SETTLEMENT, AGRICULTURE AND POPULATION CHANGES IN THE PHIMAI REGION, THAILAND

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INTRODUCTION

Seven years ago at the IPPA conference in Dunedin, Welch (1984) presented an analysis of settlement patterns in the Phimai Region of northeast Thailand. He concluded that there was a long term continuity in settlement location which reflected two factors in site selection: proximity to land suitable for growing wet rice and relative security from river flooding. This earlier study was based largely upon the interpretation of aerial photographs of a 1600 km^2 area, within which 334 potential archaeological sites had been identified. Survey conducted in 1979-80 during the first phase of the Khorat Basin Archaeological Project (KBAP I) had been restricted to a 300 km^2 area around Phimai, with actual field survey of only 26 sites. With the limited amount of field survey it was impossible to evaluate fully changes in site location over time or to assess our ability to interpret the aerial photographs correctly.

In 1989 the Khorat Basin Archaeological Project conducted additional field survey in the Phimai region (KBAP II). Certain questions guided the conduct of the research; in particular, we were concerned with examining the variability in site size, site density, patterns of distribution and periods of occupation of sites among each of the major regional environmental zones. The pattern of variability in turn was expected to provide a basis for inferring patterns of agricultural, demographic, economic and political change from the period of initial occupation until the present. During KBAP II the authors conducted limited low intensity survey of three sample areas, totaling 700 km^2, recorded 107 sites and collected surface data from which inferences regarding the age of habitation could be made.

This paper presents a re-interpretation of settlement patterns in the Phimai region based on this new information. The analysis presented here, completed only six months after departing the field, is preliminary. The previous paper treated the sites in a largely non-chronological framework, a treatment justified by the apparent long term continuity in site use. The present study, while not negating the basic underlying continuity found in

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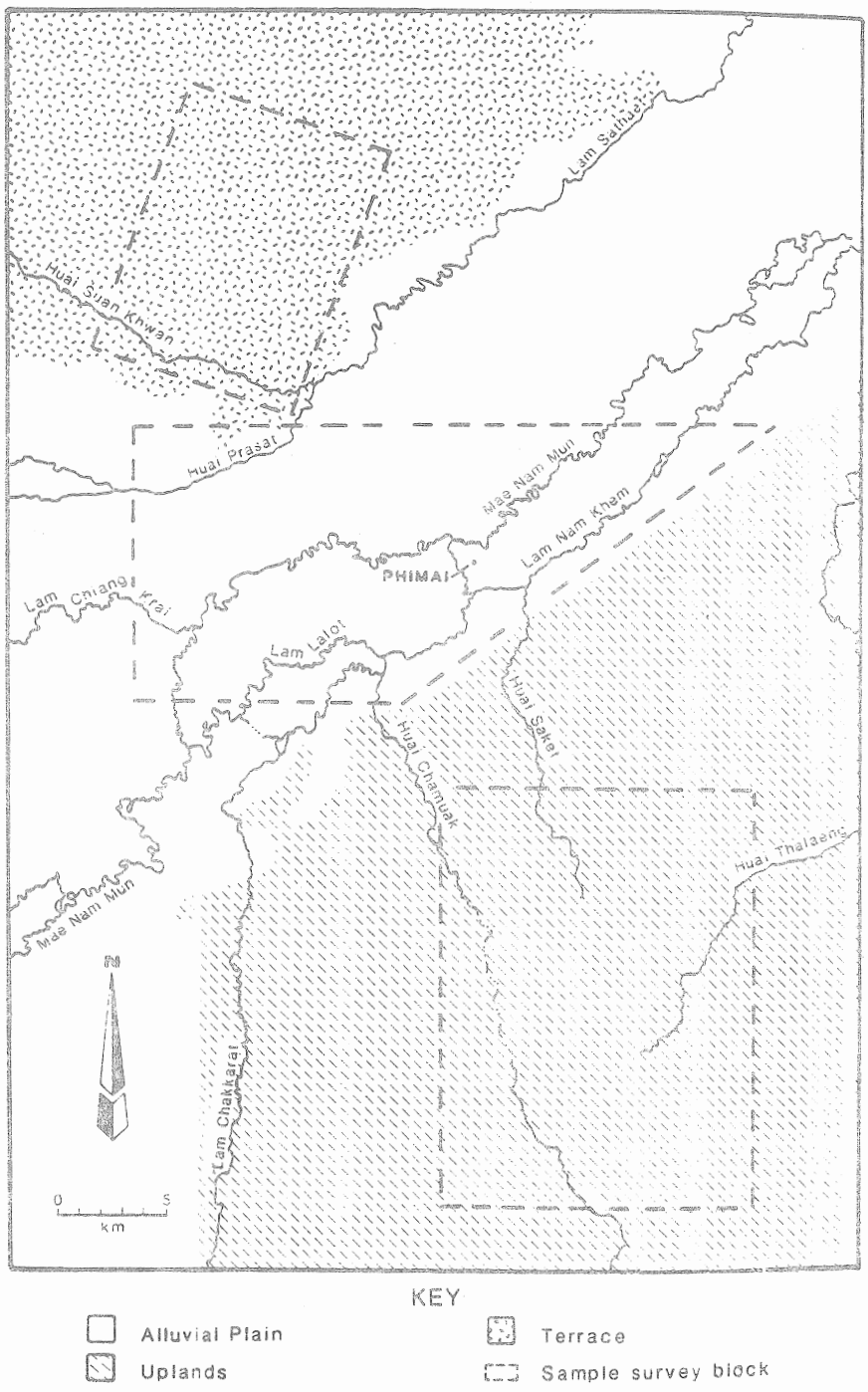

FIGURE 1: LOCATION OF PHIMAI REGION ENVIRONMENTAL ZONES AND SAMPLE BLOCKS

the earlier research, focuses instead on the changes in pattern between successive occupation phases since the apparent initial settlement of the Phimai region 3000 years ago. The changes in settlement pattern will be examined in terms of the ceramic phases previously defined for the Phimai region (Welch 1985, Welch and McNeill 1988-9).

