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The vegetation of Volcán Poás National Park, Costa Rica

by

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ABSTRACT: The vegetation characteristics of the range of habitats within the Volcán Poás National Park are described. General observations were supplemented by recording details of all trees along 10 x 50 m transect lines and representative profiles of the forest drawn. The following habitats were recognised: 1) Crater and immediate vicinity; 2) Arrayan areas; 3) Stunted forest; 4) Montane rain forest — above 2,600 m; 5) Lower montane wet forest; 6) Old pasture areas; 7) Pastures of lower slopes.

During 1972 a study of the vegetation of Volcán Poás National Park was carried out as part of an ecological survey with the intention of providing basic information for management planning, interpretation and determination of research needs. Some information was already available (BOZA, 1). The volcano, being one of the most accessible areas of montane vegetation, has been visited by scientists since the latter half of the 19th century (PITTIER, 4). However, the objective of many visits was the collection and identification of species and therefore detailed descriptions of the plant communities are not available.

DESCRIPTION OF STUDY AREA: Volcán Poás is one of the seven active volcanos in Costa Rica and is part of the western end of the Cordillera Central. It takes the form of a flattened dome with two cones rising above the massif, reaching a height of 2,708 m. Below 2,400 m the slopes are steep and drop quickly to 2,000 m. The park includes most of the volcano above 2,350 m in which there are three main geographical features:

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i) The active crater—is 300 metres deep with perpendicular stratified walls and a small laguna at the bottom. Volcanic activity has been continuous, with periodic geyser type eruptions and continual escape of gases. Eruptions occasionally are of considerable size and duration and ash is depositd over a wide area, as occured in 1952-53.

ii) The bare eroded area to the west and to the northeast of the crater—the vegetation has been destroyed by volcanic activity and deep gullies have formed in the unprotected ground.

iii) The old craters—the walls of which are still clearly visible. The oldest is probably that which now contains the "laguna"—a shallow lake 8 m deep.

The climate is characterised by a heavy rainfall of 3,700 mm a year, and high humidities. Rainfall occurs throughout the year, particularly from May to October with a drier period from December to April, with many rain-free days. There is little annual variation in temperature, which ranges from 9 to 13 C, although the daily fluctuations are much greater. The hottest months are May to July, the coldest December and January, although extremes occur on clear days in open sites in February and March. Maximums of 18 C and minimums of -0.5 C have been recorded (MACEY, 3). Temperatures are more stable in the forested areas. The Atlantic influence dominates the weather conditions, with prevailing winds from the northeast.

The volcanic soils are characterised by the presence of a number of layers, each produced by consecutive eruptions of the volcano. This layering is more extensive and pronounced near the crater, with colours varying from white to brown and black and with a texture depending on the amount and size of ash and cinders which fell. The development of these soils is hindered by periodic ash coverings, lack of vegetation cover and low temperatures which reduce microbiological activity, delaying the breakdown of material. The more developed soils of the forests are a uniform brown with a thick black humus layer. They vary in depth and show no regular profile. Wherever vegetation has been removed erosion has occured, especially on sloping ground where top soil is quickly removed by the heavy rainfall. These soils are acidic and relatively deficient in nutrients if compared to the fertile soils of the lower slopes, which are better structured and hold nutrients.

Much of the park is covered with forest vegetation except where destroyed by volcanic eruptions, clearance for pastures or by logging activities. The term "cloud forest" is often used to describe the vegetation of this altitude, a term derived from the fact that, as air blowing from the Atlantic rises over the mountains, condensation occurs and clouds cover much of the land over 2,000 m. This area is classified according to HOLDRIDGE (2) as Lower Montane Wet and Montane Rain Forests.

MATERIAL AND METHODS

As much of the study area as possible was covered on foot and extensive field notes made. These were supplemented by more detailed observations using 50 × 10 m transects from which the following information was recorded:

1. Position of each named tree
2. Approximate height of each tree
3. Total number of trees
4. Total number of species
5. Number of trees of each species
6. Type and extent of ground cover

This information was then used to draw the profiles (Figs. 3-6), and to determine the relative abundance and frequency of occurrence of each species.

