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AN ARCHITECTURAL STUDY OF THE VEGETATION'S REGENERATION IN FRENCH GUIANA*

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Introduction

This study is a small part of a research program concerning the interrelationships between an Indian tribe and its environment. This tribe, the Wayãpi, dwells in the southern part of French Guiana, along the Oyapock River. They belong to the linguistic family of the Tupi. They live still in harmony with their traditional culture in which our own civilization has very little place.

The study is a French contribution to M.A.B., and deals with different scientific fields such as anthropology, botany, pedology, medical entomology, plant chemistry and different aspects of zoology. The interrelationship between the differnt sciences has been presented during 47th Congress of the Société des Americanistes, September 1976 in Paris.

This paper deals with some aspects of the revegetation occurring in different plots previously used by Indians for shifting cultivation. Those plots had been selected and dated by anthropologists. I chose six of them, covered with secondary vegetation, and $2\frac{1}{2}$, $3\frac{1}{2}$, 4, 11, 23, and 33 years old. Two other plots, covered with primary forest, situated in the vicinity of the secondary forest plots were chosen for reference.

Only architectural aspects of this succession are treated, for I believe the size of the plots studied was too small for floristic analyses.

The study is widely based on the theory of forest architecture by Oldeman (1974), and I shall first summarize the most important concepts of his work.

Abstract of Oldeman's work

At the beginning of the tree's life, after germination, it produces an 'initial model', which is one of those described by Hallé & Oldeman (1970). Later and under propitious ecological conditions, meristems which do not initiate any growth during the model's development, may copy all or part of the model. This copy should not be confused with a ramification and is called a 'reiteration'.

Trees in the forest, which conform to the initial model, or those having few reiterations – which may occur after traumatic interferences – constitute the 'set of the future'. Those which have developed a lot of reiterations, often occurring in a successional process leading to the maximal spatial expansion of the tree, constitute the 'set of the present'. I emphasize the fact that a tree of the future is not always younger than one of the present, but it still keeps its growing potential. Of course, this potential is not reached frequently, because trees die too early. Last, the third set of trees is the 'set of the past'. It is constituted by the trees of which the old age or poor ecological conditions lead to the architecture's degradation.

When the forest is well structured, trees of the 'present' are organized in several 'structural ensembles', each of them appearing on different levels. Those structural ensembles are correlated with the floristic composition of the forest, the species of which do not all have the same growth potential. This stratification is different from distinguishing different strata in the all arborescent population. The structural ensembles consist only of trees of the present which can be defined by architectural considerations, i.e., by their morphogenetic stages.

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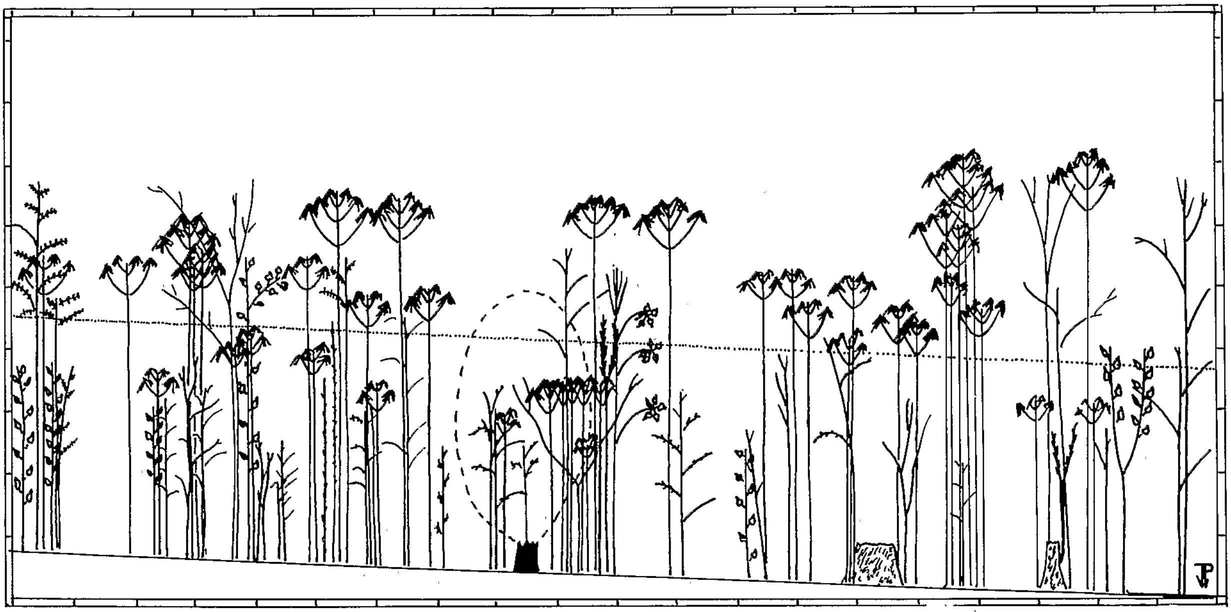

Fig. 1. $2\frac{1}{2}$ years old vegetation; dotted line is the level of liana type vegetation; dashed line, shoot.

