Modeling the Development of Early Rice Agriculture: Ethnoecological Perspectives from Northeast Thailand

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THE EMERGENCE OF RICE AGRICULTURE is a significant and enduring research topic among scholars of many disciplines working in Asia (e.g., Bellwood et al. 1992; Oka 1988). Although during the past two decades advances have been made in both biological and archaeological lines of inquiry, "the one problem on which no headway has been made in recent years is whether or not long [g]rained rice was taken into cultivation as a wet land or dry land crop" (Maloney 1991 : 124). Whether rice was initially developed as a wet or a dry crop has further implications concerning the development of the two major cropping regimes in Southeast Asia (Hutterer 1983 : 184), which in turn have implications for patterns of sociocultural development. Inundated rice is generally grown in permanent fields and is associated with settled villages, and upland ("dry" land) rice is usually associated with swidden fields and some degree of settlement mobility.

The nature of the environment manipulated by early rice cultivators is one of the key questions in resolving this issue. Although various environments have been suggested, including the humid tropics (Hutterer 1983), coastal tracts of mangrove-estuary (Higham and Maloney 1989 : 658), and hilly uplands (e.g., Siam Society 1989 : 190), the strongest evidence points to lowland subtropical contexts (Bellwood 1985 : 208). At the present stage of research, however, empirical data are sparse and open to conflicting interpretations. For even a single region we lack the archaeobotanical, palynological, archaeological, and settlement pattern data to reconstruct an early cultivating system comprehensively. And for some questions (e.g., differentiating wet and dry rice macrofossils or pollen) we lack the methodology. Hence we remain in a speculative, model-building, and testing stage of research.

This discussion will develop a model for early rice cultivation as initially focusing on seasonally inundated habitats in subtropical zones and propose how both major rice-cropping regimes might have evolved from this common beginning. It is furthermore proposed that slash-and-burn cultivation developed as a parallel cropping strategy to inundated rice cultivation, and that "dry" rice was incorpor-

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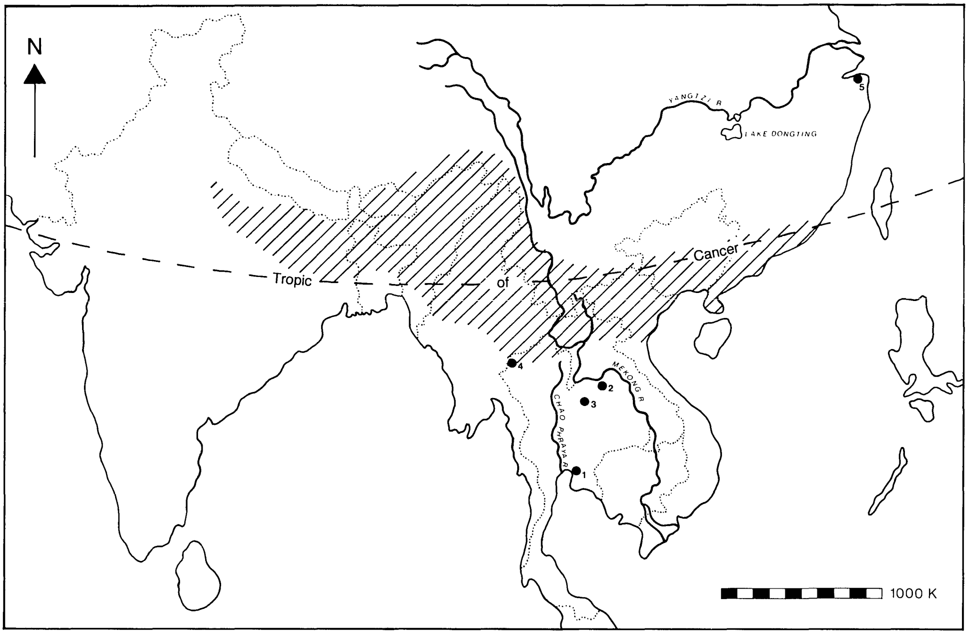


Fig. 1. Some key sites relevant to the discussion of early agriculture in Southeast Asia: Khok Phanom Di (1), Ban Chiang (2), Non Nok Tha (3), Spirit Cave (4), and Hemudu (5). The shaded area is the zone where Chang (1976) proposed that cultivated rice might have originated.

ated into a preexisting swiddening system. The model is based on the assumption that initial steps toward manipulating and then domesticating any particular species must take place within the habitat to which the wild progenitor is adapted. The perspectives offered derive largely from the author's ethnoecological research from October 1979 to May 1981 in northeast Thailand (White 1982*a*, 1982*b*, 1984, 1989), an area with early (Fig. 1) although not the earliest evidence for rice agriculture (Bellwood et al. 1992).[1] Northeast Thailand has four qualities to support using it as a location for model building for early rice cultivation: (1) evidence of a prehistoric early rice-cultivating society; (2) modern-day rice cultivators; (3) a subtropical climatic regime that is largely continuous between the prehistoric and present periods; and (4) extant stands of wild annual and perennial rice. Although the discussion will be most directly applicable to reconstructing early agriculture in the Ban Chiang region of northeast Thailand, a hypothetical model for the development of early rice agriculture in general is also offered.

In this discussion, "early rice cultivation" will refer to systems of cultivating rice prior to the use of water buffalo and plows. In northeast Thailand this time period would fall generally before 1000 B.C.[2] and would encompass Bayard's (1984*a*) General Period A, pre-metal agricultural communities, and General Period B, bronze-using agricultural communities. The village life-style of the settlers (e.g., pile-built dwellings, pottery, cemeteries), and dates substantially after well-established rice cultivation in southern China, imply that rice was probably cultivated (as opposed to gathered) by the initial settlers. In the absence of direct or indirect evidence of the use of water buffalo or plows in Thailand until after

1000 B.C. and considering the possibly primitive character of the rice exploited (Yen 1982), it seems likely that rice was only one component of a broad-based subsistence strategy and was grown initially by means of extensive rather than intensive cultivation systems. Although the northeast Thailand early cultivation system has sometimes been assumed to be dryland swidden (Higham and Kijngam 1979; Bayard 1980: 105) or wetland swidden (Bayard 1984*b*: 114; Gorman and Charoenwongsa 1978), I will argue that these early extensive systems employed inundated "permanent" plots. To develop this argument, a discussion of the climate, environment, and early settlement of northeast Thailand is a necessary first step.

THE ENVIRONMENT OF NORTHEAST THAILAND

The topography of northeast Thailand is principally comprised of an undulating to rolling peneplain, called the Khorat Plateau, lying between 250 and 130 m above sea level. The southern portion, or Khorat Basin, is drained by the Mun and Chi rivers, two major tributaries of the Mekong River (Fig. 2). These major rivers run in deeply incised channels with relatively few tributaries. Except for brief periods at the height of the rainy season, the water level in the major rivers lies 10 to 20 m below the level of the rice fields, a fact that has limited their potential for irrigation using traditional technology (Ng 1978: 38). To the north

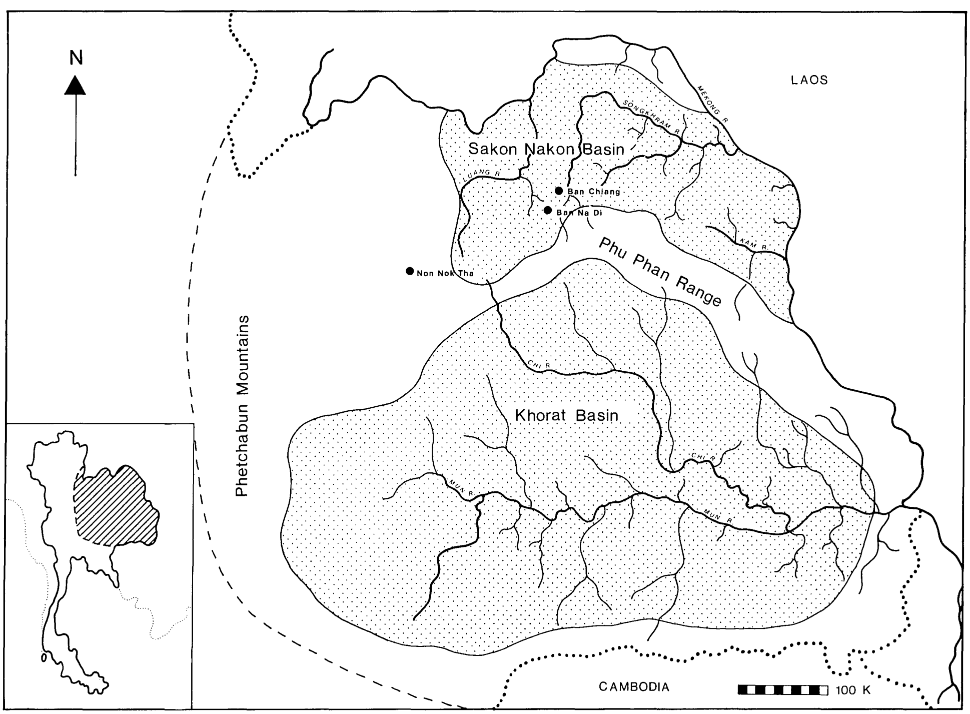


Fig. 2. The Khorat Plateau of northeast Thailand showing the Sakon Nakon and Khorat drainage basins, major rivers, and the sites of Non Nok Tha, Ban Na Di, and Ban Chiang.