Changes in vegetation with distance from the crater were examined by recording the vegetation at 10 m intervals along a transect line from the crater lip to a height of 160 m above this, on the southern side.

Quantitive data were not collected in the pasture areas. Access was difficult to a large area of the park north of the crater, which includes forest slopes below 2,300 m, therefore this area was not included in the study.

RESULTS AND DISCUSSION

Different vegetation characteristics were found in each of the following habitat types:

1. Crater and immediate vicinity
2. Arrayan area
3. Stunted forest
4. Cloud forest at 2,600-2,700 m with *Clusia-Didymopanax-Weinmannia* associations
5. Cloud forest at 2,450-2,550 m with *Quercus-Podocarpus* associations
6. Old pasture areas
7. Cattle pastures of the lower slopes, 2,350-2,450 m.

The following descriptions summarise the observations made. An attempt was made to localise some of the different habitats on the map (Fig. 1). Figures 2-6 and Tables 1-4 give the results obtained from the transects. Several transects were completed in each of the forest habitats but those given here are the most representative of the area. Any differences observed are noted in the descriptions.

CRATER AND VICINITY: To the west and to the northeast of the crater is an extensive barren area. Eruptions have killed off all the vegetation, either leaving dead tree stumps or removing vegetation completely. No plants can grow within the crater itself; the frequency of eruptions, sulphur fumes and lack of soil inhibit any germination of seeds. However, around the lip of the crater and on the surrounding eroded areas small plants of *Pernettia coriacea* and the fern *Elaphoglossum lingua* are found, their roots embedded in hardened ash or lava. Plants are found in gullies much nearer the crater than on the exposed ridges or flat areas between them. In the western area numerous small streams flow down the slopes and in these places there is often a thick covering of moss-like *Selaginella porphyrospora* and plants of *Eupatorium durandii.*

With increasing distance from the crater's edge the number of species increases with *Vaccinium consanguineum, Arcytophyllum lavanum, Myrica phanerodonta, Gaultheria* sp., mosses and lichens. Similarly, individual plants increase in size. Higher up, seedlings of *Didymopanax, Clusia* and *Monochaetum vulcanicum* appear and eventually most of the species common to this region are found. Along the transect of 400 m the numbers of species increased from 0 to 26. The changes in vegetation observed are shown diagramatically in Figure 2.

ARRAYAN AREA: Near the look-out and along the first part of the trail to the laguna is an extensive area of old stunted and dead bushes and trees. Most of these were "killed" probably during the 1952 eruption but are now regenerating new shoots. The plants are between 2 and 3 m high and the most common species are *Vaccinium consanguineum* and *Vaccinium poasanum.* Small trees of *Didymopanax pittieri, Clusia odorata* and *Myrica phanerodonta* are also found. The semi parasites *Dendrophthora* spp. are also very common.

TABLE 1

Summary of data from Arrayan area

	Species	No.	Relative Abundance	Relative Frequency
v	*Vaccinium consanguineum*	57	67	36
V	*Vaccinium poasanum*	17	20	32
C	*Clusia odorata*	4	5	11
M	*Myrica phanerodonta*	4	5	11
m	*Myrtus oerstedii*	2	2	7
D	*Didymopanax pittieri*	1	1	4
	Total	85		
	Total species	6		

In this area the soils are particulary poor; thick layers of cinders are clearly visible and erosion is widespread. This is partly due to the exposed nature of the area, but primarily a result of excessive human disturbance. The ground is bare except for the growth of some ferns e.g. *Elaphoglossum lingua* and *Eriosorus warscewiczii.*

To the west of the look-out is a similar area but it has suffered less from erosion and disturbance by visitors. Therefore the ground cover is more extensive and a greater number of species are found. Species less than one metre high forming the ground cover are; *Miconia myrtillifolia, Monochaetum vulcanicum, Nertera depressa, Centropogon gutierrezii, Elaphoglossum lingua, Carex donnell-smithii, Eupatorium durandii, Myrica phanerodonta, Pernettia coriacea, Eriosorus warscewiczii, Fumaria* sp. and *Poa* sp.

Near the edge of this area the vegetation becomes taller with more *Clusia, Myrica, Miconia* and *Centropogon. Ardisia* also appears. The diagramatic profile (Fig. 3), illustrates some of the characteristics of this area.

