VARIATION IN FOREST STRUCTURE ACROSS FOUR SITES IN COSTA RICA

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ABSTRACT (JLB)

Climatic variables such as temperature, wind, rainfall, and light availability are known to influence arboreal growth patterns. We expected that the forests of Palo Verde, Cerro Cacao, Corcavado, and La Selva would differ in their structure according to Holdrige's life zone classifications. Our findings suggest that the primary forest of Palo Verde is limited by moisture, that trees at Cerro Cacao have wind-resistant morphologies, and that the consistant climate of La Selva allows abundant growth of understory, canopy, and emergent species. The secondary forest of Corcovado was characterized by high densities of trees with relatively small diameters for their heights, suggesting high competition for available light.

Key Words: Palo Verde, Cerro Cacao, Corcovado, La Selva, forest structure.

INTRODUCTION (BME)

The difficult climatic conditions found at Palo Verde National Wildlife Refuge, Cerro Cacao National Park, Corcovado National Park and La Selva Biological Reserve create forests with very difficult characteristics. Palo Verde is a deciduous dry tropical forest, receiving approximately 1000-1500mm of rain per year (Janzen, 1983). Cerro Cacao is a tropical cloud forest at ≈1200m elevation, and is coller, wetter, and lacks the distinct seasonality of rainfall seen at Palo Verde. Both Corcovado and La Selva are lowland tropical rainforests, receiving large amounts of rain per year (3800mm and 4000mm respectively; Janzen 1983), but with Corcovado showing a more distinct three month dry season.

The structure of a forest, in its growth form, canopy structure and density, depends largely on these climatic differences. This study is part of a long term baseline descriptive study aimed at identifying differences among the forests.

METHODS (DKS)

We examined forest structure at four Costa Rican sites: primary forest at Palo Verde National Park, Cerro Cacao, and La Selva; and secondary forest at Corcovado National Park.

At Palo Verde we selected a trail 200m behind the field station, at Cerro Cacao we used the Cerro Cacao trail, at Corcovado we used Sendero Espeveles, and at La Selva our site was 320m along Camino Circular Lejano. We chose a 50m x 10m transect by laying down a drag tape through a representative section of the forest type being studied. At Cerro Cacao, the transect was 50m x 7.5m due to the high density of trees. For each tree >5cm dbh, we measured dbh, distance of the tree along transect, distance of tree from transect, and crown width parallel to the transect. Tree height was measured using a clinometer. A cross-sectional view along the transect was sketched from these data and a visual survey of the crown. Mean tree basal area, height, and density were also calculated. We determined the "index of canopy cover" using the following formula:

$$C = \frac{\sum(\pi r^2)}{A},$$

where r is the canopy radius, and A is the total area of the plot. This gave an indication of the thickness of the canopy, or how much canopy area there was per ground area.

RESULTS (ANS)

Of the three primary forest sites, Palo Verde had the lowest density of trees >5cm dbh (6.4 trees/m^2) and smallest mean basal area (mean ± SE = 481 ± 139 $cm^2/100m^2$). The density of trees at Cerro Cacao (11.4 trees /$100m^2$) and the mean basal area (1314 ± 530 $cm^2/100m^2$) were greatest of the three sites (Table 1). However, many trees at Cerro Cacao were heavily buttressed, which may have inflated total basal area relative to other sites. Densities at La Selva and Corcovado were approximately equal, however, the secondary forest of Corcovado had a lower basal area than the primary forest of La Selva ($3221\ cm^2/100m^2$ vs. $8565\ cm2/100m^2$; Table 1).

Four emergent trees at La Selva and two emergent trees at Corcovado were >35m tall (the tallest tree measured was 40.1m at La Selva). Trees at these sites were on average much taller than trees at Palo Verde and Cerro Cacao (Table 1). Forest profiles of the canopy describe the more continuous canopies found at Palo Verde and Cerro Cacao vs. the presence of emergent trees at La Selva and Corcovado (Figures 1-6).

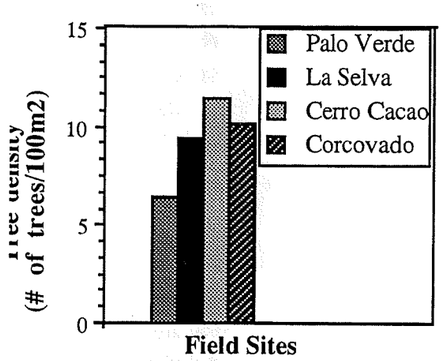

Figure 1. Tree density for four Costa Rican field sites sampled in Jan-Feb 1994.

