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SYMPOSIUM ON MANAGEMENT OF FOREST PRODUCTION IN SOUTHEAST ASIA

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SOME CONSIDERATIONS ON THE EDAPHIC CONDITIONS IN THE TROPICAL FOREST AREAS AND THEIR IMPLICATIONS TO LAND MANAGEMENT

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ABSTRACT

When for a long time climatic elements have been considered to play the main part in the distribution of tropical plant communities recent ecological studies are drawing attention to the role of edaphic condition in controlling vegetation patterns. The majority of botanists still emphasize the effects of the physical properties of soil, especially of its useful water-capacity, however, according to very elaborated works on tropical forest of Australia and Ivory Coast, the part of its chemical properties, particularly of its richness in phosphorus, is also noteworthy. The matter is discussed in consideration to land management. In appendix some data are given on the main types of soils found in the Central South Vietnam and on plant communities associated with them.

INTRODUCTION

General climatic factors have long been considered to play a preponderant part in the distribution of tropical forest communities. However, since some thirty years, the strides made in the knowledge of tropical soils, the development of ecological researches at larger scales, the problems raised by the degradation of over-exploited tropical forests and the slowness of their regeneration, or the difficulties met in the establishment of tree plantations have led to pay much more attention to the edaphic conditions in relation to tropical silviculture. From this point of view, interesting studies have been conducted in Australia (Webb, 1964, 1971), in North Borneo (Ashton, 1964), in Ivory Coast (Huttel et Bernhard-Reversat, 1975), in New Caledonia (Jaffre et Latham, 1974), in Vietnam (Schmid, 1962). It is noteworthy that the most recent works emphasize the part played by the chemical properties of the soil though the effects of its physical characters, especially in their links with the climatic elements, have also given matter to elaborate studies.

THE EDAPHIC CONDITIONS AND THE VEGETATION

In relation to vegetational cover the edaphic medium may be considered without referring to the soil. So it is possible to classify the types of vegetation on lithological or on topographical bases, or according to the depth and the fluctuations of the water-table. That is convenient where the pedological data are missing or for surveys at pretty small scales.

The distinction between forests on basic or neutral and on acid rocks, of forests on calcareous substratum, of vegetation associated to serpentines or peridotites (New Caledonia), of psammohygrophilous and pelohygrophilous forests (Ivory Coast) need commentaries. Likewise, the differentiation of plant communities according to the relief leads to distinguish ridge, slope and valley forests, and the consideration of the level and of the movement of the water-table to separate swamp forests from forests on well drained areas.

In the central part of South Vietnam, where lithological material is very diversified, the distribution of the plant communities and of the rock outcrops are correlated : in similar conditions of climate and relief, Gymnosperms are more abundant on granites, Fagaceae on dacites ; on basalts, Gymnosperms are rare but in swamp areas *Pinus merkusii* is generally associated to granites, sometimes to basalts where drainage is more or less impeded; *Pinus kesiya* is generally associated with shales or dacites.

The structure of the forests on basalts is more homogeneous, their flora is richer and the deciduous species are more abundant and more widely distributed. The typical mossy forest on organic rankers seems confined to granites. Concerning that formation, it is interesting to mention in New Caledonia it appears only on peridotites.

However, without data on soils, it is not possible to apprehend thoroughly the causes of the distribution of the plant communities, above all to have a valid idea on their dynamics: the stage of the succession leading to the establishment of climax may be only recognized from a static point of view. Besides, the soil as product of the conjugated effects of all the factors (climatic, edaphic, biotic) of the environment, past and present, is undoubtedly a good and sensitive indicator of any change in the medium, and its study is very important in any detailed survey.

THE SOILS PROPERTIES AND THE VEGETATION

Physical properties

Many botanists still consider that the physical properties of the soils are playing the main part in the distribution of the natural plant communities: there is a link between that conception and the priority formerly reserved to the study of the effects of the climatic factors, especially rainfall; so attention has particularly been paid to the soil useful water-capacity,

The water-supply of the vegetational cover is not only dependent on the rainfalls and on the physical properties of the soil (water-capacity, water–flow from the humid to the dry part of the profile) but also on the renewal of soil moisture from the water–table, subjected to topographical conditions and to permeability of soil and subsoil. It is well known that sandy soils, as well as the upper level of the water–table is not too deep, are more "humid" than clayey soils Besides, the water supply depends on the extension of the root system, related to textural and structural differentiation of the horizons, related also to variation through the profile of the chemical properties. Finally vegetation on pretty chemically rich soils needs more water than vegetation on poor acid soils.