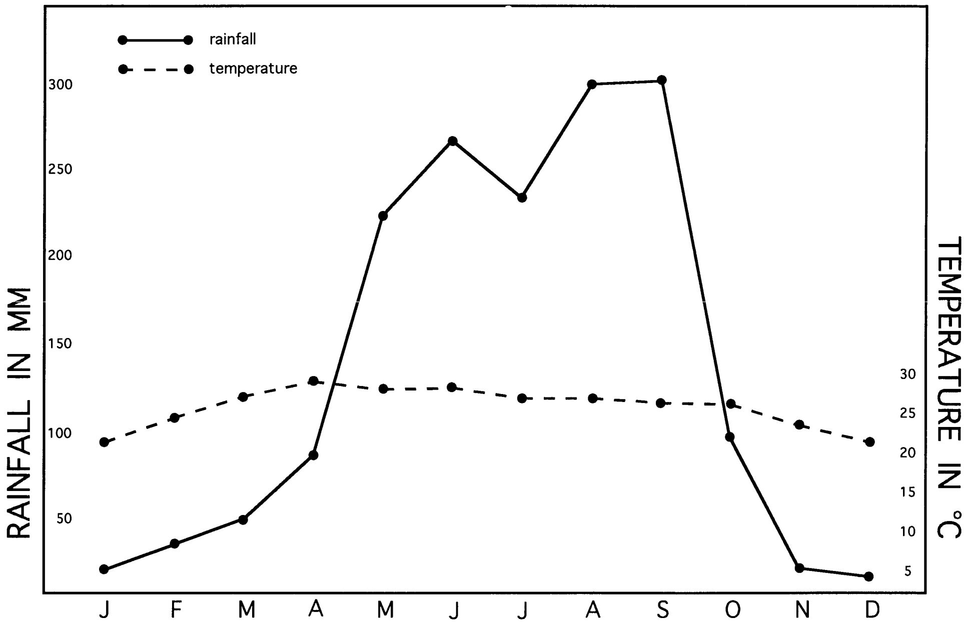


Fig. 3. Average monthly rainfall and temperature from 1951 to 1975 at Udon Thani, 50 km west of Ban Chiang. Average annual precipitation for the time period was 1520.5 mm (Ministry of Communications 1977 : 15).

between the Phu Phan hills and the Mekong River lies the Sakon Nakon Basin, which is drained by three smaller rivers, the Songkhram, the Kam, and the Luang.

The hydrology of the region is dominated by the monsoonal wind systems, resulting in alternating wet and dry seasons of approximately six months each. Average annual precipitation lies between 1000 and 2000 mm depending on location and rain shadow effects, but in most areas rainfall is less than 1500 mm, the bulk of which falls from May through September during the southwest monsoon (Fig. 3). The marked seasonality of rainfall produces pronounced fluctuation of available water resources, with expansion of lakes and streams causing local inundation and flooding during the rainy season, and contraction and even desiccation during the dry season. Local water tables also rise and fall several meters during the seasonal change. Springs in the region have small output and are generally in the hilly zones around the edge of the plateau, thus remote from populous regions (Haworth et al. 1966 : 177; Lamoreaux et al. 1959 : 37). Hence springs contribute little to dry-season water resources in the alluvial basin. Smaller lakes and the upper reaches of most rivers and tributaries usually dry up completely toward the latter part of the dry season. As there is relatively little seasonal variation in temperature, the marked seasonal fluctuation of water availability is a governing condition to which biotic forms must adapt. For example, deciduous behavior is one common response of vegetation to the dry season.

The soils of northeast Thailand are known for their low native fertility. Nuttonson states (1963 : 92): "The soils here are for the most part very poor, fine, sandy loams, high in quartz sand and silt but containing little else." The most common soils on the northern and southern basins of the Khorat Plateau are fine sandy loams, which are weathered from "red bed" sandstones of Triassic and Jurassic age called the Khorat series (Lamoreaux et al. 1959; Montrakun 1964). These rocks were themselves formed from sands, silts, and clays that millions of years ago were weathered so heavily that few minerals remained when the sandstone formed. Since most streams in the region rise on quartzitic rocks or poor sand soils, the water, and the silt and nutrients it carries, "are about as poor as one could find" (Montrakun 1964 : 92). In summary, the low native fertility of northeast Thai soils is not primarily a product of long-term agricultural usage but rather is inherent to the region's physiography.

The Ministry of Agriculture, Department of Land Development (1972) has published detailed comprehensive surveys of the distribution of 56 soil types assessed for agricultural potential in Thailand. The most common types in the region of concern are podzolic variants often known as Khorat soils associated with the middle terrace. Lower slopes are characterized by gray podzolic soils. On residuum and colluvium from acid rocks are red-yellow podzolic soils, and on summits are shallow red-yellow podzolic soils. The Khorat soils are rated as not suitable for wetland agriculture due to topography, but some variants and some locations can be moderately suited to upland (never inundated) crops. In depressed areas or shallow valleys associated with the low terrace can be found low humic gley soils often termed Roi Et soils. The Roi Et soils are rated as moderately suitable for both wetland and upland agriculture, but tend to be cultivated with wetland rice today because of favorable drainage properties. When soil type, soil depth, topography, and drainage qualities are considered, a complex mosaic is indicated on maps for areas in the Sakon Nakon Basin where prehistoric settlements have been located.

Scientific information on the spatial distribution of natural vegetation types is unfortunately much more general than that available on soils. Moreover, there is no single classification for vegetation that is both systematically developed and widely used. I will follow Lekagul and McNeely (1977 : xxii) and discuss forests in terms of the traditional, general, unquantified typology documented in Royal Forest Department publications.

An open forest, termed Dry Deciduous Dipterocarp Forest, is the dominant type on the Khorat Plateau (Fig. 4),[3] occupying 70–80 percent of the region's total forest (Royal Forest Department 1962 : 6). It grows in areas "with hot bioclimates, which have a dry season of five to six months, an average annual rainfall of between 1000 and 1500 mm . . . (and is found on) poor acid soils of the Red-Yellow Podzolic Group that either have a high degree of stoniness or a strongly lateritic character" (Stott 1976 : 23). Phytogeographers increasingly recognize several associations within this general type. While this forest type has spread due to fire, the position of Stott (1976 : 52) is that his Shoreeto–Pentacmetum association is an edaphic climax on sandstone-derived soils. Five most common trees include *Dipterocarpus tuberculatus*, *D. obtusifolius*, *D. intricatus*, *Shorea obtusa*, and *Pentacme siamensis*. The species composition and physiognomy of any individual forested area will vary according to soil qualities. Commonly, trees tend to be small and widely spaced, with increasingly open stands as soils become shallower, stonier, more lateritic, and sandier. Denser and taller stands occur on deep loams. Grasses and bamboos comprise the undergrowth.

Another type of deciduous forest, termed Mixed Deciduous Forest, is found in

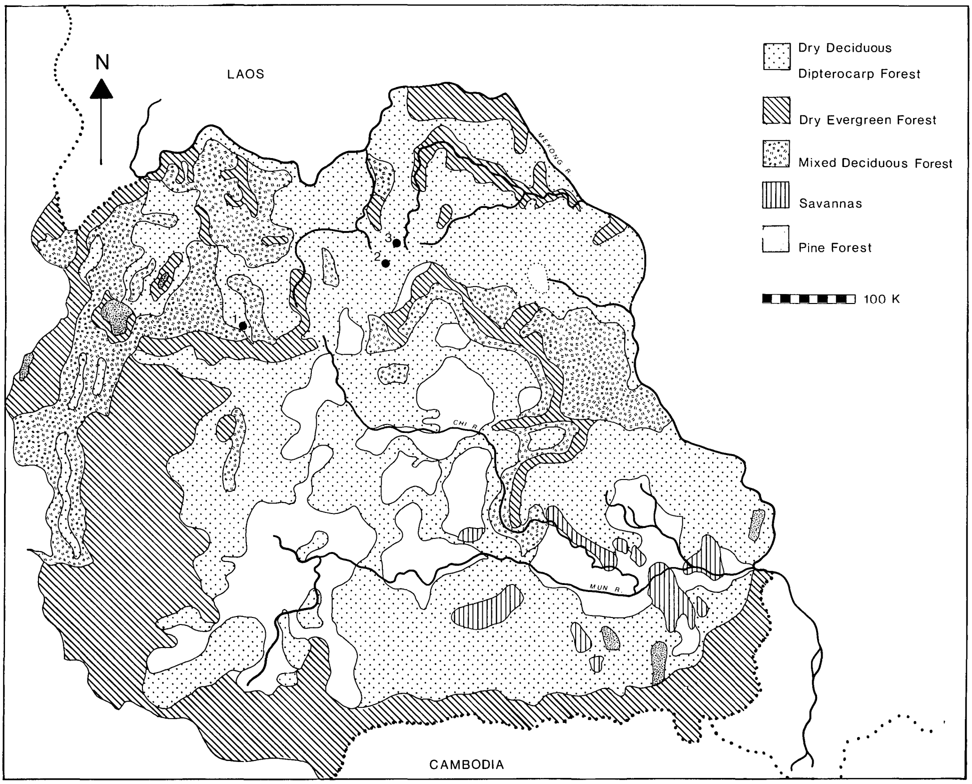


Fig. 4. Distribution of the major forest types in northeast Thailand according to the Royal Forest Department (1962). Early rice-cultivating sites, including Non Nok Tha (1), Ban Na Di (2), and Ban Chiang (3) are found in areas dominated by Dry Deciduous Dipterocarp Forest.

wetter areas with better soil quality. Significant stands are found on the Phu Phan range and northwest portions of northeast Thailand. Although denser than Dry Deciduous Dipterocarp Forest, considerable light still reaches the ground and undergrowth is thick during the wet season. Characteristic trees include *Pterocarpus macrocarpus*, *Adina cordifolia*, *Xylia kerrii*, *Lagerstroemia calyculata*, and *Terminalia tomentosa*.

Dry Evergreen Forest can be found in stretches along the lower Songkhram River, the rim of the Khorat Plateau, and some spots in the Phu Phan range. Some of the species are the same as just mentioned, but *Dipterocarpus alatus*, *Anisoptera cochinchinensis*, and *Hopea odorata* are prominent. The species composition of each forest type should not be thought of as a mutually exclusive set. Rather, individual tree species may be found in several of the forest types but will vary in prominence (relative frequency and position in the canopy) and condition (stunted vs. flourishing) according to local edaphic conditions (Bunyavejchewin 1983, 1985, 1986).