Table 1: Forest structure data for four Costa Rican field sites collected January-February, 1994.

Site	density (#trees/$100m^2$)	basal area ($cm^2/100m^2$)	mean basal area (cm/tree)
Palo Verde	6.4	3075	481±139
La Selva	9.4	8565	911±437
Cerro Cacao	11.4	15029	1314±530
Corcovado	10.2	3221	316±118
	height (m)	**mean canopy size (m^2/tree)**	**canopy cover ($m^2/100m^2$)**
Palo Verde	8.7±0.8	36.4	233.2
La Selva	14.0±1.3	46.7	439.3
Cerro Cacao	11.2±1.0	22.6	258.0
Corcovado	14.7±1.0	17.0	173.5

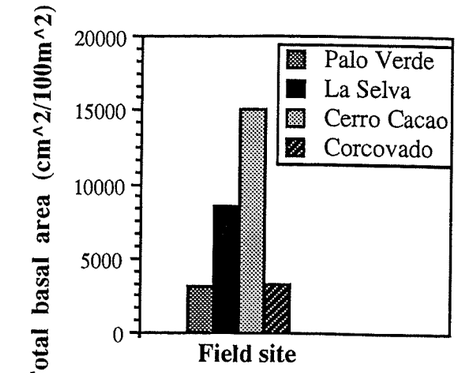

Figure 2. Total basal area in four Costa Rican field sites sampled in Jan-Feb 1994.

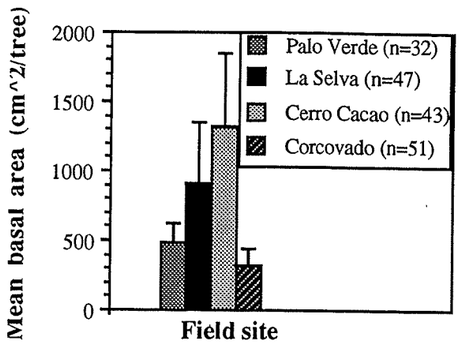

Figure 3. Mean basal area per individual tree sampled at four Costa Rican field sites in Jan-Feb 1994.

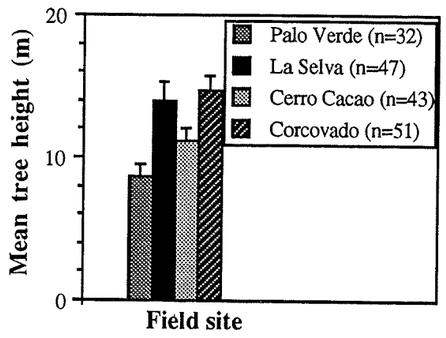

Figure 4. Mean tree height for trees sampled in four Costa Rican field sites in Jan-Feb 1994.

Trees in the secondary forest of Corcovado and the high elevation forest of Cerro Cacao had smaller canopy sizes than trees at either Palo Verde or La Selva. The index of canopy cover calculated for La Selva (439.3 m^2 of canopy/100m^2 of forest floor) indicates that approximately twice as many trees occupy each vertical position in the canopy at this site (Table 1). Depictions of the forest profile also illustrate the greater number of trees at La Selva using each canopy level (Figures 1-6)

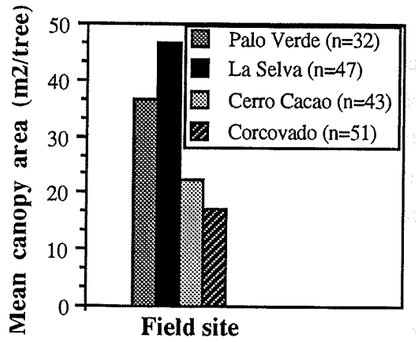

Figure 5. Mean canopy area of trees sampled at four Costa Rican field sites in Jan-Feb 1994.

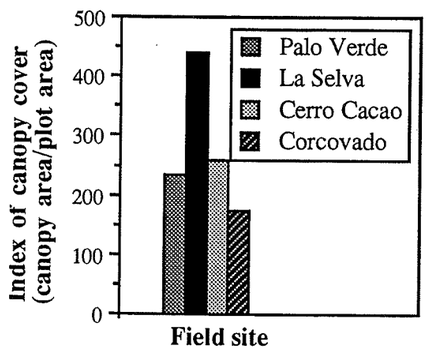

Figure 6. Sum of individual tree canopy areas in a 100 m2 plot in four Costa Rican field sites sampled in Jan-Feb 1994. Values indicate relative numbers of canopy layers.

