FOREST SUCCESSION ON A DEFORESTED AREA IN SURINAME[1] /

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Compendio

En un terreno desmontado mecánicamente se estudió la sucesión vegetal dentro de una parcela de 0.45 ha durante 11 años. Se describió el desarrollo de la vegetación con base en la composición florística, el porcentaje de cobertura de las especies, el perfil longitudinal y el incremento del área basal. En general, después de una extensión vigorosa de plantas anuales y de gramíneas, ciperáceas y solanáceas arbustivas, se desarrolla en 2 – 3 años un bosque secundario de Cecropia obtusa, *quen en 5 años alcanza su altura máxima de 17 m. Ahora en este bosque un grupo de otros pioneros arbóreos, que antes formaba un segundo estrato, está penetrando el dosel y ganando dominancia (*Vismia guianensis, Isertia *sp.*, Inga *sp.). En un sitio con drenaje impedido gramíneas y ciperáceas se han mantenido y en otro sitio con quema intensiva y acumulación de cenizas los árboles se han desarrollado solamente cerca de los fustes caídos y troncos derribados.*

Introduction

Objective

A better knowledge of cause and effects of man-induced disturbances is a pre-requisite to tropical forest ecosystem manipulation and sylviculture" (FAO 1978, p. 230).

In this respect succession studies are of major importance. In tropical America the first succession studies were made by Kenoyer (10) in Panama (1929), Marshall (12) in Trinidad (1934) and Benoist (2) in French Guyana. More recently Budowski (4) and Gómez-Pompa & Vázquez-Yanes made important contributions to our knowledge of secondary succession of tropical lowlands. Despite these studies this knowledge is still very incomplete.

In Suriname in 1967 a series of succession experiments was started by the Centre for Agricultural Research in Suriname as a part of studies of rainforest regeneration after selective timber exploitation. The object of these experiments was to obtain detailed information of the course of the succession after human interference at different levels of intensity in the original forest.

Experimental plots were laid out in virgin forest, exploited forest, on deforested areas and on areas deserted after shifting cultivation. This paper deals with an experiment on an area deforested with heavy machinery. The author summarizes the data recorded during the first 11 years of this experiment by his predecessors and the data he recorded himself.

Site

The experimental plot is situated at Blakawatra in the north-eastern part of Suriname at about 70 km

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This paper is the result of the combined efforts of the scientists and students who worked on this experiment. I wish to thank all those who participated at any time in this study. The help and encouragement of the late Mr. J. Procter of the Centre for Agricultural Research in Suriname and the advises of Dr. ir. J. H. A. Boerboom of the Agricultural University in Wageningen were greatly appreciated. Last but not least I thank Mr. H. Sabajo for his assistance in the field.

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from the coast. The location is near the edge of a dissected plateau of late Tertiary age at 20 m above sea-level. The soil is a well-drained sandy to slightly sticky loam, as contrasted with the surroundings of the plot which consist of bleached white sands. The relief varies from nearly flat to slightly concave.

In August 1966 the area was cleared by heavy equipment for the purpose of planting pines. An area of 80 x 120 m was set aside for the experiment. Since 1967 the experimental plot has been surrounded by plantations of *Pinus caribaea* Morelet.

Detailed information on the forest covering the area before clearing, is not available. Some data were obtained later, from the analysis of wood samples collected in the windrows that were left after clearing. Probably the original vegetation was a mesomorph evergreen seasonal forest with a tendency towards the xeromorphic forest, locally called savanna-forest (Heyligers (9)). The nearest high forest to the plot is a swampy forest along a small creek, at a distance of about 250 m. The distance to the nearest savanna-shrubland is 100 m.

Climate

Suriname has a permanently humid tropical climate with a mean annual rainfall between 2000 and 2500 mm. In the driest months, September and October, precipitation generally does not drop below 60 mm. Yearly variation in total rainfall and rainfall distribution is considerable. The temperature is fairly constant throughout the year. In the capital Paramaribo the monthly mean temperature varies between 26.1°C in January and 28.3°C in October, the yearly mean temperature being 27.1°C. Schulz (15) give more details of the Suriname climate.

Methodology

Lay-out

In August 1966 the experimental area was deforested with heavy machinery. An attempt to burn the debris at the time of clearing was unsuccessful. Afterwards the debris was piled in windrows of about 10 m wide which were burned in November 1966. From this month on no more human interferences took place. November 1966 is considered as the starting point of the succession. In February 1967 a permanent measuring plot of 50 x 90 m was laid out. This was divided into 45 subplots of 10 x 10 m. A surround of 15 m width separates the measuring plot from the pine-plantations. Five subplots coincide with the windrow that lies centrally in the measuring plot (Figure 1).