Another notable vegetation type is found in certain areas of northeast Thailand along major Mekong tributaries, particularly along the Mun. The Royal Forest Department (1962) terms "Savanna" large expanses of low-lying land that flood suddenly when the Mekong, Mun, and Chi rivers back up. The land can be inundated to 50 cm or more for as long as six weeks. The sudden and prolonged flooding, followed by desiccation in the long dry season, prohibits survival of most trees. Climax vegetation consists of a poor, thin grass with very occasional trees such as *Dipterocarpus obtusifolius* on elevated spots. The water conditions are not considered suitable for rice cultivation without elaborate water control, but the land is a major source of fish during the flood stage.

What is the relevance of these current vegetation types to the prehistoric settlement of the region after 4000 B.C.? Pending forthcoming results from the Thailand Palaeoenvironment Project, I will assume, based on the faunal evidence from Ban Chiang tradition sites (Higham and Kijngam 1979), that alternating wet and dry seasons and the presence of open, probably deciduous, forests characterized the relevant prehistoric period. Even if total rainfall was greater in the past, there may have been only limited shifts in the distributions and proportions of the same basic forest types as exist today. The vegetation for the region as a whole would not necessarily have been significantly richer or more evergreen, given the porous, unfertile sandy soils and the likelihood that, at the latitude and interior position of the Khorat Plateau, there was still a dry season of five or more months.

PREHISTORIC SETTLEMENT IN RELATION TO THE ENVIRONMENT

In order to develop the background to the model further, we need to examine how the early agricultural sites were distributed relative to the environmental variation. Using the only class of published information sufficiently detailed quantitatively to assess site catchments—namely, soils—two studies have commented upon northeast Thai sites dateable to General Periods A and B, one study in the Nam Phong region west of Non Nok Tha (Wilen 1986–1987) and one in the Kumphawapi region west of Ban Chiang (Kijngam et al. 1980; Wichakana 1984). Both conclude that sites of this period are found in significant association with soils moderately suited for inundated rice agriculture, usually of the low terrace and near streams.[4]

These studies are less insightful than one might wish. A flaw of both is the use of only the Ministry of Agriculture ratings for wetland agriculture; both studies ignore the ratings for upland agriculture. At least in the Ban Chiang area, the low-terrace soils in question (Roi Et) are also rated as moderately suited for upland as well as wetland agriculture. Mudar (n.d.; 1993 : 79, 82) points out that both settlement pattern studies were biased in favor of a wet rice subsistence strategy. Moreover, it would be surprising if early agricultural sites were systematically located away from streams and the pockets of agriculturally favorable land in this generally dry and unfertile region.

Applying the geological category "low terrace" and soil classifications for modern-day agriculture, though "scientific" and a first step, does not necessarily provide much insight into the environment experienced by early settlers cultivating a primitive rice without plows or water buffalo. What did these locations have to offer in terms of various natural resources including wild rice, yams, fauna, and the capacity for various kinds of cultural manipulation of the environment? As many locations near streams were not selected by the early settlers, what might have been the environmental cues, such as vegetation, that would have stimulated settlement in some locations but not others? How can we gain a more comprehensive understanding of the environmental variation and the distribution of a variety of natural resources within the regions of early settlement and site catchments beyond soils classified for modern-day agricultural methods?

Ethnoecological Study of Environmental Variation

Developing a better understanding of natural resources and environmental variation in a region of early rice agricultural settlement was a major goal of my ethnoecological study undertaken from Ban Chiang village. Ethnoecology will here mean the study of the ecology of a region from the point of view of human exploitation of that region. This study included the following objectives:

1. *Documentation of natural resources.* This particular study emphasized edible plants, with special interest in plants that might have been wild progenitors of species possibly domesticated in Southeast Asia. Documentation included not only presence in the environs, but also the species behavior and environmental preference. Strategic behaviors of plants, such as the timing of seed production and mechanisms of seed dispersal, affect patterns of human exploitation. Moreover, plants generally have specific preferences as to conditions of light, soil, and water that will affect where and with what abundance such resources are found.

2. *Documentation of plant communities.* Groups of plants with similar environmental preferences tend to be associated. From the point of view of human exploitation, beyond knowing the exact location of an individual plant, collectors frequently operate at a higher level of generalization and will know which plant communities are likely to yield a particular resource.

3. *Ethnographic and ethnohistoric inquiry into human exploitation of both wild and cultivated resources in the region.* The goal of this inquiry was to provide ideas about the techniques and strategies for exploitation as well as the strengths and limitations of environmental variants within a particular region.

4. *Examination of individual site catchments in relation to environmental diversity and resource distribution.* Such an examination facilitates the development of hypotheses for prehistoric settlement patterning relative to ecological variables.

During this 20-month study, in pursuit of objective number two, an indigenous classification system was discovered which the Lao-speaking inhabitants used to discuss environmental diversity. Different land types are defined by hydrology, soils, and the vegetation that would grow under those edaphic conditions. Knowledgeable farmers can judge even from cultivated areas such as bunded rice fields what the natural vegetation would have been, based on soil quality, remnant trees left standing in the rice fields (Grandstaff et al. 1986; Montrakun 1964 : 92), and even the species of weeds, which vary by land type. Environmental referents are also found in many local place-names. At least some of the indigenous land types correspond broadly to forest types employed by the Forestry Department, although some indigenous types subdivide a Forest Department type, and some indigenous variants have no Forest Department equivalent. In contrast to the broad vegetation zones depicted on the Forest Department maps, the local classification system reveals an intricate mosaic of environmental variation, a means to gain some idea of the natural vegetation and natural resources in the various pieces of the mosaic. Overall, the indigenous system was found to be highly refined and attuned to human use.

TABLE 1. APPROXIMATE FORESTRY DEPARTMENT EQUIVALENTS TO INDIGENOUS LAND TYPES

INDIGENOUS LAND TYPE	FORESTRY DEPARTMENT REFERENT
din khōk	Dry Deciduous Dipterocarp Forest
din thām	?
din dong	Dry Evergreen Forest
din thom	Mixed Deciduous Forest
din dǭn	Mixed Deciduous Forest
tung	Savanna

For the purposes of this paper, five key variants will be discussed (Table 1). Each term is preceded by the term *din* translated here as "land." *Din khōk* (pronounced "coke")[5] corresponds broadly to Dry Deciduous Dipterocarp Forest, the most common forest type in northeast Thailand found on the poorer, more lateritic, and most rapidly drained soils of the upper watershed. Many subvariants are recognized, depending on the dominant species and soil quality.

The second land type is called *din thām* (pronounced "tahm"). In contrast to the rapidly drained upper watershed, there comes a point along a stream where the water overflows the adjacent land for several days following heavy rainstorms in August and September. *Din thām* is not equivalent to the Savanna discussed above, whose vernacular is *tung*; *din thām*, whose period of inundation is considerably less than *tung*, has greater diversity of plants, including many shrubs and some trees, such as the key species *Barringtonia acutangula* and *Lagerstroemia floribunda*, which withstand some prolonged inundation.

The last three key land types, which seem to be variants of Mixed Deciduous Forest and possibly Dry Evergreen Forest, can be found in areas of intermediate drainage and better soil quality. Species among the three overlap considerably, but each type has a few characteristic trees and distinctive soil. *Din dong* (pronounced "dohng") is associated with whitish sandy sediments of considerable depth, often on the higher terraces. An iron pan is either absent or has formed two or more meters below the soil surface. In most locations, *din dong* is recognized by the presence of the magnificent *Dipterocarpus alatus*, an emergent tree which can reach a height of 40 m before branching and which the Royal Forest Department (1962; also Nuttonson 1963 : 75) considers characteristic of Evergreen Tropical Forest. (Other sources list it as found in Mixed Deciduous Forest, e.g., Lekagul and McNeely 1977 : xxvii.) Other characteristic trees include *Anisoptera cochinchinensis* and *Hopea odorata*.

Din thom (pronounced "tome") and *din dǭn* (pronounced "dawn") are two variants of the Mixed Deciduous Forest. Different edaphic conditions result in somewhat different emphases in species composition, depending upon local variations in soil depth, richness, and particle size, and specific water conditions (e.g., water table). *Din thom* has red-and-yellow mottled clayey soil, and prominent trees include *Terminalia alata* and *Pterocarpus macrocarpus*. *Din dǭn* has blackish sandy soils, and a characteristic tree is *Adina cordifolia*. Most *din dǭn* locations are on well-drained alluvial sediments adjacent to intermediate reaches of streams.

Although the many variants of *din khōk* may dominate the total land area in the Ban Chiang region as a whole, the subtle undulations in the landscape and complex soil mosaic mean that some of each vegetation type can be found within a three-kilometer radius of Ban Chiang village (Fig. 5). Unfortunately, there is not a one-to-one correspondence between the indigenous land types and the Ministry of Agriculture soil types. Distinctions significant to local farmers are not evident in the Ministry of Agriculture soil maps and vice versa.

For example, locations in the vicinity of Ban Chiang where local inhabitants identify *din thām* are shown as Roi Et variant 13, but most locations where this soil is indicated would not be considered *din thām* by local farmers. Middle-terrace Khorat soil 21 in some locations supports vegetation considered *din dong*, others *din dǭn*, and still others *din thom*. Other soil types underlie these indigenous forest types as well.

Although the lack of a clear relationship of vegetation to scientific agricultural soil classifications might at first seem to call the indigenous system into question, plant geographers working in Southeast Asia have observed the same discrepancy between vegetation and soil zonation as recorded by soil scientists. Some conclude that vegetation may provide a more precise indication than soil survey maps of those soil conditions which have the most effect on the distribution of natural vegetation (e.g., Ashton and Ashton 1976: discussion, 70, 91). Padoch (1986) also notes that traditional cultivators on Borneo use wild plant species to judge soil qualities relevant to agriculture; their system was independently validated by a forest botanist. Thus archaeologists should not overstress modern agricultural soil surveys whose criteria may not be appropriate to address natural vegetation or primitive agriculture mapping needs.