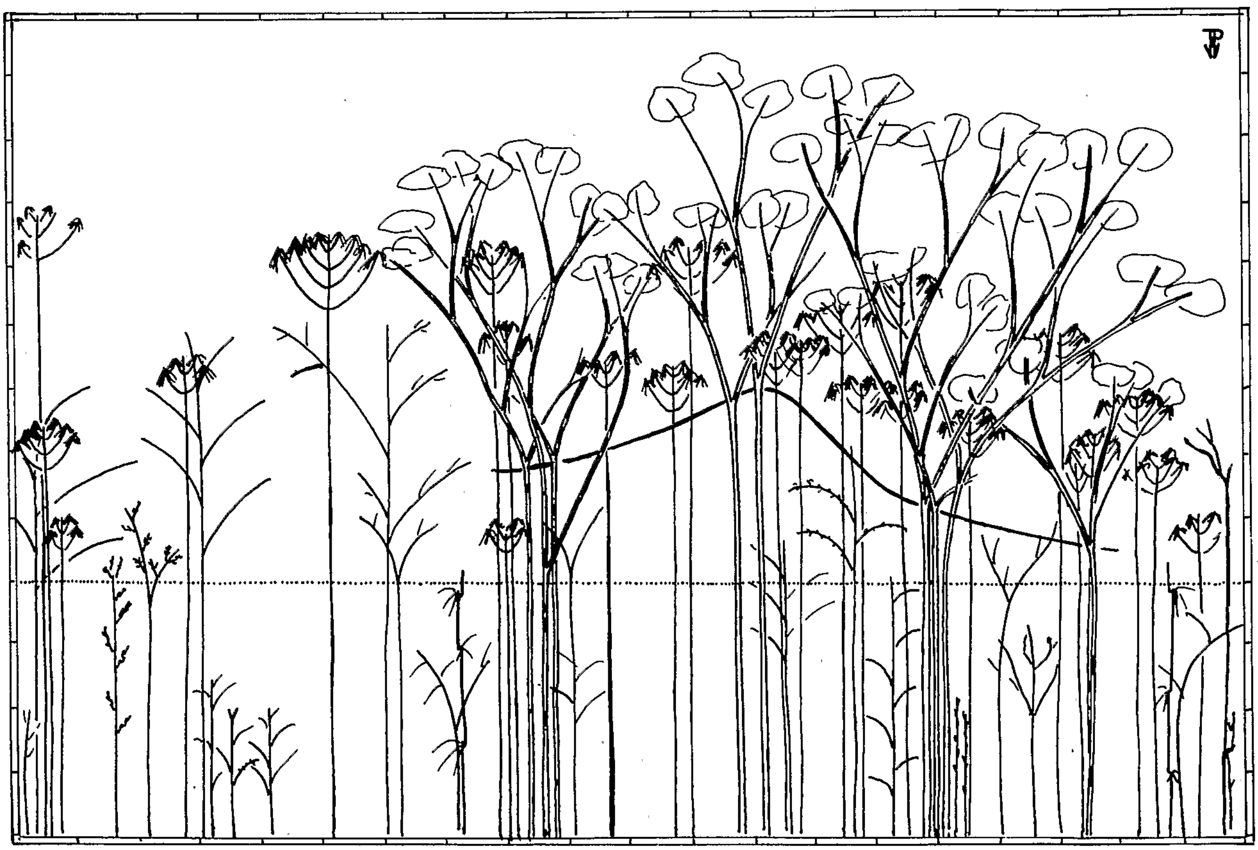

Fig. 2. $3\frac{1}{2}$ years old vegetation. Dotted line, level of the liana type vegetation; one line, trees of the future; two lines, trees of the present; black line, inversion surface.

In each structural ensemble, the different points where bigger reiterations appear, constitute an irregular surface which is called the 'inversion surface'. Still following Oldeman, the levels of those surfaces correlate with different stories where the tendency to produce always bigger organs, such as stems, reverses and becomes a tendency to produce smaller organs such as little branches around the crown. This architectural inversion involves the regulation of vertical gradients of light and humidity which change to a higher or lower degree than in the average gradient.