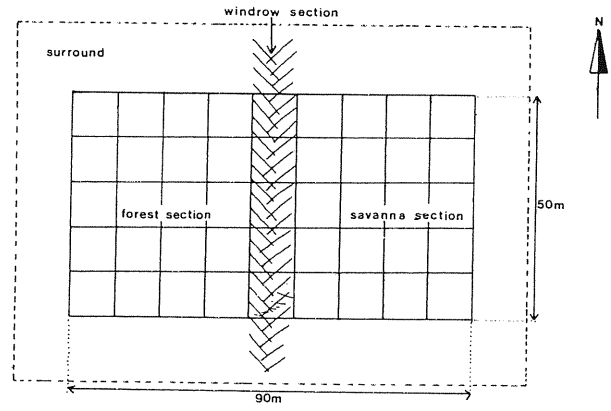

Fig. 1. The experimental plot; explanation: see text.

Recordings

Since the start of the experiment several scientists and students have been working on this experiment. The following methods of recording the vegetation were used:

- mapping. The first recording, 3 months after burning, was a mapping of all young plants that were established on the bare ground. This was done in 7 subplots and repeated 6 months later in 2 of the 7 subplots. The author made a mapping of the groundcover in 4 of these 7 subplots 133 months after the beginning of the succession.

- estimation of cover. In several subplots the cover percentage of every species was estimated. This was done 6 times during the course of the experiment. The number of measured subplot varied from 23 to 6 in different recording years. The first estimation was done 3 months after burning. The last one by the author, 133 months after burning. These data are summarized in diagrams (Figures 2, 4, 6) which show the cover percentages plotted against time.

- description of the structure of the vegetation. Additionally the structure was described by measuring maximum heights and estimating mean heights of the different vegetation strata.

- girth measurements. Thirty-five months after the burning, girth measurements of the trees that by then had colonized the plot, were started. Above a lower girth limit of 200 mm, measurements

were regularly repeated and the last one was done by the author, 134 months after the burning.

- profile diagrams. The author drew profile diagrams on 3 plots that were considered to be characteristic for each of the three vegetation types that developed. This was done 134 months after the beginning of the succession.

- floristic inventory. The author made a floristic inventory of all the species in the experimental plot 132-134 months after the burning.

The data of the earlier recordings were published in internal reports by Consen *et al.* (5), Van 't Leven (11), Visser (16) and in Anon. (1). The results over 1967-1974 were described by Boerboom (3) and summarized in FAO 1978 (7).

The experiment was not designed with the aim of statistical analysis of the data. The variability of the number of recorded plots and the different recording methods hinder the interpretation of the data. Consequently the data have only a relative value, but they offer a good basis for a description of the succession in this particular plot.

Results

Differentiation within the experimental plot

Within the experimental plot the succession proceeded along different lines. Three definite seres can be distinguished.

In the western part no deviating conditions occured. Here, soon after clearing, trees became the dominant component of the vegetation.

In the central part of the plot the burning left a thick layer of ash in the windrow of charred trunks and stumps. Here the burning released a large amount of nutrients and killed all the viable diaspores in the soil. These factors established that in the windrow the starting point of the succession differed from the rest of the experimental area. Consequently a different sere developed.

The eastern part, characterized by a slightly ponded topography and a somewhat heavier sticky loam soil, was nearly completely flooded for a few weeks owing to extremely heavy rainfalls 7-8 months after the burning. This inundation caused a radical deflection of the succession by killing most of the dicotyledonous seedlings, established a few months earlier. Thus a savanna-like vegetation developed.

The succession in the experimental plot will be dealt with separately for the forest, the windrow and the savanna section.

The course of the succession

A. The forest section

The first colonization

In the forest section seedlings became established during the first wet season after the burning. At the first recording in February 1967 the total cover of the vegetation was less than 0.1% . The seedlings were fairly evenly distributed over the area. Half of them belonged to monocotyledonous species (Gramineae and Cyperaceae) and half to dicotyledonous ones (Figure 2). There were also a few sprouts from roots that had remained in the soil after clearing.

At the age of 9 months the vegetation already covered 40% of the area and reached a height of 1.5 m. It was an unevenly distributed vegetation of scattered single-species colonies together with some shrubs and tree seedlings. Species having the ability to spread rapidly were dominant. Herbs, mostly annual plants, covered 7% of the area. *Scleria secans* L. (Urb.) that had spread by the formation of long lateral shoots covered 2%. The shrub-forming Solanaceae grew vigorously and formed the most conspicuous feature of the vegetation at this time.

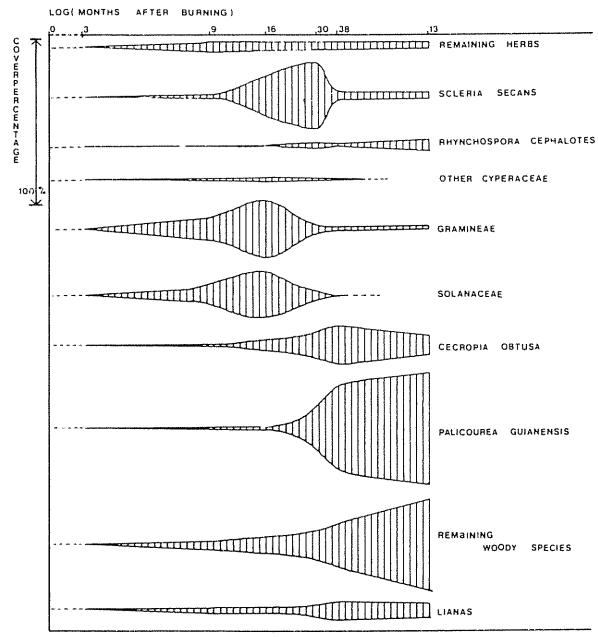

Fig. 2. Cover percentage diagram of the forest section.

