A 10,600 YEAR POLLEN RECORD FROM NONG THALE SONG HONG, TRANG PROVINCE, SOUTH THAILAND

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Abstract

Although long occupancy of south Thailand has been recorded at Lang Rongrien rock shelter, little detailed palaeoenvironmental work has been published from the peninsula. This account begins to rectify the situation using palynology and microfossil charcoal analyses from a core extracted at Nong Thale Song Hong. Interpretation of the results is difficult, and there are unresolved inconsistencies in the radiocarbon dates. The fire record is longer than expected, given the latitude of the site, and the vegetation was never stable for long, probably due to hydrological changes, altering climate and soils, as well as human impact. The topography makes the site more useful for tracing local vegetation changes and lake level variations than oscillations in regional vegetation.

Introduction: location and physical background

Nong Thale Song Hong is a shallow bean-shaped lake located at 7° 52 N., 99° 28'50" E. (Figure 1) north of Trang, south Thailand. The sediment core was collected by Dr Lisa Kealhofer (College of William & Mary, Virginia) and Dr Joyce White (University of Pennsylvania Museum) in December 1994. The site is at c. 100m altitude and has no inflowing or outflowing streams and the core was extracted from the deepest part of the lake, but borings were not made to determine the spatial variations of the stratigraphy. The highest point in the nearby region is at about 400m altitude, around 14 km south west of the lake. Nong Thale Song Hong is located in an area of acid to-moderately-acid shales, sandstones and sandy shales of the Kanchanaburi Series (Figure 2) which have often been metamorphosed to phyllites, argillites, quartzites and slates (National Resource Atlas 1969). The Kanchanaburi Series ranges in age from the Early Carboniferous to Devonian and Silurian. The soils near the site are red-yellow podzolics (Figure 1). Red yellow podzolics correlate roughly with the ferrugineous soils of French and Belgian soil classifications (Young 1976) and have some weatherable minerals remaining, so they are more chemically fertile than ferrallitic soils. They form under seasonally dry climatic conditions, while ferrallitic soils develop under ever-wet conditions. Red-yellow podzolic soils commonly occur under various types of wooded savanna vegetation whereas ferrallitic soils are characteristic of humid tropical rainforest areas. The 1:50,000 soil map for the area shows the site to be surrounded by the Fang Daeng soil series. To the north, in the hills, soils series 104, 'slope complex' (colluvial soils) occurs, while the other soil series in the vicinity is the Kho Hong 'mottled association'. The fact that the Kho Hong association is mottled confirms that there has been drying out, with oxidising conditions replacing reducing conditions.

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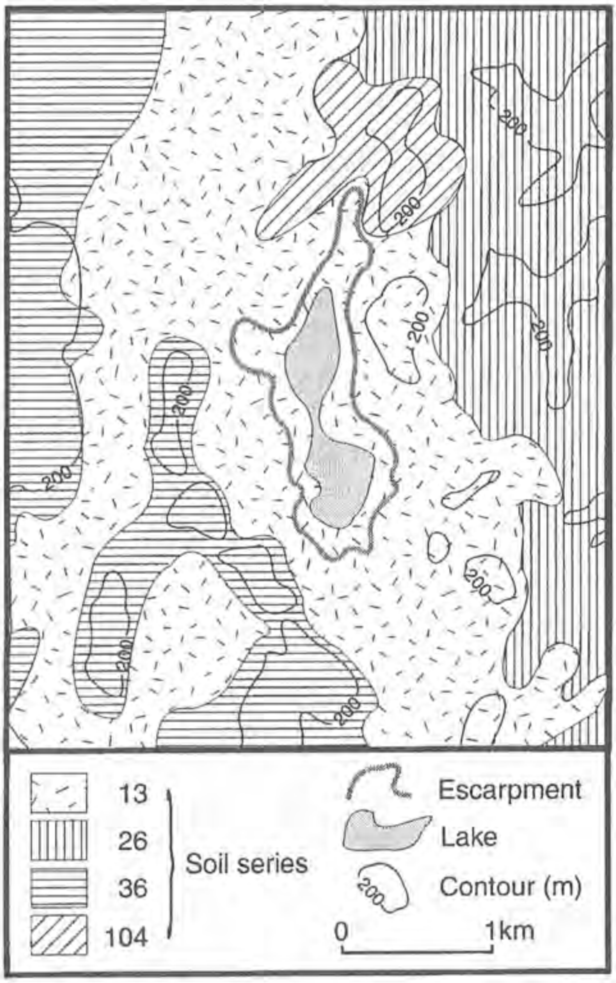

Figure 1 Location map.

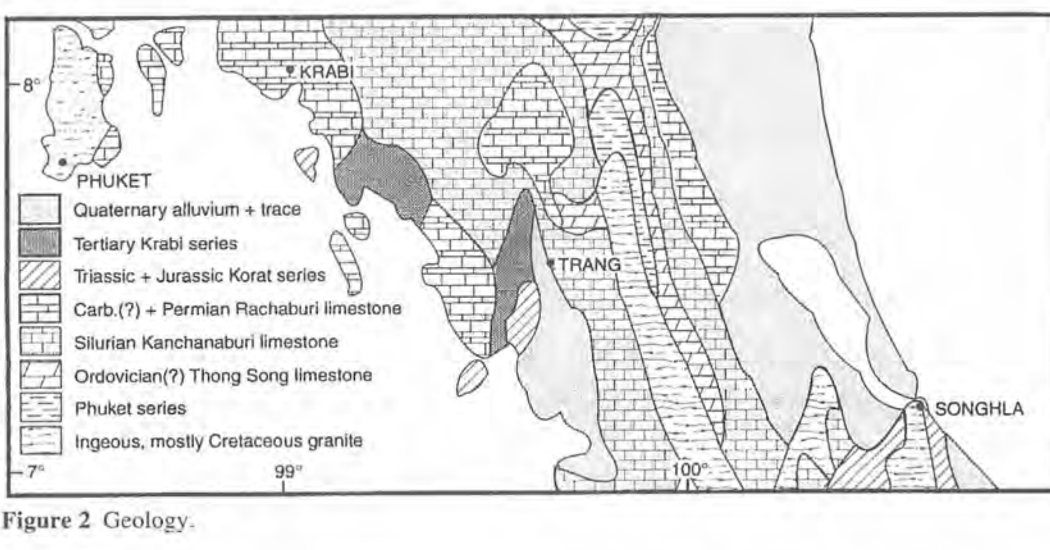

Figure 2 Geology.

Table 1 Rainfall and temperature records of the Trang recording station: 1931–60, temperature 22 years

	J	F	M	A	M	J	J	A	S	O	N	D
Rainfall	38.6	25.5	64.2	176.9	214.2	216.8	238	254.9	282.2	303.4	255.1	106.2
Temperature	26.7	27.7	28.7	29.1	28.2	27.6	27.2	27.2	27	26.7	26.7	27.5

(from Donner 1978)

The present climate is characterised by mean annual temperatures ranging between 26–28°C, a mean annual relative humidity above 80 per cent, due to the surrounding seas (Trang has a mean of 88.6 per cent for October), and a mean annual evaporation of between 800–1,000mm (Donner 1978). This is a region with variable mean annual rainfall. The east of the peninsula differs from the west, and extreme values have been recorded: Ranong, on the west coast, had 6,699.5 mm in 1955 and Narathiwat, on the east coast, had 625.9 mm on the one day of 2 January 1995. Rain falls throughout the year and the Trang area has a Koppen type Am climate with heavy annual rainfall and a short drier season from January to March, so most rain falls in summer, from the south west monsoon. Trang had a mean annual total of 2,177.7 between 1931–60 (Table 1). The south west monsoon starts in April and reaches a maximum in October. Thereafter the north east monsoon begins to dominate. The east coast differs. It has moderate rainfall from January to September while most precipitation occurs during the period of the north east Monsoon in early winter (from October–December). Additionally, rainfall amounts tend to be lower on the east than the west coast. Higher west coast rainfall means lower losses through evaporation.

The nearest hydrological station to the pollen site with long records is in the Trang-Satun catchment on the Khlong Na Ngu at Satun. This has its maximum discharge in November. A ten year record from the Mae Nam Trang at Ban Prude Tai also shows a November flow maximum and the difference between low and high water is 6m. Seasonal changes in lake levels have not been recorded.