Application to the study of the plots

In the first plot the vegetation is $2\frac{1}{2}$ years old. One can observe (Fig. 1), a few arborescent plants which all conform to their initial model. Some of them grow above the level of a liana type vegetation, but those pioneers do not have any reiteration; in this way, it is impossible to distinguish a set of the present. On the other hand, pioneer trees, as the others, are passing a phase of the future (expansion), a phase of the present (stagnation), and a phase of the past (recession), even if they never, or almost never, have reiterations. This behavior is shown for example by *Cecropia*. A set of such trees in their stagnation phase constitute a set of the present; but missing the reiterations, the diagnosis is more difficult.

One can observe in this plot a regenerating, old shoot which reiterates the model, with a more important biovolume than that of the other trees, because of the already well structured root system.

In the second plot, the vegetation is $3\frac{1}{2}$ years old (Fig. 2). Some of the trees show reiterations and constitute the set of the present. Extending the survey beyond the designated plot one sees that the set of the present is discontinuous and emerges as little islands above the level of the liana type vegetation. The same architecture is found in the third plot (Fig. 3), where the vegetation is 4 years old.

The vegetation in the fourth plot (Fig. 4) is 11 years old. The set of the present shows now two levels, two structural ensembles and two inversion surfaces. This architecture does not change during the following years and can be observed in the 23 years old vegetation (Fig. 5), as well as that of 33 years old (Fig. 6). During this time, the set of the past appears.

The first plot in the primary forest (Fig. 7) is quite typical

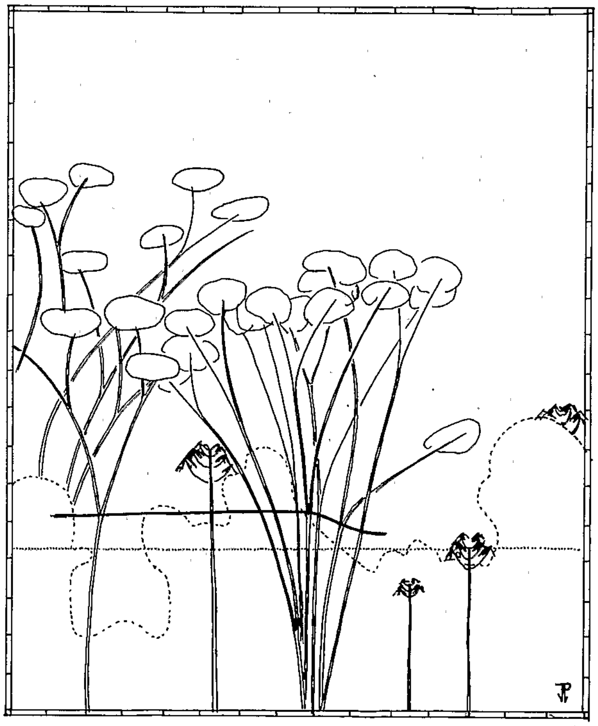

Fig. 3. 4 years old vegetation. Same convention as in Fig. 2. Dashed line, shape of the set of the future.

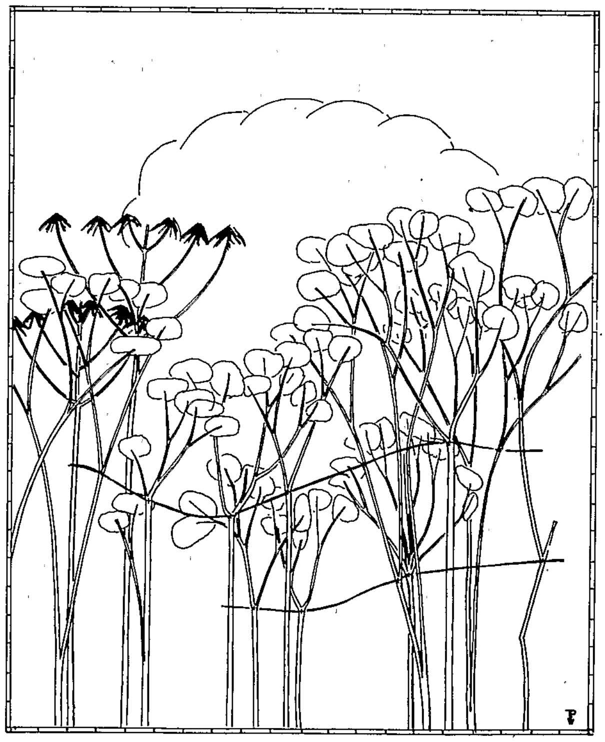

Fig. 4. 11 years old vegetation; the set of the future is not drawn. Same convention as in Fig. 2.