THE SITE SAMPLE

The Phimai region has been divided into three major environmental zones (Fig. 1): the alluvial plain, the terrace zone and the uplands (Welch 1983, 1985). A large rectangular sample block of each environmental zone was selected for intensive survey. Potential archaeological sites (mounds, moated areas, canals, reservoirs, etc.) were identified from aerial photographs and surveyed either during the 1979-80 or 1989 fieldwork phase. Interviews with village headmen and elderly residents and limited pedestrian surveys resulted in discovery of additional sites. While these methods certainly do not guarantee full 100% coverage of the sample survey blocks, we would conclude that 80-90% of the habitation sites in each area have been visited and recorded. Flooding of the access to several sites in the alluvial plain, the difficulty of identifying upland sites on the photographs, and scheduling conflicts leading to cancellation of planned random transect survey prevented a higher level of coverage. Nevertheless, the survey resulted in some of the most complete coverage to date of any survey area in Mainland Southeast Asia.

As a result of the surveys, 58 sites were identified in the 270 km^2 alluvial plain sample block, 22 sites in the 130 km^2 terrace zone area, and 13 sites in the 300 km^2 upland survey block. These include 47 probable habitation sites in the alluvial plain, 22 in the terrace zone, and 11 in the uplands.

In addition, other sites outside the rectangular sample survey areas were surveyed. Sample transects radiating out in several directions from Phimai were surveyed to delimit the distribution of Phimai black pottery. Limited survey was also conducted of sites in the vicinity of salt dome outcrops. In total, 143 sites have been recorded during the two years of fieldwork.

Information from all sites has been entered into R:Base database files and statistical analyses conducted to determine site density, site area density, percentage frequency of sites by environmental zone, and site location relative to soil types for the sites in each environmental zone during each prehistoric and early historic occupation phase. Tables 1 and 2 present the results of these analyses.

Based on surface and subsurface archaeological evidence, sites have been dated to five phases of occupation: Tamyae (1000-600 BC), Prasat (600-200 BC), Classic Phimai (200 BC-AD 300), Muang Sema (AD 600-1000) and Lopburi (AD 1000-1300). No settlement pattern has been postulated for the Late Phimai phase (AD 300-600) because the differences between Classic Phimai and Late Phimai ceramics are not yet well enough established to assign sites confidently to the Late Phimai phase. Sites from which all Phimai tradition pottery appeared likely to date to the Late Phimai phase have not been counted in the Classic Phimai phase roster of sites.

Env. Zone	Total Sites #	Moated Sites #	Site Dens. #/km^2	Site Area ha	Area Dens. ha/km^2	Ave. Size ha	EPD #/km^2
			Tamyae Phase				
Alluvial Plain	3	3	.01	55	.20	18.4	10
			Prasat Phase				
Alluvial Plain	16	7	.06	185	.69	12.5	34
Terrace	4	0	.03	21	.16	5.3	8
Uplands	1	1	<.01	6	.02	6.0	1
			Phimai Phase				
Alluvial Plain	33	15	.12	396	1.47	10.8	73
Terrace	14	5	.11	72	.55	5.1	28
Uplands	6	6	.02	85	.28	14.1	14
			Muang Sema Phase				
Alluvial Plain	23	8	.09	224	.83	8.0	41
Terrace	7	3	.05	35	.27	4.9	13
Uplands	9	6	.03	99	.33	11.0	17
			Lopburi Phase				
Alluvial Plain	27	10	.10	251	.93	9.3	46
Terrace	12	5	.09	48	.37	4.0	18
Uplands	9	6	.03	89	.30	9.9	15

Site Area = Total Area of Habitation Sites
Area Dens. = Total Habitation Site Area/Sample Block Area
EPD: Estimated Population Density = (Site Area X 50)/Sample Block Area

TABLE 1: SIZE AND DENSITY OF HABITATION SITES IN PHIMAI REGION SAMPLE BLOCKS

SETTLEMENT PATTERN ANALYSIS

Tamyae Phase

Based on evidence collected to date, the initial occupation of the Phimai region dates to between 3000 and 2500 years BP. Evidence of this initial phase of settlement, the Tamyae phase, has been found at five sites, three in the sample survey blocks, all on the alluvial plain (Fig. 2). Four of the five sites are located alongside a river or stream. The

Soil Type	Portion	Tamyae	Prasat	Phimai	Sema	Lopburi
		Alluvial Plain				
Alluvial Complex	.18	-	2	3	-	1
Phimai	.41	1	2	9	8	8
Kula Ronghai	.27	2	11	16	15	17
Roi Et	.01	-	1	2	-	-
Renu/Khorat	<.01	-	-	2	-	1
		Terrace				
Roi Et	.26	-	1	3	3	1
Roi Et, saline	.23	-	2	9	4	10
Sung Noen	.04	-	1	1	-	-
Chatturat	.16	-	-	1	-	1
		Uplands				
Roi Et	.18	-	1	5	6	5
Satuk	.20	-	-	2	3	6

Portion = Portion of environmental zone covered by Soil Type

TABLE 2: NUMBER OF SITES BY SOIL TYPE

large size of these sites probably reflects their later growth and not their original Tamyae phase size.

No evidence of Tamyae phase settlement was found in the uplands or the terrace zone, even at the three sites excavated in these zones. However one major interpretive problem remains: the absence of Tamyae sherds on the surface. The only evidence of Tamyae phase occupation has been found in road or bank cuts or recovered during excavations. The actual number of Tamyae sites is probably much greater than indicated on the basis of surface survey; thus conclusions must remain tentative.

Prasat Phase

The number of sites known to date from the Prasat phase is much higher than from the Tamyae phase. Twenty-one sites definitely or probably were occupied; all Tamyae phase sites continued to be inhabited (Fig. 3). There may be more sites; but several pottery types continued in use during the succeeding Classic Phimai phase, making phase assignment less than easy.