Solanum subinerme Jacq. had spread by means of subterranean shoots. Thirteen percent of the area was covered by Gramineae. Since the first recording, nearly no new seedlings of woody species had become established apart from a few of *Cecropia obtusa* Miq.

Development of a stratified vegetation

Sixteen months after the burning the cecropias had grown vigorously and formed a very open upper layer of 4-5 m height. At the same time *Scleria secans* and the Solanaceae had continued their growth and formed an impenetrable layer 1.5 m high, interspersed with young secondary trees.

Thirty months after the beginning of the succession a clearly stratified wood had been formed comprising an open 8-11 m high *Cecropia* layer, sharply separated from a 3-7 m high layer, mainly consisting of *Palicourea guianensis* Aubl., *Isertia* sp. and partly moribund *Scleria*. A third layer was formed by overgrown Solanaceae and *Scleria*, including some small trees of the species mentioned above and a few others. The Gramineae had been greatly reduced, probably as result of the increasing shade of the tree layers. Lianas had developed and covered 7% of the area.

Developments in the later stages

After the third year changes were less rapid. In 60 months *Cecropia obtusa* reached its maximum heigh of 11-17 m, whereas 75 months after the burning a process of slow decline started. Gradually trees were losing branches and leaves until whole crowns broke off and new shoots developed at lower parts of the stem. Finally the trees die. The decline is a slow process and 133 months after the beginning of the succession about 55% of the cecropias were still alive.

The species of the second layer on the other hand kept growing vigorously. In particular *Palicourea guianensis* showed a remarkable growth and covered after 133 months about 60% of the area. But the trees did not reach the top of the canopy and still form a dense second layer of relatively small trees at about 12 m height. However, some of the other woody species succeeded in penetrating the upper layer, in particular *Isertia* sp., *Inga* sp. and *Vismia guianensis* (Aubl.) Choisy. After 30 months the cover percentage of *Scleria secans* had sharply decreased, but after 133 months some remnants still survived as a thin ground cover. The *Solanum* shrubs had vanished. So the undergrowth became sparse in the dark interior of the forest section. But it harbours an increasing number of species including components of all strata of the original forest, e. g. *Dicorynia guianensis* Amsh., *Paypayrola guianensis* Aubl. and *Astrocaryum paramaca* Martius, each represented by a small number of individuals.

A hundred and thirty-three months after clearing 35 tree species were counted on the 0.2 ha of the forest section. It is remarkable that all the trees forming the canopy were established in the first months after the burning. In the dense shade no more seedlings of the pioneer species were found. Figure 3 gives an impression of the situation of the forest at that time.

B. The windrow section

The first colonization

In the windrow a very heterogenous vegetation sprang up. Where the site was covered with a thick ash layer, algae were the first colonizers, soon forming a dark crust. Five to six months after the burning annuals became established in the central parts of the windrow. *Portulaca oleracea* L. and *Erechtites hieracifolia* Rafin., the most common species, produced two or three generations within a few months. Then they gave way to invading Cyperaceae, Gramineae and Solanaceae (Figure 4).

Remarkable were a few herbaceous species that in the early stages of the succession were found only near or at the charred stems: *Phytolacca rivinoides* H. et B. and the ferns *Pityrogramma calomelanos* (L.) Link and *Pteridium aquilinum* (L.) Kuhn.

Tree establishment and later stages

No tree seeds germinated in the ash layers but where stems and uprooted stumps are found and some soil had been accumulated, i. e. mainly along the edges of the windrow, the secondary species mentioned for the forest section, became established. Three months after the burning their cover percentage was less than 0.1% , but after 30 months particularly *Cecropia obtusa* had demonstrated a vigorous growth. The dominance of this species in the windrow is much more striking than in the forest, while *Palicourea guianensis* is represented by only a few trees. During the succession *Scleria secans* behaved the same as in the forest. The Cyperaceae, Gramineae and Solanaceae slowly disappeared when after 30 months the shade became more dense. But 133 months after the burning remnants could