The physical properties of soils have also to be considered from the point of view of the stability of the system soil–vegetation. Clayey soils with degraded structure are sensitive to sheeth or gully erosion; in the podzolic soil mountainous areas, under forest, landslides are frequent; in zones affected by typhoons, the tallest forests often are found on pretty shallow and stony soils, being constituted of trees having tap roots strongly anchored in the subsoil (Araucariaceae).

In Vietnam, on basaltic tablelands under monsoon climate, brown soils from recent lavas, rich but shallow, and hydromorphic soils (grey or black basaltic earths), where the physical properties of the upper horizons prevent the root system to penetrate deeply, are occupied by dense deciduous forests (*Lagerstroemia*) or by open forests. In the case of the forests on latosols (red basaltic earths), the part of deciduous tree species is greater around Bah Me Thuot, where the concentration of mineral nutrients in the upper horizons is pretty high, than around Pleiku where the upper horizons are very leached. Lowland forests on podzolic soils from old alluvial deposits (grey earths) are comparatively rich in evergreen Dipterocarpaceae. In mountains, the forest vegetal cover appears stronger but more heterogeneous on the granitic massifs, where the light demanding species (*Pinus*) may be locally abundant, than on the dacitic massifs ; in both, landslides are frequent under "virgin" forests generally associated to podzolic soils, the underlying clayey horizon forming, when it becomes slippery by the effect of excessive humidity, a sliding level for the upper horizon which may be carried away down the slopes owing to the weight of the big trees.

Chemical properties

Concerning the effects of the chemical properties of soils on the distribution of natural plant communities, researches have been till now limited to the part of major nutrients, except in the case of vegetation associated to soils containing high percentages of poisonous material (ultramafic rocks, copper ores) whose extension is very restricted but whose study is especially interesting to understand some aspects of plant physiology.

From the works carried on in Africa (Ivory Coast), in Australia, in New Caledonia, it appears that every major nutrient is following a particular cycle, and that in tropical zone the amounts of available phosphorus are generally the more critical, except on calcareous parent material. The amounts of nitrogen have to be taken in consideration not so much as basic environmental data, since nitrogen is renewable from the atmosphere thanks to the activities of saprophytic and symbiotic organisms, than in their relations to the other factors which are conditioning the working of the whole ecosystem.

The amounts of available nutrients depend on the chemical composition of the soil parent material, of the retention capacity of the soil (cation and anion exchange capacities), on the bringing up by ground water (in hilly areas, fertility of soils at the foot of the slopes compared with soils on the ridges); taking in account the level of the reserves in the majority of tropical forest soils, amounts of nutrients brought by rainfall (N, K, Mg) are not negligible, especially in coastal areas: they may compensate losses by leaching. But the conception of available nutrient has to be discussed on physiological bases as much as on pedological bases: the tree species, with or without the help of mycorrhiza, may absorb nutrients which, according to soil analysis data, are not present under available states. So total phosphorus content may be more meaningfully related to distribution of plant communities than Truog phosphorus.

Studies on tropical forest soils emphasize that in climax communities the living plant material is always containing a high percentage of the total amount of mineral nutrients present in the whole soil-vegetation ecosystem, often, in the case of major cations, much higher than the soil; besides the soil reserves are concentrated in the upper horizons, being linked to the organic matter, and the underlying horizons, especially in the case of ferrallitic (latosol) soils, are generally constituted of chemically almost inactive material, implicated only in water exchanges. The phenomenon is particularly pronounced in the ferrallitic soils on ultramafic outcrops, where the upper horizons contain appreciable amounts of some elements, Ca, K, P, which are nearly completely missing in the parent rock. So the tropical forest ecosystems are especially unstable, the destruction of the vegetative cover leading to a strong disturbance of the upper soil horizons by consumption of organic matter, leaching of nutrients or/and losses to the atmosphere. Generally, on soils very poor in nutrients, the evergreen species with sclerophyllous leaves are predominating and the organic matter tends to accumulate, above all in conditions of impeded drainage or in the presence of poisonous elements (sulphides in marine deposits, ultramafic subsoil).