The majority of Prasat phase sites are located on the alluvial plain. The preferred location for the new settlements was upon Kula Ronghai soils, sandy loams located on recent alluvial terraces. These are mostly found on the alluvial plain flanked by Phimai

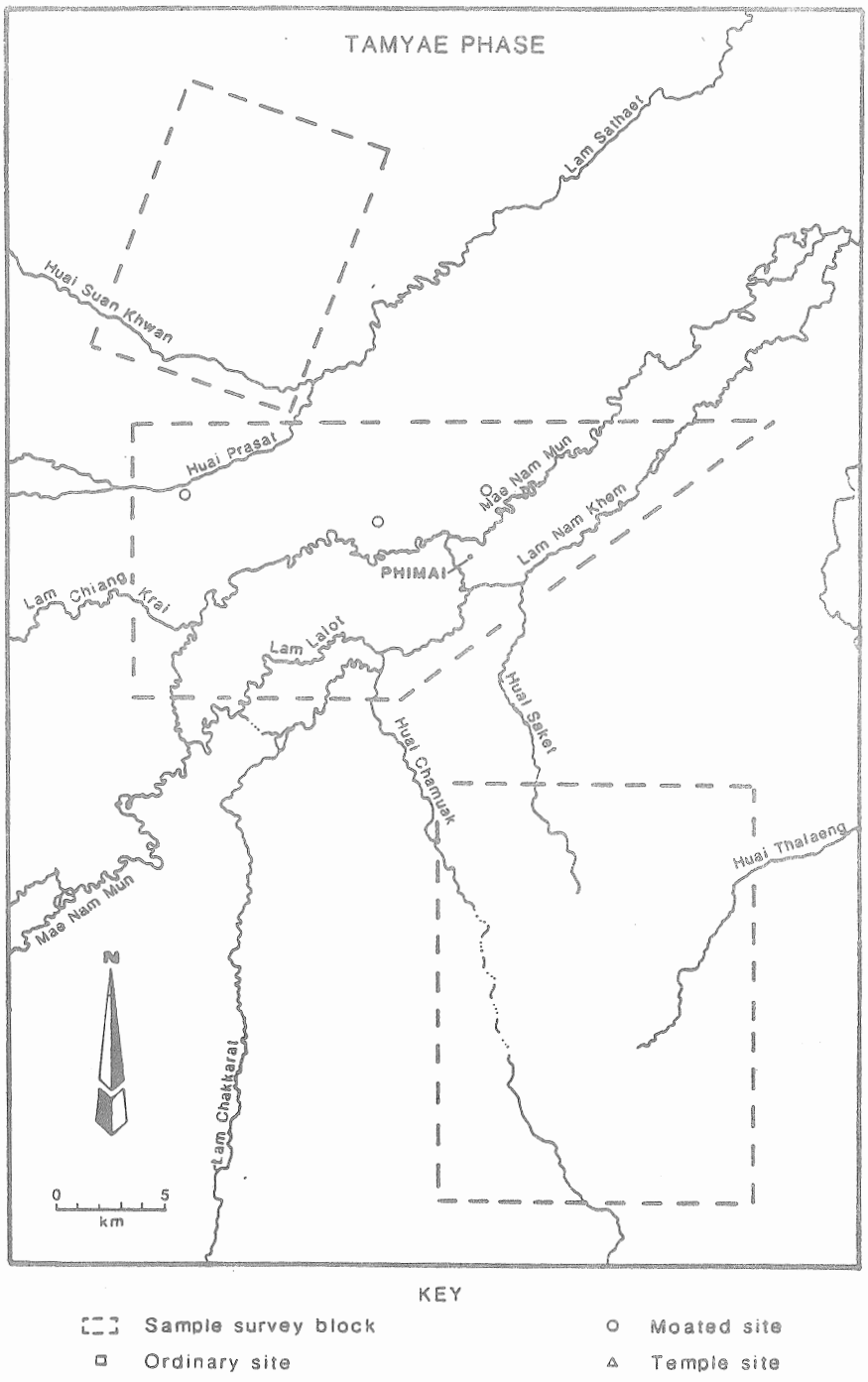

FIGURE 2: TAMYAE PHASE SITE LOCATIONS

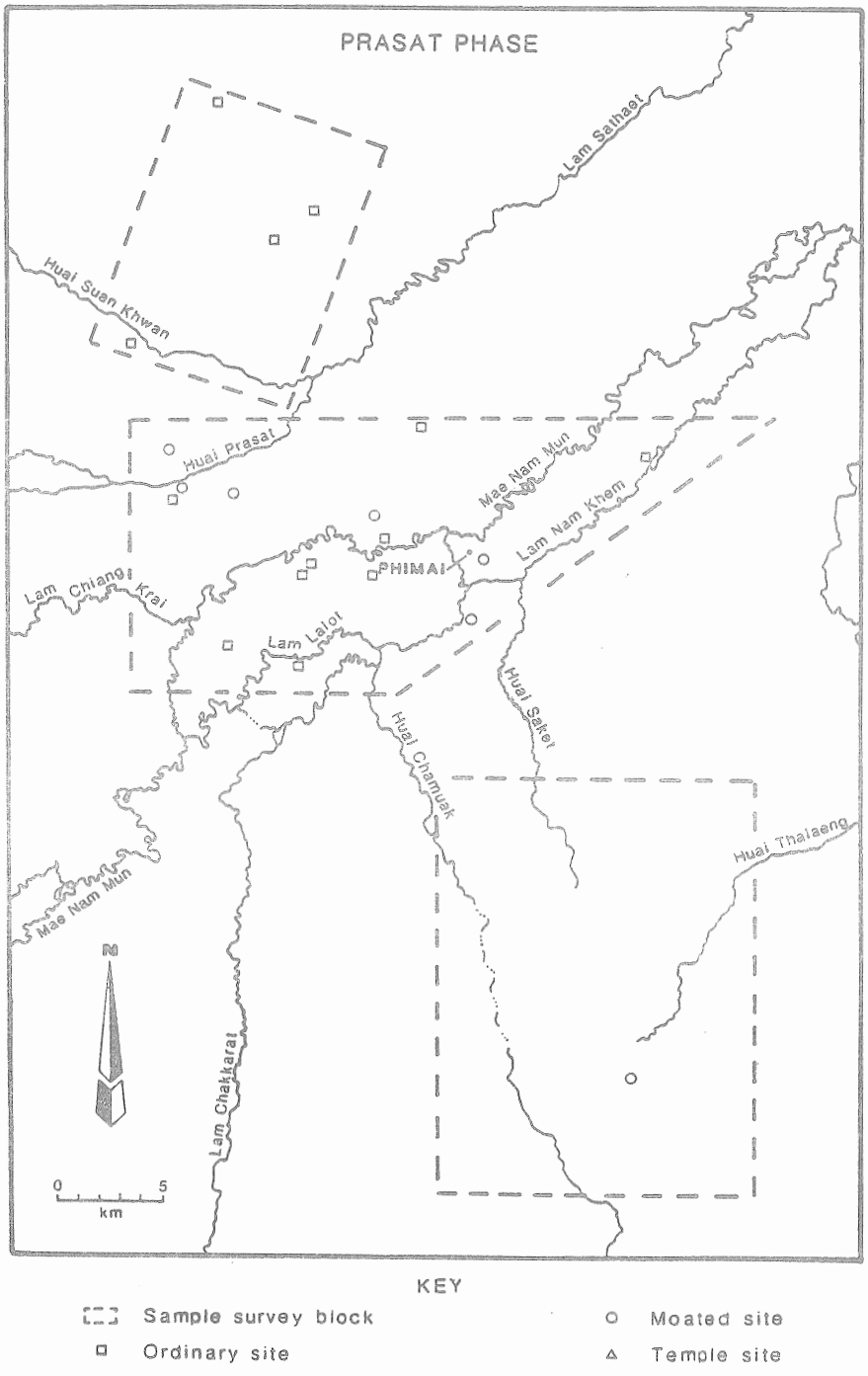

FIGURE 3: PRASAT PHASE SITE LOCATIONS

clay soils, the soils best suited for wet rice agriculture on the Khorat Plateau. The Kula Ronghai soils are only moderately well suited for wet rice but their slightly higher location, giving some security from flooding, made them more favorable sites for habitation than the low lying Phimai soils.

The earliest evidence for settlement in the terrace zone (four sites) and in the uplands (one site) dates to the Prasat phase. These sites are located on low alluvial terraces. Soils surrounding them are variants of Roi Et soils, sandy loams which are generally moderately well suited to wet rice agriculture. However some of these are Roi Et saline phase soils which require special techniques to overcome the serious problems caused by high soil salinity.

Classic Phimai Phase

The distinctive streak burnished rice tempered Phimai black pottery of the Classic Phimai phase is a widespread, common and non-ambiguous horizon marker, making sites of Classic Phimai phase easily recognizable. As a result the sample is both large and one in which we can place a good deal of confidence (Fig. 4).