Pending the forthcoming results of the Thailand Palaeoenvironment Project, we shall assume for the purposes of this paper that the natural environmental variation as understood by local Lao-speaking inhabitants of the Ban Chiang region is representative of the prehistoric environment. In-depth study of the Ban Chiang domain and a preliminary survey of other prehistoric sites in the area lead to the following testable hypothesis: *the early agricultural sites tend to be located upstream from* din thām, *downstream from* din khōk, *and in close association with* din dǭn. In other words, it is proposed that early settlements were found at intermediate locations along the drainage system which are below the rapidly drained zones with Dry Deciduous Dipterocarp Forest, and above locations that flood for longer than two days at the height of the rainy season. The early sites appear not to be closely associated with *din dong* or *din thom*, nor have they been found near the larger lakes or the few major springs in the region.[6] Figure 5 illustrates the proposed hypothesis, showing that the prehistoric sites at Ban Chiang, Ban Om Kaeo, and Ban Tong all conform to the proposed location relative to the indigenous land types. However, each site location does have access within a few kilometers to several land types. Hence the sites are located with access to much greater environmental heterogeneity than one might conclude from Forestry Department maps or than the casual visitor might perceive in the seemingly monotonous landscape of northeast Thailand.

Because the ethnoecological study revealed that the different indigenous land types vary significantly in terms of natural plant and animal resources and edaphic conditions for different crops, the settlement location as hypothesized above has specific implications for access to resources and potential for environmental manipulation.

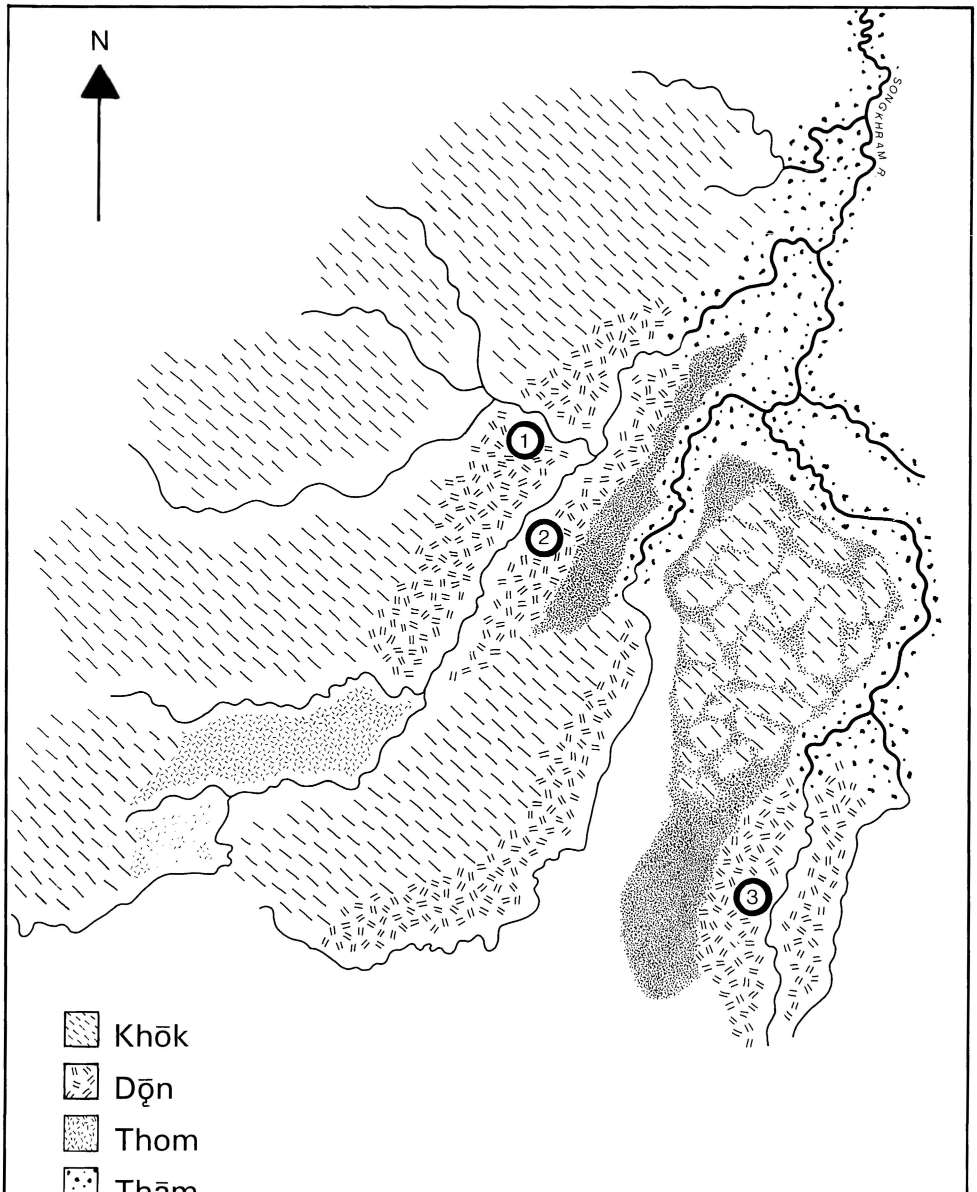


Fig. 5. The location of the prehistoric sites of Ban Chiang (1), Ban Om Kaeo (2), and Ban Tong (3) in relation to indigenous land types.

SETTLEMENT LOCATION AND EARLY RICE EXPLOITATION

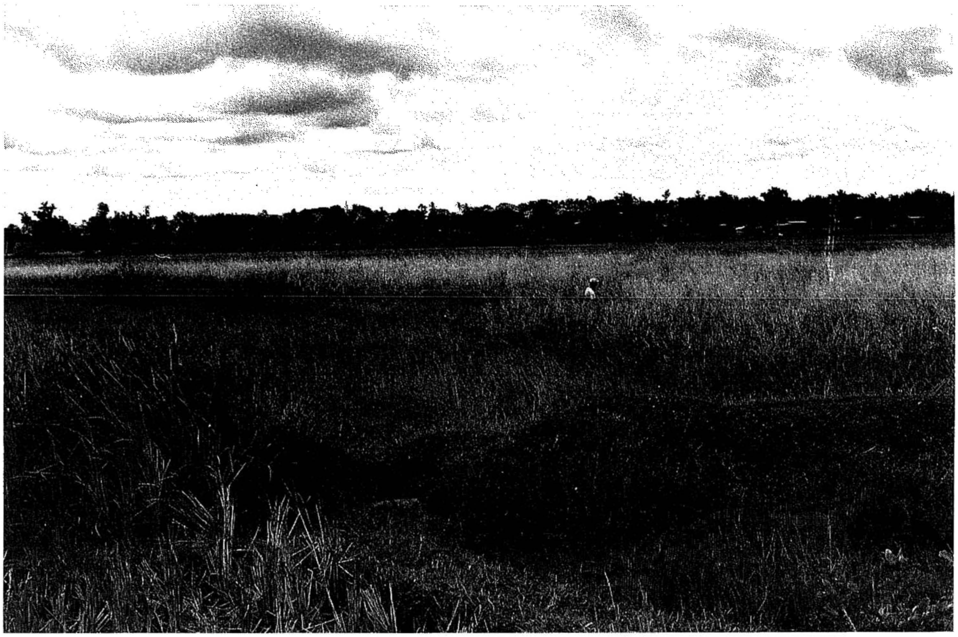
Assuming for the present that early rice cultivators expanded locales where wild rice grew naturally, key questions are the following. Does wild rice grow in the Ban Chiang region today? If so, what are its environmental parameters and ecological behavior?

Noncultivated rice (hereafter "common wild rice" or "wild rice," following Oka 1988) grows in the Ban Chiang region today along streams and lake edges during the rainy season (Pls. I and II). Villagers recognize it based on the following qualities: (*a*) it has long awns; (*b*) the seeds abruptly fall off the stalks at maturity (due to a brittle rachis) at the end of the rainy season; (*c*) it grows under certain environmental conditions.

Among the specimens of common wild rice collected in the Ban Chiang region during the ethnoecological study, both annual (*Oryza nivara*) and perennial (*O. rufipogon*) were identified by T.-T. Chang of the International Rice Research Institute (Loresto personal communication). The perennial and annual forms were not differentiated by local inhabitants. Although there is some disagreement as to whether a perennial or an annual wild rice was the immediate ancestor of the cultivar *Oryza sativa* (Chang 1976; Oka 1975), Chang (1989) notes there may not be a clear distinction between these two forms. Oka (1988) states that there is an annual–perennial continuum in wild rice and argues from genetic evidence that the domesticate derived from an intermediate form. Taxonomic distinctions important to botanists would in any case lack significance to early human exploiters. The key observation is that annual behaviors of wild rice would have been of primary interest to early rice manipulators and the annual habit was ultimately encouraged in the process of domestication.

Reproduction through an annual production of seeds is the annual plant's only strategy to survive the dry season. Therefore, rice populations at the annual end of the continuum invest more resources in ample and regular production of viable seeds than rice populations at the perennial end. The seeds of wild rice produced at the end of the rainy season are dispersed onto dry or drying ground. Dormancy helps delay germination until the next rainy season begins in several months. In humid tropical regions that do not have a pronounced dry season or other locales that maintain year-round moisture, such as some lake interiors, there is less ecological reason for plants to rely on an annual crop of large seeds. Rice in such locations will tend toward a perennial habit, with less investment in dispersal of an annual crop of large viable seeds (Chang 1989; Oka 1988: 37; Shastry and Sharma 1974).

Thus common wild rice is not found ubiquitously in all marshy or swamplike areas. The annual forms are adapted to a very specific location relative to water sources—zones which are dampened and gently inundated during the rainy season, but whose soil surface is dry during most of the dry season. Annual wild rice also seems to compete well in areas subject to disturbance. Thus, in a lake,[7] annual wild rice grows around the perimeter between the wet-season high-water line and the dry-season low-water line, the area also most exposed to disturbance by grazing animals. To the casual observer, the stand appears nearly monospecific (Pl. I).[8] Perennial rice does grow in interior portions of northeast Thai lakes. However, where the earth remains wet throughout the dry season, rice is usually



Pl. I. Common wild rice along a lake perimeter in northeast Thailand. In the left foreground is cultivated rice in bunded fields. The man in the middle ground is standing in the midst of a patch of wild rice.