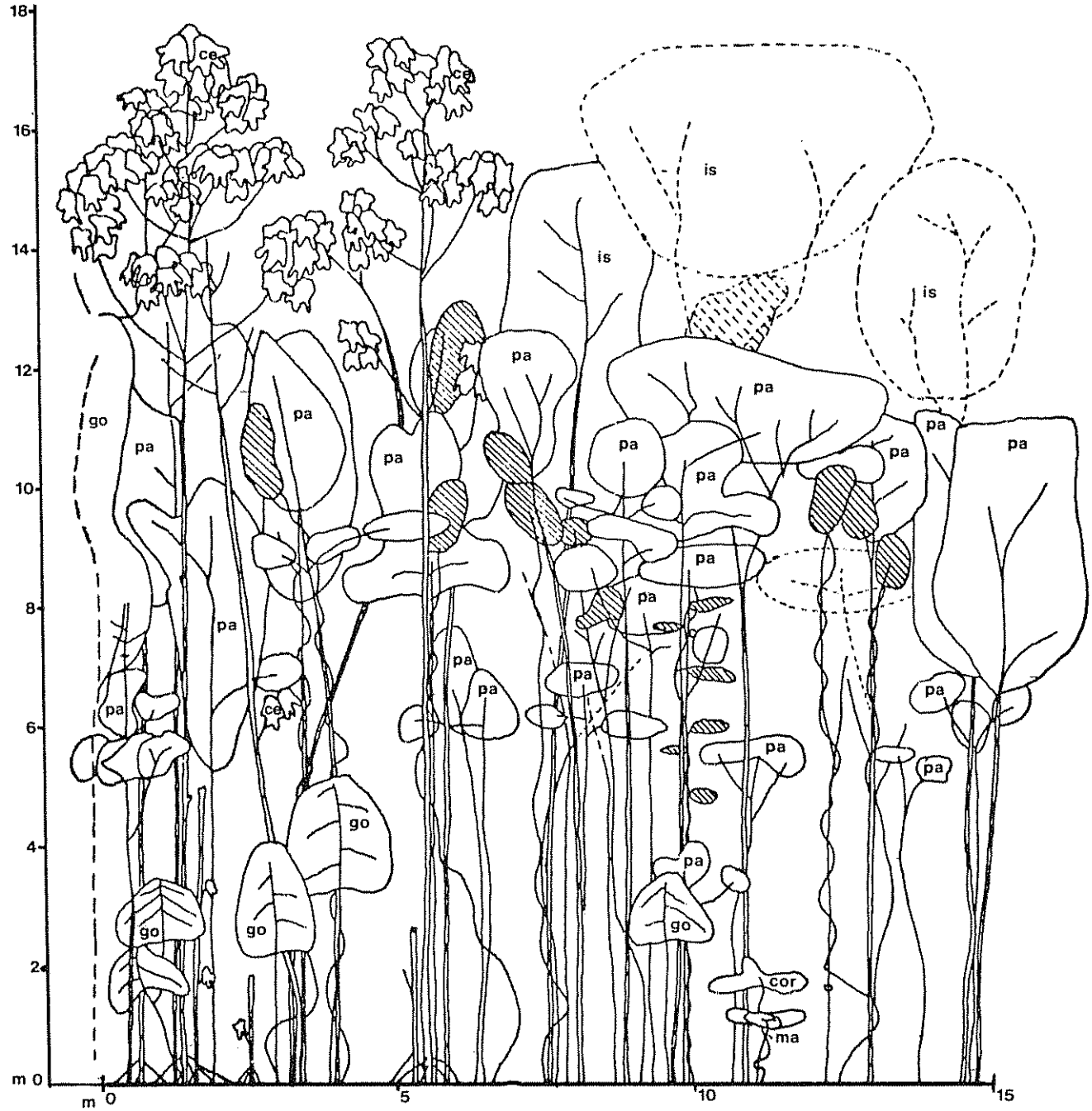

Fig 3. Profile diagram of the forest section; 134 months after burning ce: *Cecropia obtusa*; cor: *Cordia Nodosa*; go: *Goupia glabra*. is: *Isertia* sp. ma: *Maprounea guianensis*; pa: *palicourea guianensis*.
– – – – – dotted individuals stand outside the plot, while their crowns hang over the plot.
▨ lianas
Plot size: 15 x 5 m².

still be found and still no big trees were growing in the central part of the windrow (Figure 5).

Cecropia obtusa is declining slowly, but the process started much later than in the forest section and was still not very obvious after 133 months. The main other tree species are *Vismia cayennensis* (Jacq.) Persoon, *Goupia glabra* Aubl., *Laetia procera* (Poepp. et Endl.) Eichler and *Tapirira guianensis* Aubl.

C. The savanna section

At first the succession, the "savanna" seemed to develop in the same direction as in the "forest", but

