THAILAND FOREST SOILS

by

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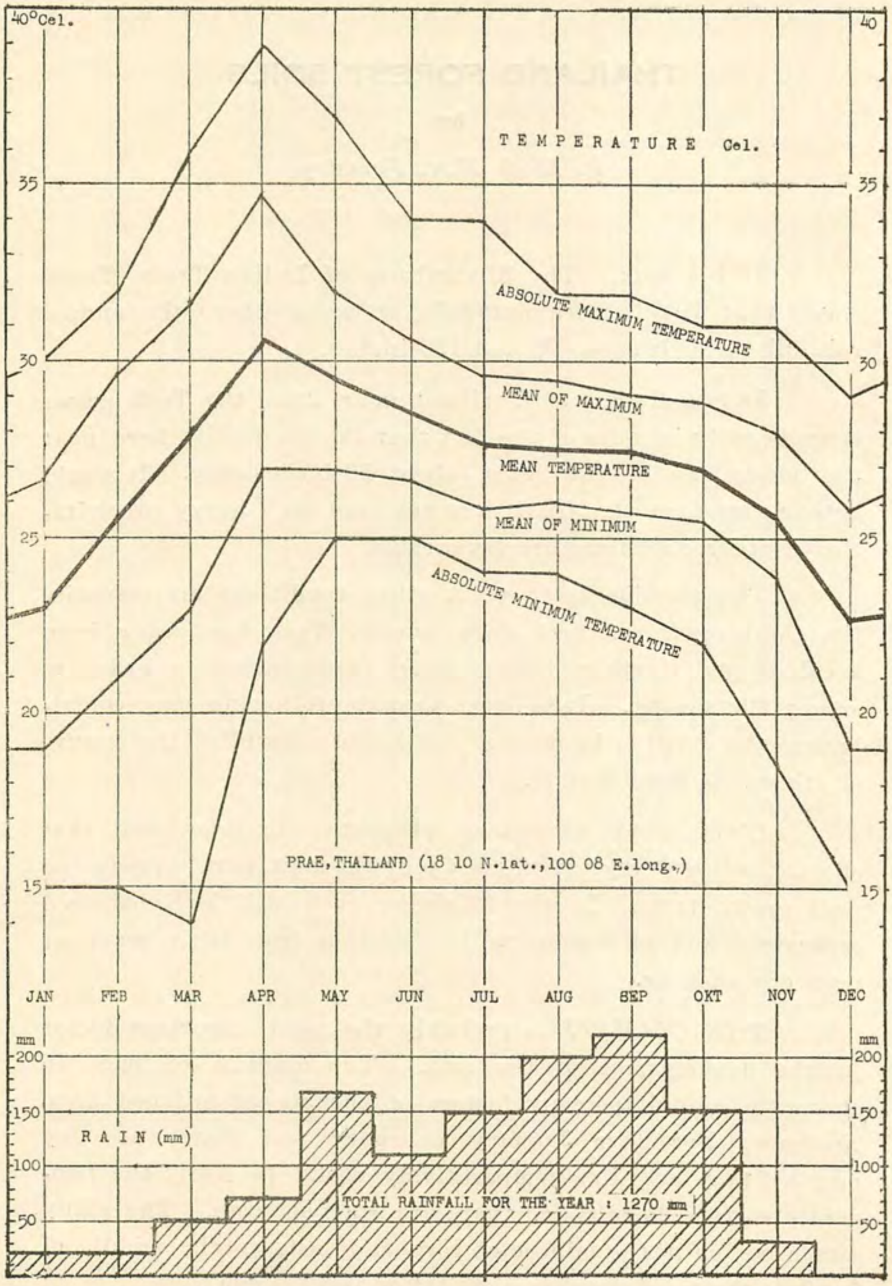
In his book, The Silviculture of Indian Trees, Troup states that Teak occurs naturally in areas where the annual rainfall varies between 30 and 150 inches.