STUNTED FOREST: Following the trail from the crater to the laguna the shrubs and trees increase in size, forming an almost impenetrable forest where *Vaccinium consanguineum* reaches a height of 6 m with a trunk diameter of 15-20 cm. One of the effects of the adverse conditions, namely proximity to the crater, low temperatures, strong winds and poor soils is to produce slow growth and peculiar twisting of the branches. This results in an almost interwoven, tangled forest where it is difficult to separate dead trees from living. The predominant species are *V. consanguineum, Hesperomeles obovata, H. heterophylla, Sphyrospermum cordifolium* and *Clusia odorata.* On the forest floor are numerous seedlings of *C. odorata, Ardisia pleurobotrya* and *Myrrhidendron donnell-smithii,* together with ferns, e.g. *Magiogyria semicordata;* epiphytes —*Cavendishia costaricensis* and *Dendrophthora costaricensis*—; and bromeliads.

At the forest edges, where a trail has been cut, *Muehlenbeckia tamnifolia, Smilax subpubescens* and *Chusquea* are common, with the occasional *Myrica* plant. As the forest canopy gets higher and conditions more favorable, *Clusia* and *Didymopanax* become the dominant trees and *Weinmannia* appears.

CLOUD FOREST AT 2,600-2,700 M — THE MONTANE RAIN FOREST: The forests of the slopes around the laguna are dominated by *Clusia odorata* (31% of trees), *Didymopanax pittieri* (26%) and *Weinmannia trianea* (13%) which form the upper canopy about 15-20 m high. Below this is a lower level of smaller trees (6-10 m), including *Ardisia pleurobotrya* and *Miconia biperulifera.* The vegetation forms a complete canopy producing a damp shady forest where most of the trees are covered with mosses and liverworts. Epiphyte *Ericaceae* are also found, e.g. *Cavendishia costaricensis.* Wherever more light penetrates the forest or along the banks of the laguna the number of species increases with *Myrrhidendron* and *Chusquea* being particularly prominant. Prop roots were common on *Clusia.*

TABLE 2

Summary of data from forest at 2650 m

	Species	No.	Relative Abundance	Relative Frequency
C	*Clusia odorata*	9	39	38
D	*Didymopanax pittieri*	6	26	31
W	*Weinmannia trianea*	3	13	19
A	*Ardisia pleurobotrya*	2	9	12
O	?epithyte covered	3	13	
X	Dead trees	7		
	Total	23		
	Total species	4		

Along the ridge tops the trees become lower in stature, only 10 m high, compared to those on the slopes. Other variations were also noted. For example, on the western side of the laguna *Weinmannia* and *Adisia* trees formed a greater percentage of the total, *Weinmannia* being 31% compared to a combined 21% *Didymopanax* and *Clusia*. This greater relative abundance was also observed on the slopes away from the laguna, together with some differences in species composition: *Brunellia costaricensis* occasionally appeared, although generally found at lower sites, together with *Miconia coriacea* and the tree fern *Cyathea*. Very few *Clusia* trees were observed.

Forests on the west side of the road near the crater are fairly similar, with *Clusia* being the dominant species (28%). However, here trees are thinner and taller, growing with large numbers of small *Ardisia* (31%).

LOWER MONTANE WET FOREST — CLOUD FOREST AT 2,450-2,550 M: These forests include those areas between the Tower and the road which are easily accessible and have therefore been exploited. The destruction of the virgin forests is clearly visible; the canopy is broken, few trees of large size remain, and hence the characteristics of the forests have altered drastically. A secondary growth of *Miconia* has developed, which is relatively more abundant than those species of the upper canopy, such as *Quercus* spp., *Didymopanax* and *Podocarpus* spp. which still dominate the lower vegetation in many areas (Fig. 5). In lower areas *Podocarpus* is more common but there are few large trees left. In these more open forests there is a greater variety of undergrowth; more tree seedlings, vines, ferns, *Chusquea* and *Bomarea acutifolia* with its conspicuous bright red flowers.