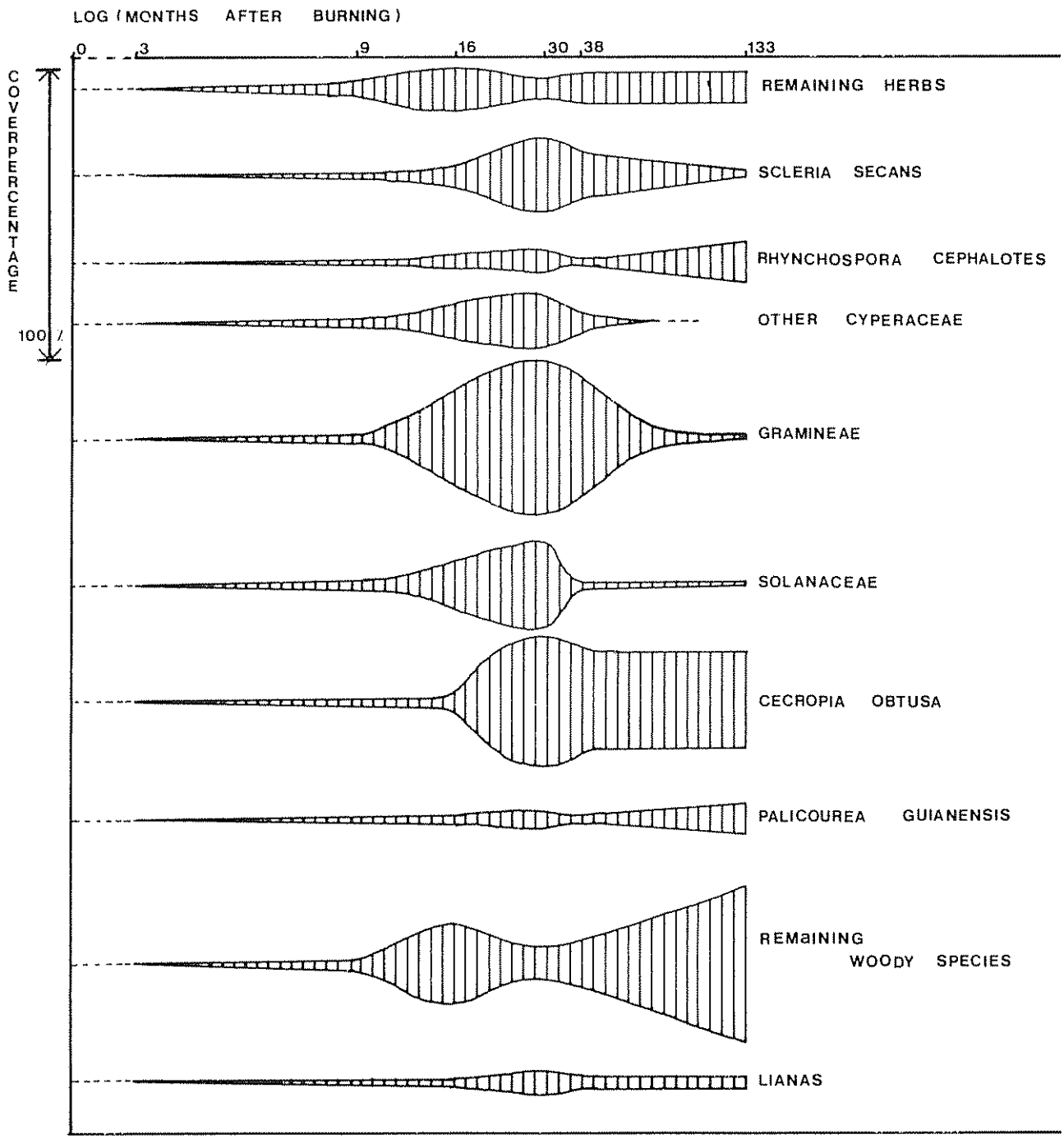

Fig. 4 Cover percentage diagram of the windrow section

most of the area was flooded and the greater part of the dicotyledonous seedlings died. Only on a few higher spots tree seedlings survived. After about 30 months a closed vegetation of Cyperaceae and Gramineae had developed with *Rhynchospora cephalotes* Vahl. as the most dominant species.

Thus a savanna-like vegetation resulted.

During the next 100 months nearly no new woody species became established. However the trees on the small elevations grew up and their crowns began to spread laterally over the low vegetation.

Moreover two *Vismia* species occuring in the border penetrated the grassland by means of suckers arising from horizontal roots (see Figures 6 and 7).

