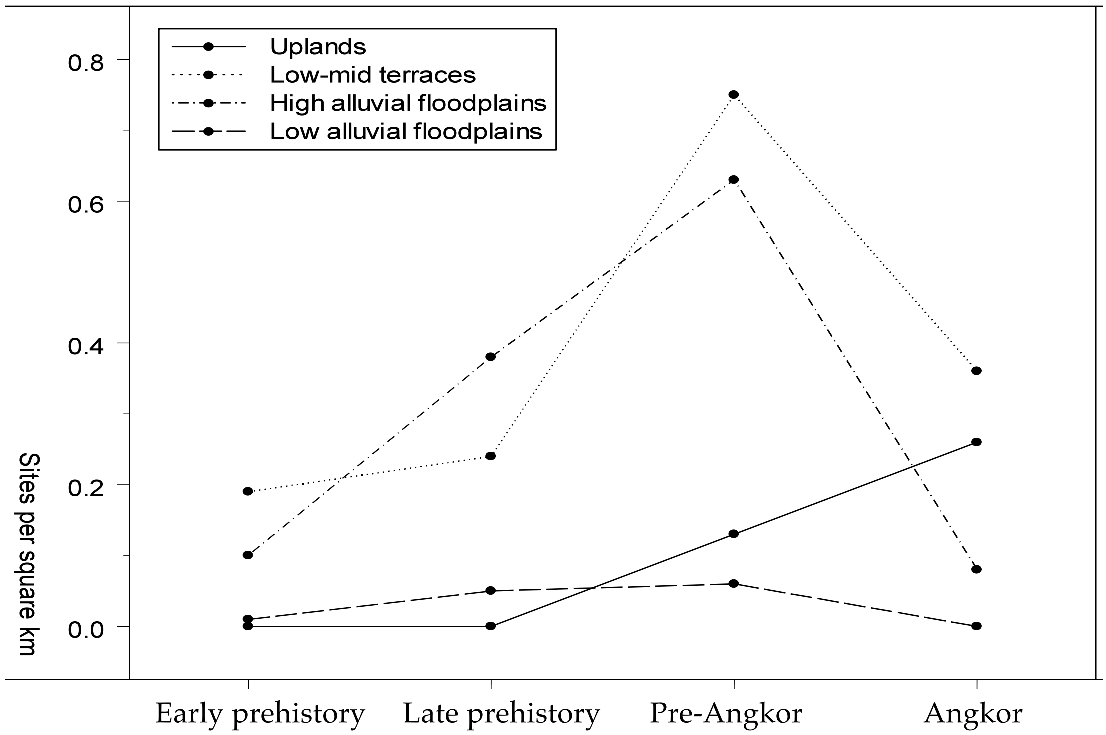

Figure 37. Changes in site density over time, by landscape type. Note, site density has been adjusted for the duration of each time period.

Site size appeared to have remained consistent over time (Figure 38). Areas of low elevation in the alluvial floodplains consistently maintained the largest average site size, whereas higher elevations, such upland and terraces, maintained a low average site size.

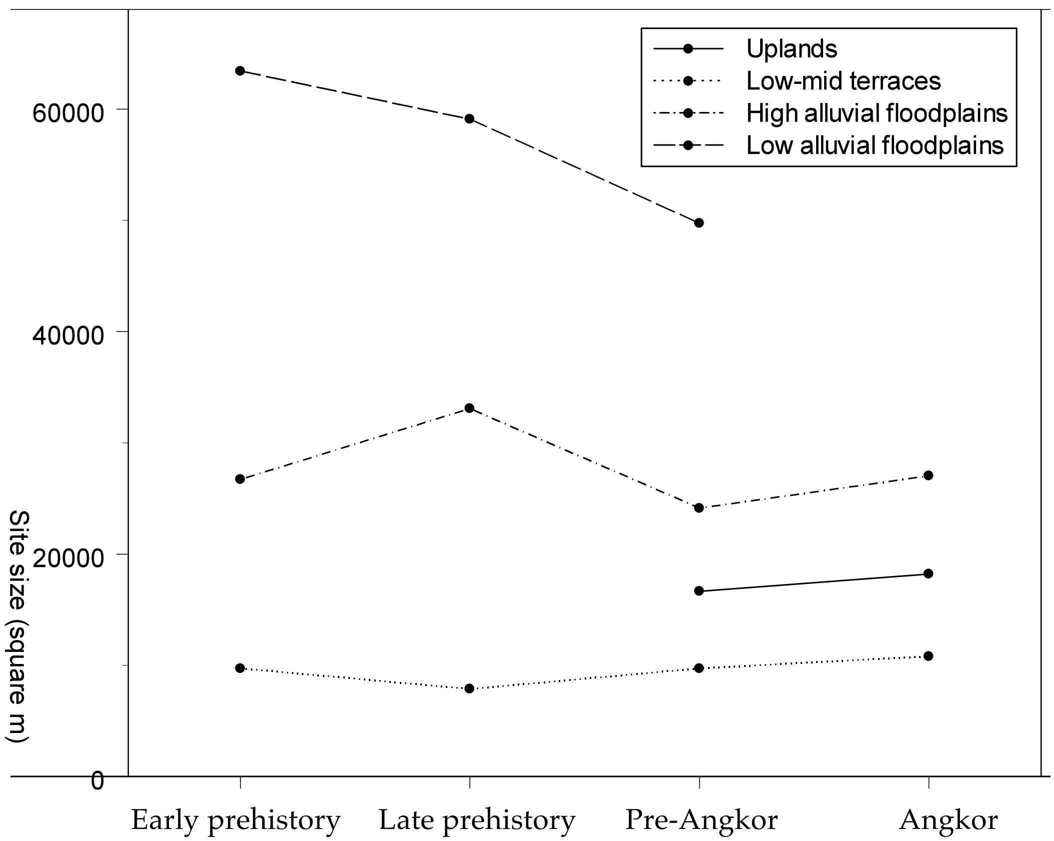

Figure 38. Changes in site size over time, by landscape type.

Soils and land use proportions, relative to expected values, are presented in Figures 39 and 40. Overall, site distribution favoured alluvial floodplain soils, Kula Ronghai and Phimai/ Tung Samrit, particularly during late prehistory. Interestingly, the agriculturally poor Chatturat/ Non Thai soils, were also generally over represented in all periods, except late prehistory. With regard to land use, the consistently high proportion of sites overlaying modern villages, and the low proportion of sites within forest/ scrub areas, were noticeable trends.

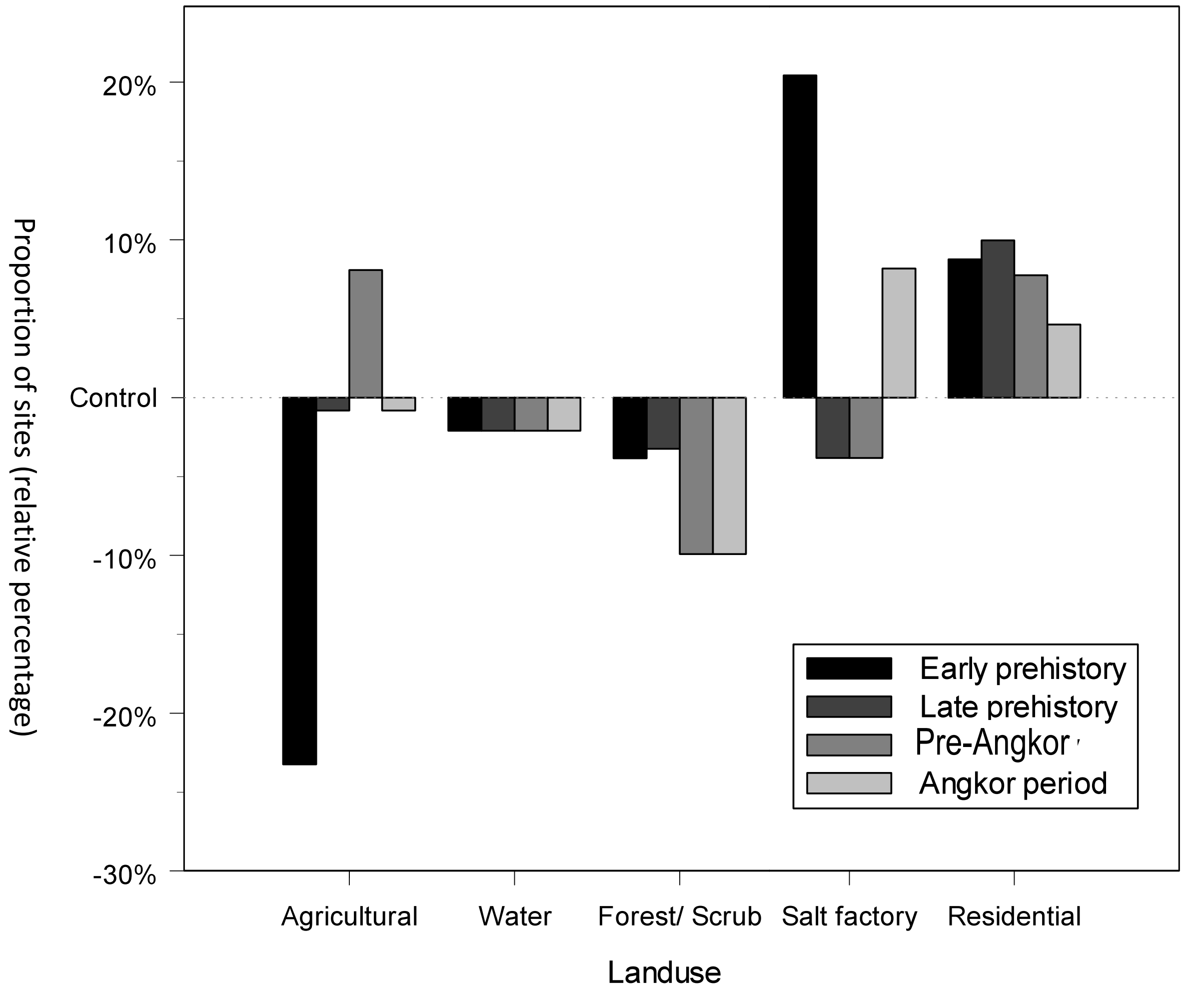

Figure 39. Proportion of sites within modern land use categories, over time.

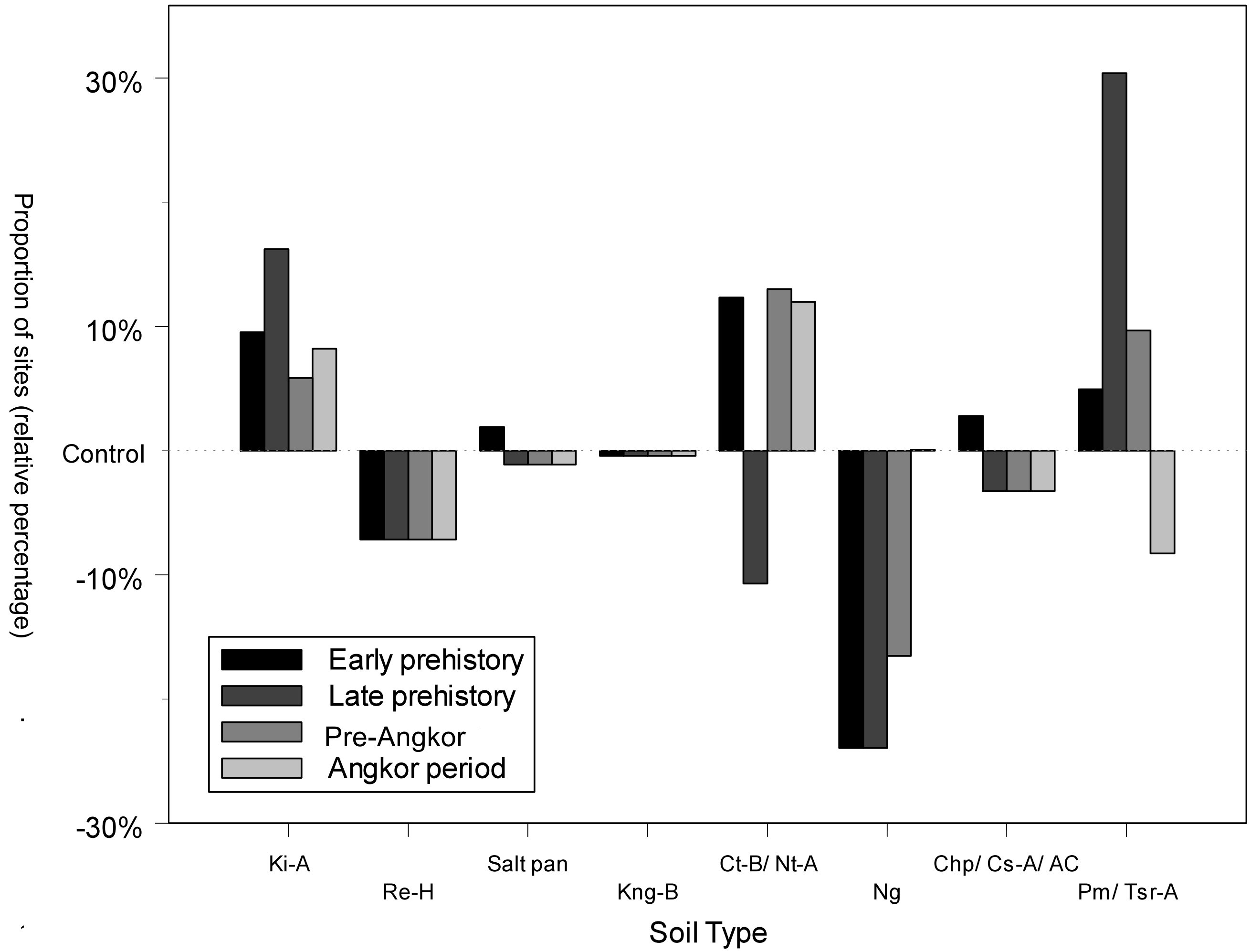

Figure 40. Proportion of sites within soil types, over time.

Table 53 displays Nearest Neighbour results for all survey areas with fixed boundary constraints. Clustering decreased during late prehistory, before rising again to original levels into the pre-Angkor and Angkor periods. This could be a feature of the amalgamation of large alluvial floodplain sites during late prehistory, which subsequently lowered overall clustering levels.

Table 53:

Nearest Neighbour Results for All Periods

Site pattern theme	Observed mean distance	Expected mean distance	Nearest neighbour ratio	Z-score	P-value
Early prehistory	1107.97	2752.41	0.40	-6.57	**<0.001**
Late prehistory	1994.68	4082.48	0.49	-3.79	**<0.001**
Pre-Angkor	1512.04	3042.90	0.50	-5.00	**<0.001**
Angkor	694.42	2119.77	0.33	-6.432	**<0.001**

The regional site distribution trends showed a definite shift over time. The distribution of sites shifted, from a northeast-southwest direction during prehistory, which followed the Mun River Valley, to a northwest-southeast direction from the pre-Angkor period onwards. The later trend angled somewhat towards Phimai, the road to Angkor, and trade routes to the Tonlé Sap basin. There was also a concentration of historic period sites emerging from the Mun River, west of Phimai.

7.6.2 Discussion

Environmental and cultural trends relate the location of sites to the surrounding landscape, providing a context for evidence of occupation. Previous studies have suggested a strong relationship existed between the natural environment, and the archaeological occupation of the UMRV (Chapter 3). However, this could not be confirmed and analysed in more detail until a systematic survey of all landscapes was conducted. The PSKAS project results indicated elevation, water access, fertile soils, and later agriculture and trade, had a strong relationship with settlement patterns in the UMRV.