Pl. II. Wild rice growing along a stream near Ban Chiang. This is the type of locale where early rice cultivators are hypothesized to have settled.

abruptly replaced by a perennial reed. Oka (1988 : 52–53) documents that *Leersia hexandra* is a major competitor with perennial wild rice and that phytotoxins in the root zone may have a role in controlling the competition.

Along streams, common wild rice is also restricted to areas with gradual and gentle flooding regimes (Pl. II). Following even a major rainfall, *din khōk* drains too rapidly to support common wild rice, which needs some degree of inundation; and the August and September floods on *din thām* are too prolonged and turbulent for the plant. Therefore, wild rice along streams is found above *din thām* and below *din khōk*. These intermediate locations, which are generally considered *din dǭn* by local inhabitants, have a relatively gentle flooding regime and deeper inundations last at most a couple of days. The likely locations for common wild rice along streams, therefore, correspond to where several early agricultural sites in the Ban Chiang region have been discovered.

Although prehistoric settlements might have shown a preference for stream locations near common wild rice, this does not imply that the inhabitants had a major interest in collecting it. As noted above, the early sites have so far not been found near the larger lakes, which were more likely to support larger stands of wild rice than streamside locations. The streamside location has advantages for easier environmental manipulation, particularly of water, and greater diversity of resources (see below). At locations along sizable lakes, the water level is contingent upon that year's rainfall. There is no easy way to raise water in years of light rainfall, or to drain water in years of heavy rainfall. Streamside locations present more options for water divergence both to and from areas where rice is growing. So far, the early villages have been found along streams high enough in the drainage system that their flows are seasonal. At this point along the water courses, the streams are closer to the level of the bunded rice fields (Pl. II) in contrast to further down the drainage system where the major tributaries flow through deeply incised channels. As Ng (1978 : 38) points out, even for today's villagers, it is only the tributaries with *seasonal* flows that are amenable to simple damming techniques.[9]

Some Observations on "Wet" versus "Dry" Fields

Two systems of rice cultivation are traditionally contrasted: "wet" and "dry." Growing rice in "dry" (i.e., better termed *upland* or noninundated, as will be used hereafter) fields is associated with shifting-field, slash-and-burn cropping technology with a polyculture vegetative structure portrayed as imitative of complex natural tropical ecosystems. Shifting cultivation is seen as technologically simpler and less labor intensive than rice grown under "wet" or inundated conditions (hereafter termed *wetland* cultivation in contrast to *upland* cultivation). Wetland rice cultivation is associated with monoculture, bunding, ploughing, and transplanting. Wetland rice cultivation has been portrayed as artificial, environmentally transformative, and at odds with the high-species diversity considered characteristic of the tropics (Janzen 1975 : 53). This view has been particularly well articulated by Geertz (1963), for Java. However, cropping systems for rice grown on inundated land actually vary greatly in their technological level and transformative effects.

In contrast to the portrayal of wetland rice cultivation in the equatorial tropics as intrinsically intensive and environmentally transformative, cultivation of wetland rice in the seasonal tropics of northeast Thailand can be seen as an imitation and expansion of the natural ecological niche for wild annual rice. While species diversity of some subtropical plant associations can be high and junglelike (e.g., Dry Evergreen Forest), *freshwater swamps tend toward low diversity*, commonly supporting large stands of single species with scattered individuals of other species (Janzen 1975 : 45), as the author observed in the nearly monospecific stands of wild rice or reeds in northeast Thai lakes.

Wetland rice cultivation that can be observed in the Ban Chiang area today essentially mimics the annual wild rice regime with respect to water conditions and species diversity: the rice is grown in monospecific stands in fields that are slowly and gently inundated and dry naturally as the rains terminate. In Thailand this system is referred to as "rainfed rice agriculture" in contrast to "irrigated rice agriculture." The latter, virtually absent in the Ban Chiang area, is used to refer to significant diversion of water by canal systems from perennial rivers and lakes, which usually allows cultivation of rice under inundation during the dry season.

Observations during the ethnoecological study in northeast Thailand show that initial cultivation of an area with wetland rice need not require extensive or thorough land clearance and dike construction. A farmer who had opened up new rice lands four years prior to observation employed several traditional methods. This farmer accomplished both initial water control and forest clearance through damming a stream. The dam flooded a substantial area, which killed much of the undergrowth and small trees. These were burned off during the following dry season. During the next rainy season rice could be planted over a considerable area without diking. Large trees need not be cleared before rice is first planted and tree clearing can be gradually accomplished over a period of years. Since large trees in northeast Thai deciduous forests are not necessarily densely grouped, complete removal of large trees is not always onerous or even desirable from the farmer's point of view, since the leaf crop provides fertilizer. Aside from land flooded by the dam, rice was planted in natural depressions where water tends to collect from runoff and seepage, again without the need for dikes. If land alongside these areas is fairly flat and low-lying, the cultivable area can be gradually expanded by only short temporary dikes that retain water only during the beginning of the rainy season. Plowing is not essential to prepare the land. Even today, under certain circumstances, land is hoed and then trampled or puddled to disrupt weeds and prepare the proper muddy consistency. Rice seed can be broadcast or even dibbled into the soil without transplanting.

Observations on Field Permanency

A seasonal wetland cultivation system such as described above would probably be a permanent or at least a semipermanent field system. If the cultivator undertakes the major effort of any amount of land clearance, there needs to be good reason to abandon that plot and clear new plots of land. In upland shifting cultivation, the reason is that yields on humus-poor tropical soils, particularly for nutrient-hungry annuals, decline so much after one or two years it is not worthwhile to replant. The decline in yield is due to exhaustion in the soil of the nutrients released in the burn, and to competition from weeds. The land has to regenerate to forest in order to shade out weeds and produce a significant biomass to act as nutrient storage. The subsequent burning of the forest releases plant nutrients and suppresses competition.

Rice grown under inundation is not necessarily dependent on fertile soil rich in plant nutrients to produce a yield because the varieties of rice grown in inundated fields absorb nutrients directly from the water via rootlets protruding from the lower stems. Chang notes (1989 : 408) "Its semi-aquatic plant structures transport air from the shoot to the root zone, enabling the micro-organisms associated with the rhizosphere to biologically fix nitrogen." Mutualistic associations of plants with mycorrhizal fungi which provide minerals to the plant are common in tropical areas with nutrient poor soils (Janzen 1975 : 15). Montrakun (1964 : 33) states "Padi is a unique crop in that it will grow and produce something to eat on almost the poorest soil. . . . [P]adi can be grown on the same soil year after year with practically no fertilization and still produce something to eat." The two important conditions are sustained inundation of 5–15 cm, and minimization of weeds. Farmers claim that if the soil is properly prepared (ploughed and harrowed so as to uproot and remove preexisting weeds) and kept under water, little weeding during the remainder of the growing season is necessary. The key is to maintain an optimal water level and to prevent soil from being exposed to the air, which will allow seeds of weed species to take root.

Another reason not to move the wetland fields, according to my informant, is that soil texture and permeability improve over time with repeated cultivation of inundated rice.

Why Inundated Rice Was Not Grown in Shifting Fields

Arguments for a wet swiddening of rice for early cultivators in northeast Thailand usually refer to extensive forms of wetland rice cultivation observed on Borneo (Bayard 1984*b* : 114; Gorman and Charoenwongsa 1978).[10] The Borneo systems (Geddes 1954), termed "swamp rice" (Dove 1985), "padi paya" (Padoch 1982, 1988), or "wet shifting cultivation" (Seavoy 1973), however, are found in areas whose ecology differs significantly from that of northeast Thailand. The major problem with using the Borneo analogy is that these examples come from areas with only a brief dry season (Padoch 1988; Seavoy 1973). The plant dynamics that promote moving inundated rice fields in Borneo do not apply to subtropical northeast Thailand.

In the Borneo examples, preferred locales for planting "swamp rice" are small interior valleys with flat bottoms drained by *permanent* watercourses. The vegetation in adjacent marshy areas (generally perennial grasses, herbs, and reeds) is cut and burned during the brief dry season. Following land preparation consisting of removal of larger root clumps and unburnt tufts and trampling, a muddy zone is created where rice grains can be broadcast or dibbled in, or seedlings can be transplanted *on top of disturbed roots* which were only partially removed. Little or no attempt is made at water control, although occasionally temporary diversions of water may be undertaken with flimsy dams or trenches (Dove 1985 : 224; Padoch 1982 : 69). When the roots are slashed and turned, seedlings are transplanted, and standing water can be maintained, weeding can be less of a task with swamp cultivation than with dry swiddens in secondary forest (Dove 1985 : 224).

Seavoy (1973) explains why these swamp rice fields must be shifted. He states that the mud fields can be best prepared during the second stage in the succession, when the perennial reed *Scleria bancana* has taken hold. The roots of this *Scleria* reed crowd out other competing vegetation (serving the function of tree shade in upland swidden systems), particularly the first succession, quick-growing perennial grass *Isachne glabosa*. The rice planted on top of the disturbed roots of *Scleria*, which grows more slowly than rice, can produce one crop before the *Scleria* regains dominance. The point in fallowing the area is to allow for *Scleria* to reestablish and crowd out *Isachne*. Periods of fallow might be as short as one year (Padoch 1988 : 24) or up to three to five years (Seavoy 1973 : 221). Dove (1985 : 83) states that the cropping of swampland two years in a row occurs, and even annual cropping is not discounted as a possibility (Padoch 1982 : 70).

The ecological dynamics of wetland shifting systems from equatorial Borneo are not applicable to the seasonal tropical environment of northeast Thailand. Entrenched perennials are not major competitors for wild annual rices growing in the seasonal water zone of Thailand (Oka 1988 : 31). On the contrary, some forms of wild annual rice may be ready colonizers of open, disturbed, low-lying, seasonally inundated areas. Both the author and Oka (1988 : 55) observed wild rice growing densely in low-lying fallow bunded fields and areas such as ditches that had been disturbed in the near past. If there are no major competitors for rice in the seasonally inundated zone, and rice produces a reliable yield irrespective of soil nutrients, then there is little rationale for leaving fields fallow and moving to a new location the next year.