On the alluvial plain the number and density of sites grew substantially during this phase; it is also likely, though not demonstrable, that many smaller Prasat phase settlements expanded in size. Well over half the sites are greater than 10 ha, with an average site size of 11 ha; site density is 1.2 sites/10 km^2. Approximately half these sites are completely or partially surrounded by moats. Sites are most commonly located on recent terrace Kula Ronghai soils. The number of sites on the Phimai floodplain soils is substantially less, especially as a proportion of the land area actually covered by Phimai soils.

There was also a considerable increase in the number of sites (14) in the terrace zone. The site density is similar to that on the alluvial plain (1.1 sites/10 km^2) but the average site size is much smaller, suggesting a lower population density in this zone. Most terrace zone sites cover only one to five hectares; most of the larger sites are moated. The majority are located on and surrounded by Roi Et saline phase soils, the most common soil type in the survey block.

The number of upland sites also increases; all six sites are moated. The average size is greater than in other zones but the density is much lower (0.2 sites/10 km^2), reflecting the limited distribution of soils suitable for growing rice. Upland sites are most commonly located on Roi Et, or Roi Et loamy, soils in low valleys drained by intermittent streams between the wooded high terrace hills. A few are located on Satuk soils on the hillsides adjacent to Roi Et soils.

Muang Sema Phase

The Muang Sema phase corresponds with the first part of the early historic period in northeast Thailand. Sculptures in the Dvaravati art style and inscriptions found at a few northeast Thailand sites indicate the beginning of Indian influence.