Neolithic settlements were located on naturally raised areas in upper alluvial floodplains and low terraces, beside the large fossil channels of the late Holocene. This is reflected in the soil preference for old alluvium, and the narrow elevation use (151-155 m ASL). During the Bronze Age to early Iron Age, or late prehistoric period, greater occupation was revealed in the low-mid terraces, directly upon the original Late Holocene river channels. The infilling of swamps and single-string rivers, would have created a highly fertile valley for Bronze Age and early Iron Age settlements

By late prehistory, the intensification and growth of large earthwork-encircled mounds were present in the alluvial floodplains. This reflected the growing significance of wet-rice agriculture, as did the prevalence of ploughshares and rice in burial ceremonies (Higham, 2012; Higham & Rispoli, 2014). Strings of new, small sites associated with emerging channel networks, indicated the population gathered near these agricultural centres. These smaller sites took advantage of the anatomising channel networks of the upper alluvial floodplains. The volatile nature of these channels however, is reflected in the intermittent and localised movement of occupation during this period.

In the centuries between late prehistory and the Angkor period (mid sixth – tenth centuries CE), occupation patterns spread into the UMRV uplands for the first time. This spread, however, appeared to have been reliant upon fertile headwaters that fed the tributaries of the Mun and Chi River basins. Where viable, major alluvial floodplain centres continued to be used.

Concurrent with the spread of Angkor-style artefacts throughout the UMRV in the ninth century CE, many late prehistoric and pre-Angkor sites located upon anatomising channel networks were abandoned, as large single string rivers reformed. Large, isolated sites, located deep within the alluvial floodplains, continued to grow. Environmental factors, such as soil, land use, and elevation, were less of a priority in settlement distributions, as other, more socio-political, concerns emerged.

8. Mounds to Monuments: Development in the UMRV

The physical and socio-political landscape of the UMRV settlement has altered markedly from the large prehistoric burial and occupation mounds of the eighteenth century BCE to the network of Buddhist and Hindu temples and monuments spread across the landscape by the fourteenth century CE. The nature and pattern of this development, however, appears to vary depending upon the scale with which it is viewed. This chapter discusses the long-term settlement trends revealed by the PSKAS project results, with reference to three scales. The local scale examines settlement trends within the UMRV study area in detail, and is able to incorporate excavation into its analysis. The second, regional-scale, places the findings of this thesis within the broader context of development within Mainland Southeast Asia, with comparisons between the UMRV and the neighbouring central Thai and Mekong Delta regions. Finally, this chapter discusses the supra-regional implications for community sustainability in the semi-arid tropics, as opposed to the wet tropics of Southeast Asia.

8.1 Local-Scale Settlement Patterns: Noen U-Loke and Phon Songkhram

The settlement sequence of the UMRV (eighteenth century BCE – fourteenth century CE) spans the Neolithic, Metal Ages, pre-Angkor, and the early historic period. When we examine the trends of landscape use and settlement patterning within the UMRV, revealed in the survey results of this thesis, several key trends emerge. As might be expected, early prehistoric communities were irregular in size and spread, and were poorly integrated. Population pressure was low and resources plentiful. Kin-ship and family lineages appeared to be the strongest social unit during this period, and this was reflected in burial distributions (Chapter 4.1). By late prehistory population levels had increased somewhat, and were accompanied by the growth of large agricultural centres. For the first time, evidence of local leadership had emerged, along with the development of an agricultural surplus, and the community-based construction of encircling earthworks. There was, however, little evidence of organised production, beyond a household or village level. Furthermore, there continued to be strong kin-ship links in burial organisation. Burial goods, however, became more standardised; for example Phimai Black ceramics and exotic carnelian beads (Chapter 4.1). This appeared, therefore, to be a transitional period for long-established communities.

The long-term and gradual evolution of sites appears to have been a feature of occupation of the UMRV. This was particularly apparent in the alluvial floodplains, where sites contained an abundance of simple cord-marked vessels, iron tools, and bead manufacturing. In contrast, the presence of human remains, or items likely associated with burial, such as bronze bells, did not appear to be affected by whether a site was of single or dual-period occupation. The presence of religious or administrative features also did not maintain a relationship with occupation duration. It appeared that reuse was more likely in sites with a production focus, at least from late prehistory onwards. Whilst reuse was common, this was not a static process. Several of the large, continuously occupied sites showed evidence of small-scale shifts in occupation over time. These small-scale shifts reflected the gradual evolution of multi-period occupation sites in the UMRV. An excellent example of this is Noen U-Loke.

Noen U-Loke

Noen U-Loke is a prehistoric burial mound, located in the upper alluvial floodplains of the Huai Yai River, a tributary of the Mun River, at the centre of the study area. The PSKAS survey revealed the movement of surface artefact concentrations, located along a natural prominence, overtime (Figure 41). The intensive, systematic, pedestrian survey revealed a Neolithic burial site, located within the southern edge of the Noen U-Loke outer moat, with diagnostic material partially exposed by the earthwork construction. This initial occupation mound or "mound one" primarily contains Neolithic material, with some evidence of early Bronze Age occupation. The bulk of the Bronze Age material, however, was recovered further north, towards the main mound, labelled mound two in Figure 41. This was where the construction of encircling earthworks began. This Bronze and Iron Age assemblage contained raw, worked carnelian, human and bovinae remains, along with large quantities of cord-marked earthenware ceramics. This shift explains why the 1996-98 excavation of the centre of mound two, primarily revealed evidence of Iron Age remains, and hints of Bronze Age material. The Iron Age encircling earthworks did not correlate well with surface scatter evidence of different periods of occupation. In fact, the late prehistoric, probably dating to the fifth or sixth centuries CE, outer moat, partially circumvents, and partially cuts through, the earlier Neolithic and early Bronze Age mound to the south. Finally, a large rectangular area of pre-Angkor material found in the central northern portion of the site, was also associated with intensive iron production, and the outline of “squared” moat edges in the northeast corner of Figure 41.

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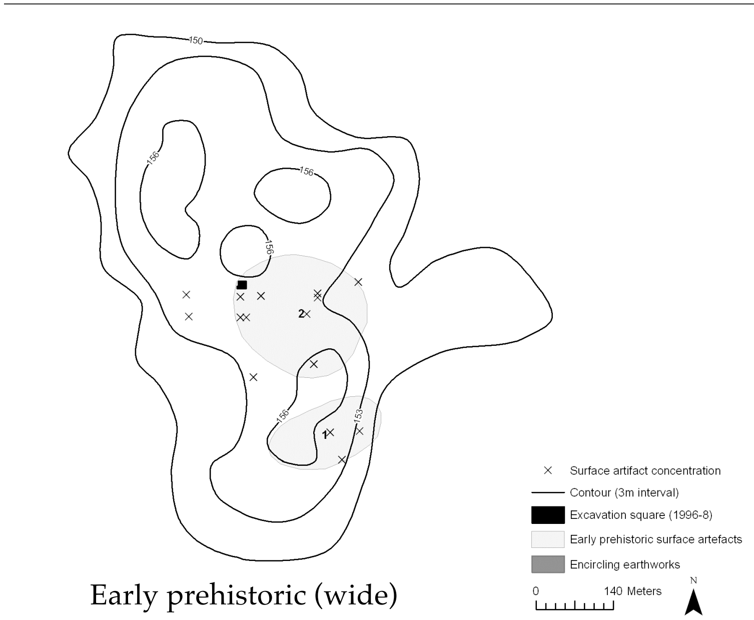
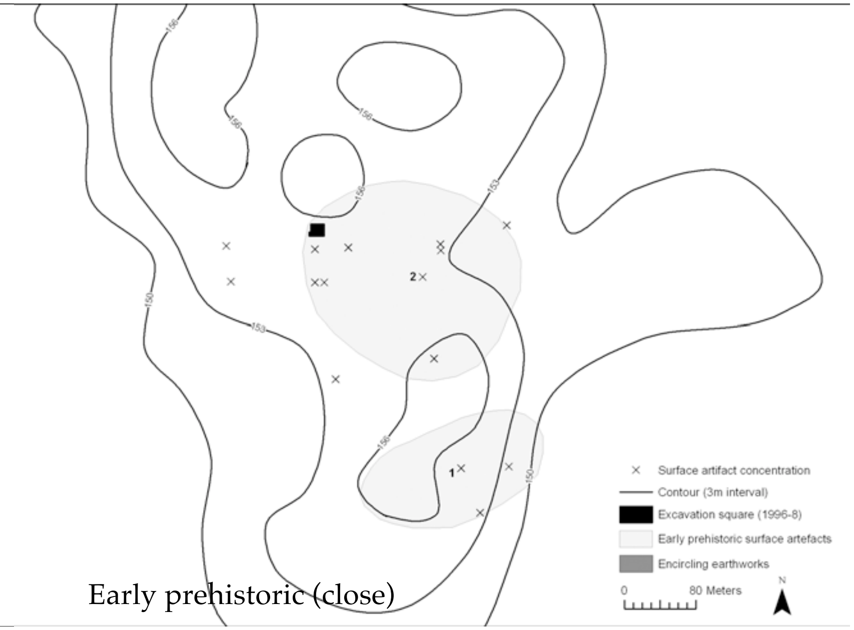
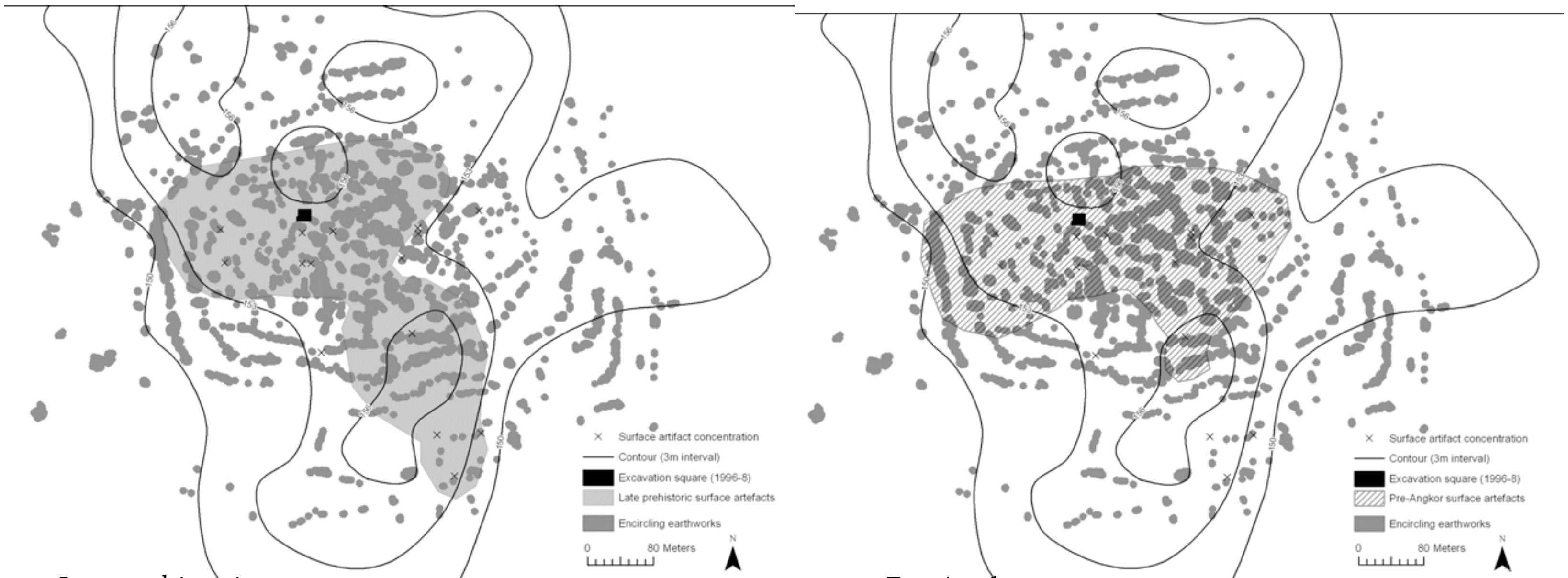

Surface artifact concentration
Contour (3m interval)
Excavation square (1996-8)
Early prehistoric surface artefacts
Encircling earthworks
0
140 Meters
N
Early prehistoric (wide)


Surface artifact concentration
Contour (3m interval)
Excavation square (1996-8)
Early prehistoric surface artefacts
Encircling earthworks
0
80 Meters
N
Early prehistoric (close)



Late prehistoric Pre-Angkor

Figure 41: Map of Noen U-Loke with surface artefact concentrations by period: 1. Original early prehistoric mound, including Neolithic material, 2. Secondary late prehistoric and pre-Angkor period mound.

Boyd and Chang's (2010, p. 277) model of the short-lived shifting, anatomising channel network gradually developing during Phases 5B (fifth century BCE – first century CE), and more rapidly during Phase 5C (first century CE – fifth century CE), may further explain this movement north. Geoarchaeological analysis by Boyd and Habberfield-Short (2007), shows the development of a strong late Holocene channel running from the northerly edge of Noen U-Loke, to the southerly edge of Ban Non Wat (McGrath et al., 2008). To fully utilise such a channel would require a shift north, from say mound one to mound two.

The ability to shift incrementally, in response to environmental or social pressure, may have aided the well-documented longevity of settlement within the UMRV. The PSKAS project has established more localised movement of individual sites than previously documented, often within individual site boundaries. As a whole, however, communities have occupied particular locales, and a small number of significantly sized sites, for over four millennia. Such longevity implies community strength and organisation. It also highlights the focus on reactionary and 'naturalistic' settlement during late prehistory, rather then a "mechanistic" and anthropocentric worldview so prevalent during the later historical and modern eras (MacKee, 2008). This view, perhaps exacerbated by the increasingly cyclical and unpredictable late prehistoric seasonality, would have encouraged emergent complexity, and resilience. One might argue such a cyclical and 'naturalistic' approach during prehistory, would have naturally fed into, and perhaps allowed for the adoption of, religious concepts of a ceremonial landscape, from the mid sixth century onwards (Allerton, 2009; Grave, 1995). Mahayana Buddhism, for example, emphasizes the "holistic" interdependence and independence of both humans and natural systems (Khisty, 2006). The strong, inwardfocused communities in the UMRV, however, would not have been easily dissipated or consumed by neighbouring polities.

By the pre-Angkor period significant pressure upon the communities of the UMRV was evident in the archaeological record. Population levels peaked, small "hamlets" split from larger mounds, and new dependent populations emerged. Those in monastic communities and living in agriculturally unviable uplands, for example, required an increase in wet-rice surplus, to be produced by alluvial floodplain centres. These long-term and gradually developing agricultural centres, such as Noen U-Loke, were not standardised, and reduced overall settlement integration during this period. It appeared the initial spread of socio-political and religious concepts, as well as strengthening pan-regional trade networks during the mid sixth century, only served to divide the community, rather than unite it into a single polity.

Local occupation retained much of their original settlement patterns and connections during the transition from prehistory to history, whereas religious and/or socio-political displays of power maintained a distribution highly focused on riverine routes. It would appear this socio-political and religious evidence is misleading in its indications of hierarchy. The careful placement of these displays, near high traffic routes and trading hubs, suggests they acted more in a demonstrative or communicative role. Indeed, in local settlement patterns small-scale villages and households continued as the dominant social unit.

The PSKAS results appeared to show a lessening population pressure, along with an expanding ownership pressure, entering into the Angkor period. The introduction of a managed environmental landscape during the Angkor period, served to progress socio-political aims of local leaders. Production reached more industrialised levels, with rest houses newly constructed in the UMRV, such as Prasat Phon Songkhram. These facilitated the storage of salt, salted fish, and rice in large quantities (Hendrickson, 2007). Less of a divide was evident between the socio-political and religious spheres of life, and the UMRV occupation patterns of the Angkor period. This was reflected in the shift of regional settlement distributions in a southeast direction, towards Phimai and the road to Angkor. Large alluvial floodplain sites expanded and became more isolated. This reflected the organisation of a landownership system, and the intensification of settlement within proto-city boundaries. However, many long-occupied sites were re-developed to accommodate this socio-political push, rather than establishing new settlements. This re-development is, perhaps, best exemplified by the site of Phon Songkhram.