DISCUSSION (LCB)

We attribute the low density of stems and low total basal area at Palo Verde to moisture limitations. Presumably, trees have large canopy areas because there are fewer trees competing for the space.

The shortness of trees at Cerro Cacao and the large mean basal area may be due to the sustained high winds at this location. Catastrophic stem failure in wind storms appeared to be a dominant cause of mortality in mature trees. Presumably, they have excited strong selection for trees that invest more carbon in trunk structure while limiting height growth. The extensive buttresses in the Cerro Cacao forest may also function to improve stability in high winds.

The trees at La Selva were extremely full and had large, extensively overlapping canopies. One would expect the trees at La Selva not to be limited by moisture or temperature and, thus, to have the highest growth rate of the four sites. The high index of canopy cover indicates intense competition for light and suggests that light many commonly limit plant growth at La Selva.

At Corcovado, unlike the other three sites, we a secondary forest. The high density of trees, small total and mean basal areas, and large mean height indicate that trees within these systems invest heavily in height growth. Presumably, this is attributable to intense selection against trees that are overgrown and shaded out. We expect that over time the forest we surveyed at Corcovado will have reduced density of stems but increased basal area and canopy cover, resembling the primary forest at La Selva. Growth probably is more limited by moisture at Corcavado than La Selva because of Corcovado's pronounced dry season.

Our measurements of forest structure at different sites in Costa Rica generally support expectations based on climatic patterns (Hartshorne, 1983).