The natural vegetation of the area is said to be lowland tropical rainforest dominated by tall trees in the Dipterocarpaceae family (National Resource Atlas 1969; Donner 1978). Dominant species include *Dipterocarpus alatus*, *D. gracilis*, *D. chartaceus*, *D. costatus*, and *D. grandiflorus*, with *Hopea odorata*, various *Shorea* species, *Lagerstroemia speciosa*, *Schima wallichii*, etc. Lauraceae, Myrtaceae and Annonaceae are generally predominant in the lower levels and Acanthaceae and Rubiaceae are well represented as undergrowth shrubs. Bamboos are rare, except for climbing forms, but palms, canes and other monocotyledons are abundant. However, the only ecological study from the region (Ogawa et al. 1965) from Khao Chong, twenty two km east of Trang, on the western slopes of the central mountain range, shows that when the Dipterocarps are removed other taxa take over as dominants, e.g. *Eugenia clarkeana*, *Alstonia spathulata*, *Padbruggea pubescens*, *Sterculia* spp., etc.

Where swamp forest occurs (Donner 1978) it consists of *Lagerstroemia speciosa*, *Elaeocarpus* spp., *Fagraea fragrans*, *Alstonia spathulata*, *Eugenia* spp., *Saraca* spp., and many types of canes.

Human occupancy and land use

The oldest archaeological site in the region is the Lang Rongrien rock shelter (Anderson 1997) which ranges in age from 3500 BP to greater than 43,000 BP. This is located at 8° 13'N., 98° 53'E. (Anderson 1988). The site seems to have been a hunter camp before the last glacial maximum and chipped stone tools (mainly flakes) and stone debitage, as well as faunal remains, were found, while there were traces of camp fires. The cultural remains above these consisted of 1m of occupational midden, with implement assemblages resembling those labelled elsewhere as Hoabinhian, dating to the early Holocene. During late prehistoric times the site was used as a short term shelter and, between 4000–2500 years ago, as a burial site.

As at Hoabinhian sites in Peninsular Malaysia (Bellwood 1993), plant remains were absent, but Bulbeck (1985) suggested that teeth excavated from the Gua Cha, Kelantan, rock shelter indicated that the people had a well balanced diet with considerable fibrous, starchy vegetables, especially yams, and a relatively large proportion of sweet foods, e.g. fruits and honey. Phytolith analysis of sediments from Gua Chawas, another limestone cave in Kelantan (Bowdery n.d.) partly substantiates this (phytoliths are microscopic pieces of biogenic silica which assume the shape of the plant cells in which the silica is deposited). Unfortunately yam pollen has never been found as a fossil and that from fruit trees is not possible to identify to the species.

Other sites in the Trang-Krabi area, which may date from 6000–5000 BP, include Khao Khanab Nam, Na Ching and Tham Phi Huato. The occupation of Khao Khanab Nam appears to relate to the period of high sea level from around 6000–5000 BP. The middle Holocene sites contain pottery (absent from the early levels at Lang Rongrien) and ground stone tools, especially adze/axe blades. These suggest that forest trees could be felled but whether or not they could be used to cut down large dipterocarps needs to be tested through experiment. No edge wear analyses have been carried out on these tools. Evans (1931) reported adze heads from Chong in the Trang-Phattalung hills. It is not clear from the literature if any lakeside occupation has been detected in the region.

As for later times, Chinese sources indicate that several small coastal settlements in Peninsular Thailand had developed into something larger and more culturally elaborate by the third century AD (O'Connor (1986). However, the west coast has less natural harbours or rice plains than the east and the only important early settlements found so far are at Amphur Takuapa, Phanga Province, and Khuan Luk Pat, Krabi Province. Both of these sites are situated on river systems. Kuan Luk Pat, the less studied of the two, is the older and has yielded finds of small seals similar to those from Oc-Eo, which may date to the first-third centuries AD. Old, but undated, tin workings (Bourke 1905) occur in the Trang-Phuket region. These are largely in alluvial deposits. What are termed 'Indian' remains were also found, imprecisely dated, but probably from the 11th–12th century. Finds include unbaked clay tablets from the limestone caves of the Trang area, some with Buddhist texts in Sanskrit, which possibly also date to the eleventh century AD.

There appears to be little other historical information from the Trang Province, but the Kra Isthmus was a very important trading point on the India-China route. Indian merchants (Donner 1978) used to call at Phuket to trade in tin (there are several deposits in the Mae Nam Trang valley), gold and spices while Chinese junks served ports on the east coast. There was a trade route from Trang across the peninsula to Phattalung in the east.

The current occupants of the area are ethnically Malay but the Chinese operate the rubber plantations, plant pepper and mine tin. Mokens, Orang Laut, or sea gypsies, are found along the coast. They used to use materials from the forest to build their boats and to make implements and utensils. Brandt (1961) reported that *orang asli* were present in the Trang-Phattalung area. They are commonly called the *sakai* in south Thailand. The Tonga group living in the Khau Banthat Range between changwat Trang and Phattalung were said to include some who lived in caves, to have had blowpipes, quivers, Jews' harps, and pandanus baskets, and to have spoken a Mon-Khmer language. They did not move erratically, but within a defined area, and only when food ran out. Their constructions consisted of bamboo sleeping platforms and windscreens of bamboo and thatch Other plant materials used by the *orang asli* include coconut shells for bowls, scrapers and belts of rattan, wooden cudgels, leaves as plates, bamboo to cook rice and vegetables and store water, bark cloth from an *Artocarpus* species and *Antiaris toxicaria* (*ipoh*, also used to poison darts). No attempt was made to preserve food, e.g. by drying, or the use of salt.

South Thailand is mainly an area of tree crops (Donner 1978), the foremost being rubber, which was introduced to Trang from Malaya in 1901. Rice is the crop with the second largest cover in the province, followed by coconuts, maize, cassava and peanuts. Double cropping of rice is rarely practised. The minor crops include mung beans, sweet potatoes and sugar. There are the usual bananas, pineapples and water melons.

Perennial fruit trees are grown on upland soils more as forest than orchard, or they are grown in gardens or farmyards. The largest numbers of trees are various types of oranges, followed by the rambutan, limes and mango. There are about nine million areca palms and about one million kapok trees in south Thailand.

Forest products include rattans, e.g. *Calamus caesius*, which is used to make cane seats, with its core used for reed furniture, and *C. scipionum* which is used to make walking sticks. *Dipterocarpus* spp., *Anisoptera* spp. and *Shorea hypocha* contain resins employed to make varnish, while *Garcinia hanburyi* has a bright yellow gum, called *gamboge*, which is of much commercial value. *Palaquium obovatum* produces gutta-percha, an insulating material. *Dipterocarpus* spp. yield wood oil for torches, caulking boats, varnishing, and water-proofing basket ware. Cardamom is derived from the fruits of *Amomum crervanh*, *jelutong*, a base for chewing gum, from *Dyera costulae*, and incense sticks from *Mansonia gagei*, *Aquilaria crassna* and *A. agallocha*. *Hydnocarpus kurzii* contains *chaulmoogra* oil which is used to counteract leprosy, corphya leaves from *Corphya umbraculifera*, an exotic palm (Smitinand 1980: 94), are used to make hats and *Phung-ta-lai* fruits from (*Scaphium macropodum*) *Sterculia lynchnophora* are exported for confectionery.[1]

Evidence for past environmental changes from South Thailand

The main evidence for past environmental changes in south Thailand comes from coastal geomorphology (c.f. Tjia 1996). Much of the Sunda Shelf was dry land during the last glacial period, but sea level rose rapidly during the early Holocene, and was 4m higher than present between 6000–4800 BP, about 2m higher around 4000 BP, 2m about 2500 BP and 1.5m about 2000 BP with regressions in between these dates (Figure 3).