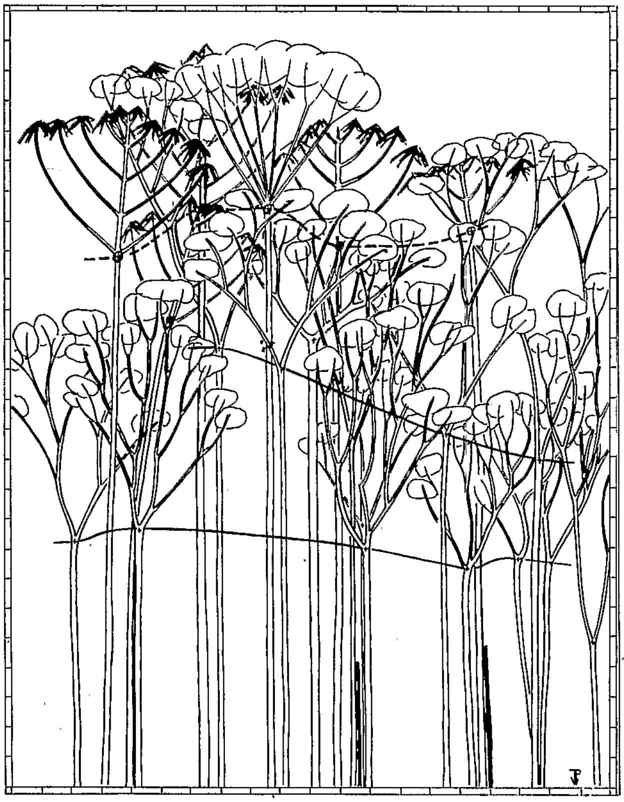

Fig. 5. 23 years old vegetation. Same convention as in Fig. 4. Dashed line connects points where lower ramifications occur on unreiterating pioneer trees.

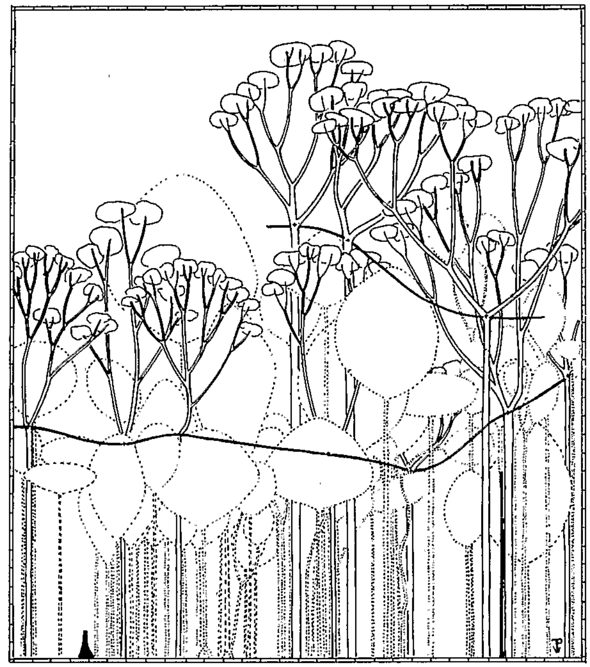

Fig. 6. 33 years old vegetation. Black line, inversion surface; trees of the present are drawn with unbroken lines, of the future with dashed lines, of the past with large black line.

of the forest in French Guiana, with regard to the height of the emergent trees. The second one (Fig. 8) is quite exceptional with emergent heights of 55 meters. In both of them, we distinctly see a new structural ensemble above the others, which only includes emergent trees.

It is possible to analyze the variation of a few measurable parameters which occur during the time of forest regeneration. Those parameters are the number of inversion surfaces (or the number of structural ensembles), the absolute height of their average levels, and the relative height of the inversion surfaces calculated in percentages of the total height of vegetation (Fig. 9).

The variation in numbers of inversion surfaces shows that we can find four phases during the sylvigenetic process: in the first one, between 0 and 3 years old, the arborescent vegetation architecture is not yet structured. In the second, from 3 years to an age of about 5 years, the vegetation shows only one inversion surface, one structural ensemble. The third phase, including the 11, 23 and 33 year old plots, display two structural ensembles with two inversion surfaces. The primary forest finally has three structural ensembles and three inversion surfaces, and constitutes the last phase of the succession. We cannot date exactly the primary forest plots; we assume that the tallest one is the oldest.

Besides the structural ensembles generated by the reiterations described, there are pioneer trees which never or nearly never reiterate. They constitute a set of unreiterating pioneer trees, which appear very early (about six months after burning the fields), and grow till 23 years. During that time, these trees are taller than the previously described structural ensembles and we can think that they play the part of an upper structural ensemble, regardless of the change of ecological gradients.