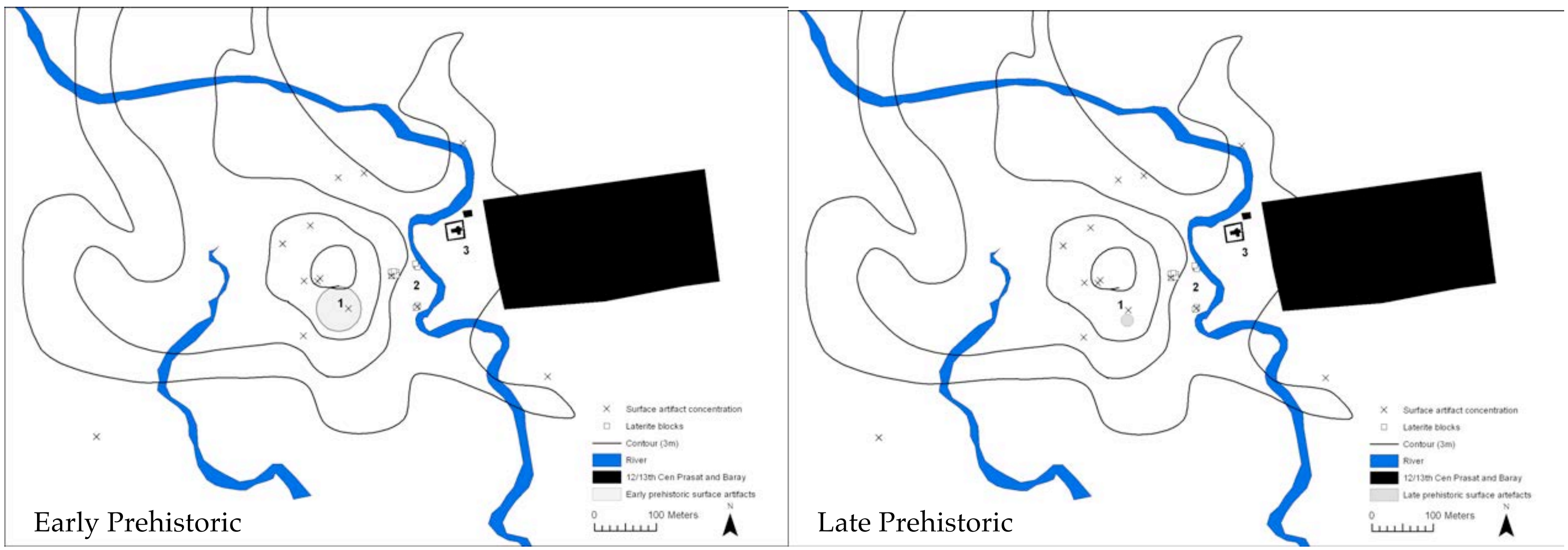
Phon Songkhram

This site is a significant, multi-period site from the PSKAS survey is Phon Songkhram. Located in the middle terraces, Phon Songkhram is a large burial and occupation mound, which contained evidence of continuous occupation throughout all prehistoric and historic time periods. Prasat Phon Songkhram is a large mound site located in the middle terraces of the UMRV, beside a small tributary of the Mun River. In 2009 a small-scale excavation of the late twelfth to early thirteenth century laterite *Arogayasala* (hospital) and pond complex, built during the reign of King Jayavaraman VII, was completed by the Fine Arts Department of Thailand (Fine Arts Department of Thailand, 2005). The hospital is at the eastern edge of a 300 m diameter occupation mound, with the Phon Songkhram River diverted through the eastern third of the mound, between laterite-block embankments. The laterite embankments were likely a post-Angkor feature, as locals recalled moving the laterite blocks, to bolster up the river banks, from an "old temple" site (recorded by PSKAS volunteers in 2012). As the excavation was intended to establish the base of the hospital complex as part of a Fine Arts Department of Thailand reconstruction project, test pits did not reveal any underlying earlier occupation strata. However, the PSKAS reconnaissance survey in 2012 revealed evidence of a substantial early brick structure, surrounded by large quantities of pre-Angkor period ceramics, and located within the eastern half of the adjacent occupation mound. Several meters west of the brick scatter, closer to the peak of the occupation mound and at an approximate depth of three metres below ground surface, human remains and prehistoric pottery were reportedly unearthed by local residents, during the construction of a town well (reported to the PSKAS team in 2011). Thus, while Phon Songkhram is best known as an Angkor-period site, it is likely that it was a significant settlement during the prehistoric and pre-Angkor periods.

Phon Songkhram is now the modern administrative centre for the sub-district of Phon Songkhram, with a large population living on the original pre-modern occupation mound. The Angkor period baray, and associated canals, are still used today to store water for the community. Additionally, a large Buddhist temple has been constructed some 200 m from the original late twelfth to early thirteenth century hospital site (see Chapter 4.2 for a detailed background).

A relationship can be established between the continued reuse of Phon Songkhram and the modern Phon Songkhram River, which has not significantly shifted since the late Holocene. During the late Holocene, the deep river channels south of the current Phon

Songkhram River, provided an optimal environmental for stone tool production, and an abundance of resources for early prehistoric settlers living in survey area B (Chapter 7.2.1). These large rivers dissipated during late prehistory, when an occupation shift towards the alluvial floodplains occurred. During the Angkor period, when deep single-stream rivers had returned to the region, the Phon Songkhram River formed part of the riverine trade network. This connected Phon Songkhram to the Mun, and eventually, the Mekong Delta. Occupation then re-focused near the modern salt factory of the low-mid terraces. There was, concurrently, the construction of the late twelfth to early thirteenth century CE hospital site in Phon Songkhram, along with (potentially, Figure 42) an overland route to the west, that utilised the flat in-fill of the original Late Holocene river. Thus complex relationships are shown between past and modern landscapes; a mix of long-term focus on water availability, and the changing political, social, and cultural needs of the community.


1
2
3
Surface artifact concentration
Laterite blocks
Contour (3m)
River
12/13th Cen Prasat and Baray
Early prehistoric surface artifacts
0
100 Meters
N
Early Prehistoric
1
2
3
Surface artifact concentration
Laterite blocks
Contour (3m)
River
12/13th Cen Prasat and Baray
Late prehistoric surface artefacts
0
100 Meters
N
Late Prehistoric

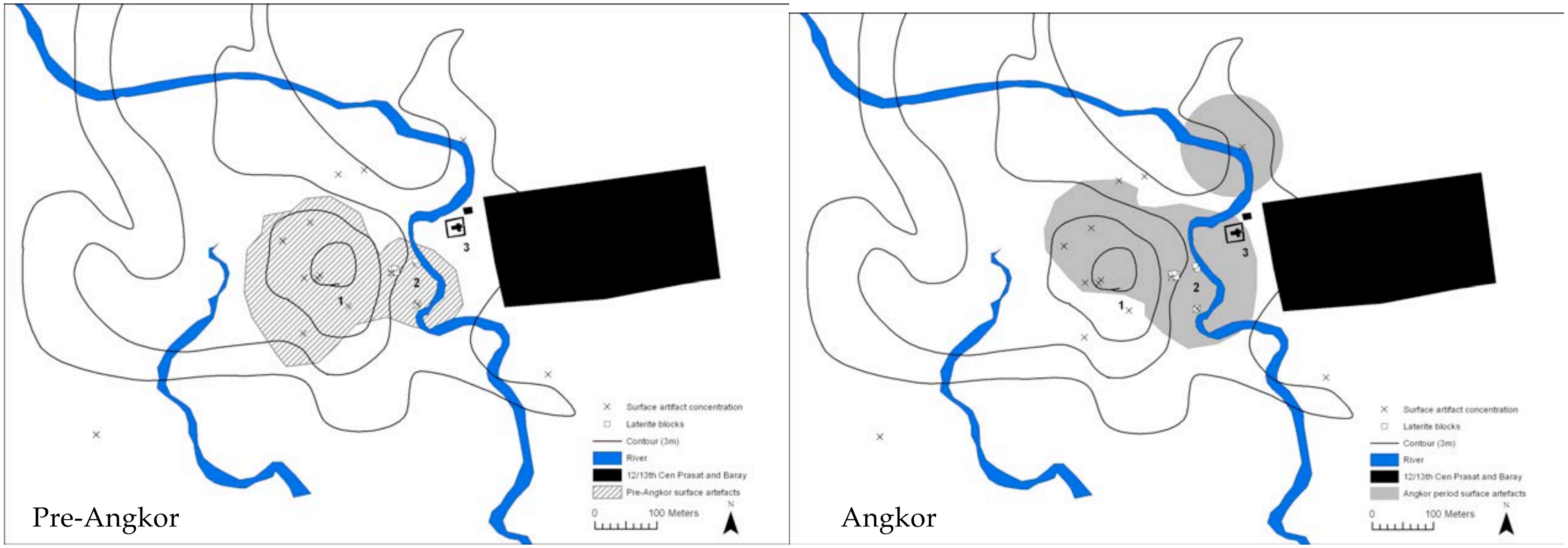


Figure 42. Map of Phon Songkhram village with surface artefact concentrations by period: 1. Early prehistoric burials, 2. Pre-twelfth century CE temple location, brick structure, 3. Late twelfth – early thirteenth century CE Arogayasala.

When we examine the local settlement trends of the 104 sites surveyed during the course of this thesis, in concert with the findings of previous excavations, it is apparent that prehistoric development in the UMRV is irregular in its site distribution and patterning, with a variety of site types and site sizes. This is epitomised by the changeable and constantly adapting occupation of Noen U-Loke and neighbouring Ban Non Wat mounds. Given this flexible and highly localised settlement, it is perhaps not surprising that the spread of Early-First-Millennium-CE "indianised" ideas of social hierarchy and religious iconography appears to have been somewhat opportunistically and inconsistently utilised in the UMRV. Furthermore, there is a paucity of evidence to support a hierarchical, structured land ownership system, until the spread of Angkor influence and structures pervade the UMRV from the southeast in the ninth – tenth centuries CE. This later historical period marks a clear change in settlement trends; with villages in the alluvial floodplains merging into 'super-villages', presumably controlling large tracts of rice producing land, and, concurrently, small and medium sized settlements are established along river valleys of the middle terraces and uplands. This marks a move towards greater socio-political control and manipulation of the landscape, which is reflected in settlement distributions (Figure 37). However, kinship, the reuse of settlement mounds, and a focus on natural waterways continue to be a theme in settlement in the UMRV, up till, and including, modern populations. How do these trends compare to concurrent development in wider Mainland Southeast Asia?

8.2 Regional Comparisons: Transitions from Prehistory to History in the UMRV, Central Thailand, and the Mekong Delta

The transition from small-scale, acephalous prehistoric groups to the development of complex, large-scale "state" polities, during the first half of the first millennia CE, is a critical topic of debate in Mainland Southeast Asia (Currie et al., 2010; Glover & Bellwood, 2004). The nature of this transition in Southeast Asia, particularly any deviations from traditional, western linear models, has implications for our understanding of cultural evolution pathways worldwide. Several indicators have been used in the PSKAS project to study socio-political development over time including the size and separation of sites, the presence/ absence of ceramic sub-regions, and the relationship of ceremonial and residential sites. When compared to regional examples, from central Thailand and the Mekong Delta region, these factors appear to indicate the transition from prehistory was to history in the UMRV was both unique and protracted in it development.

Archaeological evidence presented by Higham and Rispoli, strongly supports the integration, or at least regular trade, between central Thailand and the UMRV, via a pass in the Phetchabun mountain range (Higham & Rispoli, 2014). This relationship appears to continue into the pre-Angkor period, when iconographic evidence, in monuments, temples, and isolated statues, emerges in the UMRV, leading many to describe much of the UMRV as the 'hinterland' of the Dvaravati polity(s) (Chapter 4.2, Diskul, 1956; Quaritch-Wales, 1969). Certainly the prevalence of "biscuit" or "orange" ware ceramics in both central Thailand, and recovered during the PSKAS surveys, would appear to support such a conclusion (Chapter 6.3.1). Upon closer examination, however, the comparisons in development, between central Thailand and the UMRV, become less compelling. A comparison of settlement organisation and ranking, for example, highlights the disparity in settlement development, between central Thailand and the UMRV. The KSTUT systematic pedestrian survey of the Upper Chao Phraya River Valley in central Thailand, noted that occupation spread into a variety of landscapes during the metal ages, with average site size increasing markedly in the upland areas during the Bronze Age (Eyre, 2006; Eyre, 2010). Depopulation of the Central Thai uplands began in the Iron Age (first – fourth centuries CE), and was completed by the mid sixth century. This coincided with an increase in alluvial flood plain sites, a third of which were continuously occupied from the first century onwards. These reused sites, Eyre notes, are primarily on soils well suited to wet-rice agriculture (Lopburi low phase and Ban Mi). Overall, occupation evidence declined during the pre-Angkorian period in the Upper Chao Phraya River Valley. The PSKAS project noted an almost exactly contrary pattern in terms of landscape use, with a spread into higher elevations and a slight increase in occupation levels during the mid sixth to ninth centuries CE. However, the reuse of Iron Age sites located on alluvial floodplain soils, well-suited to wet-rice agriculture, is common between the two project areas. This may partially relate to the need to support a growing Buddhist monastic community in both central Thailand and the UMRV.

Rank-size analysis in the KSTUT survey metal age, including late Iron Age sites, displayed very similar results to those from PSKAS, with a strongly convex shape to the graphical representation of the data. KSTUT's post-Iron Age or 'Dvaravati' results, however, are dominated by the large town of Chansen. In comparison, the PSKAS UMRV results of the mid sixth to ninth century CE results remain poorly integrated, even when large nearby towns, such as Muang Sema, are adjusted for. It is likely the large, late Iron Age mounds of the UMRV alluvial floodplain, such as Non Ban Jak and

Non Muang Kao, continue to grow entering into the pre-Angkorian period, and create multiple competing centres. The settlements in the UMRV could not be said to mirror the ranked pattern of settlement integration, developing in the Upper Chao Phraya River Valley, central Thailand. This is perhaps surprising, given that many place Muang Sema as an important second tier settlement in the 'hinterland' of the Dvaravati polity(s) (Mudar, 1999; Supajanya & Vanasin, 1982).

Beyond a focus on wet-rice agriculture, there appears to be few connections in landscape use between the UMRV and central Thailand. The other point to consider is the relatively low numbers of Buddhist boundary markers or sema stones (seventh – twelfth centuries CE) in the Mun River, and their relatively isolated placement. Stephen Murphy suggests this indicates less of a Dvaravati influence and a "much stronger Chenla and later Khmer influence in the region, which could have made its way here by following the Mekong River, originating from the area around Sambor Prei Kuk in present day Cambodia" (Murphy, 2010, p.149).

Thus we turn to the southeast. There is strong historical evidence for communication and perhaps trade, between northeast Thailand and late prehistoric communities located northwest of the Tonlé Sap basin, below the Dang Raek Mountain Range (Chapter 4.2, Higham, 2012, p.285; Jacques & Freeman, 1997, p.57). Furthermore, the archaeological evidence of a relationship between northwest Cambodia and the UMRV is growing, as more of 'pre-state' sites (first - eighth centuries CE) within the northwest Cambodia, are recovered. The late Iron Age site of Phum Lovea highlights antecedent qualities that preceded the development of the Angkorian state in full, in the early ninth century CE (D. O'Reilly & L. Shewan, 2015). These qualities included ‘increasing socio-political complexity, intensified inter and trans mercantile activity, differential access to resources, social conflict, technological transfer, and developments in site morphology’.