Phosphorus

After Beadle (1962) "it is possible (in Australia) to predict the leaf-form (mesomorphic as opposed to xeromorphic) and approximate size of vegetation if the phosphate content of the soil (or parent material) is known", and in the sandy coastal region of South Queensland it is a standard practice to assess site index for exotic *Pinus* plantations by the total phosphorus content of the topsoils. However, other nutrients such as calcium, may be significant in vegetation pattern areas (Webb, 1969).

Bernhard-Reversat (1975), in a work on the rainforests of the Ivory Coast, brings into relief the great disparity of the P content (total as well as " available") between the soils of the three stations studied; the differences between the P content of the litters are of the same order. Moreover she establishes that the cycle of the phosphorus is almost closed and that under natural conditions the losses outside the ecosystem are negligible. In the case of soils on tertiary sands, the reserves in Nitrogen are greater where the percentage of P is low, the comparatively high P content in the valley soils enhancing the activities of micro-organisms so the losses of N by decomposition of the litter.

In New Caledonia, on soils associated to ultramafic outcrops, the P content of living plant tissues is abnormally low.

The relations between the P content of the soils and the characters of the vegetal cover has not been yet studied in Vietnam. It seems on basaltic outcrops that the P content is varying the same way as exchangeable Ca content. Some hydromorphic soils under open forests are pretty rich in total phosphorus.

Calcium and Magnesium

The "chemical fertility" seems related to the content of exchangeable bivalent cations, the degradation of the exchange cemplex inducing losses of both elements and the lowering of Ca/Mg ratio. Even in the case of ferrallitic soils, on peridotites in New Caledonia, the ratio Ca/Mg is generally greater than one in the upper horizon but in the depth Mg becomes predominant; on brown soils which are very rich in Mg and poor in Ca, the floristic composition of the vegetation is totally different.

According to Bernhard–Reversat (1975), Ca is not well retained as P in the topsoils under the Ivory Coast forests, being not so quickly reabsorbed by roots or microorganisms from the products of decomposition of the litter: the losses in the leaching water would be compensated by the bringing up of Ca from the rainfalls. However, these data do not agree always with them from studies on other ecosystems.

In New Caledonia, it is noteworthy that some tree species (*Arillastrum*) growing in the natural state only on ultramafic rocks, being normally associated to soils pretty rich in Mg, may be cultivated on sandstone or alluvial soils but do not tolerate calcareous soils; other species

(*Acacia spirorbis*) seem to grow as well on soils very rich in Mg as on calcareous soils.

Potassium

According to Bernhard–Reversat, K would be the element which is circulating the more rapidly through the ecosystem, the yearly cycle of the K being characterized by quantitative flow greater than the reserves of the soil. The rainfalls bring to the soil large amounts of K from the foliage they are passing through but, as in the case of the P, it seems that the absorption by roots or microorganisms is very effective and the losses in percolation waters are generally low.

The relation between the distribution of tree species and the richness in K of the soils have not yet been much studied. In Vietnam, large bamboo stands are generally associated with soils having a comparatively high K content (granite or schist parent material).

DISCUSSION

In the territories where, as in Vietnam, climatic and lithological conditions are very diversified and often change greatly within short distances, it seems that every plant community, or series of plant communities in the case of rapid succession on disturbed areas, is associated with clearly defined edaphic conditions, generally with a soil well characterized by its morphological, at least by its analytical features. In disturbed areas, the properties of the soils may change in the course of the succession but the main features of the original soil remain normally a long time perceptible: according to the way and the extent of the changes, and by comparison with soils under undisturbed vegetation, it is possible to foresee the way and the rapidity of the evolution. So the study of the soil brings reliable data in the survey of actual and potential distribution of plant communities; moreover it is retaining the advantage to not require, as in the case of study of the climate, long periods of observation, and to reveal narrowly localized variations of the medium.

Where the external ecological conditions remain uniform for long distances it happens that distinct climax communities are found on soils looking similar. Besides, in the case of old and complex ecosystems, such as tropical forest, soil and vegetation are forming a close entity, relatively isolated of the outside environment whose effects are more pronounced on the secondary than on the climax plant communities. It may then be difficult to discern in edaphic or pedologic medium variations which are significant to vegetation living, and still more difficult to give them a right interpretation.

From the works to which we have referred, the main data to collect on soils could be :

Concerning morphological characters of the profile :

Aspect of the litter, depth, continuity, and their seasonal changes; colour, depth structure of the upper horizons and distribution of the roots through the profile ; level on the profile where the effects of processes of accumulation (per ascensum or per descensum) are obvious ; depth of soil over the underlying presumed parent material, eventually over the water-table (at least if this depth is not greater than a few meters).