In order to analyze the variation of absolute levels of inversion surfaces, I have to anticipate the floristic changes during the succession. The first structural ensemble which occurs in the succession is constituted by different species of *Inga* (Mimosaceae). This is also the case in the third phase where one finds these *Inga* trees again in the upper structural ensemble. This fact suggests an uplift of the inversion surface level, which stays at around five to six meters in height during the second phase, then increases during the third one to about 20–21 meters. This height

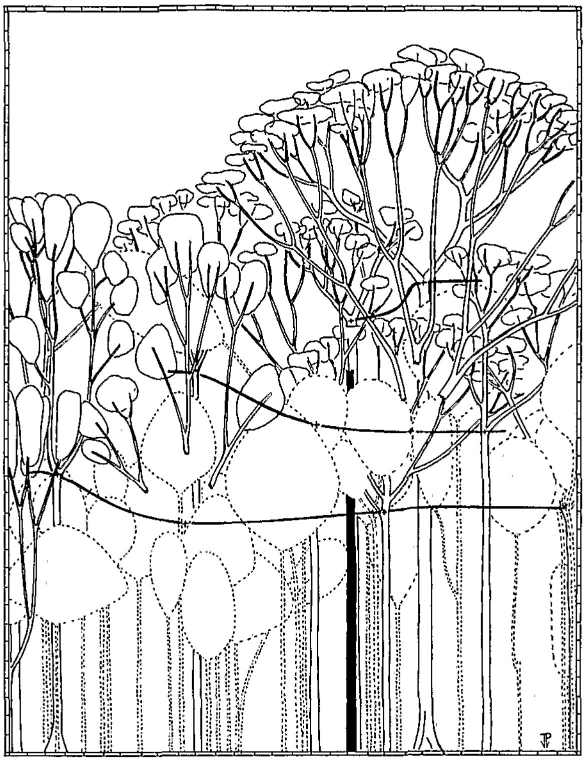

Fig. 7. Primary forest; same convention as in Fig. 6.

increase of the inversion surface is the result of floristic changes as well as looping branches. For changes between phase 3 and 4, I lack data but offer the following hypotheses:

– The upper structural ensemble during phase 3 continues to increase in its height and becomes the upper one of phase 4.

– The height of the upper structural ensemble during phase 3 is stabilized. The structural ensemble becomes the middle one in phase 4, after having regulated the ecological gradient in such a way that a new level of reiterations appears, leading to the development of a new and upper structural ensemble.

The height of the lower inversion surface increases during phase 3 from 5 to 12 meters. In the primary forest, the level is about 14 to 16 meters. Here also, I lack data to determine if this phase 3 lower structural ensemble stays the lower one in the primary forest or if it becomes the middle one.

If we assume that the floristic composition of the structural ensemble does not change, the variation of relative levels of inversion surfaces correlates with loops on one hand and crown growth on the other. The relative level decreases when only the crown grows up. It will increase – until death – when just loops occur. It will stay equal between a time T 1 and a time T 2 if the ratio loops to crown growth is constant. However, we found many intermediate situations and can also assume that a floristical change correlates with an increase of the relative level (compare Table 1).

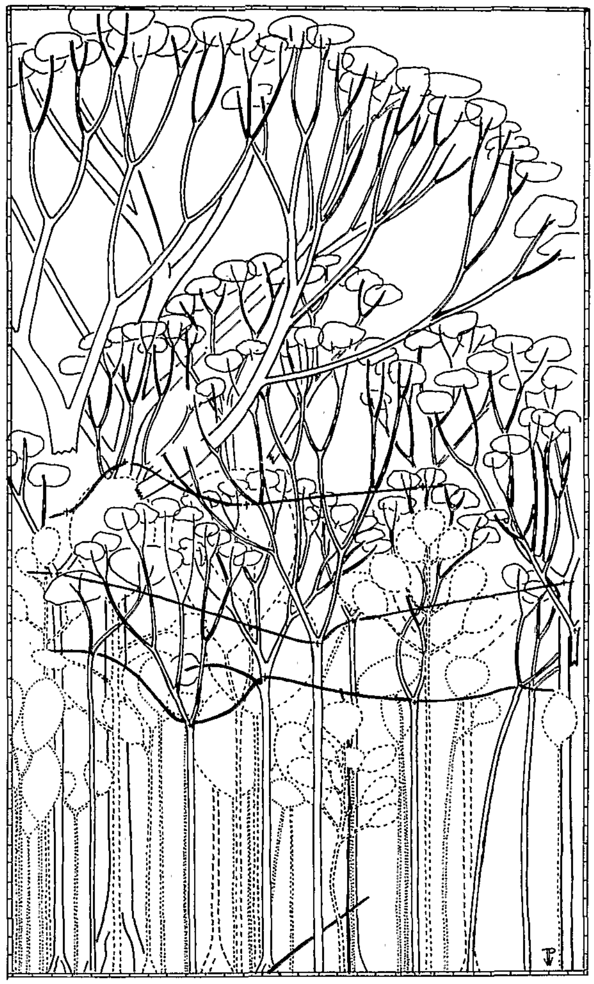

Fig. 8. Primary forest; same convention as in Fig. 6.