Higham (2012; Higham et al., 2014) presents evidence that similar qualities in late Iron Age settlement are present in the UMRV, most notably: the development of a sophisticated canal structure from encircling earthworks to encourage a wet-rice surplus, the presence of ‘elite’ families, the industrial exploitation of iron and salt, and commonalities in interment ritual and ceramic styles. The ceramic style ‘Phimai Black’, for example, which originated in the UMRV, has been found as far southeast as Prei Khmeng, Phum Snay, Phum Sophy and Kok Treas in northwest Cambodia (O’Reilly & Shewan, 2015; Pottier et al., 2003). Similarities in the organisation of agricultural field systems, further emphasises a relationship between northwest Cambodia and northeast Thailand. Hawken’s (2013) dissertation has revealed a localised and irregular ‘radial’ agricultural field structure in the Tonlé Sap region, Cambodia. Although undated, these structures display similar qualities to those constructed in late Iron Age northeast Thailand, in support of a decentralised and highly localised Iron Age community. These archaeological parallels support a strong relationship, and perhaps even a tandem cultural development, having occurred either side of the Dang Raek Mountain Range.

Further southeast, within the Mekong Delta itself, an “overgrown tribal confederacy” was emerging during the first half of the first millennium CE (Nguyen, 1995; Sedov, 1978; p.113; Van Tan, 1986; Wheatley, 1983). There are indications this confederacy consisted of several competing polities, with Chinese documentary sources describing the ‘kingdom’ of Funan located in the Mekong Delta during the first to the sixth centuries CE, and encompassing the major maritime trading port of Oc Eo (Brown, 1996; Higham, 1989; Pelliot, 1903; Stark, 2000). Did a relationship in settlement and cultural traditions stretch as far southeast as the heart of the Mekong Delta?

Similarities in the transition through ceramic assemblages can be used as evidence of a common socio-political and/or economic trajectory over time, or as direct evidence of trade or partnership. When comparing the Mekong Delta to the UMRV several parallels in ceramic sequences are apparent. Early cord-marked, paddle-and-anvil earthenware vessels, recovered from Angkor Borei (fifth century BCE –second century CE) have obvious parallels with the cord-marked earthenware vessels typical of the Bronze and Iron Ages in the UMRV (fifteenth century BCE – fifth century CE, Stark, 2000, p.76; Sarjeant, 2011). Furthermore, the succeeding 'fine orangeware' (first century BCE – third century CE) and 'fine buffware' (third century CE onwards), or 'Type V' ceramics, recovered from various settlements of the Mekong Delta, display striking similarities in form, fabric, and finish with the 'Indic-style' thin, buff, wheel-turned earthenware vessels recovered in pre-Angkorian sites of the UMRV (mid sixth – ninth centuries CE, Malleret, 1959b, pp. 99-100; Stark, 2000, pp. 76-80). However, the ceramic sequence appears to have occurred some three centuries earlier in the latter region. Evidence for a somewhat delayed transmission and trade of material culture between the Mekong Delta and northeastern Thailand is supported by Alison Carter's 2013 study of Iron Age (fifth century BCE – fifth century CE) trade and manufacturing of stone and glass beads across Cambodia and Thailand (Carter, 2012; Also see study of Prohear in Cambodia by Schlosser et al., 2012). Carter's (2013) study noted the trade of beads between the Mekong delta and northeast Thailand regions occurred following an expansion of inland trade networks in the mid-first millennium CE. This continues and is consolidated later in the First-Millennium-CE, by the construction of the northwest road, connecting Phimai in the UMRV to Angkor Wat in the Tonlé Sap Basin (Hendrickson, 2010).

Comparisons in settlement patterns, between the UMRV and the Mekong Delta, however, are less convincing. It is difficult to compare prehistoric complexes, as so few have been published from the Mekong Delta, so evidence here will focus on the protohistoric and historic settlement patterns. The site, and by inference socio-political, organisation in mid-first millennium CE Mekong Delta is developing tiers, well above that recorded in the UMRV - with the largest recorded sites several times larger than those recovered from the UMRV (Table 54). This discrepancy may be partially explained when we note that Mekong delta settlement size estimates are primarily based on a walled structure enclosing the settlement, rather then the spread of surface artefacts. Both Matthew Gallon and Karen Mudar have demonstrated that walled enclosures, primarily in central Thailand 'Dvaravati' complexes, do not accurately represent residential settlement. Large areas of open, unoccupied land within walled settlements, can substantially exaggerate site size and population estimates. Within Kamphaeng Saen of central Thailand, for example, only 68 percent (or 35.7 ha) of the enclosed area contained evidence of occupation (Gallon, 2013, p. 293). When large, walled centres in the Mekong Delta are reduced in size by approximately a third, results become more comparable with the UMRV, but are still (on average) far larger than their northeast Thailand counterparts (Moore, 1988, p. 9). There remains little evidence of the upper levels of site hierarchy in the UMRV, which characterise neighbouring polities of the Mekong Delta.

Table 54:

Comparison of Mid-First Millennium CE Site Sizes in the UMRV, Central Thailand, and the Mekong Delta

Region	*Site*	*Site Size (ha)*	*Source*
UMRV	Average mid-first millennium CE	10	Welch, 1985; This thesis, Appendix C
	Noen U-Loke	7.8, 20 (with moats)	This thesis, Appendix C
	Non Muang Kao	45 (with moats)	Higham et al., 2007; This thesis, Appendix C
	Muang Sema	150 (walled)	FAD, 1959; Wangsuk, 2000
Central Thailand	Average mid-first millennium CE	13	Adapted from Eyre, 2006; Gallon, 2013
	Chansen	91.5	Eyre, 2006, p. 216
	U-Thong	96.3	Gallon, 2013, p.312
	Sri Thep	469	Gallon, 2013, p. 312
	Nakhon Pathom	659	Gallon, 2013, p. 312
Mekong Delta/ Tonlé Sap	Phum Sophy	300	Stark, 2006a: Table 1
	Angkor Borei	300 (walled)	Stark et al., 1999
	Sambor Prei Kuk	400	Gallon, 2013, p. 312
	Oc Eo	450	Malleret, 1959a; Manguin & Vo, 2000, p. 113

Comparisons between the UMRV and neighbouring polities to the west (Dvaravati) and to the southeast (northwest Cambodia / Mekong Delta) that emerged in the first half of the first millennium CE, demonstrate that the UMRV was at the crossroads of several inland exchange and communication routes, bringing an influx of architectural styles and technologies, trade items, and cultural practices. Furthermore, art historical and epigraphic evidence does support the expression, at least locally, of religious and socio-political practices. This display of epigraphic, architectural, inscriptional, and stylistic features characteristic of the Dvaravati, Chenla/ Funan, and latter 'Angkor' language in the UMRV, has led many to perceive the existence of pan-regional unified states or kingdoms in Mainland Southeast Asia, including, peripherally, the UMRV. Indeed, there is currently a push in the literature to describe the development in the UMRV in terms of much earlier relationships to neighbouring polity(s) to the west and southeast – and by inference suggest the seeds of religious and socio-political development in this region are present by the Iron Age. However, consideration must be given to the purpose and source of documentary evidence, when interpreting it (Stahl, 1993; Wylie, 1985, pp. 100-101). The visibility and permanence of monuments and structures from/related to foreign 'indianised', Chinese, and Mekong Basin sources, in comparison with the regional or local products, favours an interpretation of this period as sudden and introduced, rather then gradually and indigenously developed (Stark & Allen, 1998, p. 166). Common artistic and architectural traditions can be a product of multiple interactions between peer polities (McNeil & Welch, 1991). Religious and/or socio-political features along the riverine route may have acted as display of territorial boundaries and ownership by powerful individuals, or a measure of spiritual protection for new visitors (Gallon, 2013, p. 291). Or they may have served their purpose during construction: the very act of building these temples, monuments, and enclosing walls and moats would have facilitated a break away from the kinship based communities of prehistory towards a more complex and cohesive form of community (Gallon, 2013, pp. 292-293).

Archaeologically, the evidence for integration, or development of an organisation structure to rival the major polities of Mainland Southeast Asia, is much weaker. There are common features of settlement: the reuse and development of wet-rice producing alluvial floodplain sites, participation in the growing maritime trade network, and the construction of 'Indic-style' Buddhist temples, monasteries, *sema* stones, and later Angkor style temples and monuments, in the sixth, seventh, and eighth centuries CE. Furthermore, there appears a particularly strong relationship, in terms of cultural tradition and site morphology, with late Iron Age communities of northwestern Cambodia, and links in ceramic-style with Angkor Borei and the Mekong Delta. However, these can predominately be explained in terms of the transmission of ideas and goods through trade networks. When we examine overall settlement patterns in the UMRV, there is little evidence for an integrated or multi-tier settlement system, such as we already see developing in central Thailand and the Mekong Delta, until much latter in the chronological sequence, if at all. Up till, and perhaps including, the ninth century CE, settlement appears to have been relatively modest and divided affair in the UMRV. If a polity(s) of the UMRV existed, it was certainly not large or cohesive enough to rival contemporary polities in the Mekong delta or central Thailand. The UMRV was not divorced from the political and social changes sweeping Mainland Southeast Asia in the pre-Angkor and Angkor period. Neither, however, was it absorbed by it, nor did it take an active role as a major polity in its own right. It appears that from a regional perspective, the UMRV development was localised, complex, and protracted in nature. The question is whether this pattern is specific to the UMRV, or is it indicative of a wider trend relating to resilience and sustainability in the semi-arid tropics versus the wet tropics?

8.3 Supra-Regional Comparisons: Sustainability in Semi-Arid, Tropical Southeast Asia

By studying the long-term development of communities, given their particular environmental setting, we can gain insight into why particular societies survived for millennia, or displayed resilience, whilst others collapsed under external and internal pressures. The Upper Mun River Valley is an excellent example for such a study; the PSKAS project confirms that this environmentally challenging region has been occupied continuously for at least four millennia. This is despite neighbouring polities, to the southeast and west, expanding and coalescing rapidly around it. Such resilience may relate to the localised, well-connected, flexible, and reactionary communities that developed in the semi-arid, tropical conditions of the Upper Mun River Valley.

Throughout the prehistoric and historic results of the PSKAS project, the linearity and the localisation of settlement patterns in the UMRV was readily apparent. Early prehistory, and to a lesser extent late prehistory, ran alongside late Holocene rivers and channels. During historic periods these then shifted to follow modern rivers, and overland routes that connected distant communities. This linearity was in contrast to traditional "focal village", dispersed, or hexagonal models, where local elites are argued to have emerged from large village centres (Earle, 1987; Higham et al., 1982; Welch, 1985).

Linear community models posit spatially larger social units with kin-ship links. This places less of a focus on vertical hierarchical organisation, and more of a focus on horizontal social relationships (Abbott et al., 2006). In the Murgab desert of

Turkmenistan researchers describe localised or modular patterns of settlement, with a four-tiered kin-based structure similar to that of modern Central Asian tribal organisation (Lamberg-Karlovsky, 1994; Markofsky, 2010, p. 268). Each "module" or local group maintained a patrilineage structure, encompassing a series of smaller groups using kin-ship links. These pre-khanate tribal structures also maintained a public works focus, constructing extensive irrigation networks, in order to survive the extreme conditions of the Murgab desert.

Small-scale linear communities have also been found in alluvial landscapes, perhaps most notably the Bekaa valley, Lebanon, where Marfoe (1979) has revealed a localised settlement hierarchy; major sites (over four hectares in size) were spaced along the valley floor, and connected by clusters of smaller sites. Marfoe (1979) emphasises the small, interactive groupings of a socio-cultural network, rather than a more overarching socio-political framework. Multiple, varied groups, particularly those suffering from ecological stress, took advantage of the inertia of centralisation, and hierarchical structures offered by elites. This overarching power, Marfoe argues, is only cohesive in an ideological sense; the practicalities of economic and political organisations were maintained by fixed local interactions between groups.

Kin-ship links, therefore, both appear to be critical to the stability of smaller socio-political units, and to their ability to function together. Indeed, strong familial links during the prehistoric period in diverse regions of Thailand are supported. The burial aggregation of Khok Phanom Di in Central Thailand, for example, included 17 generations of family tree (Higham, 1996, p. 255). White and Eyre (2006) also argue for "household" burials associated with lived-in residential structures at Ban Chiang, in the

Chi River Basin. Within the UMRV itself, the "egalitarian" nature of burial assemblages coupled with isotopic results from Ban Lum Khao support a discrete, kinship-based society (Bentley et al., 2009). The presence of familial burial groups in the UMRV is further supported by Iron Age burials at Noen U-Loke, which retain similarities in dental features, suggesting a close genetic relationship (Nelson et al., 2001).

If kinship-maintained, linear, peer-peer communities existed in the UMRV, were these communities patrilocal/patrilineal or matrilocal/matrilineal? Isotopic clusters from groups of females at Noen U-Loke, support limited "short-range, kin-based migration", but primarily intrinsic growth (Cox et al., 2011, p. 669). Studies of stable isotopic evidence from Ban Chiang in the Chi River Valley, and Khok Phanom Di in peninsular Thailand, argue this kin-based migration is matrilocal. These women remained close to their villages, with the men moving into the women's village, from distant localities (Bentley et al., 2005; Bentley et al., 2007). This is an arrangement still practiced today amongst many Thai communities (Oota et al., 2001). During the pre-Angkor period, local leaders (thought to be male) emerged (Higham, 2012). These leaders were associated with ponds or water management systems. By the early Angkor period clear evidence of a shift to patrilineal structures can be seen, and a centralised administrative management.

Stark (2006b) also discusses the relationship between small interactive social groups, and the development of the Angkor Empire. Stark highlights the stability of the Khmer domestic economy. This stability centred upon local "cults" or kin temples, which maintained a rural, agrarian base. It is the predictive or "fixed" interaction of local communities, which provided the stable structures of its foundation. Viewed from a complexity approach; small-scale, flexible, kin-based communities are more stable long-term than a large-scale, fixed hierarchical organisation (Ames, 2007; Chapter 5.3). This would further explain both the duration of occupation, and the commitment over hundreds, or even thousands of years, to specific segments of the UMRV. Such small-scale flexibility is particularly important when the unpredictability of the UMRV landscape is considered. Indeed, rapid localised movement, and/or the construction of earthworks, would have been critical.

How might these small local kin-based units have developed in the UMRV, and what bound them together? A focus on maintaining a regular supply of water is a well-documented feature of settlement in Mainland Southeast Asia, particularly those sites located near the Mekong and its tributaries. Water-management was critical to the rise of many political powers in Mainland Southeast Asia and their organisational structure, most notably the Angkor Empire (Boyd & Chang, 2010; Higham, 2012). Such developmental structures follow on from Wittfogal's (1955; Wittfogal, 1956) and Steward's (1949; Steward, 1955) arguments that major irrigation works require a central organising authority. However, Hunt and colleagues (2005) demonstrate that modern community management does not necessarily require elite functionaries when constructing large-scale hydrological projects merely a common focus (see also Farrington, 1980). If linear water features were the focus for local communities, this might explain the resilience and naturalistic appearance of settlement patterns, which were a feature of the occupation of the UMRV.

The above examples demonstrate that a naturalistic water focus can quickly evolve into a socio-political management of water. The approach taken by communities towards water resources, however, appears to be highly dependent upon the pre-existing organisational structure and the extent of socio-political pressure upon the community. Hendrickson (2007, p. 260) also makes the point, in his discussion of the routes and roads of the pre-Angkorian and Angkorian Empire, that natural riverine trade routes, and their associated sites, so prevalent prior to the Angkorian empire, were returned to, following the empires collapse in the fifteenth century CE (also see Groslier, 1973; Groslier, 1986, pp. 42-43). Hendrickson is suggesting the Angkor period, in the Mekong basin, marked a shift away from environmentalism, towards managing the political/structural demands of the Empire. Stark (2006b) reinforces this point, discussing the cyclical nature of collapse and regeneration in the Angkor Empire, and the need to develop anthropomorphic strategies of agriculture in central and northeast Thailand to provide a surplus for coastal trading communities. However, less of a dramatic change is seen in the UMRV, with continued evidence of integration of pre-existing sites, and partial re-use of riverine trade routes. Following natural pathways seems to be a consistent feature of the UMRV, one that was not made a secondary priority to socio-political demands. The difference may lie in the semi-arid tropical environment of the UMRV itself.