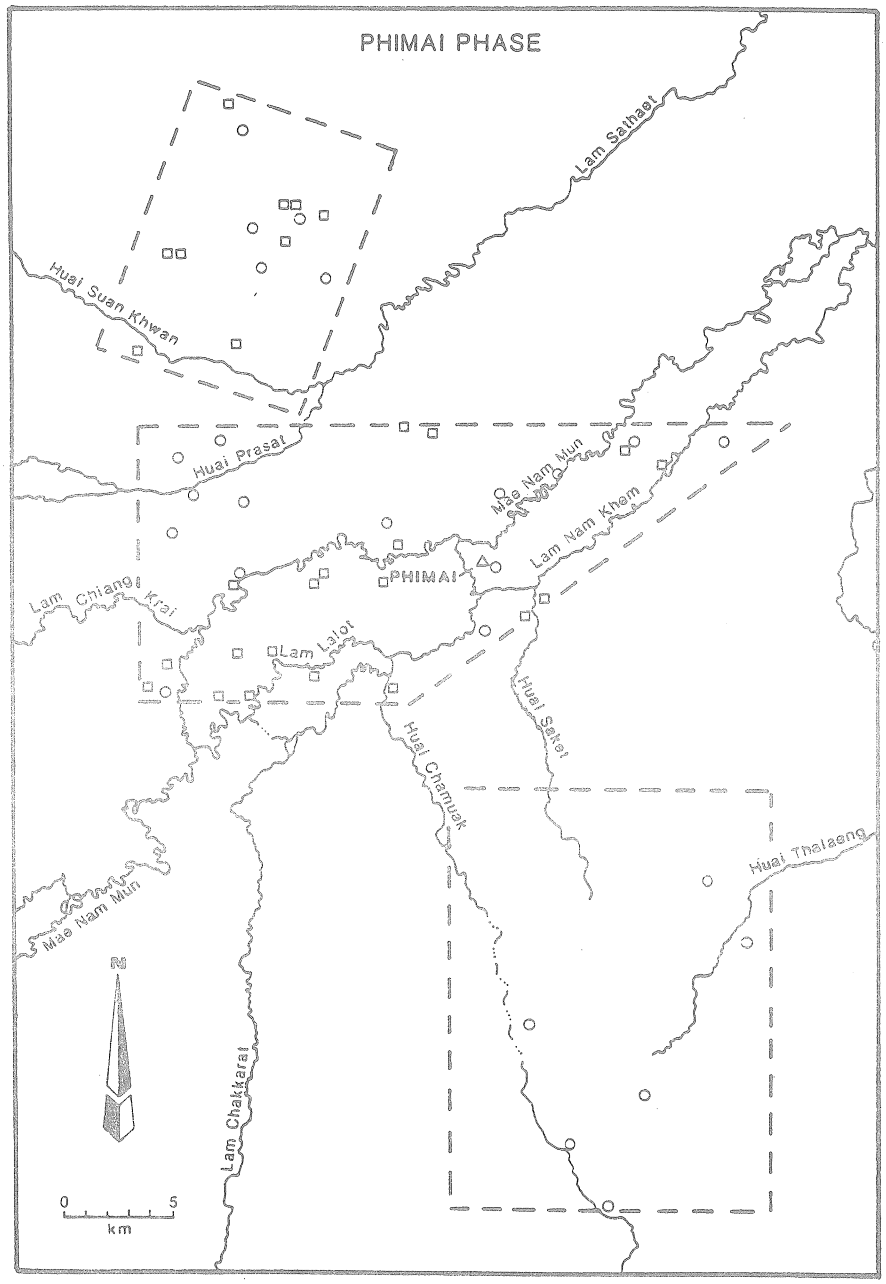

FIGURE 4: CLASSIC PHIMAI PHASE SITE LOCATIONS

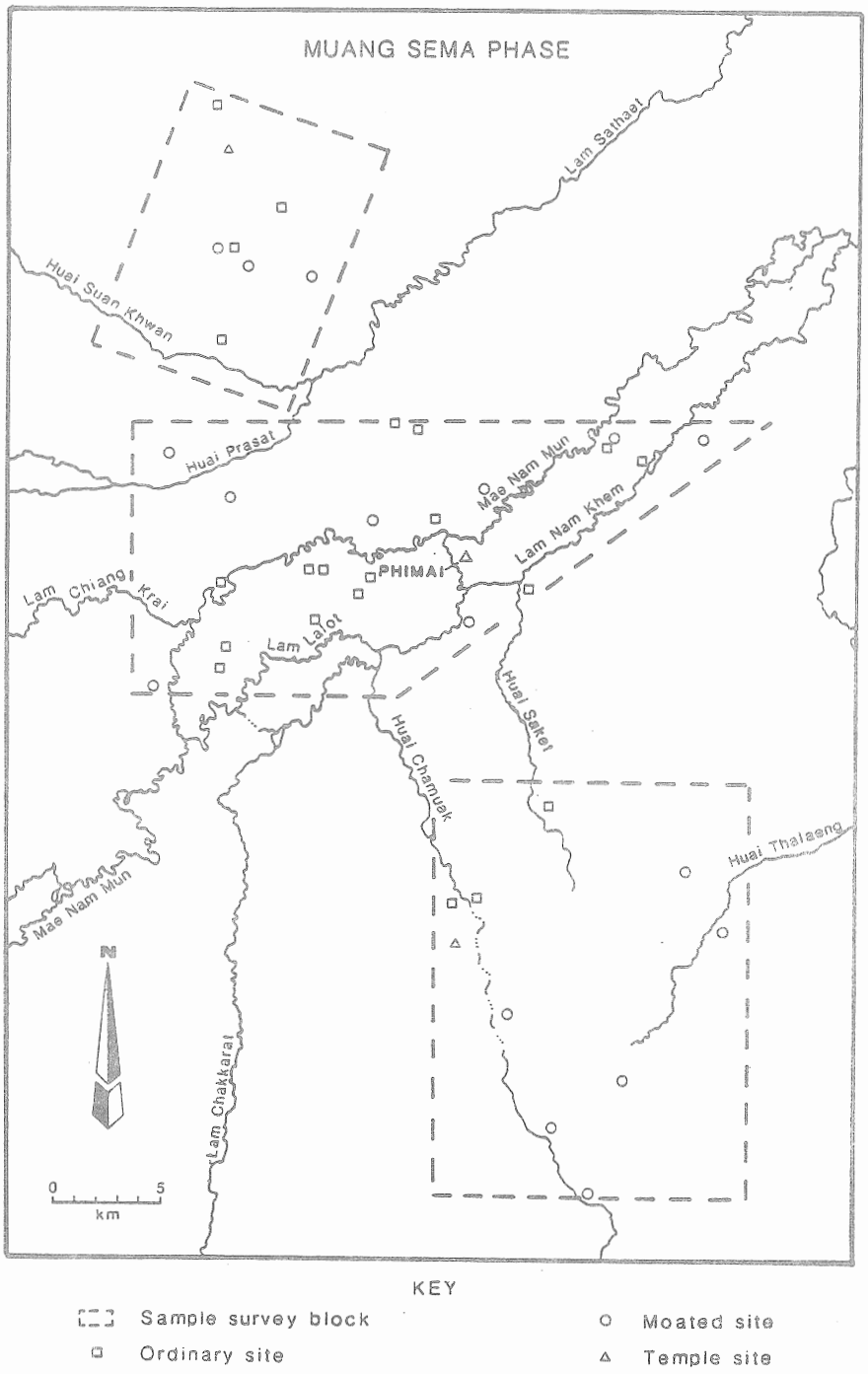

FIGURE 5: MUANG SEMA PHASE SITE LOCATIONS

The number of habitation sites in the uplands increased slightly from the number occupied during the Classic Phimai phase (Fig. 5). All the moated sites continued to be occupied. However in the alluvial plain and terrace zones there is a marked decrease in the number of sites, particularly the number of moated sites. Many large sites, both moated and unmoated, appear to have been abandoned. On average, sites are smaller in size. There are elements of continuity: many Classic Phimai sites continued to be occupied and the general pattern of site distribution in relation to soil types was little changed, with Kula Ronghai and Roi Et soils remaining the preferred settlement locations.

Lopburi Phase

The number of habitation sites occupied in the terrace zone and on the alluvial plain increased slightly during the Lopburi phase (Fig. 6). There was a major increase in the number of ceremonial sites and reservoirs, especially in the vicinity of the two major temple complexes at Phimai and Phanom Wan. In the uplands several habitation sites were abandoned before the beginning of the Lopburi phase. A few new sites were established, including several temple sites, with possible new communities located in their vicinity. A number of new sites were established in the salt dome portions of the terrace zone; some for habitation, some primarily salt and iron ore mining sites, some perhaps combining both functions.