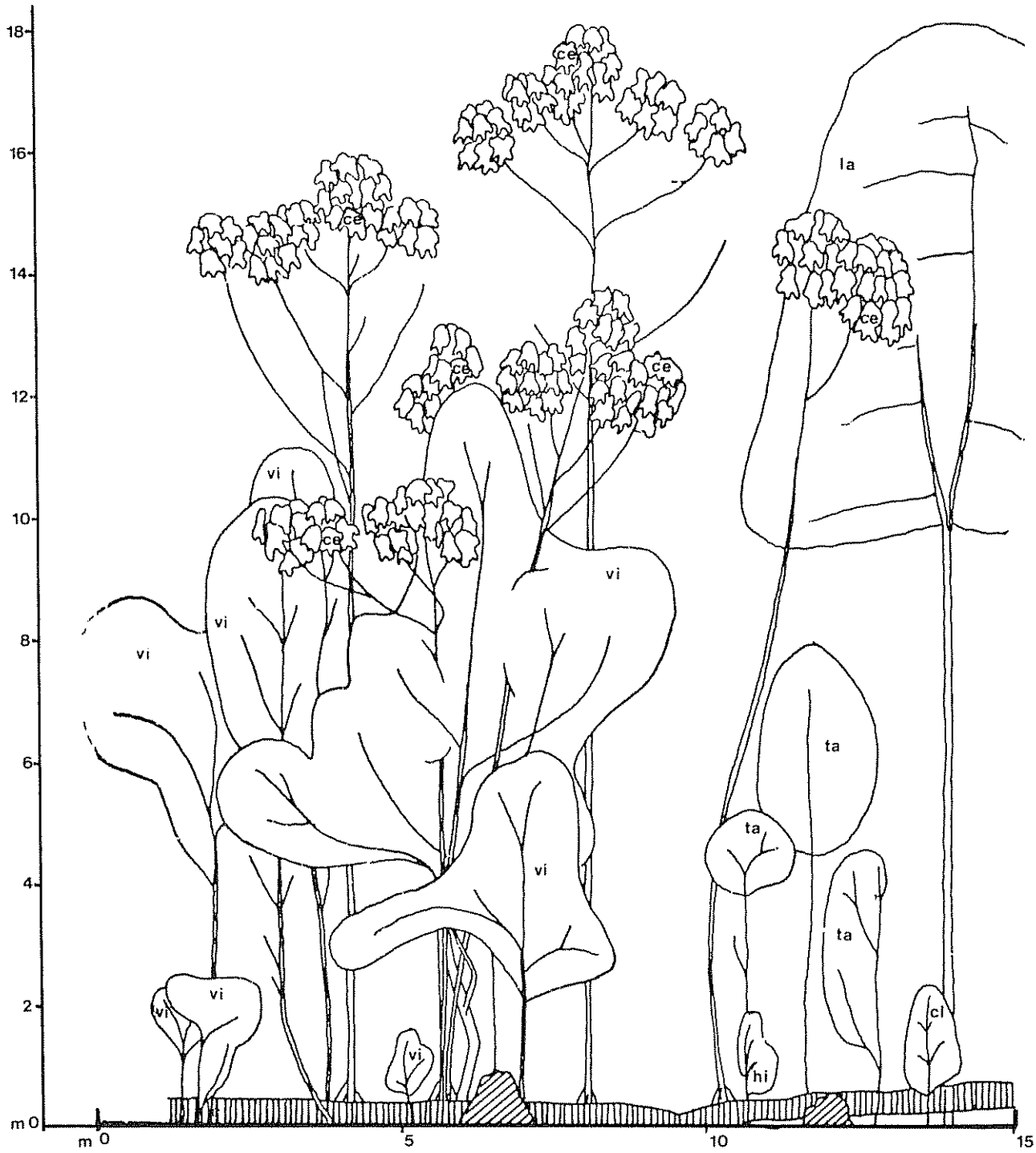

Fig. 5 Profile diagram of the windrow section: 134 months after burning ce: *Cecropia obtusa* cl: *Clusia fockeana*. hi: *Hirtella hirsuta* ta: *Tapirira Guianensis* vi: *Vismia guianensis* la: *Lactia proccra*