In one district of Thailand near Prae, the Teak grows magnificently in spite of the fact that the rainfall is here near the lower end of the scale,—about 50 inches only. It would appear therefore, that Teak does not need such heavy precipitation if other conditions are favourable.

The question as to what other conditions are essential for the growth of first class quality Teak has never been decided, and further investigation is necessary in order to supply the answer. It is hoped that the following may contribute to the existing knowledge and help to establish the nature of other important factors.

Given good hereditary properties it is evident that climate, soil and vegetation must play the main part in producing well grown trees. In the following each will be considered seperately, and an attempt will be made to trace their reactions upon one another.

THE CLIMATE is probably the most important factor in the development of the soil. The diagram on page 46 shows the most important factors of the abovementioned area. November December January February and March are dry months, they are also comparatively cool. In April the temperature rises sharply and there are some showers. The rainy season begins in the middle of May and lasts to the middle of October, the total yearly precipitation is 1270 mm.


40°Cel.
40
TEMPERATURE Cel.
35
35
ABSOLUTE MAXIMUM TEMPERATURE
30
30
MEAN OF MAXIMUM
MEAN TEMPERATURE
MEAN OF MINIMUM
25
25
ABSOLUTE MINIMUM TEMPERATURE
20
20
PRAE, THAILAND (18 10 N.lat., 100 08 E.long.)
15
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OKT
NOV
DEC
mm
200
mm
200
150
150
RAIN (mm)
100
100
TOTAL RAINFALL FOR THE YEAR : 1270 mm
50
50

SOIL: 2 soils were selected for analysis:

1) *Teak Soil.* From the top of Hui Laboen Block V.-E.A.C. Concession East Me Yome Lat. 18° 10" North. From very good mixed Teak forest (Plate III, figs. 1 and 2). There was no sign of erosion. Sample A was taken 10 cm. below the surface, sample B 100 cm. below the surface and sample C 160 cm. below the surface. As sample C still contains roots and humus the real C horizon was not reached. The samples were drawn on the 13th of February 1954, that is to say during the dry season, and the soil was described as very hard. The colour in all 3 samples was, in dry condition, grey with only slight variation in colour with depth. Stones 5-10% of the volume of all 3 samples were not included.

2) *Soil from mixed Deciduous non Teak bearing forest* (in Thai language Pa Pae). The upper storey consists of Mai Hien (*Dipterocarpus obtusifolius* TEYSM.) and Mai Tüng (*Dipterocarpūs tuberculatus* ROXB.) but *Pentacme* and *Shorea* species are also found in this forest type, which is said to cover about half of the forest clad parts of Thailand and which is by far the most common in central and north Thailand. In Burma the type is recognized as Indaing. The following description is taken from "Siam Nature and Industry" issued by the Ministry of Commerce and Communications Bangkok 1950.

"The general appearance of these forests is open, grassy, often approaching the Savannah type of forests. The trees are scattered and as a general rule of medium or small size both in height and girth.- These forests grow on well drained porous soils which are generally formed by the decomposition of Latherite. These soils are either red clay, reddish or pinkish loams, reddish or white sandy soil and sometimes of poor rocky composition.- Undergrowth consists of long grass or scattered bushes. These forests are burned regularly every year, nevertheless natural regeneration occurs fairly plentifully and often luxuriantly. The seedlings and young trees are burnt back every year, but they recover and after a few years establish themselves and become part of the forest crop".

The idea was to get a really representative soil sample from this very common type of forest, but it must be admitted that just one profile cannot represent the soil conditions in all Thailand's Pa Pae.

The profile was described as follows:—

A. Horizon very hard (as cement), dry, no stone, colour grey 15 cm deep, Sample from 10 cm. depth.

B. Horizon porous, wet, no stone, colour greyish brown, darker than the C horizon. Depth from 15 cm. to 140 cm., sample from 1 m depth.

C. Horizon very hard (as hardpan) moist, colour brownish grey with many small reddish spots, no stone, sample taken 1,70 m depth.