There is a well-established relationship between diverse and complex settlement strategies and the challenging environment of the semi-arid tropical zone. In the North Gujarat Archaeological Project of semi-arid north-western India, for example, the sustainability of fourth millennia BCE agro-pastoralist communities was explored using agency-based computer modelling (Lancelotti, 2014). It was revealed that village communities during a period of high climatic instability cannot survive solely on agro-pastoralism, and must have access to other sources (i.e. trade, hunting, gathering, and exchange between groups). In such an environment, inter-community links and trade would have been critical to survival, as was developing a resource surplus. Furthermore, developing a diverse, small-scale agro-ecological strategy would have helped absorb climatic shocks. This allowed for a more integrated and opportunistic approach to balancing socio-political and environmental priorities, which, ultimately, proved highly resilient.

From a supra-regional perspective, the consistent focus on close proximity to waterways and reuse of pre-existing sites over millennia are key features of the UMRV, and it could be argued, the semi-arid tropics more broadly. The flexibility and adaptability, and collective focus, of this strategy may explain the long-term resilience of the semi-arid UMRV. Whilst, more abundant wet tropical regions, such as those to the southeast and west, utilised an abundant resource base to expand rapidly and broadly, leaving themselves poorly equipped to deal with environmental or socio-political shocks. The study of social development and sustainability in the tropics is an exciting field of research, with important implications for modern populations living in semi-arid tropical regions world-wide. This avenue of research, however, would benefit greatly from direct settlement study comparisons across a range of tropical environs.

8.4 Summary

This chapter has discussed the findings of the PSKAS survey project at three scales: local, intermediate, and supra-regional scales. At a local or 'within site' scale the intensive, systematic pedestrian survey has revealed the irregularity of site boundaries, and the way in which the concentration of surface artefacts shifts incrementally over time. This reflects both the changing and flexible nature of occupation in the UMRV, but also the consistent reuse of site locations over millennia. The intermediate, or regional scale of investigation has revealed the localised, complex, and protracted occupation within the UMRV. It would appear strong community links and structuring were an integral factor in settlement patterns. Thus a trend towards small, close knits, linear structured communities as the dominant social unit in prehistory, may be a feature of development in the challenging and unpredictable semi-arid tropical environments.

9. Conclusions and Future Work

This study is the first systematic, intensive, and widespread survey conducted in the UMRV, and one of few examples within Southeast Asia. It integrated pedestrian and satellite survey techniques to not only reveal over ninety new sites, but mapped the shape and size of those sites in great detail, and provide a wealth of new settlement data. This study also represents the first systematic pedestrian survey of settlement in the upper terraces and 'uplands' of the Upper Mun River Valley, when traditionally the river junctions and floodplains have been the focus of survey. As a result of this thesis, we are now able to test theories regarding site location, type, and size, and directly compare site assemblages.

The major aim of this thesis was to record and analyse intermediate-scale prehistoric and historic settlement patterns in the UMRV, northeast Thailand. The PSKAS project successfully completed a systematic and intensive survey across four landscape types; the alluvial floodplains, low-mid terraces, upper terraces, and uplands. This led to the discovery and analysis of **over 100 sites,** 56 through pedestrian survey and a further 48 through satellite survey**,** at a density of **1.19 sites per km^2**. This increased the number of known sites within the study area ten-fold. Results included four Neolithic sites in survey area C, at a density of 0.25 sites per km^2. The relative efficiency of systematic, intensive, pedestrian survey makes it a viable option for future projects in Mainland Southeast Asia. The introduction of this technique at the initial stages of future projects, will allow excavation to target critical sites in the landscape.

This data can then be used to address a series of major questions and assumptions:

1. Prehistoric sites in the UMRV are predominately large, earthwork encircled mounds, and historic sites large temple complexes. Both are located near to the Mun River System and its tributaries

This hypothesis was unsupported by the findings of the PSKAS project, which recovered a variety of site types across the UMRV. Earthwork encircled sites constituted only nine percent of all sites recorded using systematic, pedestrian survey, and 35 percent of all sites recorded using satellite survey, highlighting the variety of site types in the UMRV. Whilst Neolithic, Bronze Age, and Early Iron Age sites were located at the lower elevations (< 165 m ASL), late Iron Age and historic sites were found throughout the UMRV landscape, including in the dry hill slopes to the northwest (elevation > 200 m ASL)

2. There is a relatively early appearance of urbanism in the UMRV Southeast Asia during the late Bronze to early Iron Age, as evidenced by the complex burial rituals and domestication of water buffalo/ cattle

This thesis does not support an early appearance to urbanism, with little evidence for multi-tier hierarchies or extensive land ownership, prior to the mid sixth century CE. Rather, settlement patterns with the UMRV appeared to have been both localised and complex, with a late movement towards hierarchical development. Statistical analysis revealed a shift from an environmentally narrow to an environmentally broad occupation base, and a (slight) trend towards greater standardisation of site size. These changes in settlement patterns began during the mid-sixth century CE, and were realised by the tenth century CE. There was also consistency of some features of settlement over-time, most notably the close proximity to natural water features, the reuse of sites, and strong local ceramic traditions. Many of the continuing trends are still present in the villages of the UMRV today.

Regional comparisons between the UMRV and the neighbouring Mekong Delta, Tonlé Sap, and central Thailand regions, highlight the **protracted** and **unique** nature of development. Leaders based in the latter, neighbouring regions expanded their power base rapidly in the early-first millennium CE, utilising socio-political ideas emerging from India and further abroad, and manipulating the environment to aid this expansion. Settlement patterns in the UMRV, on the other hand, appear to reflect inconsistent application of hierarchical concepts. There is a paucity of evidence for conflict or warfare, and relatively few examples of Indianised and/or Buddhist expression or markers. It is not until Angkorian rulers take an interest in the Mun River Basin in the tenth century CE that gradual socio-political reform occurs in the region, and we see the introduction of techniques to ease the challenging environmental conditions of the UMRV, including the construction of barays, canals, and encircling squared moats. Thus, socio-political and anthropomorphic ideas spreading across Southeast Asia in the early-first millennium CE appear to have been selectively and gradually integrated in the UMRV, and balanced with more "naturalistic" pre-existing priorities. The UMRV is (relatively) internally driven and gradual in its growth, with focuses upon kinship, site reuse, and proximity to natural waterways.

3. Two-tier and market-place community models, formed the basis for an emerging hierarchical or heterarchical system in the UMRV

The PSKAS project findings did not find prehistoric evidence or pre-cursors to an emerging supra-regional hierarchical or heterarchical system. Rather settlement appeared linear and localised in nature, often stretched along contemporary water features. This is consistent throughout prehistory. Such a trend may relate to the unpredictable and relatively arid environment. When we examine this trend from a supra-regional perspective, there was a balance achieved environmentally, culturally, and socio-politically in the semi-arid tropics of the UMRV that has proven highly resilient. This balanced or integrated approach was aided by the modest and flexible settlements, which adapted and grew over-time (with some localised movement), as exemplified by the case studies of Phon Songkhram and Noen U-Loke. Previous region-wide studies have highlighted hierarchy, heterarchy, or the emergence of elite families, as evidence of the inevitable development of the region into a salt-rich hinterland of the Angkorian Empire (Chapter 3). The PSKAS results, however, appear to support a kin-ship based settlement in the UMRV up till, and partially beyond, the mid sixth century CE, with an emphasis upon smaller, linear, and more interactive groups. Common priorities between small groups, and the pervasiveness of key resources including salt and ceramic-grade clay, ensured that such a structure provided a flexible, but resilient, long-term base from an operational perspective. There appears to be a relationship between tropical resource abundance, or a lack thereof in the semi-arid tropical zones, and the need for an increase in complexity to ensure long-term sustainability. This relationship would be further revealed, with comparative intensive surveys, in both arid and fertile regions of Tropical Southeast Asia

Directions for Future Research

As a result of this initial project several further research directions have be identified. The next logical step for this project is the excavation of key sites that have been identified during survey. Phon Songkhram appears to have been a critical site in the UMRV landscape and a rare example of a site continuously occupied from early prehistory through to modern occupation. Although the Angkor-period Phon Songkhram temple was recently excavated by the Thai Fine Arts Department, this site would greatly benefit from excavation of its centrally located prehistoric mound and/or evidence of an earlier brick temple site in the eastern third of the village. Also a good candidate for excavation, site 46, located along Huai Yai River, is a rare example of a single-period Neolithic site in the UMRV. It would be useful to compare the Neolithic assemblage and burials to the nearby multi-period Ban Non Wat site and compare their differences and similarities in their cultural traditions.

Beyond excavation there are also landscape and settlement pattern studies that could be the focus for future post-doctoral research, most notably the intriguing line of laterite blocks running through survey area B. Is this evidence of a local road and if so where does it lead? Additionally, uncovering the purpose and nature of pre-Angkor period settlement in the uplands of the UMRV will be a focus of future research. Are there any historical records, and/or excavation evidence, such as iron slag and forestry tools, to indicate why settlement expanded into this environmentally challenging area?

From a more general perspective, this thesis has highlighted key areas that need to be explored further. Inland trade routes were critical to the exposure of ideas and concepts, as well as the passage of technology and ceramics, across Mainland Southeast Asia. Further examination of the spatial patterning and nature (riverine vs. road networks) would greatly aid our understanding of the relationship between neighbouring polities, empires, and communities developing in Mainland Southeast Asia. Is there evidence of settlement along trade routes to the west, for example the pass through the Phetchabun's linking central and northeast Thailand, or to the southeast, through the Dang Raek mountain range and into the Tonlé Sap region? Additionally, sites of ritual significance, such as cemeteries, monuments, and temples, appear to have varied in their placement in prehistoric and historic communities. This should be investigated further through spatial analysis of site types. Is there any evidence of reverence for pre-existing ritual sites? Do sites of ritual significance maintain a relationship to trade routes or passages? Finally, an emphasis in future research should be placed upon integrating new survey techniques and technology into the archaeology of Mainland Southeast Asia, particularly during the initial phases of research. This can greatly aid in targeting key sites, in a region where the sheer wealth of unexcavated archaeological sites can be overwhelming. The Neolithic period, for example, remains one of the most poorly understood, but significant, periods in Mainland Southeast Asia. Given the narrow environmental range of Neolithic sites discovered in this thesis, predictive analysis could be utilised to further reveal where are Neolithic sites likely to be located in the UMRV, so they can be targeted by further excavations. Greater use of standardised site and artefact databases across Mainland Southeast Asia will greatly aid such a process and make available a wealth of comparative settlement data.

Conclusion

This research has successfully applied both systematic, intensive pedestrian and satellite survey to a sample of the UMRV, northeast Thailand, increasing the number of known sites ten-fold. This has revealed a detailed picture of settlement pattern data, which encompasses over three millennia of occupation, across several landscape types, and a variety of site types. Settlement pattern data indicates the UMRV experienced a relatively late and gradual shift towards more hierarchical levels of social complexity, despite evidence to suggest early transmission of indianised ideas through inland trade routes. There is a consistent focus on local linkages in the UMRV, with extensive site re use, and proximity to natural water features. This demonstrates the significant variation in trajectories that exist across Southeast Asia, even within the boundaries of modern Thailand. A better understanding of this variation requires more long-term, community level, or intermediate-scale projects. This will assist in the development of detailed local sequences for comparison. A significant problem in continuing with this research is that the wealth of archaeological material in this region. To date, over three decades of survey and excavation have been carried out in the general area of the PSKAS project, and yet we are more aware than ever that we are just scratching the surface. However, as part of a larger movement, towards analysing the settlement patterns of the UMRV in a more up-to-date, systematic, and community-driven manner, this research constitutes an important first step.

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Appendix A: Land use and Natural-Ground-Surface-Visibility Classification

An understanding of post-depositional forces acting upon the surface material across the entire study area is needed to predict their affects upon our results. Of particular concern is the surface visibility of natural, original soil, which might be obscured by scrub, grass, and plantations, or anthropogenic foundations, industrial complexes, and roads. Manually recording land use and natural ground visibility within each grid unit is overly time consuming, and in effect, only records the land use and visibility at artefact concentrations (Markofsky, 2010, p. 86). As an alternative, a dry-season (April 2012) IKONOS, three band (RGB) + panchromatic satellite image of 0.8m horizontal resolution, was purchased. The RGB bands were remotely classified into a series of visibility (1, 2, 3, 4) and land use (cleared, residential, forest, agricultural) categories. The resulting maps were compared to the survey results, and any needful adjustments made. What follows is a description of the land-use reclassification process, its accuracy, and conversion into natural-ground-surface-visibility.

Land use

Land use is a complex, variable concept that must encompass agricultural, industrial, and residential activities as well as extant natural resources. As such, the process of reclassifying remote satellite imagery into a series of discrete categories can be undertaken using a variety of methods, each with their own associated requirements, costs, and resulting accuracies (Rozenstein & Karnieli, 2011 for a review of modern techniques). For the purposes of this dissertation a supervised, stepped classification on IKONOs three band + NIR satellite imagery captured in April 2012 was conducted. This approach produced a reasonably fine intensity of 0.8m, and provided a relatively straight forward and replicable classification process.

Two-hundred and twenty-four ground cover and land use recordings taken during the course of the 2012 survey were used as training sites to develop a signature for the IKONOS imagery. This ground-truthing process is a crucial component of classifying ground-cover remotely. It compares the classification of several arbitrary location points within the remote spatial classification against in-field observer classification (assumed to be "accurate" or "truthful"). This is then used to directly generate a signature collection for adjusting the band classification (Congalton, 1991). Water was clearly distinguishable in the Near Infra Red (NIR) band (Figure 43). The first step was to extract this from the survey area and reclassify it.

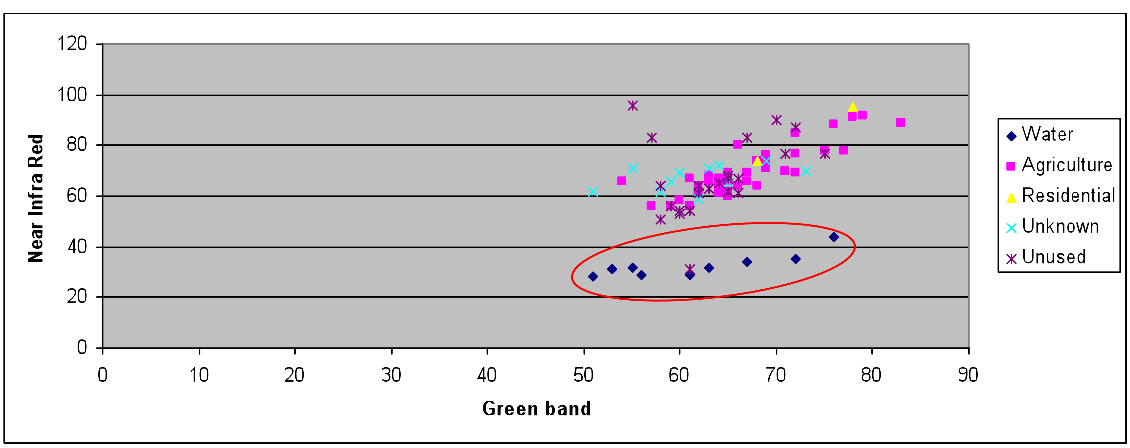

Figure 43. Near-Infra-Red versus green band statistics for IKONOS imagery.

The clearest separation of the remaining land use categories (residential, industrial, agricultural, and forest) is within red (B3) and in NIR (Figure 44). A reclassification of Band three (B3) was used to separate forest and agricultural/industrial categories, and the agricultural/industrial results were then further reclassified using the NIR band.