The Lopburi phase is marked by the appearance of four new site types, all rectangular. Reservoirs are frequently difficult to date precisely but are generally associated with Lopburi phase remains. Walled temple compounds contain one or several structures in Khmer style enclosed within a rectangular wall of laterite or brick. Rectangular walled towns are large settlements surrounded by laterite or brick walls, of which Phimai is the only example in the survey area.

The most intriguing site type has not really been described before, although some of the sites within this type have been noted previously. These sites consist of a large rectangular area enclosed within earth walls. The interior areas are low lying, currently in rice fields, contain no surface evidence of occupation, and would have been unfavorable as habitation sites. All contain a mound of some sort within the walled area. All are located in proximity to Khmer temples but none enclose these temples. NR-A-30, formerly described as a large reservoir (Welch 1983, 1985), is located south of Phimai; a second site is located near Prasat Phanom Wan; a third near Prasat Sida includes a large Classic Phimai phase moated habitation mound within its walls, in addition to several canals radiating from the mound; the last surrounds the moated site of Ban Phlap Phla, about 3 km south of Prasat Ku Sila Khan, a rest house on the Phimai-Angkor road. One possible interpretation of these sites is that they served as structured gardens with ponds and circulating water, similar to gardens frequently associated historically in Java with temples and elite class compounds (Dumarçay 1982).

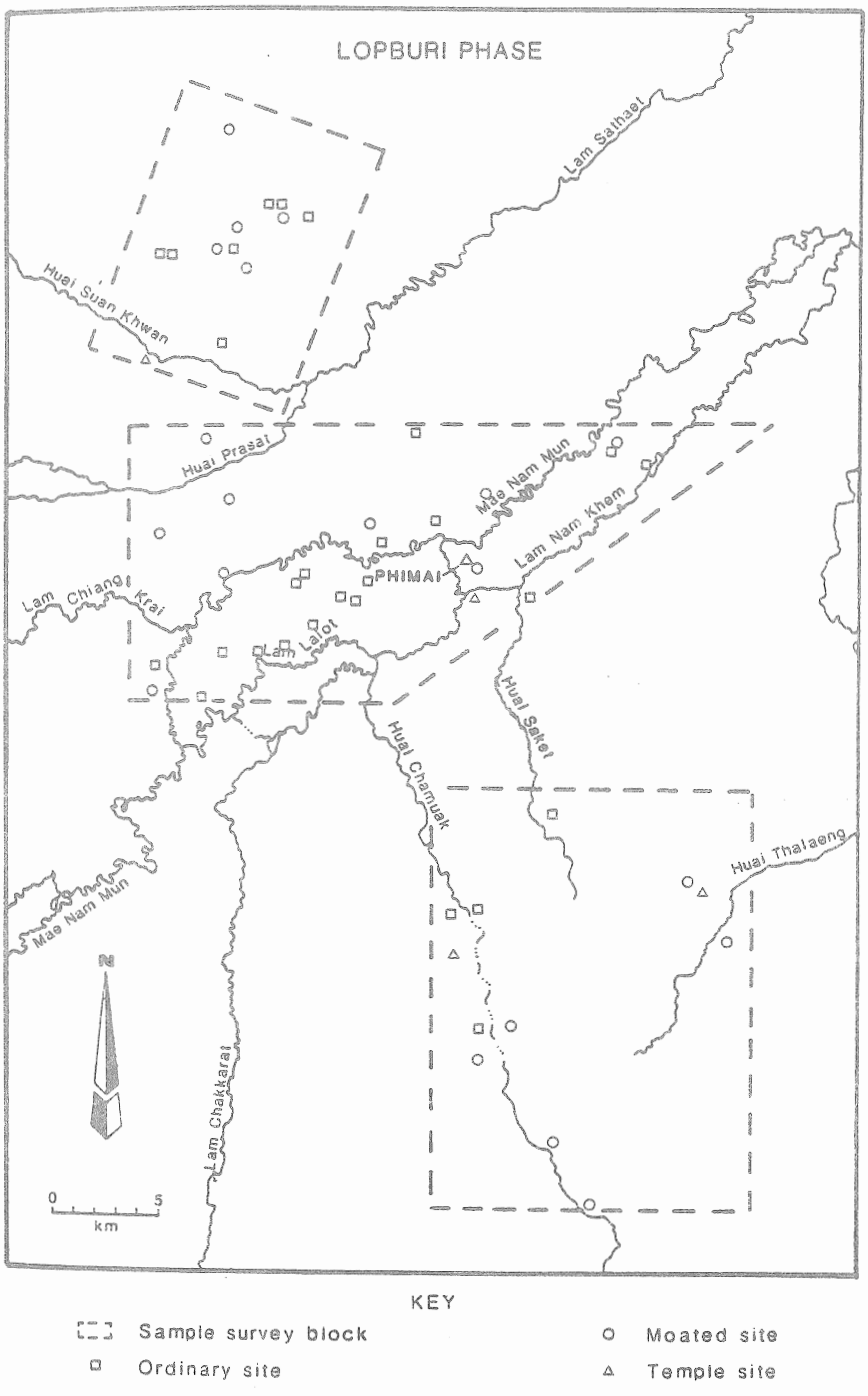

FIGURE 6: LOPBURI PHASE SITE DISTRIBUTIONS

Modern Phase

A brief look at settlement patterns in the last two centuries is of interest for what it reveals about determinants of settlement patterns in the Phimai region. Evidence comes from two sources: informant interviews and accounts of early travellers in northeast Thailand.

During interviews villagers related one of two general types of history. In one set of villages residents were unable to report any oral traditions of their ancestors immigrating to the village. They could trace ancestry back 200 or even 300 years at their present village. In some cases the village appeared in a legend whose events were supposed to have occurred at the time of the Phimai temple. The oral traditions support the archaeological evidence that these villages have been continually occupied for a long period of time. Most of these villages are located on the alluvial plain, although a few upland and terrace zone villages with easy access to Roi Et soils also have been occupied for at least the past 300 years.