Moreover, in northeast Thailand, there is little evidence that perennial marshes were the focus of early cultivators, who seem to have been more interested in seasonal streams, probably because of ease of water control. Even if, as indicated by a small sample of the mollusc *Pila polita* in basal Ban Chiang (Higham and Kijngam 1979), perennially wet areas were associated with the early settlements, these habitats would likely have been very limited in areal extent. As noted previously, the early sites are not near the larger extant lakes; no perennial lake is in Ban Chiang's catchment today.

The wetland swidden system described for the humid tropics of Borneo should be conceived as an extensive strategy to cultivate wetlands that remain wet longer than naturally preferred by annual rice. In the drier subtropics, early rice cultivation may have been aimed initially at extending rice cultivation into *drier* rather than wetter lands (see below). In any case, phrases such as "seasonal swamp rice cultivation" or "simple wetland rice cultivation" are more accurate for the system of early rice cultivation in the Ban Chiang area. The phrases "wet shifting" or "wet swidden" rice cultivation, *should be dropped* for northeast Thailand, because they imply an impermanence of fields which as yet has no proof and lacks ecological rationale. Hence, while superficially satisfying as a way to combine a traditional preconceived notion that shifting cultivation must have preceded permanent fields with an acceptance that rice cultivation must have begun in wet environments, the concept misleads efforts to reconstruct early rice cultivation in northeast Thailand.

Implications of Permanent Inundated Fields for Early Rice Cultivation

The degree of rice field permanency during this early period is significant with respect to the theoretically associated developments of settlement stability, private land tenure, accumulation of wealth, and social ranking. Accurate reconstruction of the changes in regional settlement systems and agricultural and economic bases for social development has a critical role in the discussion of Southeast Asia's long-term cultural development (Bayard 1980; Higham 1984*b*; Wolters 1982). If cultivation of rice in fairly permanent inundated plots preceded the appearance of water buffalo, iron, and the plow in this region, introduction of these innovations did not necessarily result in a major shift from an impermanent to a permanent field system, as has sometimes been proposed (e.g., Higham 1984*b*: 251–252; Higham and Kijngam 1979; Wilen 1986–1987). Rather, it is likely that cultivation of rice in fixed plots of favorable wetlands occurred from the initial settlement of the Ban Chiang region. This scenario is supported by the possible long-lived use of sites like Ban Chiang for cemeteries and habitation, perhaps for centuries, from the base of the site.

There are a number of interesting parallels between the scenario proposed in this paper and that of early Near Eastern cereal cultivators. McCorriston and Hole (1991) stress the relationship between marked seasonality of rainfall with a pronounced dry season, proliferation of annual plants, and the origins of agriculture. Sherratt (1980) has proposed that early cereal cultivators also focused on locales with a high water table or seasonally fluctuating surface water, requiring little or no water control, rather than locales of high rainfall. He also states that such locales likely needed only minor forest clearance, and because their fertility was naturally replenished through runoff, such locales had prolonged productivity, allowing repeated cultivation in fixed plots. In the Near East, this ecological context allowed the earliest cereal-cultivating settlements to be long-lived, stable nuclear communities. The same seems to be the case with early rice-cultivating villages in northeast Thailand. Elsewhere (White 1990) I have argued that the greater expandability of the "seasonal-swamp" style of early cereal cultivation, but with *inundated rice* as the cultivar, helps to account for some of the differences in long-term regional sociocultural development between Southeast Asia and the Near East.

IMPLICATIONS OF SETTLEMENT LOCATION FOR USE OF OTHER RESOURCES

If the early settlers in northeast Thailand cultivated varieties of relatively primitive rice in depressed areas using simple land clearance and preparation techniques, it seems reasonable to assume that yields were low. Moreover, as they are today, yields were probably unreliable from year to year due to the notorious variability in timing and amount of rainfall in northeast Thailand. The variability in rainfall is particularly marked during the initial peak of rains in May and June, when the rain clouds may be only 20 km wide. These early rains tend to be short downpours of limited areal coverage leaving lands dry that are not directly under the passing cloud (Takaya 1987: 130). The author observed an example of this great local variability in rainfall when a village only 4 km distant from Ban Chiang transplanted their rice in September, two months after Ban Chiang, due to a

TABLE 2. COMMON WILD YAMS IN THE BAN CHIANG AREA

LOCAL NAME	TENTATIVE BINOMIAL[a]	INDIGENOUS LAND TYPE
man hōerp	*Dioscorea alata*	*din dǭn*
man koy	*Dioscorea hispida*	*din dǭn*
man pōerm	*Dioscorea esculenta*	*din thom*
man nok	*Dioscorea* (?) *glabra*	*din khōk*
man sāeng	*Dioscorea* sp.	*din thām*

[a] Identified at the Royal Forest Herbarium, Bangkok, where voucher specimens were deposited.

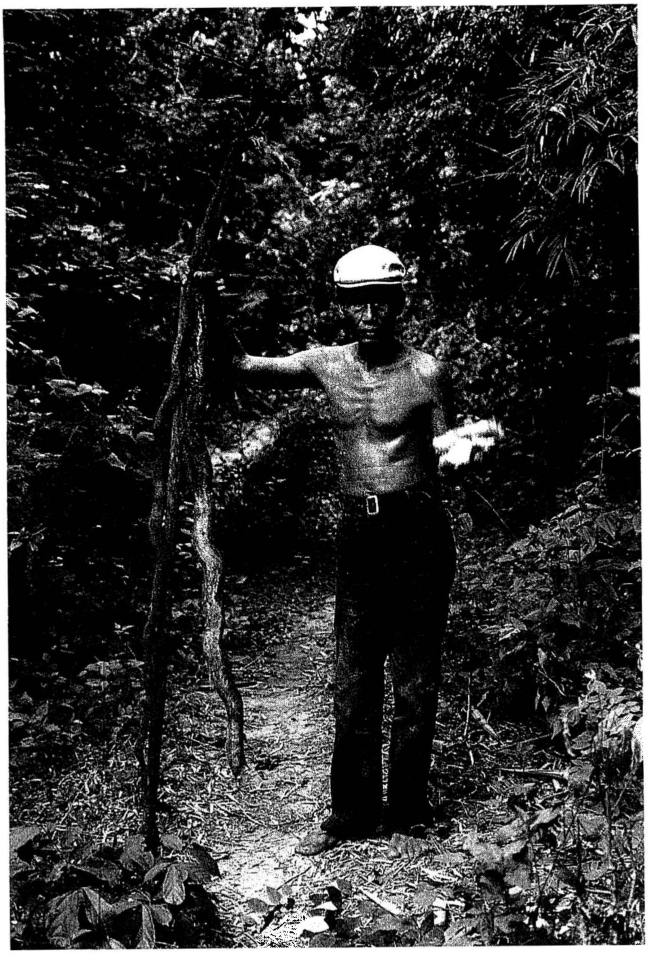
localized deficiency of early rainfall. The length and intensity in the drop in rainfall during July between these initial showers and the major rains beginning in August (see Fig. 3) is also a period of vulnerability for farmers. Northeast Thailand's erratic rainfall produces minor droughts every four to five years (Ng 1978:39).

The early settlers in all likelihood, therefore, used a broad spectrum subsistence strategy and not only exploited (as do current inhabitants) but *relied on* a wide range of resources, as well as both wetland and upland strategies of plant exploitation. Probably both cultivated and noncultivated foods were involved, although at present we have no archaeobotanical remains to prove this assertion. The faunal remains, however, do indicate a broad spectrum subsistence strategy (Higham and Kijngam 1979). Wild yams (eaten as snack food today but considered a traditional famine food by local inhabitants) illustrate additional locally available sources of carbohydrate. Local inhabitants recognize at least five common noncultivated yams of the genus *Dioscorea* (or *man* as they are known to villagers) that grow in forests in the Ban Chiang area (Table 2; White 1989). The two most important species are found on *din dǭn*: *man hōerp* (the greater yam or *D. alata*, Pl. III) and *man koy* or *D. hispida*, (Pl. IV). Thus the early settlements located on *din dǭn* would have been well situated to exploit these two yams, which may have been crucial to the diet during a time when rice was a less reliable carbohydrate source. The ethnoecological study in the Ban Chiang region documents numerous other cultivated and noncultivated food resources potentially available to prehistoric settlers, too many to be fully discussed here.

Implications of Settlement Location for Land Use

The hypothesized preferred location for early settlements, on *din dǭn* near streams, above *din tham*, and below *din khōk*, has both possibilities and limitations for the exploitation of both wetlands and uplands. Hypothetically, the location was near several major sources of carbohydrate, including wild rice and two species of wild yam. This location would also presumably be advantageous for the cultivation of both types of plants, and hence both wetlands and uplands.

However, the locations that apparently were not chosen by early settlers are also revealing. The hypothesized preferred location is not necessarily the most fertile location in the region for the collection or cultivation of any one resource. Interestingly, both prehistoric sites and modern-day villages do not seem to be located in close association with *din thom*, considered by local farmers to be the



Pl. III. Wild *Dioscorea alata* from *din dǫn* near Ban Chiang.

most fertile rice land when topographically suitable. When asked why this might be the case, my informant noted that diseases like malaria were associated with that forest type. A lack of association of early sites with *din dong*, considered the best garden land, is also noteworthy. The most likely explanation for the above is that *ease and potential for environmental manipulation and optional strategies in the face of unpredictable rainfall were more important than maximum productivity under ideal circumstances.* Crops (either wet rice or upland crops) grown on *din thom* are particularly vulnerable to the July dry period, as this land type dries out rapidly. Clearing the dense, tall vegetation of *din dong* probably required much more labor than the shorter and sparser vegetation on *din dǫn*.

A full description of upland cultivation in the Ban Chiang region today cannot be fully addressed here due to space considerations. However, a few key points should be mentioned with regard to the regional potential for upland cultivation.