Two pollen diagrams from the area have been published (Hastings 1983; Thanikaimoni, in Stargardt 1983, 1998) but both are from east of the mountain divide and extend back to no

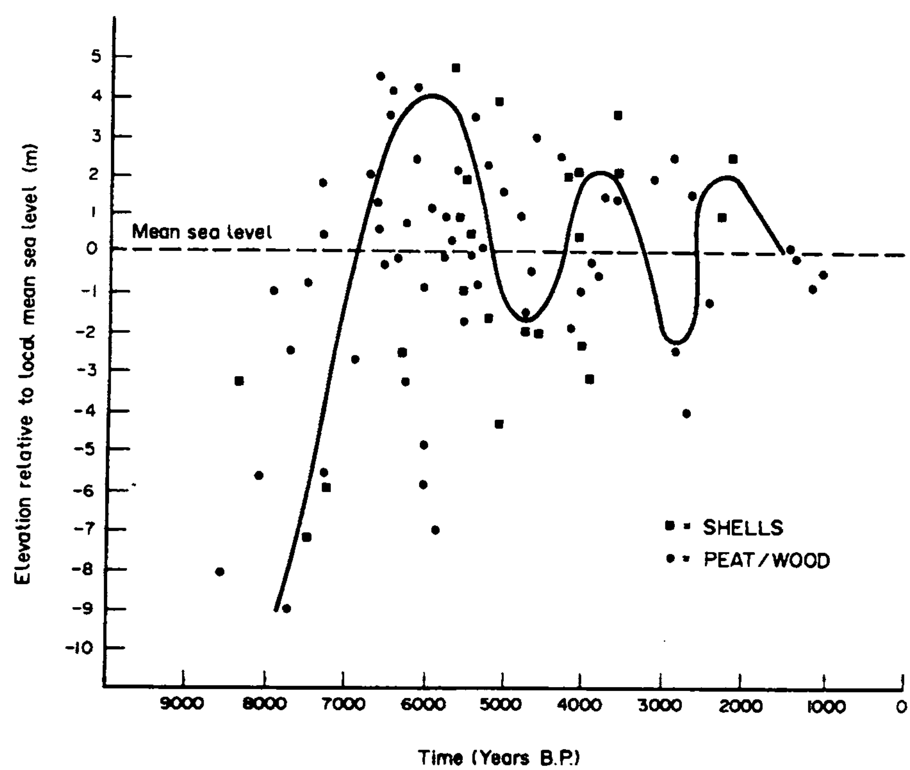

Figure 3 Holocene sea-level curve.

more than 4,000 BP. The Sathingphra core has not been directly dated, and as Allen (1988–89: 169) has pointed out, the inferred age of the basal sample is incorrectly calculated, so there is no reason to accept the argument (Stargardt 1983, repeated in Stargardt 1998) that forest clearance began 4000 years ago, while only one radiocarbon date (laboratory number not given) is available from Narathiwat.

Where *Borassus* pollen is present in the upper part of the Sathingphra diagram it is safe to assume that wet rice cultivation was taking place as this introduced sugar palm is typically planted on rice field bunds. However, we know from the Lang Rongrien, Krabi, dates on charcoal that people have been using fire on the peninsula for at least 37,000 years and the possibility that natural forest fires occurred during drier periods, e.g. El Nino events, cannot be ruled out, especially for glacial times.

Only ten samples from the Narathiwat core have been analysed and no indication is given of how many pollen grains were counted and it is not clear which taxa were used to derive the percentages. The lowermost sample was dominated by palm pollen, especially that of *Areca*. Only three species of *Areca* appear to have been reported from Thailand: *A. catechu*, the cultivar, *A. laosensis* and *A. triandra* (Smitinand 1980). *A. laosensis* seems to have a local name solely in Trat, and may be confined there, but *A. catechu* occurs widely. It is tempting to think that the *Areca* may have been cultivated, especially in view of the late date for the deposit. *Areca* pollen is also present at Sathingphra (Thanikaimoni 1983), in core KL 2 from Khok Phanom Di (Maloney 1991), as well as at Nong Thale Song Hong. Grass pollen was fairly abundant too, as was the possible forest clearance indicator, *Macaranga*.

Further up the diagram, more mangrove and mangrove transition taxa occurred. The latter included *Pandanus* and *Nipa*. Hastings suggested that the conditions had become more brackish. This is certainly true, but well developed mangrove forest is not represented. Three possible explanations of the changes were put forward: that a minor marine transgression took place; that tidal inlet patterns changed due to siltation or marine transgression; or, simply, as a result of the mangroves moving landwards. It is difficult to disagree with any of these alternatives, or to choose among them.

Continuing upwards, the variations are suggestive of vegetation succession within a freshwater swamp forest. *Melaleuca* in particular became better represented and *Elaeocarpus*, a taxon which can grow in a wide variety of ecological conditions, had high percentages throughout, indicating that it probably grew near the pollen accumulation site. The percentages of some low pollen producers, e.g. *Dysoxylum* and *Aglaia*, were large enough to suggest that they too were to be found locally. A re-emergence of *Hibiscus*, a minor pollen taxon lower down, in the upper part of the diagram is also notable. This plant produces very large, distinctive, pollen grains which are unlikely to travel far. More important though is the appearance of *Trema*, a weed tree, which may indicate disturbance of the vegetation. A rise in palm pollen also took place, but closer identification of the palm pollen is needed to deduce what this means. Hastings interpreted this part of the diagram in terms of the first impact of man, using *Trema* and *Lycopodium* to do so, but *Lycopodium* can be a common wetland plant and has spores which are almost certainly only locally dispersed. The taxon may sometimes be identifiable to the species level, e.g. *L. cernuum* (cf. Knox 1950; Huang 1972). The disappearance of Dipterocarpaceae is far more significant as the family includes taxa which yield excellent timber and because the pollen is usually under-represented in the pollen record. This is a better indicator of disturbance.

Nong Thale Song Hong: field and laboratory methods

The pollen core was extracted using a modified Livingstone piston sampler. This type of borer uses the barrel of the corer as the tube in which the sample is retained. Once a core section has been extracted, the top and shoe of the borer are removed, the barrel is stoppered at its top and bottom, labelled, and stored for transport back to the laboratory. It is then replaced by another barrel, and the process begins again. The disadvantage of this method is that it is only possible to know what type of sediment you are coring through by looking at what adheres to the outside of the barrel, and to the shoe. Sediment characteristics cannot be recorded until the core is extruded in the laboratory.

The samples upon which this research is based comprised two cubic centimetre sub-samples taken at 5 cm. intervals from the 5.5 to 145.5 cm levels of a 3m core. The material was all fine grained: clay, silt, to medium sized sand with clay predominating. Standard laboratory techniques were used in processing except that samples were left to disaggregate in cold hydrofluoric acid for a week to gently destroy as much silica as possible, then the process was speeded up by heating in a water bath for about five minutes. The subsequent preparation involved treatment with Calgon to deflocculate and disperse the clays. Five tablets containing a known number of marker *Lycopodium clavatum* spores (cf Stockmarr 1971) were added to each sample to derive pollen and microfossil charcoal concentration figures. The pollen spectra have been interpreted using information concerning the topography of the site, ecological and botanical literature and field work experience in other parts of Thailand. The author has not visited Nong Thale Song Hong.

Radiocarbon dating

Five AMS radiocarbon dates have been obtained from the core (Table 2). All the samples were pre-treated at the Beta Analytic laboratory and measured using the Oxford University accelerator. The dates from core sections 2TS1, 2TS2 and 2TS3 (Table 1), are consistent, but the two dates from section 2TS4, while consistent for that section of the core, do not fit in with the overlying sequence.

It has been assumed here that the dates from 2TS1-3 are in a reliable sequence and that the base of the core is about 22,000 years old. This is being tested by measuring the $\delta^{13}C$ values for several other samples from the cores and through phytolith analysis. Only one sample from 2TS4 contained enough pollen to be countable and this suggested a duplication of core 2TS3. The pollen record from c. 10,650 upwards shows a coherent set of vegetation changes and it is difficult to see how either tectonic activity or inwash of old carbon from the slopes could explain the inversions and the lack of countable pollen in the other samples.