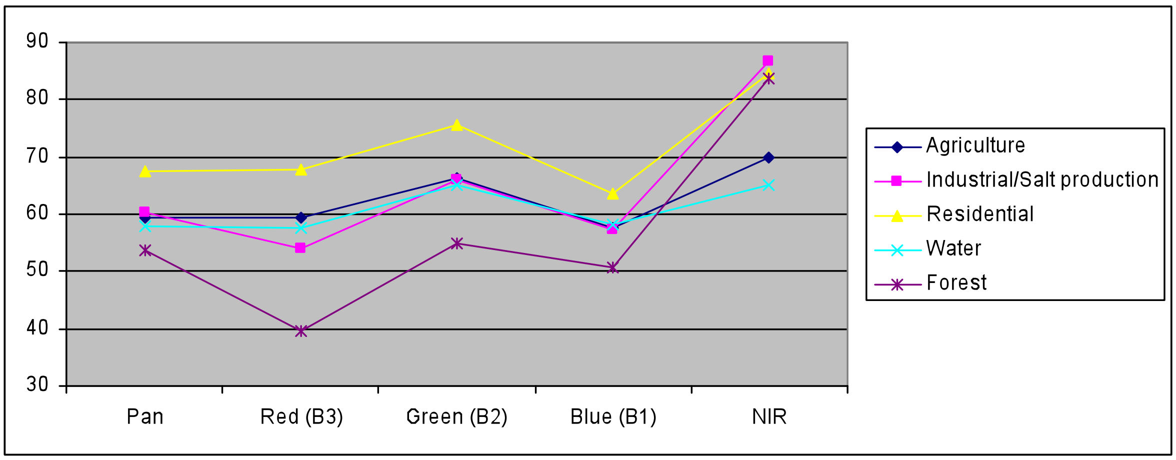

Figure 44. Average IKONOS band signature for each land use category.

Residential areas tended to cluster into small, dense villages. This density allowed a manual outlining of the perimeter of villages within the survey area, and reclassified them as “residential”. Incidental trees within villages were absorbed into this residential category. The local road network was provided as a shapefile by Nakhon Ratchasima Rajabhat University. This was also converted into a raster and combined with the residential classification.

Upon further investigation of the forest band classification it was decided that plantations and scrub offered a very different survey environment to the heavy forest and should be separated into two independent land use categories.

To achieve this, a further 21 sample points from the Community Forestry project were used to generate two separate band signatures for light forest/scrub/plantations and heavy forest. Within the study area dense vegetation maintains a relatively high NIR, typically above 87 um, and low Red Band signature, below 39 um. The Normalised Difference Vegetation Index (NDVI) was used to separate the two vegetation types, using the formula:

$$NDVI = (NIR - Red)/(NIR + Red)$$

Within the resulting NDVI output, values ≥ 0.35 were reclassified as dense forest and ≤ 0.35 reclassified as light forest/scrub/plantations. Tree shadows caused an artificial specked effect for the dense forest results, this was somewhat removed by a majority filter (four pixel). Both vegetation categories were integrated into the final stepped land-use classification, ranking above agricultural lands, but below water, residential, and industrial land use categories.

In total 244 sample sites were used for the stepped land use reclassification, constituting 0.0001 percent of the total number of pixels within the study area. The reclassified output generated using this signature is displayed in Figure 45.

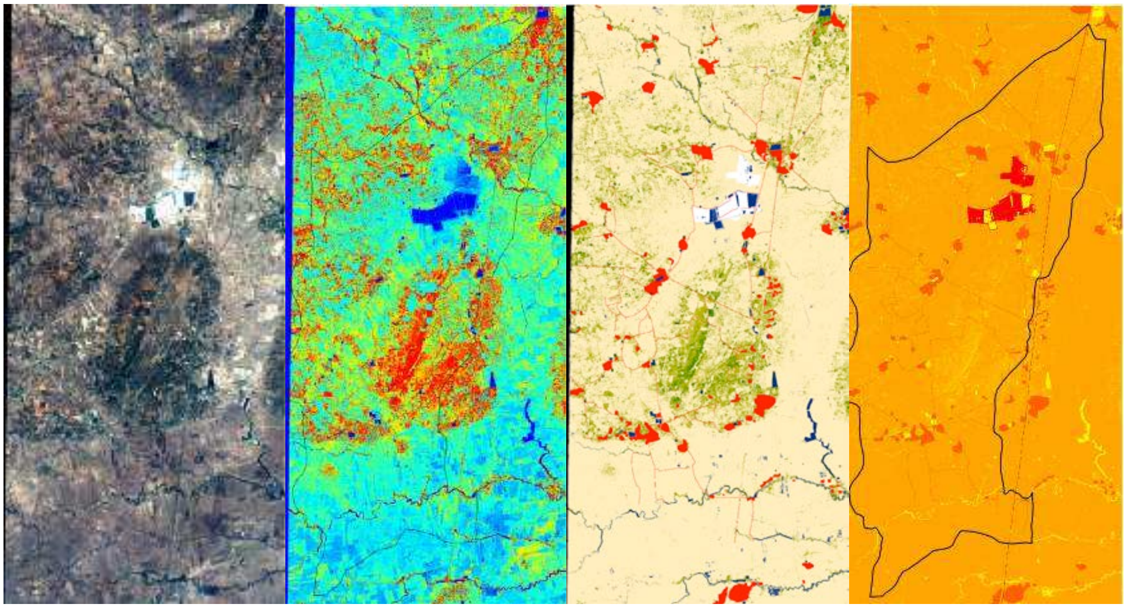

Figure 45. Reclassification of IKONOS imagery, (left to right) original IKONOS, NDVI, reclassified land use, ground surface visibility.

To assess the accuracy of the land use output some 1000 independent, random points were taken from aerial imagery. The results indicate the output is 90.2 percent accurate, exceeding the USGS industry standard for remote sensing land use classification accuracy of 85 percent (Anderson et al, 1976).

Natural-ground-surface-visibility

The visibility of the natural ground surface, which contains archaeological material, could potentially have a significant impact upon survey results (Van Leusen, 2002, pp. 4-6). Rather than repeat the sampling process and create a separate visibility classification of the IKONOS imagery, visibility was derived from land use categories.

First it was assessed whether land use is a good measure for ground visibility. With each land use ground-truthing sample an independent, interval measure (poor <20 percent visible, fair 20-50 percent visible, good 50-80 percent visible, and excellent >80 percent visible) of the percentage of “natural soil” visible was taken. Natural soil was defined as the original soil and did not included compacted river clay used as housing foundation or imported, fertilised, agricultural soil. However, natural soil that has been disturbed or upturned as a result of agricultural planting, such as bund construction for wet-rice paddies, will be included, as artefacts should still be visible and located within meters of their original context. The relationship between land use samples and ground visibility is summarised in Table 10. The assessment of visibility was undertaken by several individuals during the 2012 field season and should only be viewed as an approximate measure.

A Chi-squared test of land use versus visibility ranking returned a significant ($p <= 0.05$) result of $p = 0.0239$. Unused land use was removed from this significance test as its sample was less then five. Given their significant relationship it was deemed appropriate to directly convert land use categories into average percentage natural soil visible (Figure 45).

The ground surface visibility map was later compared against the density of surface artefacts from systematic, intensive pedestrian survey areas B & C to see if results needed to be adjusted to compensate for natural ground visibility (Chapter 7.1).

Saline Soil Classification

The Khorat Plateau of northeast Thailand sits some 100-70m a top the substantial Mahasakra salt formation, rendering the region one of the largest producers of salt worldwide. The area has a long established relationship with salt production. Historical records and mapping by Hendrickson indicate the Khorat and Sakhon Nakhon basins of northeast Thailand were the preferred supplier of salt for the Angkorian Empire (800-1400 AD) (Hendrickson, 2007, p. 226). Higham notes that large Iron Age salt sites of the UMRV, such as Non Dua, are of an industrial scale, and are likely a source for regional trade (Higham, 1989, p. 215). Archaeological excavation of small clay-lined kilns indicates household production occurred during the Iron Age at Ban Salao (Duke et al., 2010). Furthermore the increasing seasonality of the late prehistory would have provided optimal conditions for the manufacturing of salt in the UMRV (Yankowski & Kerdsap, 2013).

Areas of high salinity were derived from digitised from Landsat 7 EMT+ (1999, bands 4, 3, and 2) and ASTER (2001) satellite imagery (Wannakomolch, 2005). To help prevent residual salt patches cause by irrigation using salty water, we applied a majority filter to the salt map. The results indicate saline deposits are widespread, with coverage of 13.96 percent of the study area. The highest concentrations of salt are in the 148-203 m ASL (mean = 175.28 m ASL) elevation range, along middle-upper terrace areas with a slope greater than three percent.

Appendix B: Recording Forms and Field Notes

PSK Survey 2014

Grid square Recording Form

Date: ______________________ Time: ______________________

Team: ____

GPS Coordinate (centre): ______________ E ______________ N

Artefact Density (no./within a 1m radius dog-leash. If <20 are found within whole CU then automatically sparse):

☐ Sparse

☐ Moderate (2–5 sherds per 1m dogleash)

☐ High (5–15 sherds per 1m dogleash)

☐ Very high (>15 sherds per 1m dogleash)

Description:

Landform	*Type of site (one or more)*	*Type of Artefacts*
☐ Mound	☐ Artefact scatter	☐ Ceramics
☐ Rice paddy	☐ Earthworks or built structure	☐ Shell
☐ Scrub	☐ Burial	☐ Stone
☐ River cutting	☐ mining or production	☐ Metal
☐ Woodland	☐ Other (describe below)	☐ Other
☐ Other (describe below)		

Visibility Ground Surface Current Land-use

☐ <20% (poor) ☐ Agricultural ☐ Forest Reserve

☐ 20-50% (fair) ☐ Industrial

☐ 50-80% (good) ☐ Residential

☐ >80% (excellent) ☐ Unused

☐ N/A ☐ Unknown

Unusual Artefact Info:

1. Description — Unusual pattern/features/form

2. Description — Unusual pattern/features/form

Photo numbers:

Nos. (e.g. 201-211) Description

____

____

____

____

____

____

Notes:

____

____

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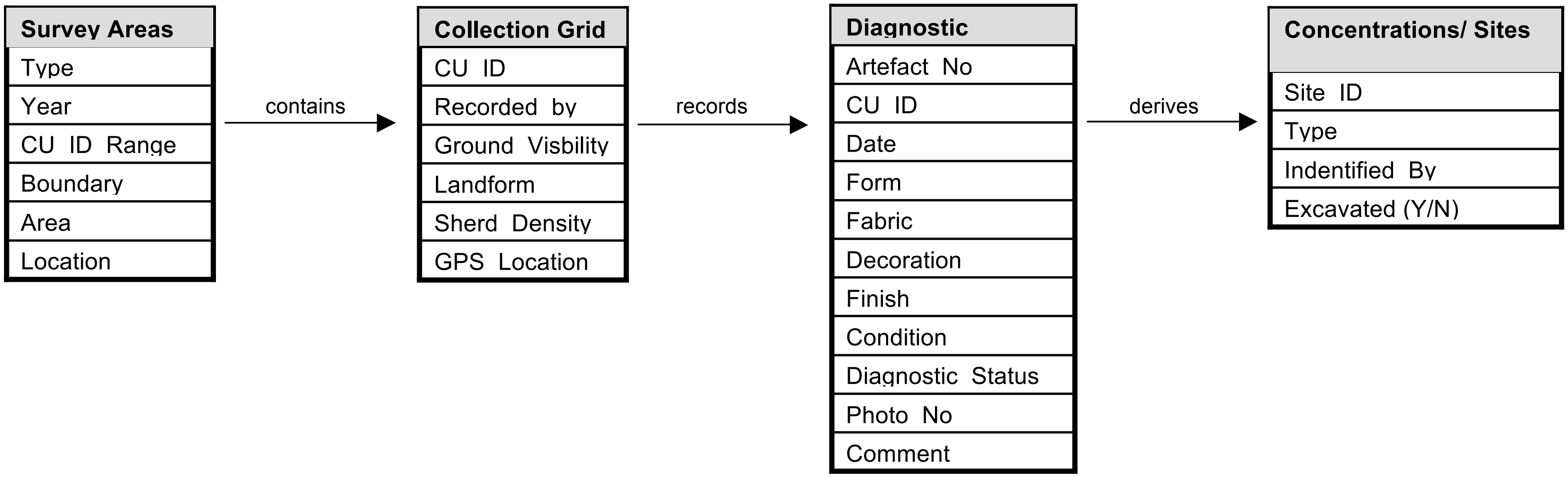

Figure 46. Conceptual data model of survey results.

Table 55:

Survey GIS File Database

PSKAS GIS File database:

Archaeological Feature Dataset

1. [Feature class: Point] 2012-2014 trulocat GPS locations
2. [Feature class: Point] Grid square grid-center with diagnostic artefact densities
3. [Feature class: Points] Known archaeological sites
4. [Feature class: Polygon] Site perimeter around grid squares containing ≥ 5 diagnostic artefacts (Sites)

Environmental Feature Dataset

1. [Feature class: Points] Modern villages and towns
2. [Feature class: Polylines] Modern rivers and streams
3. [Feature class: Polylines] Fossil rivers
4. [Feature class: Polygon] Survey areas
5. [Feature class: Polygon] Study area
6. [Feature class: Polygon] Salt deposits digitised from Landsat EMT
7. [Feature class: Polygon] Modern land use derived from IKONOS satellite imagery and aerial photograph.
8. [Feature class: Polygon] Soil categories supplied by NRRU GIS database

Raster Catalogue

1. [Raster dataset] 30m ASTER digital elevation model (UMRV)
2. [Raster dataset] IKONOS 0.8m pan-sharpened image (Phon Songkhram Sub-District)

Tables

1. [Database Table] 2012-2014 Diagnostic Artefact Attributes
    a. [Domain] Artefact material (e.g. Earthenware, copper/bronze, sandstone)
    b. [Domain] Artefact type (e.g. dish-on-stand, Buddha statue, axe)
    c. [Domain] Grid square ID
    d. [Domain] Finish (slip, buff, glazed)
    e. [Domain] Decoration
    f. [Domain] Time period (EP, LP, PH, KHM, unknown)

2. [Database Table] 2012-2014 Grid square
    a. [Domain] Date collected
    b. [Domain] Team
    c. [Domain] GPS coordinate
    d. [Domain] Grid square ID
    e. [Domain] Site ID
    f. [Domain] Land use
    g. [Domain] Site type
    h. [Domain] Natural-ground-surface-visibility
    i. [Domain] Dog-leash artefact count

j. [Domain] Photo numbers
k. [Domain] Notes

Relationships

1. Relate 2012-2014 Grid squares [Field: Grid square ID] to 2012 - 2014 Diagnostic Artefact Database [Field: Grid square ID]
2. Relate 2012-2014 Grid squares [Field: Site ID] to Sites [Field: Site ID]

Appendix C: Site and Artefact Summaries

Table 56:

Pedestrian Survey Site Summary

Site	Date Recorded	GPS (centre)	Grid squares	Artefact density	Landform(s)	Type of site	Type of artefacts	Visibility range	Diagnostic artefacts	Notes
1	14/03/2014	180572 1704718	1009	Sparse	Sugar Cane	Artefact scatter	Ceramics, stone	Fair	916, 917	The bottom of a Buddha image, stoneware ceramics
2	07/03/2014 – 08/03/2014	180680 1704039	1013, 1017, 1019, 1020, 1023, 1029, 1030, 1031, 1032, 1040, 1044	High – very high	Cassava fields, sugar cane, residential	Artefact scatter	Ceramics, shell, bone,	Good - excellent	935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 976, 977	"Non Noi" disturbed historical site, likely associated with sites 1 & 3.
3	08/03/2014	180668 1704229	1026, 1039, 1045, 1046	Sparse – high	Cassava fields, sugar cane	Artefact scatter	Ceramics, bone	Fair - excellent	950, 951, 952, 953, 975, 978, 979, 980, 981, 982	
4	10/03/2014	182340 1704574	1003	High	Cassava field	Artefact scatter	Ceramics	Good	905, 906, 907	
5	08/03/2014	180976 1703967	1028	Sparse	Cassava field	Artefact scatter	Ceramics	Fair	954	
6	16/03/2014	183957	1012	Moderate	Cassava	Artefact	Ceramics	Fair	934	