One area which is relatively untouched is that behind the "Potrero Grande" excluding the edges. Here *Didymopanax* and *Quercus* are the dominant species (40% of trees) and stands of *Brunellia costaricensis* are common. The

canopy is at about 20 m and allows little light to penetrate. There is therefore little undergrowth, apart from some seedlings, moss and ferns (*Magiogyria*). This is a complete contrast to the boundaries with the pasture areas. Trees have been cut and a dense tangled undergrowth developed which is virtually impossible to penetrate. Again the variety of species found, particularly shrubs, herbs and ferns, is increased significantly. The very edge of these areas is characterised by large numbers of *Escallonia poasana, Hesperomeles obovata* and *H. heterophylla.*

TABLE 3

Summary of data from forest at 2500 m

	Species	No.	Relative Abundance	Relative Frequency
M	*Miconia biperulifera*	27	58	48
Q	*Quercus* sp.	9	20	14
A	*Ardisia pleurobotrya*	5	11	14
D	*Didymopanax pittieri*	4	9	19
C	*Clusia odorata*	1	2	5
X	Dead trees	7		
	Total	46		
	Total species	5		

PASTURE AREAS: Approximately 30 years ago sizeable stretches of forest were cleared to provide pasture for cattle, leaving only a few isolated or dead trees with large epiphyte loads scattered over the area. Now these pastures are no longer maintained and natural succession processes are slowly reverting the area back to its original state. The following information is based on observations near the residential area at approximately 2,500 m.

Small plants of *Monochaetum vulcanicum* and *Escallonia poasana* appear first, followed by *Myrtus oerstedii, Vaccinium consanguineum, Pernettia coriacea, Disterigma humboldtii* and *rubus floribundus,* together with the ferns *Magiogyria semicordata, Eriosorus flexuosus, E. warscewiczii* and *Lophosovia quadripinnata.* Old tree trunks, decayed and rotten, become grass covered and provide a fertile area for the new growth of the above mentioned plants. As the groups of plants scattered over the pasture increase in height, providing greater shade, other species such as *Centropogon gutierrezii, Miconia myrtillifolia,* vines, a shield fern, *Ctenitus* sp., and seedlings of the larger trees appear. The isolated trees found in the area and, therefore, the most likely seed sources include *Quercus, Ardisia pleurobotrya, A. compressa, Rapanea pellucidopunctata, Drymis granadensis* and *Weinmannia,* together with the large shrubs *Myrtus, Disterigma* and *V. poasanum.* Trees with heavy epiphyte loads of

bromeliads are very common. A variety of grass species including *Pennisetum clandestinum* and *Paspalum boscianum* with *Halenia rhyacophila, Plantago hirtella, Hypochaeris radicata, Carex nigrum,* and *Shagnum* provide the ground cover.

In the "Potrero Grande" during the rainy season there is a small pond where a small population of *Isoetes storkii* grows, this plant is found in abundance in the laguna. Since cattle and horses no longer graze here the population of *Hypericum strictum* is rapidly encroaching on the remaining grass cover. Similarly *Ulex europeaus* is also invading the area from the roadside where it is well established from 2,400 to 2,480 m.

TABLE 4

Summary of data from forest behind the Potrero Grande

	Species	No.	Relative Abundance	Relative Frequency
D	*Didymopanax pittieri*	10	24	25
M	*Miconia biperulifera*	16	38	29
W	*Weinmannia trianea*	6	14	18
A	*Ardisia pleurobotrya*	3	7	4
C	*Clusia odorata*	2	5	7
Q	*Quercus* sp.	2	5	7
C	*Cyathea* sp.	1	2	4
B	*Brunellia costaricensis*	1	2	4
m	*Miconia coriacea*	1	2	4
X	Dead trees	7		
	Total	43		
	Total species	9		

LOWER PASTURES: The pasture areas below 2,450 m on the southern slopes form a separate category. The reason for this being that the altitudinal zoning of vegetation is very marked between this and higher areas. These are shady pastures used for dairy cattle. *Miconia coriacea* and *Solanum ferrugineum* replace the *Monochaetum* and *Ericaceae* spp. in more open areas. Many of the smaller plants—*Centropogon, Hypochaeris* and *Rubus* are the same as at higher altitudes. Larger trees have been left standing, giving extensive shade; the most common species are *Podocarpus, Drimys granadensis, Didymopanax* and *Quercus.* The orange flowered parasite *Psittacanthus schiedeanus* is very common. At the lower limits of the park boundaries a number of new species come in, e.g. *Magnolia poasana* and *Conostegia macrantha.*