LITERATURE CITED

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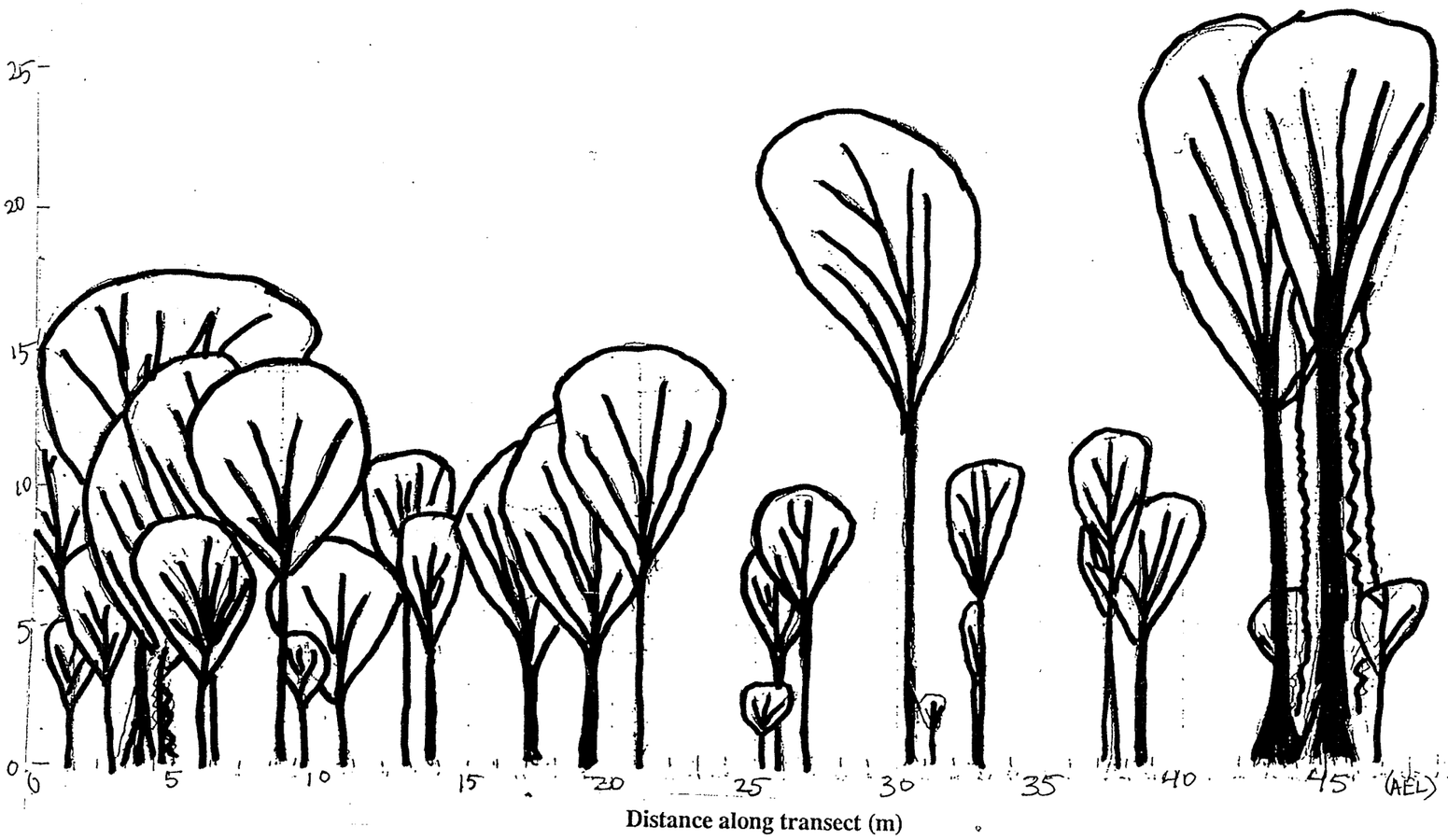