Concerning physical properties :

Texture and structure (shape, stability);
moisture capacity (for each horizon).

Concerning chemical properties :

pH (on the field and after drying); base exchange capacity, exchangeable Ca, Mg, K; total and "available" P (for pH, exchangable cations and available P, data on seasonal cycles would be useful).

Concerning mineralogical composition :

Types of clay and/or hydroxides ; residual minerals.

When the knowledge of the soils is useful in vegetation survey, reciprocally the study of the distribution of the plant communities makes easier for the pedologist the delimitation of the different soil unities. However, to this end, the climax formation, for their floristic richness and their tendency to constitute close ecosystems, are not so interesting that secondary formations where the plant species being more straightly depending in the behaviour on the environment appear as better indicators of the ecological conditions. So, in Vietnam, floristic composition of herbaceous strata in savanna on basaltic red earths appears closely related to the degree of evolution and leaching of soil.

IMPLICATIONS TO LAND MANAGEMENT

It is clear that for the correct delimitation of the area to be maintained under protection forests and of the areas to be reserved for logging activities or to be brought in different forms of cultivation, it is necessary to refer to the properties of soils.

The choice of the protection areas is based on environmental, scientific, social or aesthetic criteria too well known to justify any discussion.

Surveys in view of proper delimitation of exploitable forest, have to be accompanied by researches on methods of logging and silvicultural practices, to maintain, if possible to improve, the productivity. Considering that, at least in the tropical countries, steady manuring of forest soils is unrealizable, the knowledge of their chemical properties is very important to regulate the exploitation. On soils rich in mineral nutrients and having a good exchange capacity, the regeneration will be easier; on deep soils, where the nutrients are concentrated in organic upper horizons, the exploitation has to be conducted carefully, particularly where there is risk of erosion: to lay bare the soil, even for a short time, has to be avoided; on soils deep and chemically very poor, whatever the relief and the actual state of the vegetation may be, only light exploitation (forest products having high commercial value) will be authorized and the maintaining of protected forest is advisable.

Concerning the areas open to cultivation, the physical or the chemical properties of soils will be considered first, according to the type of culture which is planned. The physical properties are held as the most important in the case of intensive agriculture where it is possible to bring to the soils large quantities of fertilizers: that case is still restricted to very limited areas. The soils not very deep and pretty rich in nutrients, even if their physical properties are not very good, appear generally suitable to annual crops. It is always preferable to maintain deep soils under perennial cultures or under permanent pastures (plants with extensive root systems). Forest plantations (for production or only for reclamation) may thrive on the poorest soils, where the physical conditions are not to bad, with species having mycorrhiza. So, in Fiji islands, *Pinus caribaca* is growing well on very evoluted and leached ferrallitic soils which were covered before its introduction by a meager steppe vegetation. Under *Pinus*, the soil is improving by incorporation of organic matter and fixation of some nutrients; however in other sites, on not no poor soils, plantations of pines may depress the fertility.

To illustrate the remarks above some data on the main types of soils in central part of South Vietnam and on the vegetation associated with them, are given in appendix with some suggestion in matter of land management.

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Bernhar
Huttel,
Jaffre.
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Webb, I
Webb, I

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APPENDIX I. MAIN TYPES OF SOILS AND PLANT COMMUNITIES IN CENTRAL PART OF SOUTH VIETNAM

Abbreviations :

D.S.	:	duration of the dry season (in months)
A.B.	:	annual rains (in mm)
U.W.C.	:	useful water capacity of soil.
U.H.	:	upper horizons.
R.	:	reserves in major nutrients
B.E.C.	:	base exchange capacity
A.E.	:	Available elements (exchangeable Ca, Mg, K, and P)
C.	:	climax.
J.	:	regressive series.
R.	:	ratio of follow to culture duration

Type of soil and environment	Main properties of Soil	Plant community associated	Land Management
A. Deep, well drained soils			
I. Ferrallitic soils (latosol) on basaltic tablelands (basaltic red **earths**)			
a) No iron concretions in the	U.W.C. high	Semi-deciduous tall	Shifting cultivation