The samples were carefully analyzed in the laboratory for Agricultural Chemistry at the Royal Veterinary and Agricultural College in Copenhagen, by the writer, under the guidance of Professor Tovborg Jensen and his assistants. In the following, the 2 soil types will be compared feature by feature, in order to make the differences and / or similarities clear.

Particle size distribution was investigated by the Andreasen Pipette method after dispersion in 0.002m Natrium Phyrophosphate Solution.

The following table shows the results:—

	Teak A	Teak C	PaPae A	PaPae C
less than 0.2mm	93%	94%	69%	75%
,, ,, 0.02mm	79%	84%	27%	47%
,, ,, 0.002mm	42%	57%	7%	27%

In the Teak Soil the mechanical composition was fairly homogenous throughout the whole profile, 93% to 94% of the fraction under 2mm was less than 0.2mm and 42 to 57% belongs to the clay fraction i.e. less than 2 thousands of a mm. This is a clay soil according to the classification method developed by the U.S. Department of Agriculture. In spite of the high clay fraction the soil is well drained.

In the Pa Pae Soil the mechanical properties were very different. The A Horizon had only 69% less than 0.2mm, the rest was coarser material, and only 7% belonged to the clay fraction. This soil falls according to the above-mentioned standard method under the designation of sandy loam. The C Horizon 160 cm. below the surface had 75% under 0.2 mm and 27% in the clay fraction (i.e. under 2 thousands of a mm, soil class sandy clay loam). The condition in this profile seems to indicate an erosion, but also a removal of the clay fraction from the surface layers and an accumulation of this clay fraction in a hardpan below, making this layer so dense that it stops the water percolation. Hence the wet condition of the B horizon. Also sheet erosion is evident here, and very rapid. Small sticks and stones are left on mounds and the surrounding soil is removed by rain splash. As small sticks do not survive attacks from termite and decomposition more than a few years and the mounds they cover are often an inch high, the erosion in these forests may amount to one half of an inch per year on sloping ground.

Carbon, Humus, Nitrogen.

The Carbon content was found by the Ter Meulen apparatus, and the humus content calculated by multiplying the carbon content by 1,724. The Nitrogen content was found by the Kjeldahl method.

	TEAK SOIL			PA PAE SOIL		
	A	B	C	A	B	C
Carbon%	1.97	0.89	0.62	0.78	0.0003	Nil
Humus%	3.39	1.53	1.07	1.34	0.0006	–
Nitrogen%	0.204	0.120	0.188	0.061	0.0156	0.0257
C/N	9.67	7.42	5.70	12.7	not investigated	

The figures show a surprisingly high humus content in the Teak soil. 1.6 m below the surface, the humus content is still 1.07% whereas the Pa Pae soil contains only 1.34% humus in the top layer and nothing below. The C/N ratio indicates a rapid decomposition and nitrification everywhere except in the Pa Pae topsoil, where the ratio is 12.7. The C/N ratio is very low in the deeper layers of the Teak soil indicating that plenty of nitrogen must be freely available to the roots.

Silicates/Sesquioxides (Latherites Lathosols) In order to clarify the terms Laterites and Lathosols, a short explanation may be necessary.*)

Lathosolization in a process going on in most tropical soils with a medium or heavy rainfall. The silicates are decomposed and dissolved in rain water containing carbon dioxyde and thus leached out. The sesquioxydes $(Al, Fe)_2O_3$ remain in hydrated form usually finely dispersed and forming the main part of the clay fraction of these soils. The degree of Lathosolization may then be expressed by the ratio $\frac{Si\,O_2}{(Al,Fe)_2O_3}$