The pollen and pteridophyte spore record

Only core sections 2TS1 and 2 will be considered here. Firstly, looking at the general changes in the pollen and pteridophyte concentrations (Figure 4), it appears as if there was greater deposition in the early period but these figures have been derived using just two radiocarbon dates and sedimentation rates may have varied quite considerably at different times during the Holocene. Using those same two dates to calculate pollen deposition/cc/yr indicates that the high pollen and pteridophyte concentration rate is more apparent than real (Figure 5) but the concentrations/cc and concentrations/cc/yr run largely parallel for the middle to later Holocene. The same is true for microfossil charcoal particle concentrations. The high value for the c. 10,300 BP level may not be real, but all the later ones are. A greater pollen and pteridophyte spore deposition in the early Holocene would imply wetter conditions than at present due to an intensification of the south west monsoon rainfall as the airmass passed over a larger expanse of sea as sea level continued to rise and was able to pick up more moisture. At this time the watertable may have

Table 2 AMS dates from Nong Thale Song Hong, Trang

Core number	Depth (cm)	Radiocarbon age (uncalibr.)	Laboratory number	$\delta^{13}C$, parts/mil	Sediment-ation rate (cm/yr)
2TS1	84-90	6330±50	Beta-106539	-26.0	0.014
2TS2	50-60	10,820±50	Beta-106537	-25.4	0.015
2TS3	36-40	21,170±90	Beta-106538	-22.3	0.007
2TS4	25-31	9,420±50	Beta-106540	-27.4	0.004
2TS4		16,490±120	Beta-101966	-27.9	

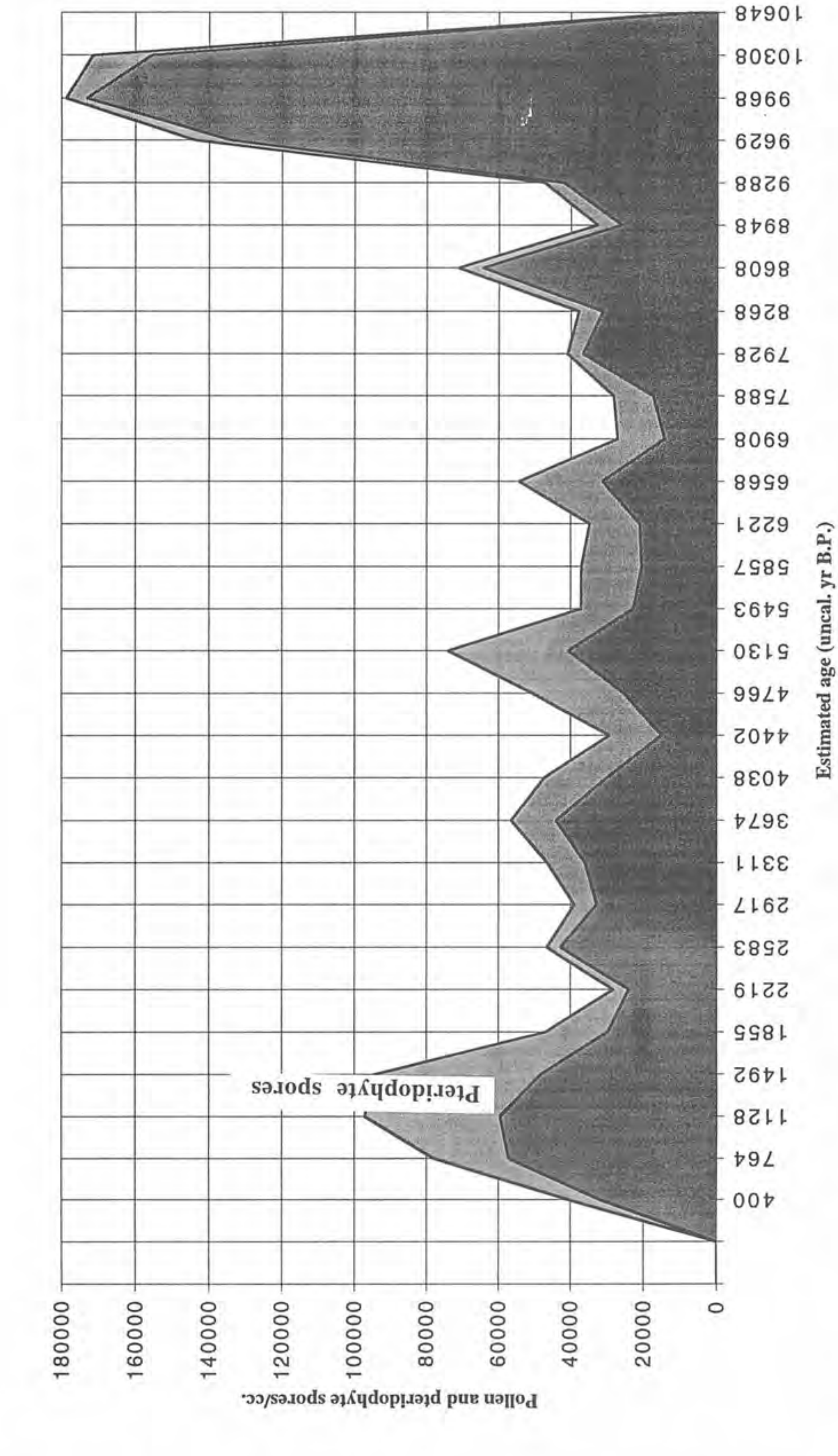

Figure 4 Nong Thale Song Hong: pollen and pteridophyte spore concentrations/cc.

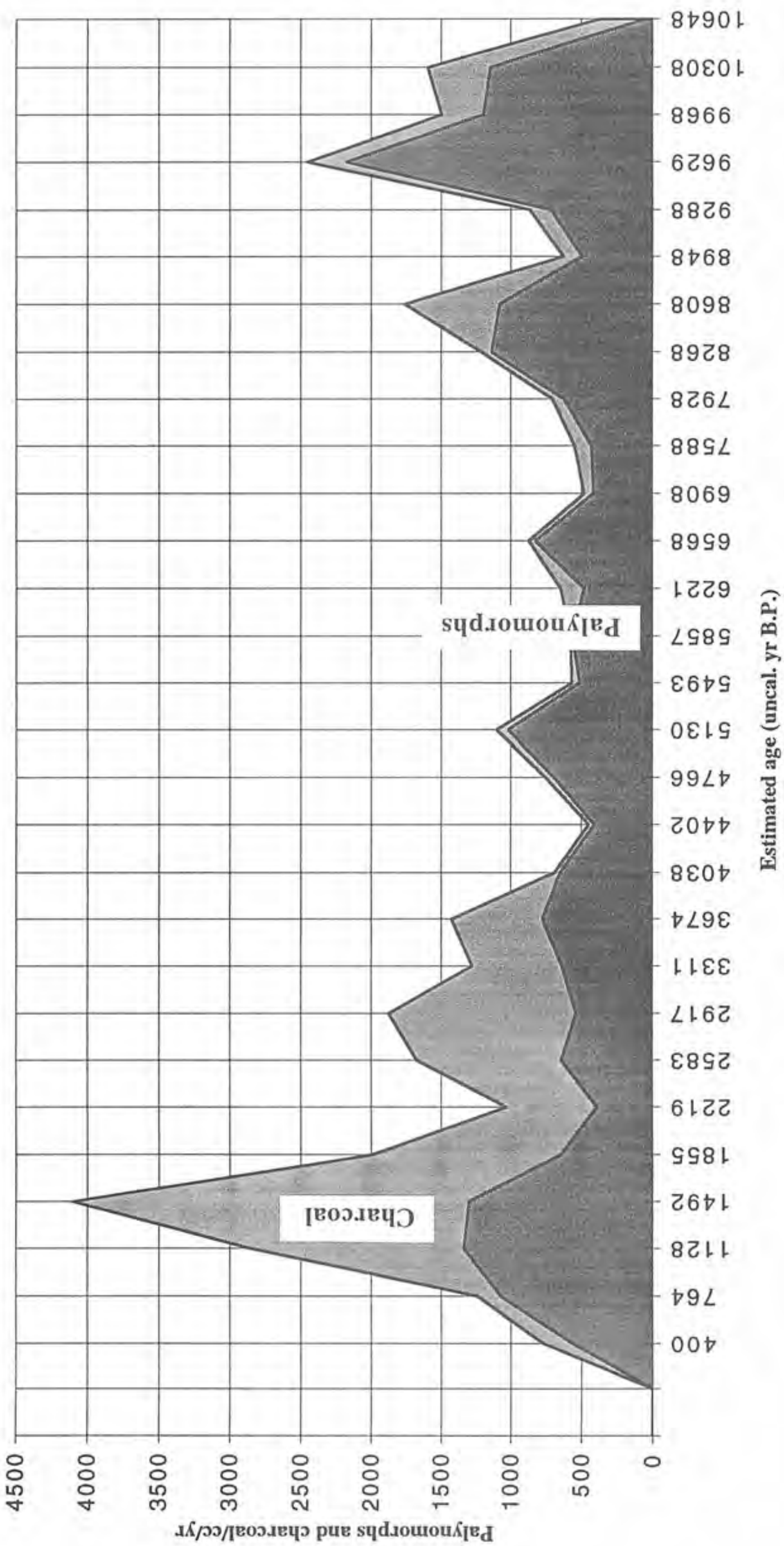

Figure 5 Nong Thale Song Hong:palynomorphs (pollen and pteridophyte spores) and charcoal /cc/year

been rising rapidly, and the rivers grading to new, higher, base levels as sea level rose.