I. Ferrallitic soils (latosol) on basaltic tablelands (basaltic red earths)

a) No iron concretions in the upper part of the profile (within at least the first two meters). Crumb structure D.S. 3–5 A.R. 1800–2200	U.W.C. high A.E. in U.H. (within the first 20–30 cm under forest) high, medium or low underneath. R. low or medium	Semi-deciduous tall forest (Meliaccae, Sapindaceae) (C) ↓ Semi-deciduous woodland. *Imperata* or *Eupatorium* savanna *Themeda* savanna.	Shifting cultivation (R: 1 to $\frac{1}{2}$) (on woodland or savanna). Plantation (coffee, Hevea).
b) No iron concretions in the upper part of the profile Dust structure D.S. 4–6 severe A.R. 2.500–3.000 (Pleiku)	U.W.C. high A.E. very low. R. very low	Evergreen low forest (C) ↓ woodland, open woodland (Eurya....) *Arundinella* savanna *Aristida* grassland (treeless).	Forest plantations (Pines)

B. Not very deep or shallow soils, not periodically flooded

a) Brown red or dark brown soils on basalts D.S. 3–4 A.R. 2.000–2.500	U.W.C. medium A.E. high R. high (Except for K) B.E.C. high	Tall deciduous forest, (Legums, *Lagerstroemia*) (C) ↓ Woodland more or less deciduous	Shifting cultivation on woodland (R: 1/2 to 1/5) Forest exploitation. In some places, plantations (Coffee) or annual cultures
b) Black rendziniform soils and young skeletal soils on basalt.	U.W.C. low A.E. and R. high	Woodland or Woodland–savanna (*Leucomeris*)	No potential
c) Sandy shallow soils (very heterogeneous) on granites. D.S. 4–6 A.R, 1.200–2.000	U.W.C. low A.E. medium or low R. medium (high for K)	Low open forest (deciduous Dipterocarpaceae) Rare stands of *Pinus merkusii*.	To protect against fire.
d) Organic rankers (on granites) D.S. very short A.R. 3.000–5.000 (!)	U.W.C. high A.E. low.	Elfin forest (Gymnosperms, Fagaceae)	To protect
e) Brown and pale–brown leached soils on shales or sandstones.	U.W.C. medium or low. A.E. and R. medium or low	Deciduous forest (*Lagerstroemia*, Legums)	Protection forest. Exploitation of Bam-

d) Organic rankers (on granites) D.S. very short A.R. 3.000–5.000 (?)	U.W.C. high A.E. low.	Elfin forest (Gymnosperms, Fagaceae)	To protect
e) Brown and pale-brown leached soils on shales or sandstones. D.S. 4–6 A.R. 1.500–2.000	U.W.C. medium or low. A.E. and R. medium or low (sometimes pretty high for K)	Deciduous forest (*Lagerstroemia*, Legums) with bamboos. ↓ Bamboos ↓ Bush. or open forest (*Dipterocarpus tuberculatus*)	Protection forest. Exploitation of Bamboos.
f) Eroded soils on shales or sandstones D.S. 4–6 A.R. 1.500–1.800	U.W.C. low A.E. variable often low.	Open forest with small Bamboos.	To protect against fire.
C. *Drainage impeded within upper horizons but flooding rare.*			
I. Hydromorphic (iron concretions or iron pan), vertic (clay layers)	U.W.C. low (bad structure preventing extension of the	Open forest (*Pentacme*, *Shorea*) with low strata	To protect against fire Rarely, shifting

soils on basalt (basaltic grey black earths) A.R. less than 2.000	roots to water-table) A.E. and R. variable, sometimes high.	having rich flora (grasses, Legums, Compositeae).	cultivation.
II. Deep soils on colluvial deposits (especially at the foot of granitic slopes) A.R. generally high.	U.W.C. high A.E. variable (renewable from the water-table)	Tall evergreen forest (Gymnosperms, *Caryota.*)	Protection forest or light exploitation.
D. Periodical flooding but pretty rapid drainage. Silty or silt-sandy alluvium.	U.W.C. high (supply from the water-table) A.E. and R. variable generally pretty high.	Tall grass savanna (Saccharae, *Phragmites*) trees rare (*Stephegyne*)	Sugar-cane culture. (with irrigation)
E. Periodical floodihg, slow drainage			
I. Clayey soils on basalts (often heterogeneous)	U.W.C. limited in D.S. A.E. variable, often high. R. high	Savanna (*Arundinella*) Grassland (*Sacciolepis*)	In some places rice-fields or pastures.
II. Silt-clayey soils on young alluvium.	U.W.C. high. A.E. and R. variable, sometimes high.	Grassland (*Echinochloa*)	Rice-fields or pastures (Buffaloes), in some places sugar-cane.