A true fully developed Latherite is recognized by a layer of high Sesquioxyde content in the B horizon, which, if brought to the surface, dried and oxydized, forms the well known honey combed red stone used for building. This form is common in level areas with alternating dry and wet seasons, and it is supposed to be formed in the region of the changing watertable. In the hills on sloping ground this layer is not found, so in the hills it is more convenient to use the term Lathosols for the red soils found there. In the standard analysis the soil samples were fused together with Na and K carbonates, treated with strong hydrochloricacid, and the Fe and Al precipitated as hydroxides in the diluted solution with ammonia. The result was as follows:—

	TEAK SOIL		PA PAE SOIL	
	A	C	A	C
$Si0_2$	61.7%	57.8%	89.4%	90.3%
$(Fe,Al)_2O_3$	24.6%	31.0%	3.5%	8.9%
$\frac{SiO_2}{(Fe,Al)_2O_3}$	2.5	1.8	25.5	10.1

*) cfr. Lyon Buckman & Brady: The Nature and Properties of Soil.— New York 1950.

This shows that the Teak soil is a typical Lathosol whereas in the Pa Pae soil, which is often loosely called Latherite soil or decomposed latherite, the lathosolization is not evident. Also this feature points to erosion of the Pa Pae soil.

A special analysis was made of the clay fraction of the Teak soil. The clay fraction (under 2 thousands of a mm) was separated from the rest by centrifugation and directly treated with strong Hydrochloric acid. The $Si0_2$/ $(AlFe)0_2$ was then separated as mentioned above. The result was:—

	TEAK SOIL		
$Si0_2$	A	B	C
$(AlFe)\,_2O_3$	58.2%	62.7%	61.3%
(AlFe)	22.1%	20.5%	23.5%
$\frac{Si0_2}{(AlFe)_2O_3}$	2.6	3.0	2.6

Phosphates (Milligram per 100 g. soil)

	TEAK SOIL			PA PAE SOIL	
	A	B	C	A	C
(Raw soil) freely available	5.83	7.00	8.32	5.16	1.83
(Heat Treated) total phosphates	30.0	21.0	15.0	not investigated	

The analysis indicates that there is a good supply of Phosphates in both soils in the A horizon; but in the Teak soil the immediately available Phosphates increase with depth, whereas in the Pa Pae soil the deeper layers contain only little phosphate

Reaction and adsorbed Cathions

	Teak	Soil		Pa	Pae	Soil
	A	B	C	A	B	C
pH	6.38	7.01	7.95	6.55	5.95	5.49
Adsorbed Cathions milliequivalents per 100 g. soil						
Calcium	15.2	18.7	19.6	2.4	Not investigated	
Magnium	3.9	0.3	0.7	1.9	----	
Kalium	0.29	0.30	0.25	0.15	----	
Natrium	0.10	0.10	0.10	0.05		
Total	19.59	19.40	20.65	4.50		do.
Adsorbed	14.5	7.1	1.7	2.85		do.
Adsorption capacity	34.09	26.50	22.35	7.35		do.
Saturation	56%	73%	92%	61.%		do.

The Teak soil is neutral at the surface, growing slightly alkaline in depth, whereas the Pa Pae soil is neutral at the surface becoming slightly acid below.

The adsorbed hydrogen ions are not directly found by analysis but calculated under the assumption that a pH of 3,8 would mean that all absorption capacity was saturated with hydrogen ions whereas a pH of 8.3 would mean that the full absorption capacity was saturated with cathions.

For a tropical Lathosol the Cathion absorption capacity as well as the cathion saturation is high in the Teak soil. This is significant, in fact it may be the most important condition required in a good Teak Soil.

These analyses show a great difference in site quality. On one hand the quite remarkable Teak soil. This is deep with a high clay fraction, good permeability and high porosity i.e. ability to let the water pass in and be retained, sufficient content of phosphates, potassium, nitrogen and high cathion absorption-capacity and saturation.

On the other hand the poorly developed or badly degraded Pa Pae soil, a hardpan dense enough to stop the water and to render the upper layers waterlogged during the rains, this makes it difficult for the roots to penetrate to the deeper layers for water during the dry season. There does not appare to be a real deficiency in phosphates, nitrogen and potassium, and the soil is able to support a forest vegetation although a poor one.