Van der Kaars (1990) attributed increases in pteridophyte spore frequencies in deep sea cores from eastern Indonesia to wetter conditions, and therefore an increase in fluvial transport. Fern spore concentrations at Nong Thale Song Hong are above 10,000/cc. around 10,300 BP, from c. 7600–3300 BP and between c. 1900–760 BP. However, most types that could be identified with any precision are taxa of dry slopes (Tagawa and Iwatsuki 1979 a,b,c,d,e, 1985, 1989) and the spores are likely to be of local origin. So, conditions in the lake basin may have been drier, not wetter, at these time periods. The highest pteridophyte spore concentrations occurred around 5100–4800 BP and in the recent period. The peaks do not show a consistent relationship with those for microfossil charcoal concentrations and the charcoal increases before c. 2900 BP, especially, appear to relate to edaphic conditions and not to regional climatic variations. With edaphic dryness on the slopes, a rise in the concentrations of tree taxa characteristic of mixed Dipterocarp forest might be expected. This does indeed occur, particularly between 7600–3300 BP but, again, the concentrations are not completely consistent with those for the pteridophytes. That the figures are much lower is not a surprise as the taxa concerned: *Acacia/Albizzia*, Combretaceae/ Melastomataceae and *Lagerstroemia* are poor pollen producers and the pollen is not likely to be well dispersed. The Dipterocarpaceae pollen concentrations (*Dipterocarpus*, *Shorea* and *Hopea* types) follow the general trend of the dry forest elements suggesting that mixed Dipterocarpaceae forest was represented on the slopes (Figure 6).

Interpretation is further complicated by two factors: the strong fire record, which may be both of natural and human origin, and the possibility that the lake was surrounded by fringing forest. Trees which could occur in such a forest include the Fagaceae (*Castanopsis/ Lithocarpus* and *Quercus*), *Elaeocarpus*, *Calophyllum*, *Carallia brachiata*, *Eugenia* and *Ilex*. Unfortunately *Carallia brachiata* is the only one of these that has pollen which can be identified to the species. Ding Hou (1970: 13) indicates that this is a tree of evergreen or mixed forests but is sometimes found at the edges of freshwater swamp forests.

It is possible that swamp forest existed for all of the 10,650 year continuous record and that grass dominated the water front vegetation. This grass could have included wild rice as pollen within the size range of rice occurs consistently throughout the record.

Vegetation disturbance indicators

Turning to the record of the disturbance indicators (Figure 7), these include *Macaranga/ Mallotus*, *Celtis timorensis* type, *Myrica*, *Ardisia*, *Maesa*, *Trema*, Urticaceae/Moraceae, and, possibly, *Schima wallichii*. The grasses cannot be regarded as completely reliable disturbance indicators since they can grow in such a wide range of ecological situations: on peats, dry land, and in the forests. The strongest records are those of *Macaranga/Mallotus*, Urticaceae/Moraceae and *Schima wallichii* which is the only taxon with pollen identifiable to the species. However, it can grow over a wide altitudinal range and in various ecological conditions. Its highest pollen concentrations occurred after the palm *Borassodendron machadonis* faded from the record around 4000 BP and it persisted until c. 2900 BP suggesting that it might have been a regrowth tree. It was also important in a sample dating to c. 1100 BP.

Borassodendron machadonis is very rare in Thailand and peninsular Malaysia today, but has a large, very distinctive pollen, cf. Ferguson et al. (1987), and could be a useful indicator type if more was known of its present day ecology. Smitinand (1976) found it at 120–160m altitude in the Surin Islands, similar heights to those of the study region.

Macaranga and *Mallotus* can grow in a wide variety of ecological situations, including fringing forest and evergreen rainforest, but are characteristic small trees of regrowth following natural and anthropogenic vegetation disturbance. Their record is surprisingly almost continuous over time, with absences only from two samples which may date to c. 10,650 and 8600 BP. There is a peak at c. 10,000 BP which corresponds to one in the microfossil charcoal record and the dry forest concentration record and suggests that the vegetation on the slopes

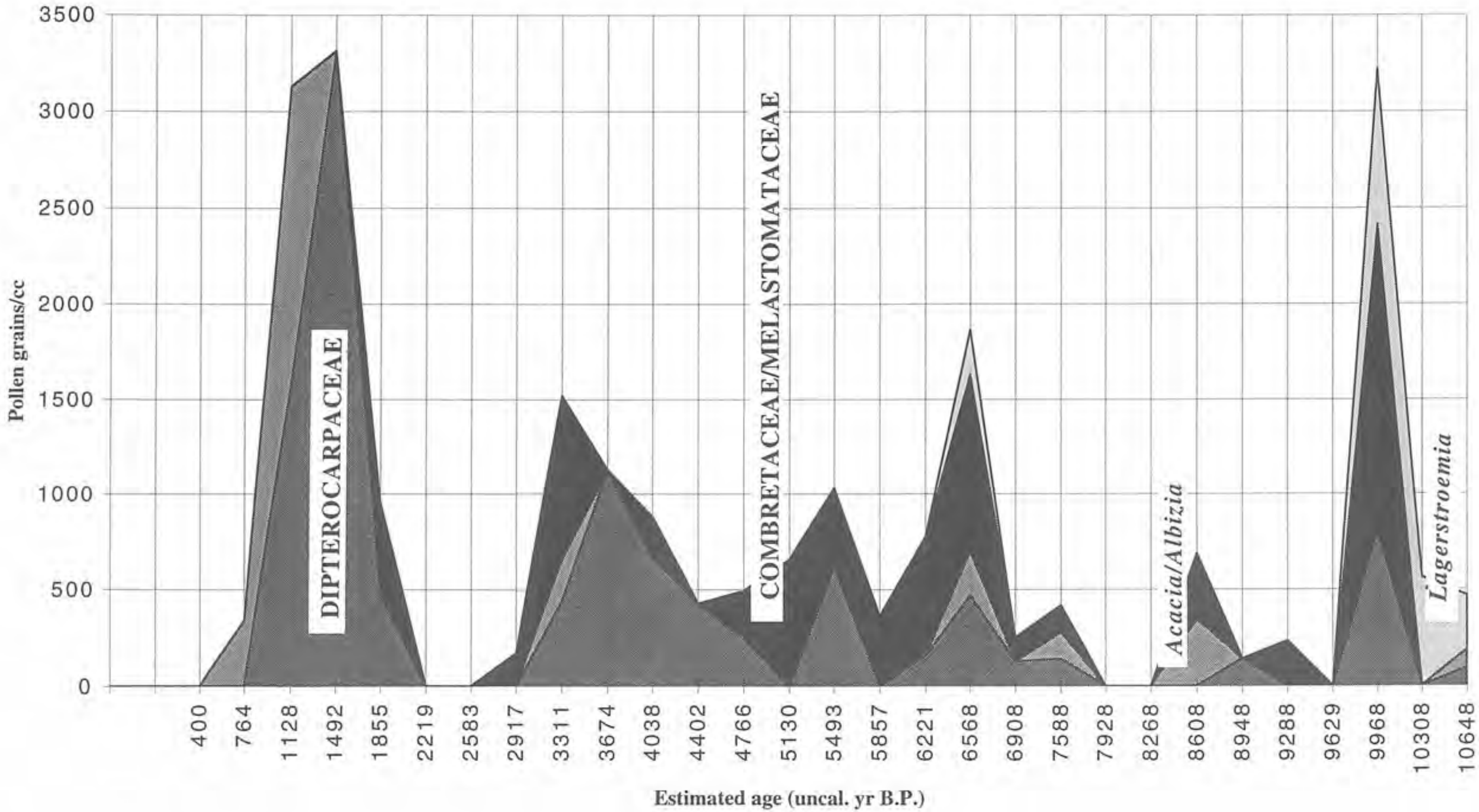

Figure 6 Nong Thale Song Hong: Dipterocarpaceae and dry forest pollen taxa.