Although some upland cultivation is undertaken in the region today, on the

Pl. IV. Wild *Dioscorea hispida* from *din dǭn* near Ban Chiang.

whole there are considerable environmental limitations upon this type of agriculture. The same factors that promote open, dwarfish deciduous vegetation on the Khorat Plateau—that is, moderate rainfall, a long dry season, and rapidly drained, nutrient-poor soils—limit the productivity of upland agriculture for much of the land area in the region. Montrakun states (1964 : 35): "Most of this forest occupies land which is considered to be not worth clearing for any other use," and that "A large proportion of the uplands, the undulating convex slopes, are too poor to produce any kind of annual crop" (Montrakun 1964 : 90). Upland cultivation requires a moist but not flooded soil that is much higher in plant nutrients than wetland rice requires. The quality and quantity of nutrients stored in the vegetation and released by the slash-and-burn operation varies for different forest types. Dry Deciduous Dipterocarp Forest is avoided by shifting agriculturalists in northern Thailand, because its low biomass and moisture content produce low-crop yields (Grandstaff 1976).

In the Ban Chiang region some limited slash-and-burn cultivation is done on small patches of denser, richer forest. It is, however, virtually always supplementary to wetland rice cultivation and is usually undertaken in an opportunistic rather than an "integral" manner (Spencer 1966 : 23). Many upland crops other than rice are cultivated, including cotton, indigo, corn, tobacco, melons, and so on. Interestingly, favored locales for upland cultivation are the termite mounds that dot the landscape. The soil from these mounds derives from deep clay beds, which are richer in nutrients than the surface soils. They can be cultivated for several years in a row.

Although upland rice is not currently cultivated in the immediate Ban Chiang region, it was grown in the past in a very limited manner to supplement the main rice crop grown in inundated fields. The variety of rice grown in upland fields had an early maturity, as is characteristic of upland varieties (Chang 1976:150), and, being photosensitive, matured in August. Because northeast Thai villagers considered harvesting rice during the rainy season extremely awkward, they usually planted upland rice only when the previous year's rice yield was inadequate to last through to the next main harvest. A small harvest during the latter part of the rainy season could tide a family over until the main harvest of the wetland rice began in late October–early November.

SOME PROPOSALS FOR THE DEVELOPMENT OF AGRICULTURE IN SOUTHEAST ASIA

The above observations on modern-day land use in northeast Thailand highlight certain interrelationships between humans and plants in the Asian subtropics relevant to the origins of agriculture in the region. I would like to conclude by presenting a series of general proposals and observations on processes involved in the development of plant cultivation and agriculture in Southeast Asia derived from the ethnoecological study in the Ban Chiang region. This study suggests that the development of upland and wetland cultivation strategies were integrally related, not mutually exclusive or sequential cropping techniques.

Early forms of plant cultivation must have developed from manipulation of *environments* as well as individual plant resources. From intimate experience of collecting in, and small-scale manipulation of, an environment, foragers learn about the environmental preferences and conditions necessary for the growth and productivity of various plants. Foragers could develop an array of strategies to promote access to or productivity of various resources, and this knowledge would become the basis for incipient agricultural practices. Of particular concern in understanding the development of upland cultivation is how fire might have been incorporated as a cultivation strategy.

The ethnoecological study recorded several strategies of environmental manipulation used by local farmers in the process of collecting wild resources. In addition to clearing out a few weeds to enhance productivity of a desirable plant and replanting the tops of wild yams to ensure a harvest the following year, local farmers used fire to get at otherwise inaccessible wild resources. For example, fire was used to assist in the collection of the lesser yam *man pōerm*. This yam is commonly found in dense thickets of *din thom*, which have defenses such as thorns, biting red ants, or stinging fruits. During the dry season the thickets can be burned, or even cut and burned. The collector then digs along the soil surface to locate the tops of yams. For yams like *man pōerm*, which grow densely in a restricted area, a significant amount of food can be collected. Similar use of fire by preagricultural societies in Southeast Asia seems highly likely.

Areas that have recently been burnt, accidentally as well as deliberately, represent a planting opportunity for local farmers. For example, a traditionally preferred locale in which to plant the most commonly grown domesticated legumes are patches of forest edge that accidentally caught fire during the dry-season burning of rice stubble. The farmers' rationale for this practice is that such areas have some sun, support for the vines, and considerable fertilizer from the ash. The legumes planted in these recently burnt patches produce a good yield. Significantly, this practice may represent an imitation of a naturally occurring plant behavior. According to my informant, the vines of certain wild legumes tend to grow on trees accidentally burnt during the previous dry season. Though one cannot prove the connection between the two, the cultivation practice may simply be an application of the legume's possible ecological role as a colonizer in the first stage in a succession following a fire disturbance. These examples show how deliberate and accidental fires can be used as strategies and opportunities for environmental manipulation.

Once environmental manipulation becomes an entrenched foraging strategy, genetic change occurs as a by-product of systematic efforts to enhance access to, productivity of, or convenience of selected resources. Simply seeding a plant in a different location (e.g., planting a rice physiologically adapted to absorb nutrients in inundated conditions in an upland field) will not necessarily produce a yield of sufficient satisfaction that the effort will be repeated. Successful trial and error required careful observation over time of "what worked," that is, what the plant responded favorably to in terms of the yield of the desired plant product. My informant pointed out that the conditions under which a plant might seem to flourish may not be the conditions under which the plant will produce a maximum yield of the desired product (as any novice gardener soon discovers). He suggested that one reason rice might not be planted on the fertile soil of *din dong* (aside from unfavorable drainage properties) was that it might produce tall sturdy leaves and stems but a lower yield of seed in comparison with less fertile soil. Under the soil conditions of *din dong*, certain varieties of rice might proportionally invest more energy in green leafy structures than in the production of seeds.

How Did Upland Rice Cultivation Develop?

If the earliest rice cultivation systems expanded locales where annual rice prefers to grow, it seems likely that wetland rice cultivation began very early in the seasonal tropics rather than the humid tropics as proposed by Hutterer (1983:200), because the ecology, and particularly the annual habit, are adaptations to seasonal expansion and contraction of bodies of water. In humid tropical regions that do not have a pronounced dry season or other locales that maintain year-round moisture, there is less ecological reason for plants to rely on an annual crop of large seeds. Rice in such locations will tend toward a perennial habit, with less investment in an annual crop of large viable seeds (Chang 1989; Shastry and Sharma 1974).

How did shifting cultivation of rice in upland fields develop, if we follow the plant geneticists and assume that rice was initially domesticated under inundated conditions? A key genetic attribute of primitive subtropical rices is photosensitivity—that is, the rice tends to mature and produce seeds based on changes in the length of day, irrespective of when the seed germinated. Ban Chiang–region farmers today will plant varieties of rice that differ primarily in the timing of maturation. On lower fields that can stay inundated longer, a rice with longer maturity will be planted early in the planting season but will be harvested late in the harvesting season. On higher bunded fields that can be kept inundated for shorter periods only, a short-maturity rice is planted late in the planting season but is harvested early in the harvest season. Farmers consider that some short-maturity varieties tolerate even intermittent inundation.

The author observed that wild rices also vary in their timing of maturation, presumably also governed by photosensitivity. Wild rice in locales whose water receded earlier (e.g., streams, shallower ponds) matured earlier than locales whose waters receded later (e.g., edges of larger lakes). It thus seems likely that the genetically controlled timing of maturity of wild rice growing in any particular locale is adapted to the water conditions as they average out over the years for that particular locale.

A farmer living near a lake in the Ban Chiang region noted that wild rice along lake edges is more productive in drier years in which the lake expands less than during wetter years.[11] This would make ecological sense, in that, if this rice is an intermediate annual/perennial, investment in a larger crop of viable seeds in dry years would enhance the plant's survival of an usually long and dry season. Thus, in drier years, wild rice would be a more productive and thus a more attractive food source.

Early manipulators of wild rice may have applied awareness of photosensitivity and the advantages of dryness for productivity and expanded the lake-edge environment outward, that is, toward areas that were likely to have shorter periods of inundation. In this process of expanding outward to drier zones, selection for seeds with earlier maturity may have occurred. This process could help account for why rice grown under upland conditions tends to have short maturity. Probably a threshold in the development of early rice agriculture was reached when knowledge of the relationship of timing of maturity and different water conditions was systematically used to exploit various topographic situations. If, over time, rice was consistently seeded on land with decreasing duration, depth, and reliability of inundation, eventually rice would be selected whose nutrient absorption was not dependent on water-born nitrogen-fixing fungi. Nutrients would then have to be absorbed from the soil. Thus richer soil would be required for upland rice than for inundated rice, and the shifting-field strategy would likely become necessary.

If manipulation of various plants and opportunistic use of fire as described above long preceded systematic cultivation, it seems likely that by the time varieties of rice were bred that produced a worthwhile yield in never inundated conditions, some sort of at least opportunistic upland cultivation was already in practice. Rice grown without inundation would then have been incorporated into a preexisting upland cultivation strategy. Once the techniques of growing rice in upland fields were developed such that reliable yields could be produced (presumably involving slashing and burning of relatively large plots of land and yearly shifting of fields), rice agriculturalists could move into hillier terrain than wet-rice agriculturalists could easily exploit.