On the other hand, in most upland and terrace zone villages, with access only to poor quality rice soils, residents were able to relate stories of migration to and settlement in that particular village. Elderly villagers, for example, might report that only two or three families lived there when they were children, that their fathers or grandfathers were among the first occupants, or that they themselves were the original settlers perhaps forty or fifty years ago.

Thus, during the nineteenth century settlements were apparently concentrated near the most favorable agricultural lands, a pattern confirmed by the accounts of early writers such as Aymonier (1895, 1897) in the 1880s, Lunet de Lajonquière (1907) in the 1890s and Prince Damrong (1969) in 1912. With the introduction of modern medicine and the rapid population growth of the twentieth century settlers began occupying sites with poorer agricultural potential. While these were sometimes new village locations, frequently people were resettling sites that had been occupied during times of peak population in the late prehistoric and early historic periods. For example, after a 1000 year period of abandonment, the upland prehistoric site of Muang Phet was resettled in 1922 by workers who constructed portions of the Khorat-Ubon Railroad.

INTERPRETATIVE DISCUSSION

Our purpose in this interpretative section is to propose a scenario of prehistoric and historic change in the Phimai region based on the settlement pattern analyses summarized above. Within this scenario we will hypothesize what we believe may be the relationships among certain critical and mutually dependent variables: population growth, intensification of the agricultural system, and centralization.

The KBAP surveys failed to uncover evidence of settlement of the Phimai region prior to the Tamyae phase. If human settlement occurred earlier it apparently involved lower population densities and a very different pattern of settlement organization from that practiced later. Earlier groups may have lived in dispersed, non-permanent household or

small kin group communities which have left little in the form of an enduring archaeological record.

The Tamyae phase evidence suggests initial settlement by pioneer groups of colonists who selected prime locations for practicing wet rice agriculture. Although we lack direct evidence, this seems the most likely explanation of their settlement choices. In this early phase of settlement, methods of agriculture were probably not intensive, perhaps involving wet swiddening, broadcasting, and planting of floating flood rice.

The beginning of the Prasat phase is marked by several important technological changes: the development of a new tradition of pottery making, the Phimai tradition; the initial use of iron; perhaps early mining of salt; construction of moats and walls around sites; and, most importantly perhaps, agricultural intensification including plowing, transplanting and use of simple forms of water control. Population increased: the majority of new sites are located on the alluvial plain, but a few are in the terrace zone and one is in an upland stream basin.

Rice agriculture in the higher environmental zones posed new problems not encountered on the alluvial plain. Soils are more loamy, better drained than floodplain soils and frequently saline. Unless the climatic regime was quite different from that of today, droughts were frequent and would have had a significant adverse effect on rice productivity. The effects of droughts are more severe in the higher environmental zones. In addition, many of the terrace soils are highly saline, requiring the development of salt tolerant varieties of rice and the maintenance of sufficient water in the rice fields to balance the soil pH. Cultivation of floating flood rice or dependence on river flooding was not an alternative for farmers in these zones. Under these conditions, successful cultivation of wet rice requires the implementation of effective strategies for water control: e.g. water storage, digging of canals, building bunds around fields or transplanting rice.

The beginning of settlement on the older alluvial terraces was made possible by the adoption of intensive wet rice agriculture; what remains to be discussed are the reasons for its adoption. Population densities[1] on the alluvial plain during the Prasat phase almost certainly reached 30 to 40 persons/km^2 and may have reached as high as 50. With moderate yields, flooded field farming could support a population of 75 to 125 persons/km^2. Intensification would not have been necessary to support the population on the alluvial plain; nor would population pressure have impelled expansion into the terrace and upland zones. We hypothesize rather that more intensive forms of rice production were adopted in response to the unpredictabilities of the climatic regime. Transplanting and water control decreased the risks of losing a crop to drought or flooding (Welch 1985: 388). Intensive agriculture in turn made possible settlement of the higher environmental zones, an expansion that may have been encouraged by the attraction of the salt, timber and iron ore resources that these zones contained.

The settlement trends apparent in the Prasat phase persist in the Classic Phimai phase. Population continued to increase; we have identified 78 Classic Phimai phase habitation sites. New settlements were established, some on the alluvial plain near the earlier

settlements and others farther away in previously unoccupied areas, especially in the terrace and upland zones. The number, density and size of sites increased in all three environmental zones. We estimate that a population density of 70 to 80 persons/km^2 was reached on the alluvial plain and about 30 persons/km^2 in the terrace zone during this period.

This estimate assumes that 80 to 90 percent of the known sites were occupied contemporaneously and that site areas were fully occupied. These assumptions are supported by the presence of *in situ* Classic Phimai phase cultural remains in thick deposits over wide areas of many sites, including the largest sites. Over 50% of the Classic Phimai phase sites were moated, surrounded by walls and/or ditches which established fixed boundaries marking the edge of the sites. We argue that in most cases these mounds are not natural, but rather are the result of human activity. As such, the area enclosed would have been the occupied habitation area; and, for the time of moating, site size should correspond well with the population.

This continued population growth may in part be related to increased labor demands of a more intensive system based on plowing and transplanting (Athens 1977; Welch 1985: 389). Higher reproductive rates would have been one method of increasing the labor supply. In turn, concentration of population into large settlements of up to 2,000 people during the Classic Phimai phase probably encouraged further intensification to produce sufficient yields in fields near the sites and reduce the distance from villages to the most distant fields.

Our scenario of expansion accords well with that proposed by Elizabeth Moore (1988). Moore was concerned with the pattern of distribution only of moated sites in the Mun River basin, but the general settlement pattern was apparently similar. She proposed that the earliest moated sites were established on the Phimai alluvial plain; from here construction of this type of site spread into the terrace zone and uplands. Expansion into the new zones was due to the attraction of their salt, iron and timber resources. Moore dates the movement from about 500 BC; that is, from the Prasat phase, when iron tools first began to be used and probably manufactured in the Mun River valley. Her proposed development sequence is based on changes in the characteristics of the moats and walls and her dating in part on the results of the KBAP I chronology.

We have no argument with her suggestion that exploitation of salt and iron was a factor drawing people to settle the terrace and upland zones in the late first millennium BC. Additional factors that we might suggest include the advantage of diversifying production to counteract climatic unpredictability, as well as social and political factors favoring dispersal of population.