		1704896			field	scatter				
7	16/03/2014	183914 1705093	1010, 1011, 1053, 1054, 1057, 1059, 1060	High – very high	Sugar cane	Artefact scatter	Ceramics, brick,	Good - excellent	918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 985, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 1002	Large historical site, disturbed, likely associated with site 6.
8	19/02/2012	209099 1700256	Gb16.6	Very high	Rice paddy	Artefact scatter	Ceramics	Good	297, 298, 299, 300, 301	
9	18/02/2012	209347 1700196	Gg16.4	Very high	Rice paddy	Artefact scatter	Ceramics	Poor	342	
10	18/02/2012	210115 1695575	Hc11.12	Sparse	Rice paddy	Artefact scatter	Ceramics	Fair	465	Small mound site, disturbed
11	18/02/2012	210045 1700062	Gs16.2, Ha15.20	Sparse - moderate	Rice paddy	Artefact scatter	Ceramics	Poor - fair	441, 1049, 1070, 1071	Partially disturbed, shallow mound
12	17/02/2012	210628 1699683	Hm15.14	Sparse	Rice paddy	Artefact scatter	Ceramics	Poor	500	Partially disturbed
13	16/02/2012	210196 1699326	Hd15.7, He15.18	Moderate	Rice paddy/ scrub	Artefact scatter, earthworks	Ceramics, stone	Poor	484, 486, 487, 488, 1092	Mound with ditch along western edge, partially disturbed
14		209799 1698659	Hc14.10, Gn14.15, Gp14.17, Go14.12, Go14.13, Go14.15, Gp14.13, Gp14.14,	Very high	Residential	Artefact scatter	Ceramics, bone, metal, stone	Fair	374, 375, 376, 377, 378, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 408, 410, 413, 414, 415, 416, 417,	“Phon Songkhram”

			Gq14.17, Gr14.14, Gs14.13,						418, 419, 422, 423, 424, 426, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 1010, 1011, 1012, 1016, 1018, 1027, 1028	
15	15/02/2012	209667 1699543	Gn15.11	Sparse	Rice paddy	Artefact scatter	Ceramics	Fair	379	
16	15/02/2012	209642 1699437	Gm15.9, Gl15.9	Sparse – moderate	Rice paddy	Artefact scatter	Ceramics	Poor	369, 370, 371, 372, 373	Near a small pond, 30m from modern road
17	17/02/2012	209350 1699625	Gg15.13, Gh15.13	Sparse – moderate	Rice paddy	Artefact scatter	Ceramics	Fair	340, 341, 353, 354	Found in sandy soil
18	15/02/2012	209160 1699549	Gd15.11	Sparse	Rice paddy	Artefact scatter	Ceramics	Poor	322, 323	
19	03/02/2012	208003 1698611	Fa14.13	High	Residential	Artefact scatter	Ceramics	Good	91	
20	02/02/2012, 10/02/2012	207971 1698468	Et14.10, Fa14.8, Et9.10	Moderate – very high	Rice paddy/ Tapioca field/ Salt pan	Artefact scatter	Ceramics, stone	Fair - good	79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 90	Heavily disturbed
21	01/02/2014 – 02/02/2014	208163 1698345	Fd14.17, Fd14.8	Sparse – high	Rice paddy	Artefact scatter	Ceramics, metal	Good – excellent	120, 121, 122, 123, 124	Beside Kok Pra Hom village, northern edge of pond. Partially disturbed.
22	01/02/2012	208055 1698250	Fb14.5	Moderate	Rice paddy	Artefact scatter	Ceramics	Excellent	102, 103, 104, 105, 106, 107	Disturbed, at the edge of a house. Likely associated

										with site 21.
23	15/02/2012	209986 1698869	Gt14.18	Moderate	Residential	Artefact scatter	Ceramics	Fair	444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 1052, 1059, 1067, 1068, 1069	Angkor period artefact scatter south of site 14.
24	10/02/2012	208662 1698445	Fo14.15, Fn14.10, Fo14.9, Fn14.8	Sparse – very high	Rice paddy	Artefact scatter	Ceramics	Good - excellent	132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201	
25	10/02/2012	209124 1698268	Gc14.7, Gh14.6	Sparse - moderate	Salt pan	Artefact scatter	Ceramics	Good	313, 314, 315, 316, 344, 345, 346, 347	Likely associated with site 25
26	09/02/2012 - 10/02/2012	209166 1698163	Gc14.6, Gd14.2, Gd14.4,	Sparse - moderate	Salt pan	Artefact scatter	Ceramics, other	Good - excellent	312, 319, 320, 321, 328, 343	Large, low density artefact scatter between ponds at

			Gf14.4, Gh14.4							Phon Songkhram salt factory.
27	10/02/2012	209105 1698160	Gc14.4	Moderate	Salt pan	Artefact scatter	Ceramics	Good	303, 304, 305, 306, 307, 308, 309, 310, 311	
28	08/02/2012 - 09/02/2012	208768 1697919	Fp13.19, Fq13.20, Fp13.18, Fo13.17	Sparse - very high	Salt pan	Artefact scatter	Ceramics	Good - excellent	171, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 233, 234, 1003, 1004, 1005	
29	09/02/2012	208859 1697746	Fs13.16, Fr13.15	High	Rice paddy	Artefact scatter	Ceramics	Excellent	235, 247, 248, 249	
30	08/02/2012	207276 1697620	Ef13.13	High	Salt pan	Artefact scatter	Ceramics	Excellent	67, 68	Small, low density artefact scatter between ponds at Phon Songkhram salt factory.
31	03/02/2012	206909 1697576	Ds13.12	Very high	Potato field	Artefact scatter	Ceramics	Good	38, 39, 40, 41, 42, 43, 44, 45, 904	
32	05/02/2012, 16/02/2012	205207 1697061	Bs13.1, Ce13.2, Ce13.3, Cc12.20, Bq13.2, Bt12.20	Sparse – very high	Rice paddy/ cassava field/ residential/ scrub	Artefact scatter, earthworks	Ceramics, stone	Good - excellent	3, 4, 5, 6, 7, 8, 11, 13, 14, 15, 16, 17, 18, 19, 24, 25, 33	Large site located near Bu Ty Por village, includes laterite blocks
33	05/02/2012	206919 1697135	Dq13.2, Dr13.3, Ds13.3	Sparse - high	Cassava field/ scrub	Artefact scatter	Ceramics	Good - excellent	22, 23, 26, 27, 28, 29, 30, 31, 32, 33	

34	05/02/2012	207530 1697238	En13.2, Ek13.5	Sparse – moderate	Rice paddy	Artefact scatter, earthworks	Ceramics, stone	Good – excellent	69, 70, 72, 73, 74, 75, 76, 77	Small artefact scatter with laterite blocks found approx. 100m west of large mound feature.
35	31/01/2012 – 01/02/2012	208061 1697287	Fb13.5, Fb13.6, Fc13.7, Fc13.8	Sparse – very high	Rice paddy/ potato field	Artefact scatter, earthworks	Ceramics, stone, glass	Good - excellent	92, 93, 94, 95, 96, 97, 98, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 900	Remains large mound site heavily disturbed by pond clearance and potato planting.
36	07/02/2012	208569 1697266	Fi13.4, Fl13.6	Sparse – high	Rice paddy	Artefact scatter	Ceramics, stone	Good	128, 129, 131	Includes laterite blocks, beside modern pond
37	31/01/2012	208784 1697247	Fp13.5	Very high	Rice paddy/ potato field	Artefact scatter	Ceramics	Good	202, 203, 204, 205, 206	Very disturbed by potato planting
38	07/02/2012 – 08/02/2012	208967 1697423	Ft13.9, Fs13.7, Fs13.8, Ga13.7, Ga13.12	High – very high	Scrub/ salt pan	Artefact scatter	Ceramics, stone	Good – excellent	237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294	"Non Ka Bunag" (potentially old salt production site?). Many piles of ceramics, heavily disturbed by pond clearance. Many stone adzes.
39	07/02/2012	209050 1697153	Gb13.4	Moderate	Salt pan	Artefact scatter	Ceramics, stone	Good	295	Small, low density artefact scatter

										between ponds at Phon Songkhram salt factory.
40	07/02/2012	209344 1697309	Gg13.7	High	Salt pan	Artefact scatter	Ceramics	Excellent	330, 331, 332, 333, 334, 335, 336, 337, 338	On bunds between modern salt ponds, some very large sherds (>20cm).
41	08/02/2012		Hj13.6, Hk13.6, Hj13.5	Moderate – high	Scrub	Artefact scatter	Ceramics, stone	Good – excellent	491, 492, 493, 494, 495, 496, 497, 498	Partially disturbed small mound with laterite blocks.
42	07/02/2012	208951 1696851	Ft12.18	High	Salt pan	Artefact scatter	Ceramics	Good	250	
43	31/01/2013	205197 1689088	2, 3, 5, 7, 9, 11, 12, 14, 15, 16, 55	Moderate – very high	Rice paddy/ scrub	Artefact scatter, earthworks	Ceramics, metal, bone	Excellent	405, 409, 411, 412, 420, 421, 442, 443, 445, 452, 460, 461, 718, 719, 720, 721, 722, 723, 901, 903, 1013, 1014, 1015, 1016, 1017, 1020, 1021, 1022, 1023, 1024, 1025, 1026, 1029, 1030, 1031, 1032, 1033, 1034, 1035, 1036, 1037, 1039, 1040, 1041, 1042, 1047, 1048, 1051, 1053, 1054, 1057, 1058, 1060, 1061, 1062,	"Noen U-Loke" mound with numerous sherds and human and animal bone.

									1063, 1064, 1065, 1066	
44	31/01/2013	205352 1688745	17, 54, 59	High	Rice paddy/ scrub	Artefact scatter, earthworks	Ceramics	Good	462, 463, 464, 466, 713, 714, 715, 716, 717, 729, 730, 731, 732, 1072, 1073, 1074	Artefact scatter found in southern moats of Noen U-Loke, likely moat cuts through remains of a small mound. Human bone and carnelian blocks found.
45	31/01/2013	206244 1688988	10	Moderate	Rice paddy	Artefact scatter	Ceramics	Poor	1043, 1044, 1045, 1046	Small mound site
46	29/01/2013, 05/02/2013	208325 1688212	1, 20, 81	Sparse – High	Rice paddy/ residential	Artefact scatter	Ceramics, metal, bone	Good	402, 403, 404, 485, 485, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 801, 802, 1009, 1076,	"Huai Yai" village mound, approx. 1.5m high, remains of at least 12 adult and child skeletons, Neolithic ceramics, and bronze/copper slag. Likely top layers of mound were removed for housing leaving early prehistoric layers intact.

									1077, 1078, 1079, 1080, 1081, 1082, 1083, 1084, 1085, 1086, 1087, 1088, 1089, 1090, 1091, 1093, 1094, 1095, 1096, 1097, 1098, 1099, 1100, 1101, 1102, 1103, 1104, 1105, 1106, 1107, 1108, 1109	
47	26/01/2013 – 27/01/2013	207056 1686828	Ea2.17, Ea2.18, Ea14.14, 21, 22, 23, 24, 25, 26, 27, 29, 30, 31, 33, 34, 35	Sparse – very high	Rice paddy/ scrub	Artefact scatter	Ceramics, metal, shell	Poor - excellent	46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620,	"Non Khaam" a large mound in sandy soil. Two thirds of mound is undisturbed. Contains abundant shell and iron artefacts.

									621, 902, 1008	
48	24/01/2013	205938 1686872	48	High		Artefact scatter	Ceramics	Fair	695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705	Small mound in sandy soil
49	25/01/2013, 12/02/2013	206241 1686217	37, 56	Moderate – very high	Rice paddy	Artefact scatter	Ceramics	Fair	627, 628, 629, 724, 725, 726, 727	Heavily disturbed small mound between Non Khaam (site 46) and Non Kok (site 50).
50	24/01/2013	205979 1685885	38, 46, 47	High	Scrub	Artefact scatter	Ceramics, shell, bone, stone	Fair - excellent	630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 804, 805, 806, 807, 808	Small, shallow (1m) mound East of Non Kok (site 50). Partially disturbed. Human bones, clay pellets, anvil, and spindle whorl found.
51	22/01/2013 - 23/01/2013	205792 1685703	41, 68, 69, 73, 75, 78, 79	Moderate - very high	Scrub/ residential	Artefact scatter	Ceramics, metal, stone	Fair - excellent	669, 667, 668, 669, 670, 671, 672, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 772, 773, 774, 775, 776, 777, 778, 779, 781,	“Non Kok” prehistoric and historic mound (perhaps with moat?). Artefacts associated with iron age burials found (beads, bronze artefacts). Partially disturbed

									782, 783, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799 800	by modern canal.
52	23/01/2013 - 24/01/2013	205391 1685810	39, 66, 67, 74	Sparse - high	Rice paddy	Artefact scatter	Ceramics, metal, shell, bone, stone	Fair - Excellent	655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 744, 745, 746, 747, 748, 749, 750, 751, 752, 780	Heavily disturbed mound in sandy soil, containing human bone and a bronze bell.
53	26/01/2013	207066 1686891	28	Very high	Scrub	Artefact scatter	Ceramics, shell, bone	Good	584, 585, 586, 587, 588	Surface artefact scatter near site 47.
54	24/01/2013	205473 1685872	64, 65	Sparse	Rice paddy	Artefact scatter	Ceramics, stone	Fair	734, 735, 736, 737, 738, 739, 740, 741, 742, 743	Artefact scatter in sandy soil
55	23/01/2013, 26/01/2013	204886 1685371	27, 29, 71, 72	Sparse – very high	Rice paddy	Artefact scatter	Ceramics, metal, shell, other	Good	583, 589, 590, 591, 592, 593, 594, 769, 770, 771	Partially disturbed mound with bronze artefacts and stone tools.
56		226842 1686074	TP1, TP2, TP3, TP4, TP5 (after Welch 1985)			Artefact scatter	Ceramics		See field report	"Ban Tamyae" large prehistoric and historic mound.

Table 57:

Satellite Survey Site Summary

Site	Date recorded	GPS (centre)	Mound height (m)	Surface artefact density	Landform(s)	Type of site	Type of artefacts	Disturbance	Diagnostic ceramics	Notes
57	06/02/2013	210266 1680663	5.5	High	Residential	Large, circular mound with moat	Ceramics	Low		"Ban Non Kilek" (mound of iron slag), prehistoric and historic site.
58	06/02/2013	212581 1680837	7+	Very high	Residential	V. large circular mound with moat, historical temples/monuments	Ceramics, brick, sandstone	Low		"Ban Sa Pruan", a significant Iron Age and pre-Angkor site, with brick, Buddhist monuments near moat, and sema stone (now at Phimai museum).
59	06/02/2013	210849 1683035	5	Moderate	Residential	Small, circular mound	Ceramics	Medium		"Ban Kok" – on map, incorrectly labelled.
60	06/02/2013	213970 1680861	6	Very high	Residential	Mid-size, circular mound with moat	Ceramics, bone, stone	Moderate		"Wat Kilek" prehistoric and historical mound, currently a modern temple where some complete vessels and mortar-and-pestle are being held.
61	07/02/2013	214466 1681069	5	Moderate	Residential	Large, irregular mound	Ceramics	Medium		"Ban Chok", beside site 60, prehistoric and

									historic artefacts. Disturbance from solar farm.
62	07/02/2013	215557 1681629	7+	Moderate	Residential	Large, circular mound with moat	Ceramics, bone	Medium	“Ban Som”, significant prehistoric and historic site but heavily looted and disturbed by residential development.
63	07/02/2013	218794 1695348	1.5	High	Rice paddy	Artefact scatter	Ceramics, brick, stucco, sandstone	High	Destroyed brick and stucco Chedi northeast of Ban Ta Chan village. Also contained evidence of Angkor period temple and occupation.
64		214490 1680750	5	Moderate	Residential	Small, irregular mound	Ceramics	Moderate	East of Wat Kilek
65	09/02/2013	219990 1687086	5	Moderate	Residential	Large circular mound with moat	Ceramics	Moderate	“Ban Sa Si Liam” - large prehistoric and historic site next to Ban Prasat.
66	09/02/2013	219742 1694687	2	High	Scrub	Mid-sized irregular mound with moat?	Ceramics, brick, sandstone	Low	Shallow mound site with brick and stucco northeast of Ban Ta Chan village. Also contained evidence of Angkor period occupation.