Within the park boundaries there appears to be three major habitat divisions; the montane and lower montane cloud forests, pasture areas and unusual sites such as the crater and surrounding area. These are a result of three determining factors: altitude, man's activity and volcanic activity, respec-

tively. Distinct vegetation associations are found, although actual boundaries are hard to define as one type merges with another. These main groups can be subdivided giving the habitat types described. Even within one habitat type there is considerable variation, some of which may be due to microclimate effects such as the degree of shelter afforded by the aspect of the slope. Another may be a reflection of the maturity of the forest; those areas closer to the crater being more affected by volcanic activity or those nearer the road by interference of man, whereas the laguna forests are mature climax forests.

Extreme edaphic conditions near the crater prevent growth of species which can be found a short distance away on less eroded or better developed soil. A noticeable effect of altitude is the progressive lowering of stature and simplification of forest structure. For example, when montane forests are compared to a tropical lowland forest, "complexity index" values of 90:360 are found (HOLDRIDGE, 2). District differences are found even within the 400 m difference in altitude within the park boundaries. Vegetation regeneration is slow and much damage can be caused in a short time. As Poás is an important watershed area it is essential that vegetation cover is maintained in order to regulate water supplies and prevent erosion. Another characteristic of the flora at this altitude is the abundance of temperate species. Possibly many "weed" seeds were introduced with the grass seed that was brought in and these include *Plantago* sp., *Trifolium* spp., *Taraxicum* sp., and *Ulex europaeus.*

The diversity of vegetation types also provides valuable habitat areas for a variety of wildlife. Perhaps most well known is the Quetzal, which although rare, still breeds at the edge of the cloud forest.

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RESUMEN

Las características de la vegetación del Parque Nacional Volcán Poás, en altitudes superiores a 2350 m, son representativas de habitats bien definidos: 1) en el cráter y sus alrededores hay muy poca vegetación, siendo *Pernettia coriacea* y *Elaphoglossum* las especies más tolerantes a condiciones extremas. El número de especies aumenta de 0 a 25 en una distancia de 400 m de la orilla del cráter; 2) en la zona de los arrayanes, en donde hay muy pocos árboles, *Vaccinium consanguineum* y *V. poasanum* son los arbustos más importantes; 3) el bosque achaparrado, un bosque bajo, de árboles con ramas muy torcidas, es casi impenetrable; 4) el bosque nublado, 2600 a 2700 m, o bosque pluvial de montano, en donde las especies más comunes son *Clusia odorata, Didymopanax pittieri* y *Weinmannia trianea;* 5) el bosque nublado, a 2500 m, o bosque

muy húmedo de montano bajo, en donde hay una gran variedad de tipos que varían en su grado de explotación por el hombre. Los árboles principales son *Quercus* spp., *Podocarpus, Didymopanax pittieri* y *Brunellia costaricensis. Miconia biperulifera* es el árbol más común en estados de sucesión de crecimiento secundario; 6) los potreros viejos se caracterizan por árboles aislados con muchas epífitas, mientras que *Monochaetum vulcanicum* y *Escallonia poasana* son arbustos muy comunes; 7) los potreros de las faldas menores, en donde hay *Podocarpus, Drimys* y *Didymopanax* y en donde *Miconia coriacea* y *Solanum ferrugineum* son comunes.

Las observaciones generales fueron suplementadas por estudios detallados de todos los árboles en una línea transecto de 10 × 50 m, que sirvieron de base para los dibujos de perfil de los bosques.