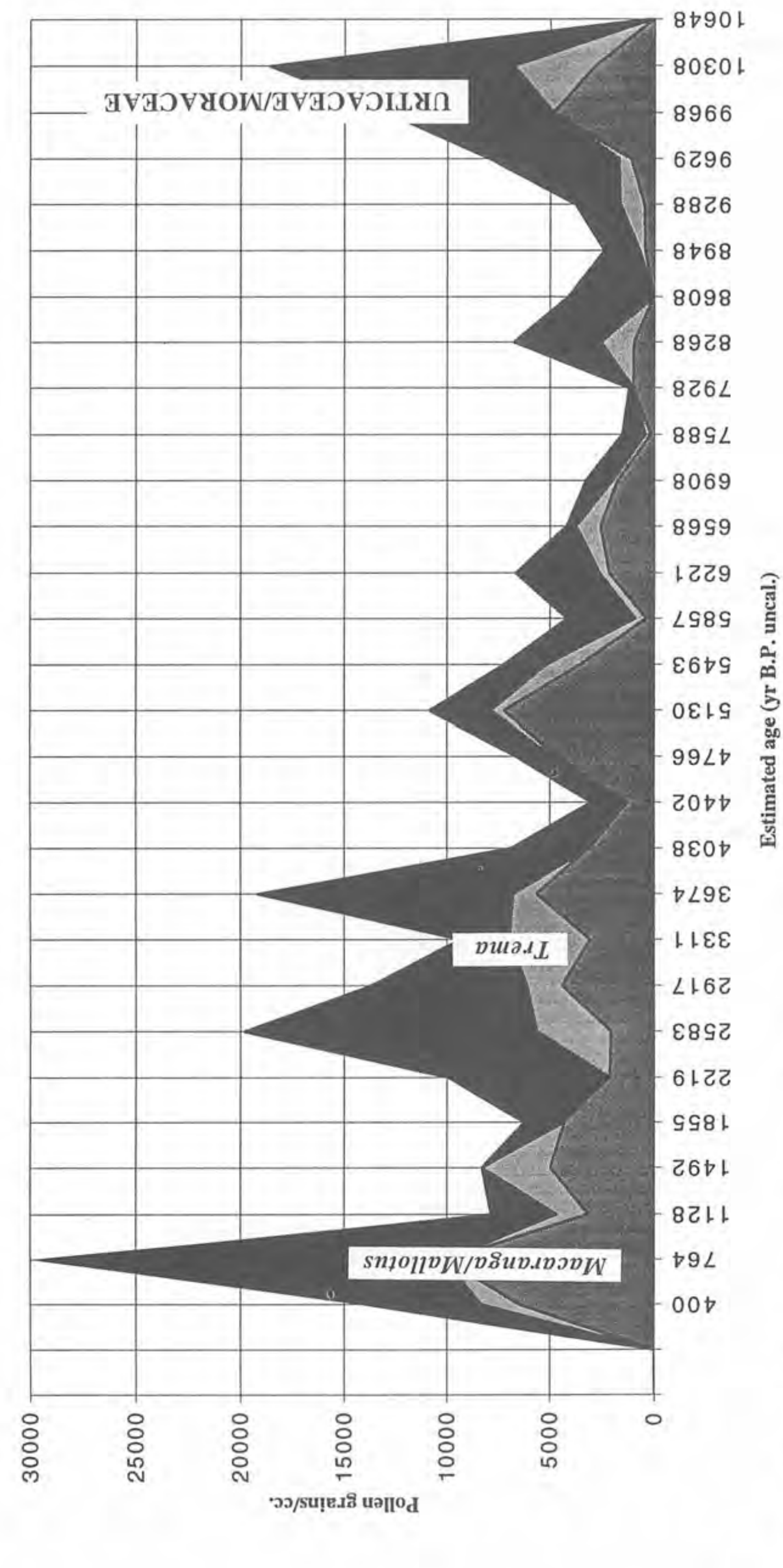

Figure 7 Nong Thale Song Hong: disturbance indicators.

around the site was disturbed, presumably by natural vegetation burning, but the possibility that human activities were responsible can neither be excluded or proven. Large trees in the Dipterocarpaceae family did not disappear, however. Urticaceae/Moraceae pollen concentrations were also high at this time period, particularly around 10,300 BP. It is tempting to think that a Younger Dryas climatic flip back to cooler, drier conditions might be represented but the pollen record becomes even more intriguing because grass pollen has some of its highest concentrations between 10,000–9600 BP while weed *Alternanthera* and Chenopodiaceae/ Amaranthaceae enter the record at c. 9600 BP. *Alternanthera* occurred continuously until around 8300 BP then disappeared entirely from the record. These occurrences could lead to speculation that some form of cultivation was practised. Such taxa can be weeds of lowland rice cultivation and of root crop cultivation, but the evidence is too tenuous for any support without detailed archaeological information from the region. Charcoal concentrations reached another peak around 8600 BP.

Macaranga/Mallotus had concentrations above 4,000/cc. again between c. 5500–4800 BP and Chenopodiaceae/Amaranthaceae pollen was present, but not significant. Gramineae pollen had quite high concentrations but only those for a sample about 6200 years old approached those for the opening of the Holocene. The forest edge seemed to be nearby between 6900–6200 BP as *Calamus*, a climbing, rattan palm, entered the record for the first time. Urticaceae/Moraceae concentrations were moderate, but weed *Smithia* pollen appeared for the first time around 6200 BP. There was also a peak in charcoal concentration then, but it was not as high as earlier ones.

Artocarpus type pollen entered the record for the first time at c. 4000 BP and remained there until c. 3000 BP. There was another rise in *Macaranga/Mallotus* pollen concentrations at c. 3700 BP, matched by one of Urticaceae/ Moraceae, but grass pollen concentrations were moderate. However, Dipterocarpaceae had their highest concentrations so far (1,100/cc.) in the diagram. Piperaceae pollen similar to that of the *Peperomia* spp. illustrated on Pl. 115: 3,4 of Huang (1972) entered for the first time. This is unlikely to be from *Peperomia*, an ornamental plant of tropical South American origin (Purseglove 1974), but probably from a *Piper* species. Historical sources indicate that pepper was grown in the area in the past and it would seem that people might have been responsible for these vegetation changes but could not, or did not want to, remove the large trees. *Garcinia* pollen made its only appearance at c. 3700 BP but my pollen reference collection does not include *G. mangostana*. The single pollen grain is triporate with upstanding pores and reticulate. It does not match any type illustrated in Seetharam (1987).

Macaranga/Mallotus, *Maesa* and *Saurauia* (sometimes a forest edge tree) were significant around 3300 BP. There was also some weed Compositae pollen is the sample. The c. 2900 BP level saw another peak in *Macaranga/ Mallotus* pollen concentration, and *Mimosa pudica* (the sensitive plant) occurred for the only time in the sequence, but Urticaceae/ Moraceae pollen concentrations were considerably lower than at c. 3700 BP, although they increased greatly in the sample dating to around 2600 BP where the *Peperomia* type pollen appeared again. Grass pollen concentrations remained moderate but regrowth *Trema* had its highest concentration in the diagram. Microfossil charcoal concentrations were high from c. 3700 BP until the top of the diagram. The decline in the pteridophyte spore concentrations between about 2900–2200 BP suggest that the slopes around the lake were burnt. There is no indication of what, if anything, was cultivated but parallels with present day northern Thailand suggest that it was probably dry land rice. *Macaranga* regrew between 1900–1500 BP.