									Likely similar to site 63.
67	10/02/2013	215950 1693705	1.5	High	Rice paddy	Artefact scatter	Ceramics, brick, stucco	High	Destroyed brick and stucco Buddhist monument south of Ban Taco village. Also contained evidence of Angkor period temple and occupation. Originally mound was approx. 100m across.
68	10/02/2013	211197 1687744	1	Moderate	Scrub	Artefact scatter	Ceramics, metal	High	Late historical residential site south of Huai Noi village, likely 200-300 YO with Chinese ware, setan coin (pre-1930's design), and iron slag.
69	10/02/2013	210554 1685875	1.5	Moderate	Rice paddy	Artefact scatter	Ceramics	High	Destroyed Angkor period site west of Ban Kok village.
70	13/01/2013	212307 1690892	0	Low	Rice paddy/ scrub	Artefact scatter		High	Historical ceramics found east of Ban Makha
71	13/01/2013	213262 1690668	6	Low	Residential	Large, circular mound with moat, and Angkor period	Ceramics, bone	Moderate	Prehistoric and historic site west of Bang Non Ma

						temple?			village
72	13/01/2013	214757 1691965	4	Moderate	Residential	Large circular mound	Ceramics	Moderate	“Ban Non Tan” prehistoric and historic site.
73	15/01/2013	212506 1696589	7+	Moderate	Residential	V. large circular mound with moat, and monument/temple?	Ceramics, bone	Moderate	“Ban Phon Chalop” significant prehistoric and historic site. Similarities to Phon Songkhram (site 14).
74	15/01/2013	211341 1696742	2	High	Scrub	Oval mound with moats	Ceramics	Moderate	Historical site 500m northwest of Ban Phon Chalop
75	16/01/2013	216733 1692742	1.5	High	Rice paddy	Small, Irregular mound	Ceramics, glass	Medium	“Non Noi” late prehistoric mound, southeast Ban Ta Chan Noi. Potential ancient salt-making site. Also a modern religious site (Buddha sighting).
76	16/01/2013	218496 1693519	4	Low	Residential	Large, circular mound		Medium	“Ban Ta Chan Noi” mound, built on large natural laterite outcrop.
77	16/01/2013	219685 1694626	3	Medium	Scrub	Large, oval mound with moats	Ceramics	Low	Prehistoric and historic mound, northeast of Ban Ta Chan Noi.

									Similarities to site 44.
78	16/01/2013	213973 1699072	3	Medium	Scrub	Large oval mound, with moats	Ceramics	Low	Predominately historic mound, with multiple oval moats. Similarities to Non Muang Kao.
79	16/01/2013	218984 1698683	5	Low	Scrub	Large, circular mound with oval moats.	Ceramics	Medium	Historical mound east of Ban Nguu, beside modern canal.
80	17/01/2013	215323 1690836	2	Low	Scrub	Small, circular mound	Ceramics, stone	Low	Small prehistoric mound with dense vegetation found east of Ban Krok Kham. Possible anvil recovered.
81	17/01/2013	219440 1689803	5	High	Scrub	Large, circular mound with moat	Ceramics	Low	Prehistoric and historic site South of Ban Salat Wa, now a Buddhist monk meditation retreat. Excellent site preservation.
82	17/01.2013	214534 1696067	2	High	Scrub	Small circular shell midden	Ceramics, shell	Low	Small prehistoric shell midden, located beside larger site and Phon Songkhram River.
83	17/01/2013	214186 1696079	1	Low	Rice paddy	V. large irregular artefact scatter	Ceramics	High	Destroyed large mound with some

										Angkor period ceramics located beside site 77.
84	18/01/2013	208723 1690306	4	Medium	Residential	Mid-sized irregular mound	Ceramics	Moderate		"Ban Macla" reports of a 16th century jar burial. Beside modern railway.
85	18/01/2013	209840 1690850	6	High	Residential	Large mound	Ceramics, stone, laterite	Medium		"Ban Makha" large prehistoric and historic mound with basalt adze, and laterite blocks found. Reports of an "old pond".
86	18/01/2013	210793 1692316	2	High	Rice paddy	Small irregular mound	Ceramics, stone	Medium		Part of a string of small prehistoric mounds North of Ban Don Muang. Neolithic ceramics recovered.
87	18/01/2013	210743 1692540	3	Low	Scrub	Small circular mound	Ceramics	Low		Part of a string of small prehistoric mounds North of Ban Don Muang. Modern Buddhist and animist significance.
88	18/01/2013	210783 1692787	3	Low	Scrub	Small circular mound	Ceramics	Low		Part of a string of small prehistoric mounds North of Ban Don Muang. Modern Buddhist and animist

									significance.
89	18/01/2013	211805 1688010	0	High	Rice paddy	Large artefact scatter	Ceramics, metal, shell	High	Large destroyed prehistoric burial mound southwest of Ban Huai Noi. Originally over 500m across, many human bones and bronze age ceramics with bronze residue found.
90	18/01/2013	212466 1688019	2	High	Scrub	Small irregular mound	Ceramics, metal, shell, stone	Medium	Small prehistoric and historic mound with basalt adze, grinding stone, animal bone, and bronze frags.
91	19/01/2013	212849 1686202	0	Low	River cutting	Small artefact scatter	Ceramics	High	“Ban Kha Khim South” small Angkor period site.
92	19/01/2013	211197 1686185	6	High	Residential	Mid-sized, circular mound with moat	Ceramics	Low	“Ban Kok” – prehistoric and historic mound, including bronze age burial at centre. Similarities to Ban Non Wat.
93	19/01/2013	209747 1685633	3.5	Moderate	Residential	Irregular mound	Ceramics, bone, metal	Medium	“Ban Ngiu” – Bronze age burial found by residents. Also

										recovered further human bone, bronze bangles, decorative clay anvil, and iron slag. Artefacts predominately Bronze Age.
94	19/01/2013	217081 1688741	7+	Moderate	Residential	Large, circular mound with moat	Ceramics, bone	Low		“Ban Ya Kha North” – significant prehistoric and historic mound with burials. Similarities to nearby Ban Prasat.
95	20/01/2013	215480 1685986	5	Medium	Residential	Mid-sized, circular mound	Ceramics, bone	Low		“Ban Tabeak” – prehistoric burial mound.
96	20/01/2013	214300 1684464	1	Medium	Rice paddy	Small mound	Ceramics	High		String of small prehistoric and historic sites in very sandy/salty soil. Large amounts of Angkor pottery.
97	20/01/2013	214606 1684742	1	Medium	Rice paddy	Small mound	Ceramics	High		String of small prehistoric and historic sites in very sandy/salty soil. Large amounts of Angkor pottery.
98	20/01/2013	215071 1685072	1	Medium	Rice paddy	Small mound	Ceramics	High		String of small prehistoric and

									historic sites in very sandy/salty soil. Large amounts of Angkor pottery.
99	20/01/2013	215550 1685399	1	Medium	Rice paddy	Small mound	Ceramics	High	String of small prehistoric and historic sites in very sandy/salty soil. Large amounts of pre-Angkor pottery.
100	07/02/2013	216351 1682284	1.5	Low	Rice paddy	Small irregular mounds	Ceramics	High	Small historic artefact scatters east of Ban Som
101	24/01/2013	218971 1698700	4.5	Low	Scrub	Large circular mound	Ceramics	Low	Prehistoric mound in forested area.
102	09/02/2013	220095 1686912	1.5	Low	Rice paddy	Small artefact scatter	Ceramics	Medium	Small scatter of Angkor period artefacts near moat of Ban Sa Si Liam.
103	09/02/2013	217566 1687160	7+	High	Residential	Large, circular mound with moat	Ceramics, bone, metal, stone, shell	Medium	“Ban Prasat” – large prehistoric and early historic burial mound excavated by Fine Arts Department of Thailand.
104		214675 1687636	4	High	Residential	Large, circular mound with moat.	Ceramics, bone, metal, stone,	Medium	“Ban Lum Khao” – large prehistoric burial mound

	shell	excavated by Origins of Angkor project 1995/6.

Table 58:

Diagnostic Artefacts Summary (By Phase)

Time period		No. sherds assignable to phase	Distinctive surface decoration (No.)	Form types (No.)	Manufacturing No. / % of all diagnostic sherds	Artefact ID
Early prehistoric	Neolithic	35	Incised & Impressed (9) Appliqué central cordon with Impressed & cord-marking (5) Impressed rice-design (1) Incised net pattern (5) Incised lines (random) (11) Burnishing (4)	VT-1 (14) VT-2 (15) VT-3 (9) VT-4 (1) BT-1 (2) Clay anvil (2)	Paddle & Anvil	305, 462, 463, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 548, 547, 549, 550, 551, 556, 564, 630, 631, 632, 633, 635, 641, 646, 664, 667, 808

Bronze Age and early Iron Age	196	Cord-marking/ comb-marking (106) Cord-marking & Red-painted ware (2)

Late prehistory	Late Iron Age	127	Appliqué central cordon & burnishing (4) Streak burnishing (4) Burnishing (22) Stamp-marking (8) Impressed Half-moon/ circles (5) Cord-marking and comb-marking (56) Cord-marking & burnishing (2)	VT-5 (1) VT-8 (5) BT-1 (9) BT-3 (10) Bell (1)	Paddle & Anvil (49) Wheel-made (6)	3, 14, 23, 47, 48, 50, 52, 62, 66, 188, 189, 193, 199, 200, 234, 236, 237, 243, 258, 259, 263, 264, 270, 294, 301, 349, 350, 351, 367, 376, 379, 380, 382, 385, 386, 389, 402, 405, 409, 412, 442, 461, 482, 495, 498, 566, 568, 569, 571, 572, 573, 574, 575, 576, 584, 589, 590, 593, 596, 597, 599, 601, 602, 610, 612, 613, 618, 619, 621, 634, 675, 676, 677, 678, 679, 690, 691, 692, 693, 694, 695, 696, 697, 698, 714, 734, 735, 738, 741, 743, 744, 745, 758, 760, 761, 764, 769, 771, 779, 782, 783, 790, 791, 792, 793, 796, 797, 902, 1013, 1014, 1015, 1018, 1019, 1020, 1021, 1022, 1023, 1024, 1032, 1035, 1061, 1062, 1063, 1064, 1066, 1072, 1074
Pre-Angkor	"Dvaravati"/ Pre-Angkor	149	Appliqué central cordon and lines (11) Band of Appliqué (21)	VT-2 (1) VT-8 (1) Carinated vessel (19) Dish-on-	Wheel-made (98) Stand scars (1)	4, 5, 11, 19, 30, 32, 41, 42, 57, 60, 83, 89, 90, 91, 93, 98, 99, 100, 106, 107, 109, 111, 113, 116, 117, 167, 170, 173, 174, 198, 202, 206,

		stand (7)	174, 198, 202, 206, 207, 225, 315, 353, 354, 366, 369, 370, 371, 374, 375, 377, 378, 384, 390, 391, 392, 393, 395, 398, 399, 402, 403, 404, 405, 410, 421, 422, 423, 424, 426, 427, 430, 432, 435, 436, 437, 438, 439, 441, 442, 444, 446, 447, 448, 449, 450, 451, 460, 461, 462, 463, 464, 486, 496, 581, 582, 583, 594, 600, 604, 609, 611, 620, 642, 664, 665, 666, 670, 671, 673, 680, 681, 682, 683, 684, 688, 699, 700, 701, 708, 715, 717, 718, 719, 721, 722, 723, 757, 759, 767, 768, 780, 784, 786, 787, 794, 795, 799, 900, 901, 904, 920, 936, 950, 960, 967, 973, 974, 977, 987, 1002, 1010, 1011, 1012, 1017, 1028, 1029, 1030, 1031, 1033, 1034, 1037, 1039, 1042, 1043, 1044, 1045, 1046, 1048, 1049, 1051, 1053, 1054, 1055, 1056, 1057, 1058, 1067, 1068, 1069, 1070, 1071
	Refined comb-marking (51)	Finger-marked bricks (5)	
	Incised parallel lines & Impressed dots/ circles/ triangles/ zig zag/ half moon (26)	Stucco (2)	
	Stamped net pattern (3)		

Angkor	Angkor	238	Appliqué band(s) (25) Appliqué band(s) and incised leaf pattern (1) Appliqué band(s) and incised waves (1) Appliqué band(s) and incised zig zag (2) Appliqué band(s) and internal ribbing (1) Appliqué band(s), incised zig zag, and red-painted ware (1) Appliqué central cordon (2) Appliqué lines (21) Appliqué lines and incised net pattern (7) Appliqué lines and incised parallel lines (2) Appliqué lines and incised wave design (7) Appliqué lines and incised zig zag (2) Appliqué lines, circle, and triangle (1)	Bottle (2) Box-and-cover (8) B-T1 (2) Buddha statue (2) Carinated vessel (1) Dish (5) Dish-on-stand (2) Jar-and-cover (3) Kendi (1) Laterite blocks (39) Lenticular pot (3) Lotus statue (1) Pedestal bowl (2) Small jar (11) Unknown (128) V-T10 (5) V-T11 (2) V-T9 (21)	Wheel-made (28) Stand scars (2)	

Note. This does not include artefacts recovered from Ban Tamyae, which are described in Welch, 1985. Complete artefact database is available upon request.


IFRAO 10 cm
IFRAO 10 cm
IFRAO 10 cm
IFRAO 10 cm
IFRAO 10 cm
IFRAO 10 cm

Figure 47. Stone tool assemblage, including adze, flakes, whetstones, grinding stones, and carved sandstone found during pedestrian survey: a-b at the southern edge of site 44, near the outer moats of Noen U-Loke (survey area C); c-e between two late Holocene rivers (survey area B); f-k isolated stone tools.

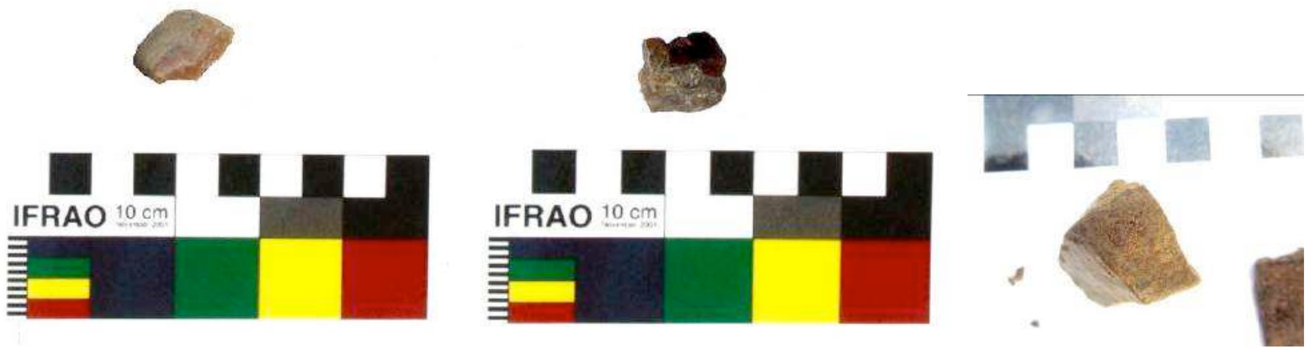

Figure 48. Examples of rough siliceous stone (likely carnelian) found during pedestrian survey at site 43.