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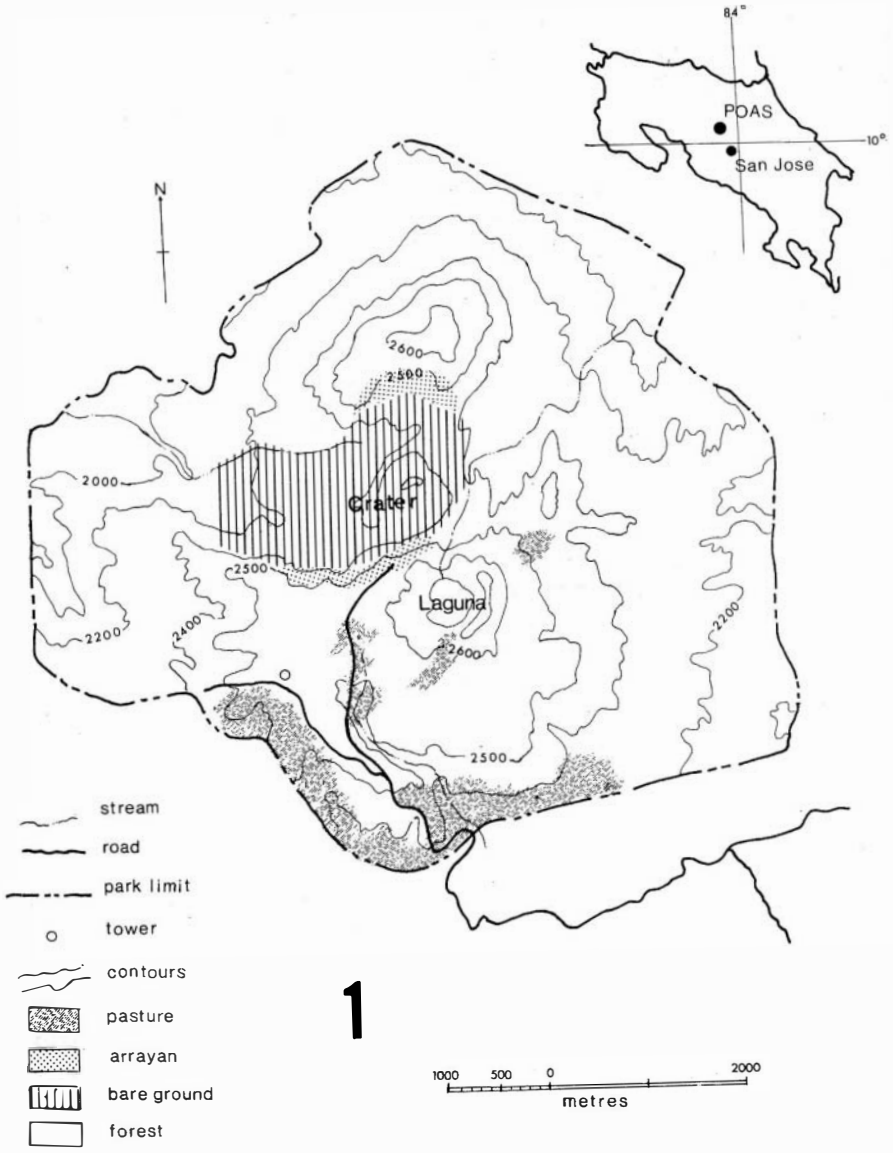
Fig. 1. Map. of Volcán Poás National Park showing main habitat types.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POAS
10°
San Jose
N
2600
2500
2000
Crater
2500
Laguna
2200
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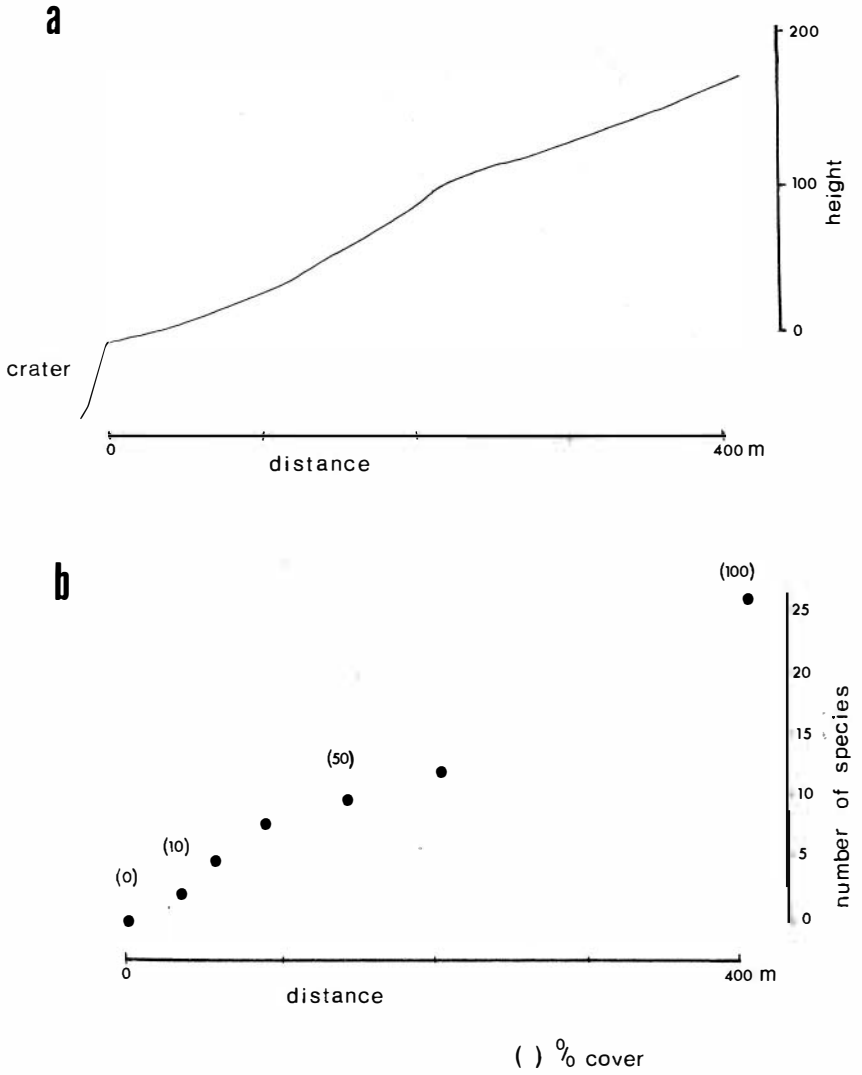
Fig. 2. a) Profile of transect line from crater lip.
b) Changes in species number and vegetation cover with distance from the crater.
c) Species in order of occurence.