The relative level of the first inversion surface appearing in the succession decreases rapidly during phase 2 (crowns of the trees grow up) then increases until 23 years (loops occur). After and between 23 to 33 years, there is very little increase. During phase 3, the relative level of the lower inversion surface is increasing too but slower than that of the upper inversion surface. This suggests a consequence of the climate regulation of the upper structural ensemble.

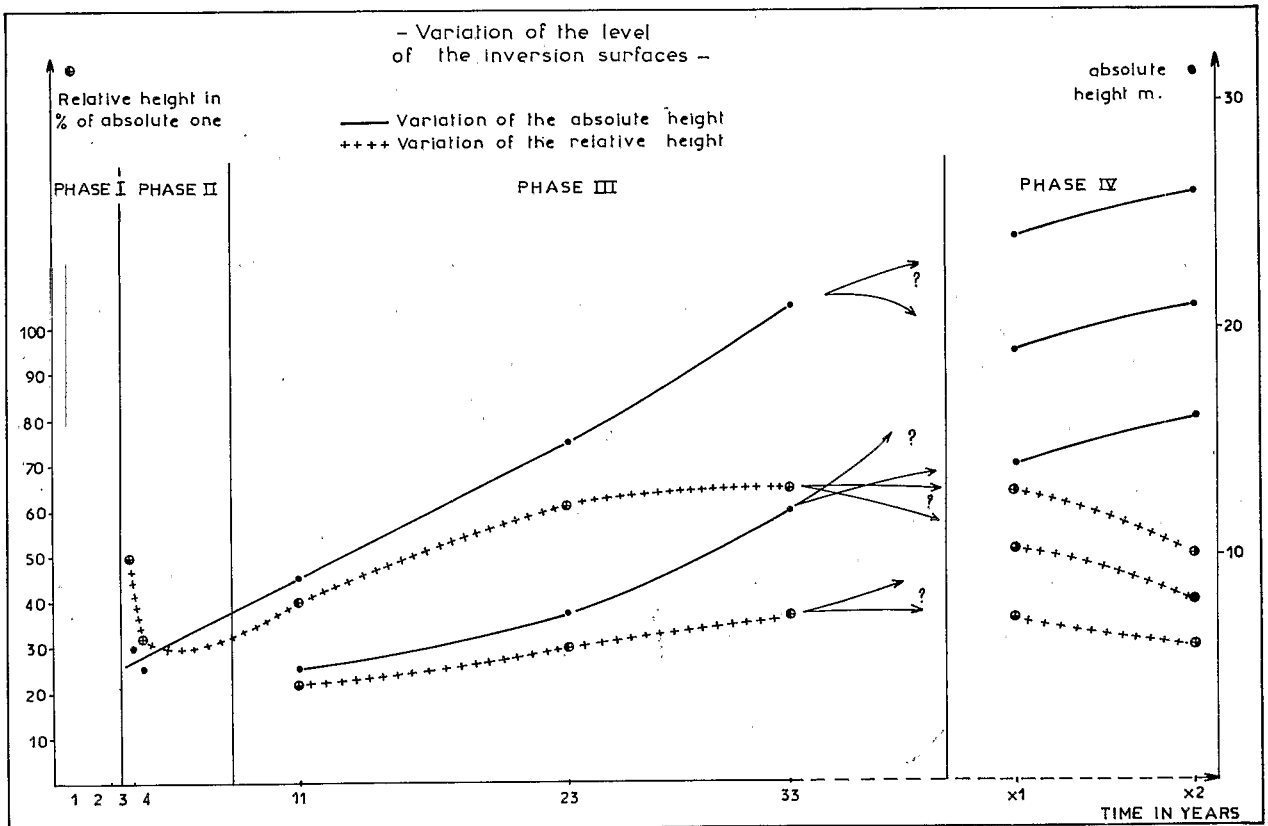

Fig. 9. Variations during the succession of the absolute average height of the inversion surface and of the average relative one (average height of inversion surface/average height of the vegetation × 100). The number of inversion surfaces defines 4 different architectural phases in the succession:
- phase 1: no inversion surface
- phase 2: one inversion surfaces
- phase 3: two inversion surfaces
- phase 4: three inversion surfaces

In phase 4 the plots on the time axis represent: × 1 the primary forest drawn in Fig. 7; × 2 the primary forest drawn in Fig. 8. Glancing at the size of the trees, it can be assumed that × 2 is older than . 1.

I emphasize the fact that in the second part of phase 3 (23–33 years), the variation in relative levels correlates with floristical changes in the structural ensembles (see Table 1).