II. Silt–clayey soils on young alluvium.	U.W.C. high. A.E. and R. variable, sometimes high.	Grassland (*Echinochloa*)	Rice–fields or pastures (Buffaloes), in some places sugar–cane.
III. Soils on iron carapace.	U.W.C. very limited in D.S. A.E. medium or low.	Open forest (*Randia*) or savanna (*Arundinella*)	To protect against fire
F. *Soils permanently soaked, generally rich in organic matter.*			
I. At low or medium altitudes.	U.W.C. high A.E. variable B.E.C. high	Evergreen forest (*Dacrycarpus, Eugenia,* Palms..) or swamp savanna (*Nepenthes,* Orchids, rare stands of *Nelumbium....*)	Areas to protect
II. Peat soils at high altitudes.	U.W.C. high A.E. low.	Woodland ↓ Swamp savanna (*Osmonda, Xyris, Sphagnum*),	Areas to protect; vegetable gardens.
c) Iron concretions or more or less discontinuous carapace within the upper part of	U.W.C. high or medium A.E. medium in U.H., low underneath,	Evergreen forest (Fagaceae, *Schima,* Dipterocarpaceae) (C)	Shifting cultivation (R: 1/5 to 1/10) (on Fagaceae woodland)

the profile, D.S. 2–3 A.R. 2.500–3.000 (Dak song and Bao Loc areas)	R. very low.	Woodland (*Vaccinium*) Open stands of *Pinus merkusii* *Chrysopogon* or ↓ *Kerriochloa* grassland (treeless)	Forest exploitation (light)
II. Leached ferrallitic or ferruginous soils (close to red and yellow podzolic soils) on shales or dacites. Relief generally strong D.S. 2–3 A.R. 2.000–3.000	U.W.C. medium A-E. medium in U.H., low underneath R- low (somktimes pretty high in the case of K).	Evergreen forest (Fagaceae) (C) Woodland (Fagaceae, Tiliaceae....) Bamboos *Pinus Kashya* Bush (*Rhodomyrtus*, ↓ *Melastoma*) *Dicranopteris*	Shifting cultivation (R: 1/10 to 1/20 Plantations (forest or tea)
III. Podzolic "soils" more or less sandy within the upper part of the profile.			
a) On granites.	U.W.C. medium	Evergreen forest, tall	Protection forest

III. Podzolic soils more or less sandy within the upper part of the profile.			
a) On granites. Relief strong; depth very variable; rock outcrops frequent. D.S. 1–4 A.R. 2.500–4.000.	U.W.C. medium A.E. and R, low (except for K). B.E.C. linked to organic matter.	Evergreen forest, tall but not very dense. (Gymnosperms, Fagaceae) (C) at high altitudes Evergreen forest (Podocarpaceae, Dipterocarpaceae) at medium altitudes (C) *Pinus merkusii*	Protection forest Very light forest exploitation (*Cinnamomum*, Cupressaceae).
b) On old alluvium Relief weak; soil homogeneous, without rock outcrops. Pretty often water-table within few meters. (Grey earths)	U.W.C. medium (but supply from the water-table) A.E. and R low	Tall evergreen forest Dipterocarpaceae) (C) .	Forest exploitation. Plantations (Hevea)

DISCUSSION

Aksornkoae : You mentioned that shifting cultivation is managed in deep, well drained soils and not very deep or shallow soils: what kind of cultivated crops in order to increase the yield in such areas?

Schmid : On the deep ferrallitic soils rich in *Ca* and *P*, it is possible where the climate is not too humid to cultivate annual plants (rice, tubers, etc.) but it is better for increasing the economical yield to plant coffee (*C. robusta*) or *Hevea*. The brown shallow soils, chemically very rich, have to be maintained under forest.

Sukwong : For the distribution of individual species such as *Pinus* spp., the biotic factor (competition) is also important. On fertile soil with dense undergrowth seedlings are very rare, but on area lacking undergrowth such as newly cut road bank, regeneration is abundantly found.

Schmid : The case of *Pinus dalatensis* I mentioned is proper to granitic areas where podzolic soils are commonly developed. This species is common in virgin forest, i.e., in areas undisturbed by man but subjected to landslides (natural accidents) which denude totally the slopes. *P. dalatensis* is also abundant on the ridges (between 1500 m and 2500 m).

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