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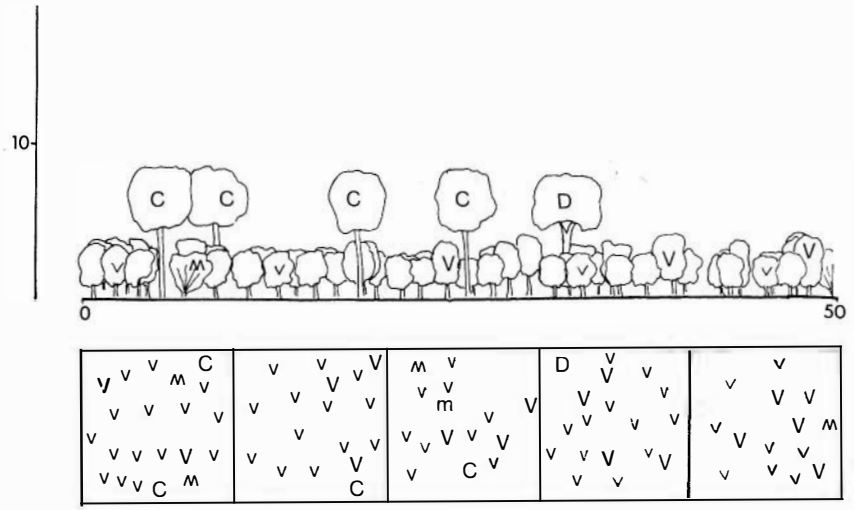
1. *Pernettia coriacea*
2. *Elephoglossum*
3. *Arcytophyllum lavarum*
4. *Vaccinium consanguineum*
5. *Eupatorium durandii*
6. *Carex donnell–smithii*
7. *Myrica phanerodonta*
8. *Gaultheria costaricensis*
9. *Didymopanax pittieri*
10. *Gleichenia costaricensis*
11. *Monochaetum vulcanicum*
12. *Clusia odorata*

Fig. 3. Profile of Arrayan area near the crater. Plants less than one metre high are not shown. See Table 1 for key and summary of data.