The upper part of the diagram is also difficult to interpret but the frequency of charcoal suggests that some form of shifting cultivation could have been practised, although useful trees were probably conserved, e.g. *Palaquium* from c. 1100 BP when charcoal concentrations decreased markedly from the very high values of 98–200,000/cc. which occurred between c. 1900–1100 BP. Indeed, Dipterocarpaceae concentrations reached their peak (3,300/cc.) in the diagram at c. 1500 BP. It seems possible that the frequency of shifting cultivation became less in the last few hundred years. *Artocarpus* type pollen reappeared around 760 BP, *Peperomia* type pollen was present in the c. 1100 and 760 BP samples, *Macaranga/ Mallotus* was also common and Urticaceae/Moraceae had their highest concentration in the diagram at 760 BP. There was an isolated peak of *Piper* at 1500 BP and *Areca*, which was present in the c. 10,300 BP sample, occurred more continuously from c. 6600–4,000 BP, but had its peak in the uppermost two samples. It seems safe to assume that it was being planted by then, so too probably were *Caryota*, a sugar palm or ornamental, depending upon the species, and *Corypha*. *Mangifera* was present in the most recent sample.

The pteridophyte spore record

Other than indicating when the slopes were dry, the record of individual pteridophytes adds little to the story. Cyatheaceae (tree ferns) and *Dicranopteris* can be regrowth taxa and they occur sporadically between 5500–2600 BP. *Dicranopteris* is often among the first weeds to re-enter following dry rice cultivation, as it regenerates from underground rootstocks, but the spore concentration figures and the frequency of occurrence would need to be greater to use its presence to argue for shifting cultivation of dryland rice.

The forest epiphyte, *Asplenium nidus*, the bird's nest fern, was only present once, around 7900 BP, *Selaginella*, another everwet forest indicator occurred at c. 8900 BP, but there were no spores of the filmy ferns (Hymenophyllaceae) which are found exclusively under very wet forested conditions. Unfortunately a significant number of the pteridophytes could not be determined very closely as they had lost their outer coating, the perine, which is sometimes distinctive to the species level.

Wet Land taxa

The Lycopodiales are often indicative of wet conditions and *Lycopodium cernuum*, which has a very distinctive spore type, cf. Knox (1950) can grow on very wet bogs. If it was not growing on the dry slopes, it might be an indicator of locally wetter conditions between c. 6600–5500 BP, around 3300 BP and 2600 BP and from 1900 BP onwards. However, this conclusion is not supported by the records for the more certainly wet-indicating taxa (Figure 8). Cyperaceae had their highest concentration at c. 10,300 BP and between 9600–8600 BP, aquatic *Potamogeton* between c. 10,000–9300 BP and floating leaved *Nymphoides* between 10,300–7,600 BP when sea level and, presumably groundwater table level, was rising, at c. 6600 BP, 4000 BP, 3300–1900 BP and around 760 BP. Given that there are only two radiocarbon dates covering the last 11,000 years, that more are needed to establish the ages of samples reliably, and more samples would need to be counted to increase the resolution of the pollen diagram, there is a reasonable correlation between the *Nymphoides* data and the sea level curve but the later sea-level rises (Bishop pers. comm.) are a likely response to isostatic readjustment of the land rather than changing global sea levels. It is difficult to draw any firm conclusions about regional climatic changes at this preliminary stage in the interpretation.

Conclusions

Evidence for climatic change is difficult to detect from the pollen diagram of which selected taxa are shown in Figures 4–8, but use of the TILIA computer program with its associated statistical package may lead to conclusions not apparent from visual inspection. The topography of the site is such that most of the pollen grains, and probably all of the pteridophyte spores, derive from within the lake basin. This leads to the conclusion that Nong Thale Song Hong is a superb site to use in trying to detect small, localised, vegetation changes, but the likely incidence of natural, dry season, fires makes it difficult to unravel the impact of human usage of fire from its natural occurrence.

What is clear is that the vegetation has never been stable over the last 10,600 years. There are a series of possible forest destruction phases that predate 4000 BP. Thereafter the demise of *Borassodendron machadonis* could be due to human impact, changing soil conditions, climatic change or a combination of all of these factors, while the rise of *Artocarpus* type pollen could be used to argue that horticulture was practised, possibly associated with local scale shifting cultivation of dry land rice. Also, large trees

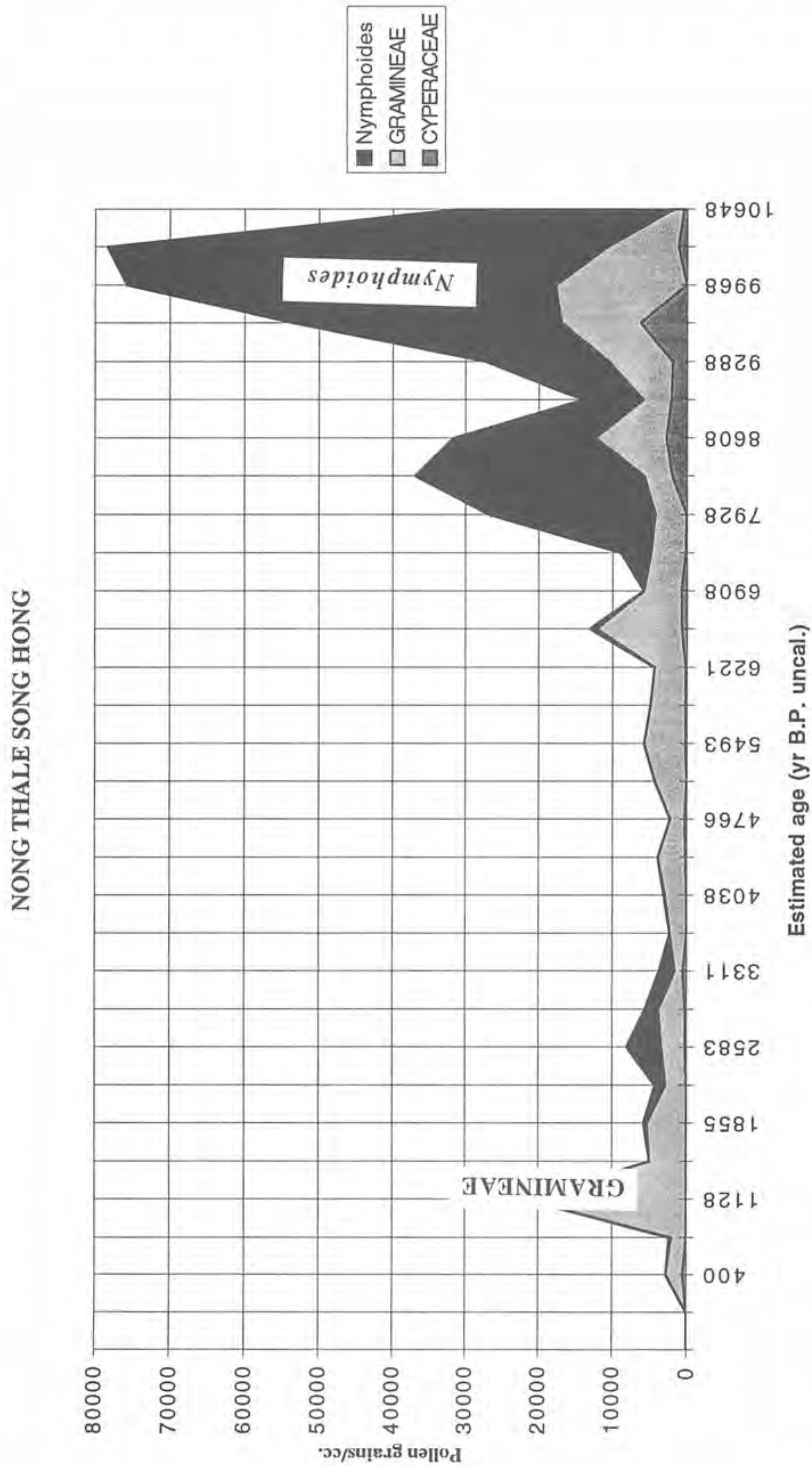

Figure 8 Nong Thale Song Hong: the main wet land taxa.

may have been conserved. The latest part of the diagram certainly suggests that some conservation was occurring and that useful plants, such as *Areca*, were being planted, but this is hardly surprising news. However, it is dangerous to use a palaeoecological record as proxy archaeology, particularly as the pollen of crop plants cannot be determined, and these conclusions must remain speculative. The situation at Khok Phanom Di was entirely different, and preferable, because palaeocological and archaeological findings could be correlated.