In the primary forest, all the relative levels decrease from the assumed younger phase to the older one. This suggests that in a well – structured primary forest, crown growth remains more important than loops. In the older plot, the relative level of the upper inversion surface is about 50 %. If in this plot the loops to crown growth ratio becomes higher than this value, we can expect the recessior of the upper structural ensemble.

To conclude this paper, we can assume that the spatial development of the structural ensembles in a succession arises from three facts: crown growth, loops and floristic changes in the structural ensembles.

The observation of the first structural ensemble which appears and consists during 11 years solely or nearly so of *Inga* species, shows that this floristic phase of a structural ensemble is passing through a stage of crown growth – the relative level decreases fast – and then through an equilibrium one in which crowns grow a little faster than loops occur. This suggest than the dynamics of a structural ensemble could be described as a succession of such floristic phases.

Table 1. List of the species which have been found in the plots.

age	2½	3½	4	11	23	33	x_1	x_2
ANACARDIACEAE								
Anacardium occidentale L.	+							
Tapirira guyanensis Aubl.								+
ANNONACEAE								
Cymbopetalum brasiliense Benth.	+							
Guatteria sp.					+			
Rollinia sp.	+	+	+	+	+			
Xylopia sp.	+				+	+		+
APOCYNACEAE								
Ambellania acida Aubl.			+					
Anacampta macrocalyx (M. Arg.) Mgf.		+						
Geissospermum sericeum (Sagot) Benth.								+
Lacmella sp.					+			
ARALIACEAE								
Didimopanax morototoni (Aubl.) Dent. & Planch.	+		+		+	+		
BIGNONIACEAE								
Jacaranda copaia D. Don.						+		+
Tabebuia sp.							+	
BORRAGINACEAE								
Cordia cf. exaltata Lam.				+				
Cordia sp.						+		
BURSERACEAE								
Gustavia augusta Alm.				+				
Protium neglectum Swart.				+				
Protium sp.								+
Tetragastris hosmanii (Engl.) O.K.							+	
Tetragastris sp.							+	+
Trattinickia demerarae Sand.						+	+	+
Trattinickia sp.							+	
CAESALPINIACEAE								
Cassia fastuosa Willd.				+	+			
Tachigalia paniculata Aubl.							+	+
CELASTRACEAE								
Goupia glabra Aubl.				+	+			
CLUSIACEAE								
Vismia cayenensis (Jacq.) Pers.						+		+
Vismia sp.							+	
COMBRETACEAE								
Terminalia sp.				+				
ELAEOCARPACEAE								
Sloanea sp.	+							
ERYTHROXYLACEAE								
Erythroxylon sp.					+		+	
EUPHORBIACEAE								
Mabea piriri Aubl.		+						
Hyeronima laxiflora M. Arg.	+				+	+		+
FLACOURTIACEAE								
Casearia ssp.	+			+		+	+	+
Laetia procera Eichl.	+	+	+		+	+		
ICACINACEAE								
Discophora guyanensis Miers.				+	+	+		+
LAURACEAE								
Ocotea cf. splendens (Meiss.) Mez.							+	
Ocotea sp.								+
cf. Ocotea							+	
LECYTHIDACEAE								
Lecythis corrugata Poiteau.		+	+	+		+	+	+
MELASTOMACEAE								
Miconia sp.				+				
Undetermined, Wayãpi name: waimutu'i					+	+	+	+
Undetermined, Wayãpi name: wilakitã								+
MELIACEAE								
Carapa guyanensis Aubl.							+	
Guarea ssp.	+					+	+	+
MIMOSACEAE								
Inga auristellae Harms.		+	+			+		
Inga cf. bourgouni (Aubl.) D.C.						+		+
Inga disticha Miq.			+	+				
Inga cf. laterifolia Miq.				+	+			
Inga rubiginosa (A. Rich.) DC.			+	+	+			
Inga cf. sciadon Steud.								+
Inga cf. thibaudiana DC.	+	+						
Inga sp.								+
Inga sp.				+				

Table 1 (Cont.)