Fig. 4. Profile of forest at 2,650 m; north of the laguna. See Table 2 for key and summary of data.



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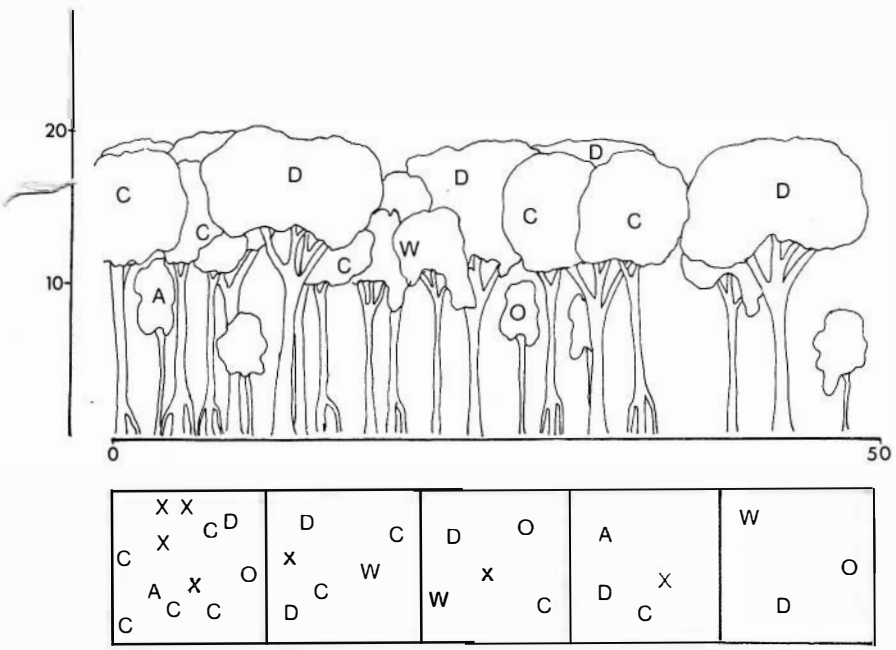

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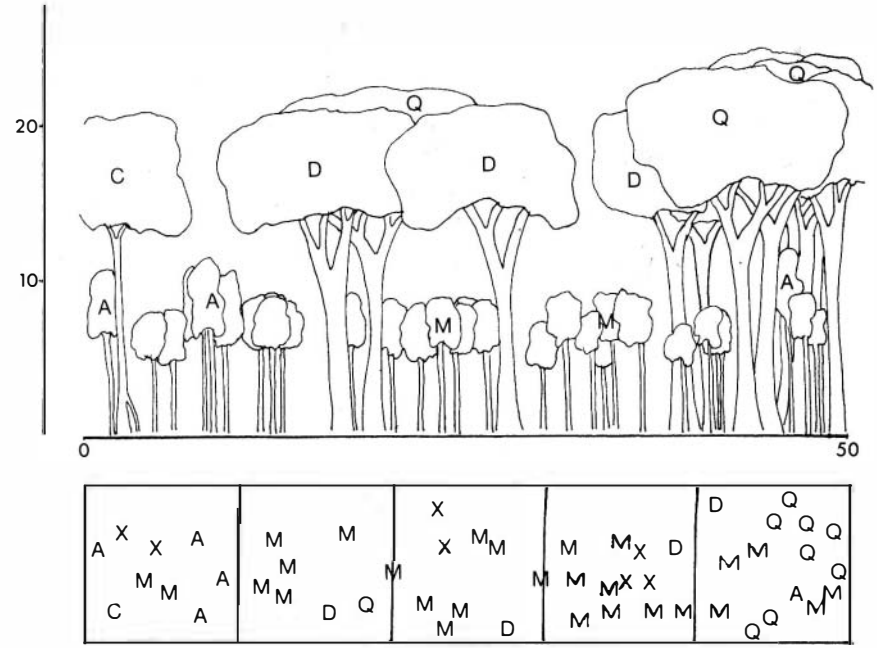
Fig. 5. Profile of exploited forest at 2,500 m. See Table 3 for key and summary of data.

Fig. 6. Profile of forest behind the Potrero Grande at 2,500 m. See Table 4 for key and summary of data.



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