SUMMARY AND CONCLUSIONS

In summary, it is proposed that both upland shifting rice cultivation and wetland rice cultivation as we see them today are highly evolved forms of much simpler,

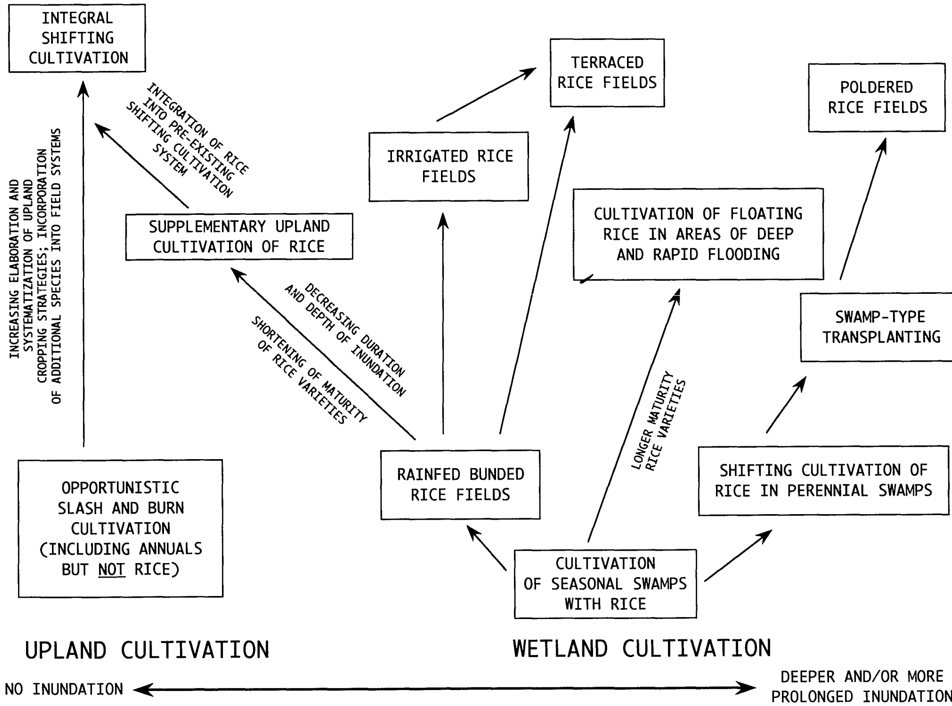


Fig. 6. Hypothetical developmental schema for some rice-cropping systems.

more opportunistic, less differentiated, and less organized versions in the distant past. The earliest stages of cultivating both wetlands and uplands likely coexisted, with rice (and other hydrophytic plants) initially grown in inundated conditions, and other plants (legumes, yams, other Southeast Asian domesticates) grown in noninundated plots. Both types of field systems probably had origins in subtropical climates with a seasonal distribution of rainfall. Although empirical evidence from archaeological contexts is not yet available to evaluate these proposals, the archaeobotanical assemblage from cave sites in northwest Thailand (Yen 1977), which contained remains of several annuals, including legumes that ultimately were domesticated in Southeast Asia, suggests that further investigation of Stone-Age contexts in that region for evidence of systematic environmental manipulation would be worthwhile (White 1994).

In conclusion, I propose that the essence of Southeast Asian agricultural development was not a transition from the cultivation of shifting fields to the cultivation of permanent fields, or from technologically simpler to technologically advanced, or polyculture to monoculture; rather it was a transition from haphazard, opportunistic, and diffuse to systematic, integrated, and focused. Various techniques (e.g., use of fire, shifting plant locations, seeding, weeding) were combined with an understanding (through observation and trial and error) of the environmental preferences of various useful plants. Depending on the environmental potential of a particular region and on sociocultural factors not addressed here (e.g., preferred diet, population pressure, territoriality, etc.; Rosenberg 1990), and as a result of choices from an array of known useful plants and optional manipulative techniques, certain plants received extended focused attention and certain cultivation strategies were elaborated. Suites of plants were incorporated into selected cultivation strategies that were increasingly differentiated over time. The systems that we recognize today as upland shifting rice cultivation and wetland rice cultivation evolved and differentiated from an ancestral swamp rice cultivation system (Fig. 6). In prehistoric northeast Thailand, earliest village settlers probably depended on a diversity of resources and exploitation strategies, but the cultivation of rice under inundated conditions held the best potential in that region for areal expansion and technological elaboration.

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NOTES

1. The earliest evidence for cultivated rice recovered thus far from archaeological deposits comes from sites in south China near Lake Dongting and the middle reaches of the Yangzi River, particularly the site of Pengtoushan dating 5000–7500 B.C. (Pearson and Underhill 1987 : 810; Yan Wenming 1991 : 120; Fig. 1). The climate of this area during that period was similar to that at the better-known but somewhat later rice-producing 6th millennium B.C. site of Hemudu to the south of the mouth of the Yangzi—namely, subtropical, warmer than the present, supporting wild tropical animals not found in that area for the last 4000 years (Liu 1985). A more temperate regime apparently ensued from about 2000 B.C. (Zhou and Wu 1989).

   The earliest archaeological evidence of rice from Thailand may consist of rice or impressions of rice in pottery found in archaeological deposits in northeast Thailand, which may date from the fourth millennium B.C. (see n. 2 below on dating). The rice from Non Nok Tha and Ban Chiang has been described as intermediate between a wild rice and a weed rice and as having some primitive characteristics (Yen 1982 : 63). Continuity from prehistory to the present of the faunal spectrum provides evidence to suggest that northeast Thailand has had a subtropical climate with marked seasonal distribution of rainfall since the time of its settlement by rice cultivators (Higham and Kijngam 1979). The Thailand Palaeoenvironment Project has extracted sediment cores from Sakon Nakon Basin lakes that are being analyzed for pollen and phytoliths in order to reconstruct the region's prehistoric environment more directly.

Although the coastal Thai site of Khok Phanom Di had been suggested as documenting a transition to rice cultivation (Higham 1984*a*), the site proved to date only to 1500–2000 B.C., and hence too late to be relevant to the early stages of rice domestication. Moreover, the rice recovered from the deposits was shown to be fully domesticated (Thompson 1992). Although currently located 22 km inland, pollen cores and faunal remains from the main deposit (stratigraphic zones A and B) indicate that the site was formerly much closer to the sea in a mangrove/estuary zone (Higham and Bannanurag 1991). It has been suggested on the basis of circumstantial evidence from pollen cores that rice might have been exploited near Khok Phanom Di as early as the 6th millennium B.C. (Higham 1989*b*: 238; Maloney, Higham, and Bannanurag 1989). However, the suggestion for 4th–6th millennium rice "propagation" (Higham 1989*b*; Higham and Maloney 1989) in this area should be viewed with skepticism. Unless protected by coastal embankments, the coastal zone where mangrove is found today is considered unsuited for rice cultivation because of daily tidal incursions of salt water (Takaya 1987 : 64). Even interior portions of mangrove swamps are marginal to rice cultivation due to chemical problems in saline and acid sulfate soils that require somewhat sophisticated management to produce reliable yields (Kawaguchi and Kyuma 1977 : 189–192). Such a location cannot be considered optimal or desirable for primitive rice cultivation.

2. At the time of writing, the beginning date for early rice cultivation in northeast Thailand is controversial. Five dates from basal deposits of three excavations in Sakon Nakon Basin village sites have suggested that rice cultivation may have appeared in the region as early as the mid-4th millennium B.C. (White 1986 : 222–223). This interpretation has been questioned and a proposal for 1500 B.C. has been proffered for the settlement of Ban Chiang (Higham 1994). The Ban Chiang Project is currently undertaking a comprehensive program to AMS date burial pottery from Ban Chiang and two other sites in northeast Thailand. In addition to this evidence, dates from sediment cores extracted from Sakon Nakon Basin lakes by the Thailand Palaeoenvironment Project should resolve the issue of dating the settlement of northeast Thailand by rice agriculturalists.
3. Figure 4 was prepared from a map in a publication of the Royal Forest Department (1962). Bayard (personal communication) has informed me that the forest types noted for areas in the Phu Wiang area do not conform to his experience.
4. Intriguingly, this agriculturally favorable location applies to Nam Phong sites only used as cemeteries during General Period B (Wilen 1986–1987).
5. Transliteration follows the Library of Congress system in Barry 1991.
6. Because the available settlement pattern data derive from studies biased toward alluvial contexts (Wichakana 1984; Kijngam et al. 1980; critiqued by Mudar n.d.), the prehistoric settlement patterns in this region should be reexamined using more comprehensive surveying techniques, such as those employed by Mudar (1993) in central Thailand. The inclusion of geomorphological techniques would help determine if early lakeside sites, which have so far not been identified, might have been subsequently covered with silts.
7. The local inhabitants do not distinguish lakes from marshes. They use the term *nong* to refer both to perennial bodies of water that in temperate regions might be called "lakes" and to seasonal ponds full of reeds that have the appearance of "marshes" to English speakers.
8. Oka (1988 : 30–31) reviews quantitative studies documenting species diversity and percent biomass showing that wild rice can strongly dominate its habitats.
9. It should be noted that Higham and Kijngam (1979) have argued that streams near Ban Chiang were perennial during the initial settlement and permanent as recently as 50 years ago. The author could not confirm this latter statement during the 20-month study in Ban Chiang. When asked if there was water 50 years ago in the nearby streams during the dry season, and where the water came from, village elders stated that the water did not *flow* during the dry season but was caught in the *wang*, or dips in the undulations of the water courses. With the paucity of springs and the probably marked seasonality of rainfall, it seems best to assume, until further evidence shows to the contrary, that the upper courses of the drainage systems in the Ban Chiang area have had seasonal flows for several thousand years, even if forest clearance has changed some of the dynamics of the region's hydrology.
10. A similar swamp cultivation system has been described for twelfth-century southern China by Ho (1969 : 25).
11. Whyte (1985 : 259) notes that annual components of perennial gramineae species increase under the influence of physiological stress involving an increase in aridity.

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ABSTRACT

Ethnoecological research in northeast Thailand suggests that both wetland and upland rice cultivation emerged from a common beginning in manipulation of wild rice in seasonal swamps. The field research revealed extensive variants of wetland rice cultivation that show how it can be viewed as mimicking wild rice ecology and hence as an extension of rice's natural environment. This picture contrasts with the traditional portrayal of wetland rice cultivation as necessarily labor intensive, technologically advanced, and environmentally transformative. Upland cultivation of rice would have emerged as rice was grown in increasingly dry locales, necessitating genetic and physiological adaptations in nutrient absorption and timing of maturity. It is hypothesized that upland rice was then integrated into a preexisting swidden cultivation strategy. Furthermore, it is suggested that the early subsistence strategies of northeast Thailand included cultivation of wetland rice in permanent fields using extensive strategies, cultivation of uplands (of species yet to be determined) probably using shifting field strategies, as well as collection of diverse wild resources.
KEYWORDS: rice, agriculture, swiddening, Ban Chiang cultural tradition, ethnoecology, Thailand.