Fallen stems

Uprooted stumps

Plot size: 15 x 5 m²

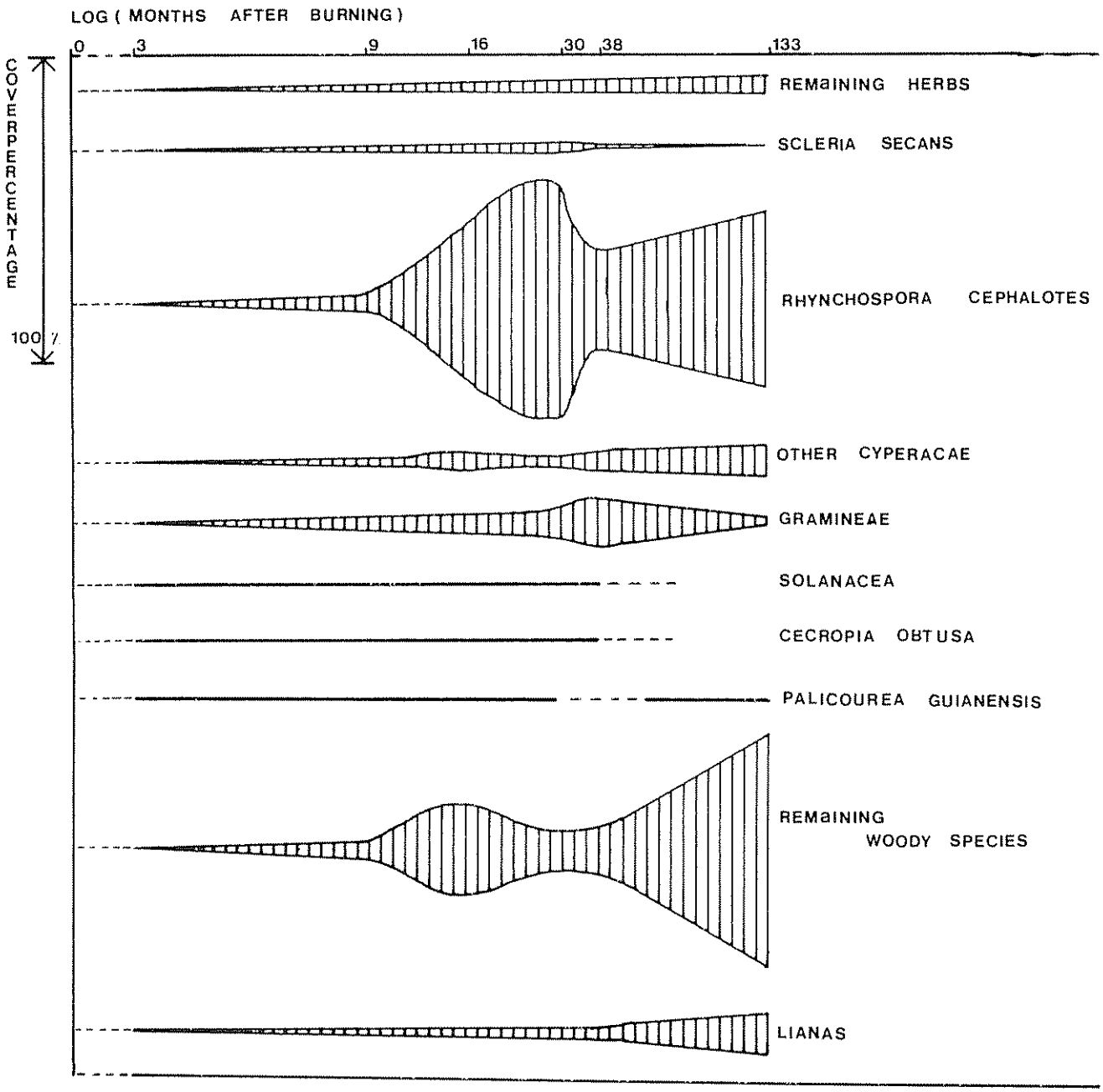

Fig. 6 Cover percentage diagram of the savanna section

Other species colonizing the grassland are *Goupia glabra*, *Maprounea guianeńsis* Aubl. and *Parinari campestris* All these species occur in the original forest.

Basal area

The graphs of the development of the basal area show the same general features as the cover percentage diagrams (Figure 8). The total basal area of the windrow is the highest of the three sections. This is due to the very vigorous growth of the cecropias, which may be ascribed to the accumulation and burning of organic material in the windrow.

In the forest-section *Cecropia obtusa* held the biggest portion of the total basal area in the first 75 months after the beginning of the succession.

Fig. 7 Profile diagram of the savanna section: 134 months after burning an: *Aniba hostmanniana*, coc: *Coccoloba marginata* go: *Goupia glabra* ma: *Maprounea guianensis* mi: *Miconia tomentosa*, st: stems of species of which the crowns are outside the plot; vi: *Vismia* sp.

Plot size: 15 x 5 m²

After that a decline of *Cecropia* started and other species like *Palicourea guianensis* developed. Although the crowns of *Palicourea guianensis* cover a bigger area than those of *Cecropia* (Figure 2), the basal area is less (Figure 8). Figure 3 indicates that this species is represented by many small trees.

In the windrow section *Cecropia* still covered the major part of the basal area 133 months after burning, but other species were growing vigorously. *Palicourea guianensis* is of minor importance. On the savanna the total basal area is low, but gradually increasing; *Cecropia obtusa* and *Palicourea guianensis* make only a small contribution to the total.

Discussion

This experiment clearly shows the course of the succession during the first eleven years after deforestation. After a vigorous expansion of annuals, grasses, sedges and shrubby Solanaceae, acoompanied by rapid growth of a small number of pioneer tree species, a second set of tree species, like *Isertia* sp., *Inga* sp., *Vismia guianensis* and *Goupia glabra*, is now gradually taking over. It is remarkable that this second set of tree species established soon after the beginning of the succession, at the same time as the first set of pioneer species. They developed steadily in the shade of the rapidly growing pioneer species