On the other hand, features of our scenario, particularly the timing, contrast sharply with the developmental sequence for Mainland Southeast Asia presented by van Liere (1989). Van Liere proposes that a sudden and revolutionary change occurred early in the first millennium AD with the abandonment of prehistoric sites and the concentration of population into large moated settlements, which he calls agro-cities. He concludes that

most of these settlements occur on the peripheries of floodplains where the flood regime is gentle.

Our Phimai region data suggest that there was no sudden change of settlement locations, but rather a gradual and continual growth and expansion from the initial Tamyae phase settlements. All five Tamyae phase settlements developed into moated sites. The earliest prehistoric sites were not replaced, but became part of a new settlement pattern incorporating large numbers of new sites. In the Phimai region and, as Moore has shown, throughout the Mun River valley, moated sites are found, not just on the edge of floodplains but in a variety of environmental settings.

Van Liere's generalization about the location of the "agro-cities" is crucial to his inferences concerning the agricultural regime practiced by the inhabitants of these moated sites. He concludes that they were flooded field farmers whose "impact on the environment must have been insignificant" (van Liere 1989: 149). While our data show that sites in the terrace and upland zones were occupied before the end of the last millennium BC, van Liere (1980) places movement into the higher environmental zones as late as the eighth century AD. He relates this movement to initial diking of fields, plowing and transplanting, and to the establishment of Khmer control, and sees an abandonment of the moated sites, except as ceremonial centers, with this movement to terrace zone villages.

We infer a very different developmental sequence from the distribution of Prasat and Classic Phimai phase sites. During the late first millennium BC settlements were established in areas where regular gentle flooding could not be expected from year to year. As we have argued above, successful rice farming in the upland and terrace zones required intensification, especially water control. Late prehistoric period farmers were in fact significantly transforming the natural environment of the Khorat Plateau, as large sections of the floodplain and low terraces were brought under cultivation and transformed from wild grassland to a landscape of bunded rice fields. Higher areas were less affected. However, the exploitation of salt, iron bearing laterite and fuel wood must have had adverse effects on the forest.

Later settlement changes in the early historic period might have been related less to population growth and agricultural development than to changes in economic and political organization. Population density on the alluvial plain and in the terrace zone appears to have decreased between the Classic Phimai and Muang Sema phases, although the reason for this is uncertain. Many large sites were abandoned and at those which continued to be occupied we find fewer remains dating to the Muang Sema phase than to the Classic Phimai phase. The population may have dispersed into smaller size villages, a transformation perhaps related to a lessening of the need for concentration for defense. During the Lopburi phase this general pattern of more dispersed settlement in small villages continued, but a few large population centers, most notably Phimai, developed around major Khmer ceremonial centers.

During the Lopburi phase, settlements were established in peripheral areas of the upland and terrace zones which had not been previously occupied. Communities were

established on lateritic salt dome outcrops which appear to have been commercially exploited for salt and iron. Other settlements were established along major trade routes. Khmer temples were frequently constructed at these new sites, reflecting the role of Khmer social organization in effecting settlement and economic change. Archaeological remains of Khmer temples on the floodplain are rare, restricted to two very large sites, Phimai and Phanom Wan. Most of the smaller temples are located in peripheral areas and are probably associated with Khmer efforts to develop these areas. The temples became the centers for gathering manpower and accumulating capital, which could then be used to bring formerly unproductive lands into production (Hall 1985).

Thus, Khmer production systems represent a restructuring of the late prehistoric systems. Late prehistoric economies had centered around numerous large moated sites which may have been politically and economically independent. Khmer production centered around temples which organized the productive potential of surrounding regions and which were organized into a hierarchical system of relationships with Phimai and ultimately Angkor at the center. This change in organization is reflected in the changing patterns of settlement location, population dispersal and concentration, and site size distribution that characterized the Phimai region.

CONCLUSIONS

Changes in settlement over time in the Phimai region reflect changes in population, agriculture, and organization from the late prehistoric period to the present. Population grew rapidly from initial settlement early in the first millennium BC through the Classic Phimai phase, when the density may have reached 70 to 80 persons/km^2 on the Phimai alluvial plain.

The pattern of settlement through all phases reflects the basic dependence of Phimai region settlements on wet rice agriculture. Settlements were first established on the alluvial plain during the Tamyae phase in locations with access to abundant suitable land for wet rice. The highest site density through all phases is found on the alluvial plain, the zone with the best and most abundant rice soils, and the sites with access to the best rice soils were occupied most consistently through time.

Intensive forms of agriculture were adopted during the Prasat phase, between about 600 and 200 BC, perhaps as an adaptive response to the uncertainty of the climatic regime. Intensification made possible the expansion of settlement from the alluvial plain to the terrace and upland zones. Settlement in these zones during the Prasat and Classic Phimai phases required the development of plowing, transplanting, and water control through bunding and perhaps simple irrigation.

During the late prehistoric period, portions of the population lived in large, frequently moated, settlements which may have been competing economic, political and religious centers. Phimai emerged as the regional center and later grew in importance into a major Khmer administrative and religious center. During the early historic period Phimai dominated a settlement pattern largely comprised of small and medium size villages. The

Khmer temples, both large temples such as Phimai and smaller temples, became new foci of settlement and networks of production and exchange.

This paper reiterates many earlier interpretations (Welch 1984, 1985) but adds the element of variation over time, providing evidence of the evolution Phimai region societies were undergoing, evidence that was lacking in the former more static analysis. Our data base should allow further testing of hypotheses concerning the relationships of population growth, agricultural intensification, and centralization in Mainland Southeast Asia.

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NOTE

[1] Estimating prehistoric populations is difficult and likely to be highly inaccurate. The assumptions underlying our estimates and the methods of calculation have been presented in some detail in Welch's dissertation (1985: 322-325). Briefly, our population density estimates assume that approximately 50 people were living on each hectare of each habitation site. This estimate is based upon present village population densities and assumes that spatial needs of prehistoric villagers would have been similar to those today, i.e. sufficient space per family to plant gardens, store tools and grain, thresh grain and raise domestic animals, including maintenance of a water buffalo or a pair of cattle. Denser concentrations limit the space for these activities, much lower concentrations would reduce areas near the houses which could be used for productive rice farming.

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