The fine Teak soil does not show any sign of shifting cultivation; it is rather far removed from old settlements and it has probably been under forest perpetually.

The degraded Pa Pae soil, which may be alluvial, lies near an old settlement along the Me Kami river and has probably been used for shifting cultivation until it was so impoverished that it was not worth further clearing and cultivating. Later annual fires during the dry seasons have killed the herbaceous vegetation, leaving the soil bare and exposed to erosion by the heavy showers at the beginning of the rains.

Analysis of 2 soil profiles only is not much on which to base far reaching conclusions. However, the results support other observations in forming a picture of the ecological development of the forests in the area which I should like to offer :

Some thousands of years ago the people living in this area were probably few in number, they may have been Sakai, Semang, Phi Tong Luang or other now vanished races, we shall never know. The probabilities are that these people lived in small groups as hunters and collectors. The Thai and Meo were still in the southern part of China, and there was hardly any extensive agriculture in the area. The people used fire for cooking and warmth, but the extensive mostly evergreen forests then covering the country, do not easily catch fire from small isolated cooking fires.

How and when the Thai invasion occurred is uncertain, there seems to have been several waves, but the Thai way of living must have changed conditions thoroughly, slowly to start with, and accelerating towards our time. Agriculture necessitated clearing, cattle needed grazing, and fire is the quickest method of attaining both ends.

With permanent rice fields along the streams and shifting cultivation on the edges of the settlements these new conditions spread. The old settlements gave birth to new ones along small streams deeper in the forest. At the same time, Meo, Yao and Karens and other hill people moved in. They started a similar process in the hills. The fires, started by shifting cultivation and extended by the cattle herdsmen, penetrated every year a little further into the extensive evergreen forests and there changing the conditions made it difficult for the evergreen species to reproduce their kind.

Until then the Teak must have had a hard life as it is a light requiring species. Only small local changes in the forest can have given it a chance for reproduction its kind, for instance the gregarious flowering of a Bamboo followed by dying of the old stumps over a certain area. The fire must have helped the Teak to spread. By and by large areas of good deep soil rich in humus, produced by the evergreen forests, which had been undisturbed for thousands of years became available. The resistance of Teak to fire in its youth is well known, but it is not quite as generally acknowledged that the mature Teak is very easily damaged by fire and that forest fires promote erosion.

The beautiful large solid Teak, that was found in this country at the beginning of this century, was in the writer's opinion produced on soil developed under evergreen forest before the forest fires became too severe and frequent to damage the trunks.

It is the writer's opinion, that the present trend in vegetation and soil conditions throughout the Teak forest in North Thailand is *deterioration*, from the original good, deep, soil which we find under evergreen and other high forest types when undisturbed. *Shifting cultivation* and *Fire* are the agents responsible for the gradual production, first of deciduous types (with and without Teak) in the forests, then ultimately of barren gullies and desert-like conditions.

In Burma an attempt has been made to protect the more valuable forest against fire with the result that the ecological process was reversed and shade tolerating species again invaded the forest, suppressing the Teak. For this reason complete fire protection was given up there.

It has not been tried in Thailand. It would indeed be difficult there as the whole population is so accustomed to forest fires that they consider them necessary and unavoidable, but when the time comes for regular intensive forest management in the Teak area, the fire will be a very useful ally if brought under control. In non-Teak-bearing forest with good soil conditions it may be used to introduce the Teak. In Teak-bearing forest it should only be used under strict control, for regeneration, or occasionally to remove objectionable vegetation or dead material.

In the badly eroded areas the fire should be kept out entirely until the soil conditions have improved and some sort of production is again possible.

Fig. 1 - 2 Very good mixed Teak forest. Block V, EAC-consession, Hui Laboen, East Me Yome, lat. 18° 10'' N., where the "Teak Soil" - samples were taken. Febr. 1954.