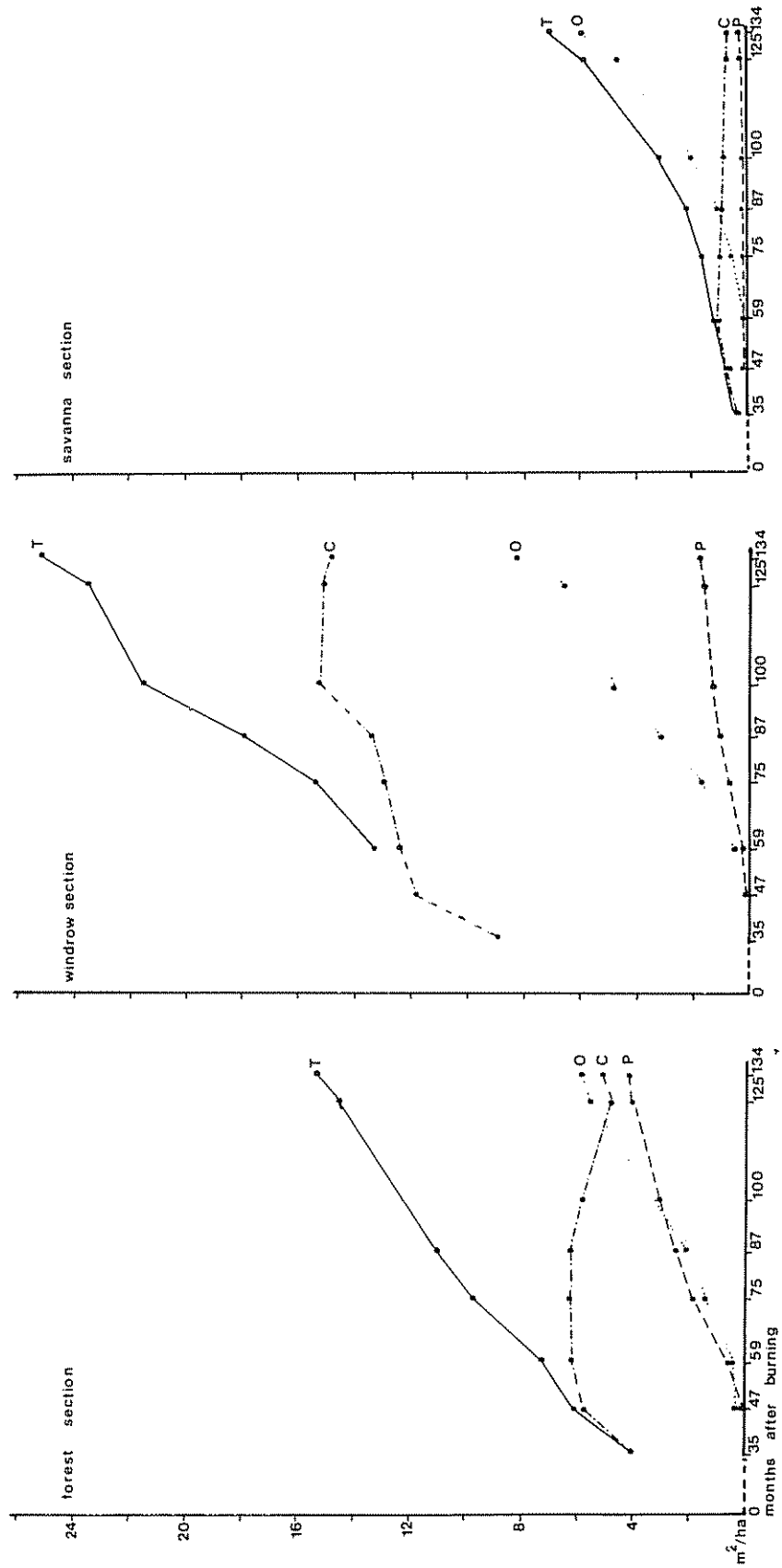

Fig. 8 Graphs of the basal area.
C: *Cecropia obtusa*; P: *Palicourea guianensis*; R: remaining woody species; T: total.

and penetrated the canopy after the decline of these pioneer species had started. All the trees forming the canopy 133 months after the beginning of the succession, established soon after the clearing. From the regeneration that established in later stages of the succession trees did not yet develop.

The present study shows that the succession is still in its early stages, 11 years after the beginning. To obtain more information about the following stages this unique experiment should be continued in the following decades.

This experiment also demonstrates that relatively small environmental changes early in the succession, such as a temporary inundation and the burning of organic material, may cause remarkable divergences in the development of the vegetation.

Once more it should be stressed that caution be exercised in generalizing on the basis of the results of this single experiment.

Summary

The succession on a mechanically deforested area of approximately 0.5 ha has been studied for 11 years. Cover percentage diagrams, species composition, profile diagrams and basal area increment are used to describe the course of the succession. After a vigorous expansion of annuals, grasses, sedges and shrubby Solanaceae accompanied by rapid growth of a small number of pioneer tree species, a second set of tree species is now gradually taking over.

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Notas y comentarios

IV CONGRESO LATINOAMERICANO DE ENTOMOLOGIA Y VI CONGRESO VENEZOLANO DE ENTOMOLOGIA

En dos congresos entomológicos reunidos en la primera semana de julio de 1981, se reunieron también diversas agrupaciones de esa especialidad, como las Sociedades Internacionales de Acridiología, Lepidopterología Neotropical, de Ecología de Culícidos, y Afidología. Las conferencias y simposia complementaron la presentación de trabajos de alrededor de 360 especialistas de diversos países latinoamericanos, norteamericanos y europeos.

El Dr. Pedro Casals, de la Facultad de Ciencias Agropecuarias de la Universidad de Concepción, sede Chillán, asistió al evento con el apoyo de la Oficina del IICA en Chile, y presentó el trabajo "Dinámica poblacional y actividad de *Empoasca curveola*" La acción de este insecto disminuyó el rendimiento del frijol cv. Pinto en 10.1 porciento en el estudio hecho en los campos de la Facultad de Ciencias Agropecuarias e Instituto de Investigaciones Agropecuarias en Chillán.