The lack of Hymenophyllaceae (filmy fern) spores shows that the forest was never very wet but a number of the tree taxa which have been attributed here to swamp forest can also grow in tropical evergreen rainforest. There are indications of local hydrological changes which may relate to a rising watertable when rivers graded to a higher sea level but more radiocarbon dating and better sample resolution is necessary to correlate lake level and sea level changes.

What has been demonstrated is that the vegetation of this part of southern Thailand has been long affected by fire and this is the first continuous record of Holocene vegetation change from a site between south Thailand and those (Maloney 1996) in the highlands of North Sumatra, one of which, Pea Bullok, extends back 30,000 years.

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Note

[1] Some plant names have been mis-spelled in Donner (1978). The names used here follow Smitinand (1980).

References

Allen, J. 1988–89. Agriculture, hydraulics, and urbanism at Satingpra. *Asian Perspectives* 28 (2): 163–77.

Anderson, D.D. 1988. Excavations of a Pleistocene rockshelter in Krabi and the prehistory of southern Thailand. In P. Charoengwongsa and B. Bronson (eds), *Prehistoric Studies: The Stone and Metal Ages in Thailand. Papers in Thai Antiquity*, vol. 1, pp. 43–57. Bangkok: Amarin Printing Group.

Anderson, D.D. 1997. Cave archaeology in Southeast Asia. *Geoarchaeology* 12: 607–38.

Bellwood, P. 1993. Cultural and biological differentiation in Peninsular Malaysia. *Asian Perspectives* 32 (1): 37–60.

Bourke, W.W. 1905. Some archaeological notes on Monthon Phuket. *The Journal of the Siam Society* 2(1): 49–62 (reprinted in O'Connor 1986).

Bowdery, D. n.d.. Preliminary phytolith analysis from excavations in Southeast Asia and Papua New Guinea. Paper read at the 16th Indo-Pacific Prehistory Association Congress, Melaka, Malaysia, July 1998

Bulbeck, D. 1985. The 1979 Gua Cha skeletal material. *Adi Haji Taha 96–97* (cited in Bellwood 1993).

Brandt, J.H. 1961. The Negrito of peninsular Thailand. *Journal of the Siam Society* 49 (2): 123–58.

Ding Hou 1970. Rhizophoraceae. *Flora of Thailand* 2 (1): 5–15.

Donner, W. 1978. *The Five Faces of Thailand: an economic geography*. London: Hurst & Co.

Evans, I. H. N. 1931. Stone objects from Surat, peninsular Siam. *The Journal of the Siam Society*, 24 (2): 203–5 (reprinted in O'Connor 1986).

Ferguson, I. K., Harvard, A.J. and Dransfield, J. 1987. The pollen morphology of the tribe Borasseae (Palmae: Coryphoideae). *Kew Bulletin* 42(2): 405–22.

Hastings, P. 1983. Palynology and the vegetation development of a lowland peat swamp in Narathiwat, Thailand. In T. Thanasutipitak (ed.), *Proceedings of the Annual Technical Meeting, 1982. Chiang Mai*, Chiang Mai University, Department of Geological Sciences, Special Publication No. 4, 122–31.

Huang, T- C. 1972. *Pollen Flora of Taiwan.* Taiwan: National Taiwan University Department of Botany.

Knox, E. M. 1950. The spores of *Lycopodium, Phylloglossum, Selaginella* and *Isoetes*, and their value in the study of microfossils of Palaeozoic age. Transactions of the Botanical Society, Edinburgh 35: 211–347.

Maloney, B.K. 1991. Palaeoenvironments of Khok Phanom Di: the pollen, pteridophyte spore and microscopic charcoal record. In C.F.W. Higham and R. Bannanurag (eds), *Excavation of Khok Phanom Di*, Vol. 2 (Part 1) *The Biological Remains*, Society of Antiquaries of London, London, pp. 7–134.

Maloney, B.K. 1996. Possible early dry-land and wet-land rice cultivation in highland North Sumatra. *Asian Perspectives* 35 (2): 165–92.

O'Connor, S.J. 1986. Introduction. In S.J. O'Connor, *The Archaeology of Peninsular Siam: collected articles from The Journal of the Siam Society 1905–1983*, pp. 1–10. The Siam Society, Bangkok.

Ogawa, H., Yoda, K., Kira, T., Ogino, K., Shidei, T., Ratanawongse, D. and Apasutaya, C. 1965. Comparative ecological study on three main types of forest vegetation in Tailand. I. Structure and floristic composition. *Nature and Life in SE Asia* 4: 13–48.

Purseglove, J.W. 1974. *Tropical Crops: Dicotyledons.* London: Longman.

Royal Survey Department 1969. *Thailand: National Resources Atlas.* Bangkok.

Seetharam, Y.N. 1987. *Clusiaceae: Palynology and Systematics.* Travaux de la Section Scientifique et Technique, Institut Francais de Pondichery, t. 21.

Smitinand, T. 1976. A preliminary study of the vegetation of Surin Islands. *Natural History Bulletin of the Siam Society* 26: 227–46.

Smitinand, T. 1980. *Thai Plant Names (Botanical Names-Vernacular Names).* Bangkok: Royal Forest Herbarium.

Stargardt, J. 1983. *Satingpra, I. The environmental and economic archaeology of South Thailand.* Oxford: British Archaeological Reports International Series 158, B.A.R.

Stargardt, J. 1998. Earth, rice, water: 'reading the landscape' as a record of the history of Satingpra, south Thailand. In Grove, R. H., Damodaran, V. and Sangwan, S. (eds), *Nature and the Orient: the environmental history of South and Southeast Asia*, pp. 127–83. New Delhi: Oxford University Press.

Stewart, L. 1994. *A Guide to Palms and Cycads of the World.* London: Cassell.

Stockmarr, J. 1971. Tablets with spores used in absolute pollen analysis. *Pollen et Spores* 13: 615–621.

Tagawa, M. and Iwatsuki, K. 1979a. Lycopodiaceae. *Flora of Thailand* 3 (1): 7–13.

Tagawa, M. and Iwatsuki, K. 1979b. Gleicheniaceae. *Flora of Thailand* 3 (1): 49–58.

Tagawa, M. and Iwatsuki, K. 1979c. Schizeaceae. *Flora of Thailand* 3 (1): 59–66.

Tagawa, M. and Iwatsuki, K. 1979d. Cyatheaceae. *Flora of Thailand* 3 (1): 101–7.

Tagawa, M. and Iwatsuki, K. 1979e. Dennstaedtiaceae. *Flora of Thailand* (1): 111–27.

Tagawa, M. and Iwatsuki, K. 1985. Pteridaceae. *Flora of Thailand* 3 (2): 231–60.

Tagawa, M. and Iwatsuki, K. 1989. Polypodiaceae. *Flora of Thailand* 3 (4): 486–90.

Thanikaimoni, G. 1983. Pollen analysis. In Stargardt, J., *Satingpra, I. The environmental and economic archaeology of South Thailand.* British Archaeological Reports International Series 158, B.A.R., Oxford, pp. 51–8 and Appendix A.

Tjia, H. D. 1996. Sea-level changes in the tectonically stable Malay-Thai Peninsula. *Quaternary International* 31: 95–101.

van der Kaars, W. A. 1990. Late Quaternary vegetation and climate of Autralasia as reflected by the palynology of eastern Indonesian deepsea piston-cores. Unpublished PhD thesis, University of Amsterdam.

Whitmore, T.C. 1978. *Palms of Malaya.* Kuala Lumpur: Oxford University Press.

Young, A. 1976. *Tropical Soils and Soil Survey.* Cambridge: Cambridge University Press.

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