age	2½	3½	4	11	23	33	x_1	x_2
Inaga sp.	+							
Inga sp.					+			
Inga sp.		+						
Inga sp.	+			+			+	
Inga sp.	+	+	+	+	+			
Inga sp.						+		+
Parkia pendula (Willd) Bth.								+
Pithe cellobium ssp.					+			
MORACEAE								
Bagassa sp.				+				
Brocimum rubescens Taubert							+	
Cecropia ssp.	+	+	+	+	+			
Helicostilis tomentosa (P&E) Rusby			+					
Pourouma minor Benoist						+	+	+
Pourouma sp.						+		
Trymatococcus oligandrus (Benoist) Lanjouw.				+			+	
MUSACEAE								
Heliconia sp.	+							
Ravelana guianensis Benth.			+					
MYRISTICACEAE								
Iryanthera sagotiana (Benth) Warb.				+	+		+	+
MYRTACEAE								
Eugenia ssp.		+	+				+	
Myrciaria floribunda (West & Willd.) Berg.				+				
PALMAE								
Astrocaryum paramaca Martius				+				
Syagrus sp.								+
PAPILIONACEAE								
Derris amazonica Killip.	+							
Dioclea sp.				+				
Pterocarpus officinalis Jacq.						+		
QUIINACEAE								
Lacunaria crenata Smith.							+	
Quiina sp.						+		
ROSACEAE								
Hirtella racemosa Lam.								+
Licania ssp.							+	
RUBIACEAE								
Duroia sp.							+	
Isertia coccinea (Aubl.) Gmel.			+		+	+		
RUTACEAE								
Fagara sp.		+				+		
SAPINDACEAE								
Cupania sp.	+	+		+	+	+		+
Talisia sp.		+						
SAPOTACEAE								
Chrysophyllum sericeum DC.								+
SOLANACEAE								
Solanum arboreum H.B.K.		+	+					
Solanum sp.			+					
STERCULIACEAE								
Sterculia sp.					+		+	
ULMACEAE								
Trema micranta Blume.	+	+	+					
VOCHYSIACEAE								
Qualea coerulea Aubl.					+			
Vochysia densiflora Spruce ex. Warm.	+							
Vochysia tomentosa (G.F.W. Mey.) DC.				+				
UNDETERMINED: Wayãpi names (Phonetic symbols)								
akusi'ɨ			+					
akusi'ɨ kusi'ɨ					+			
awi'a			+					
inãmusĩ	+							+
umi'ɨ			+	+				
ɨwaw's̃wĩ								+
kula'ɨ					+			
matau'ɨ						+		+
pa'aletwapɛ							+	
palakuta						+		
taywilenipiã					+			
tulisĩ								+
wa'inemi'			+					
wilakea							+	

Table 1 (Cont.)

age	2½	3½	4	11	23	33	x_1	x_2
wɨlapilɛlu							+	
wɨlatɨ							+	
winãmɛ'ɨ							+	
yakami'ɨ								+
yãsilɛãĩy							+	

Summary

This paper deals with one aspect of an architectural study of different phases in secondary vegetation. An investigation has been carried out on the abandoned fields of one Indian tribe of French Guiana. This study is largely based upon the theory of forest architecture by R.A.A. Oldeman (1974). A short revue of the most important concepts of this theory is presented, such as 'initial model', 'reiteration', 'set of the present, of the future and of the past', 'structural ensemble' and 'inversion surface'. Moreover, different stages of the architecture of vegetation, $2\frac{1}{2}$, $3\frac{1}{2}$, 4, 11, 23, and 33 years old have been described with help of diagrams, as well as two aspects of primary forest situated in the vicinity of secondary vegetation. Finally, a variation of a few measurable parameters through a period of time has been analyzed and conclusions drawn about the observed succession of architectural phases.

Résumé

L'auteur étudie l'architecture de differentes phases de la régénération forestière observée en Guyane française sur d'anciens essarts de l'une des tribus amérindienne du pays. Cette étude qui se fonde sur la théorie de l'architecture forestière que l'on doit à Oldeman (1974) en résume tout d'abord les principaux concepts. Puis l'architecture est étudiée sur differentes parcelles où la végétation est agée de $2\frac{1}{2}$, $3\frac{1}{2}$, 4, 11, 23 et 33 ans, ainsi que sur deux parcelles de forêt primaire proches des anciens essarts étudiés. L'auteur décrit enfin les variations, au cours de la régénération, de quelques paramètres mesurés et dégagés par l'étude de l'architecture; il décrit ainsi des phases architecturales de la régénération.

Resúmen

El sujeto de esta comunicación es un aspecto del estudio bioarquitectural de las distintas fases de la vegetación secundaria. Las investigaciones de campo han sido efectuadas en las chacras abandonadas de una tribu indígena de la Guyana francesa, la de los Wayãpi. El análisis se apoya en la teoría de la bioarquitectura del bosque, publicada por Oldeman, en 1974, y comienza defimiendo algunas de las nociones más importantes de este método, tal como el 'modelo inicial', la 'reiteración', los 'conjuntos del presente, del futuro y del pasado'. Además, han sido presentados varias fases bioarquitecturales del bosque secundario respectivamente de $2\frac{1}{2}$, $3\frac{1}{2}$, 4, 11, 23 y 33 años de edad, y también, dos aspectos de selva primaria ubicada en la vecindad del bosque secundario. El método de representación gráfica se sirve de diagramas esquemáticos. Por fin, han sido analizados algunos parámetros mesurables durante un periodo de tiempo. Las conclusiones incluyen los característicos del proceso de succesión que se observó a través de sus fases bioarquitecturales.

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