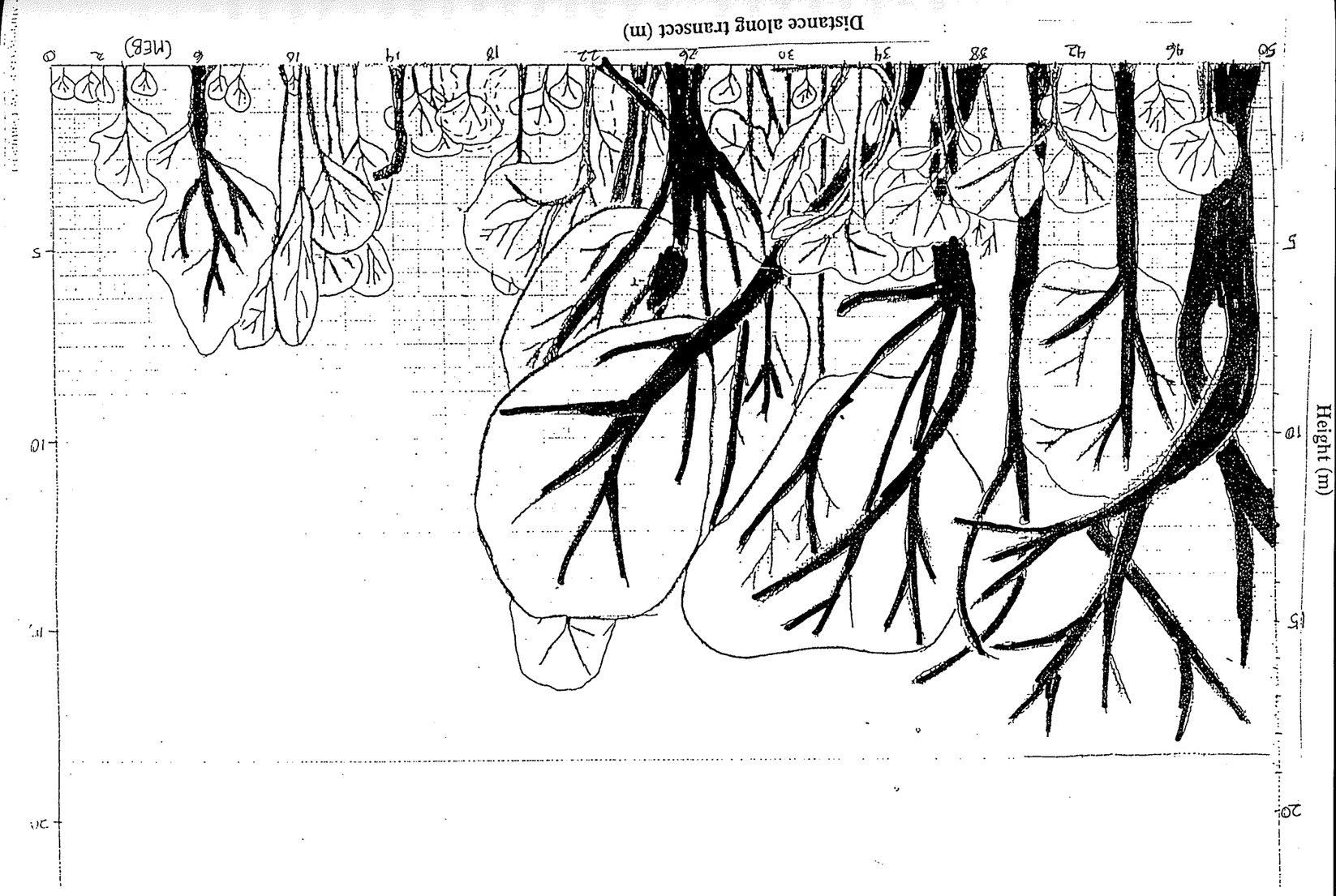
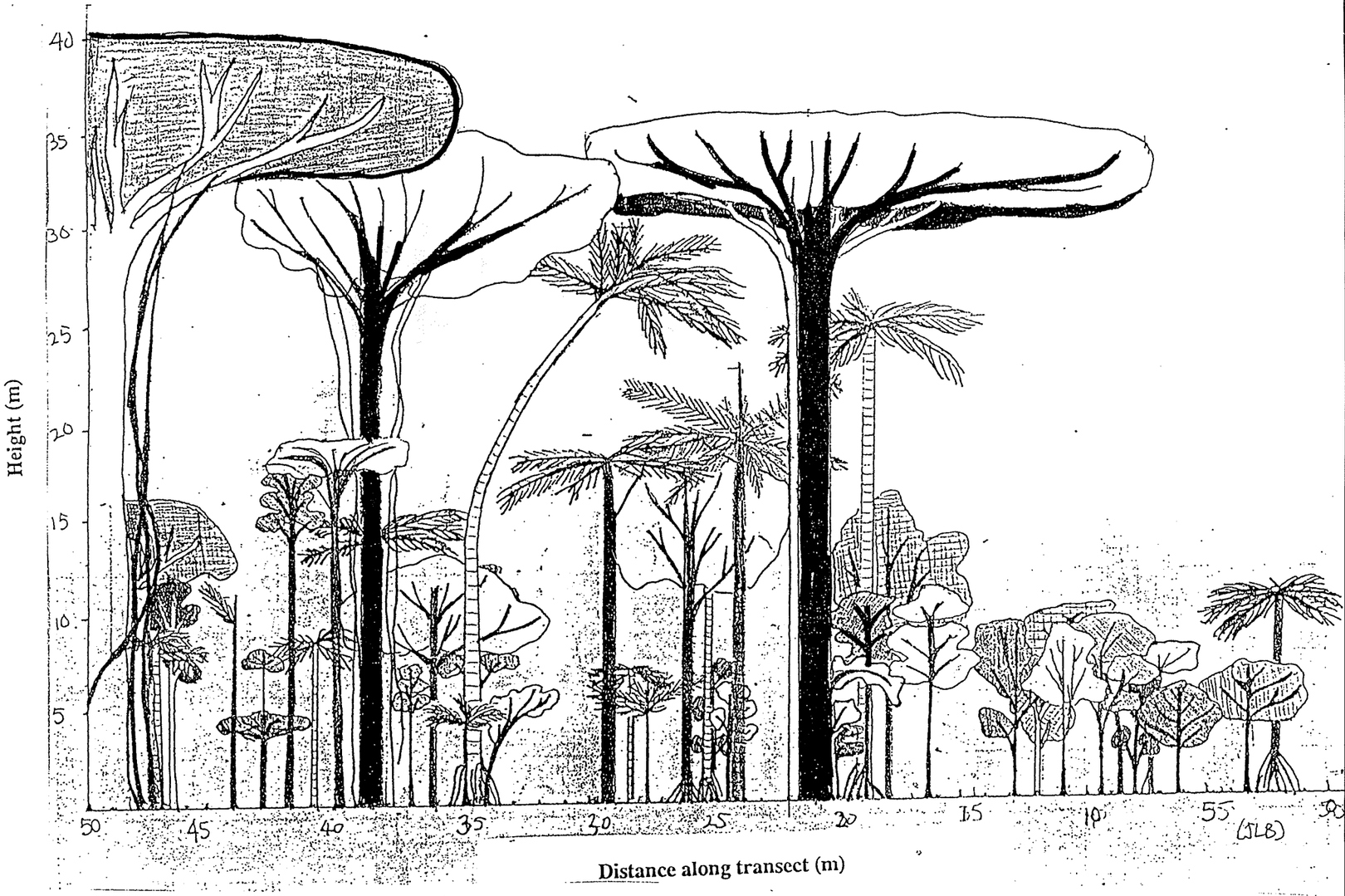


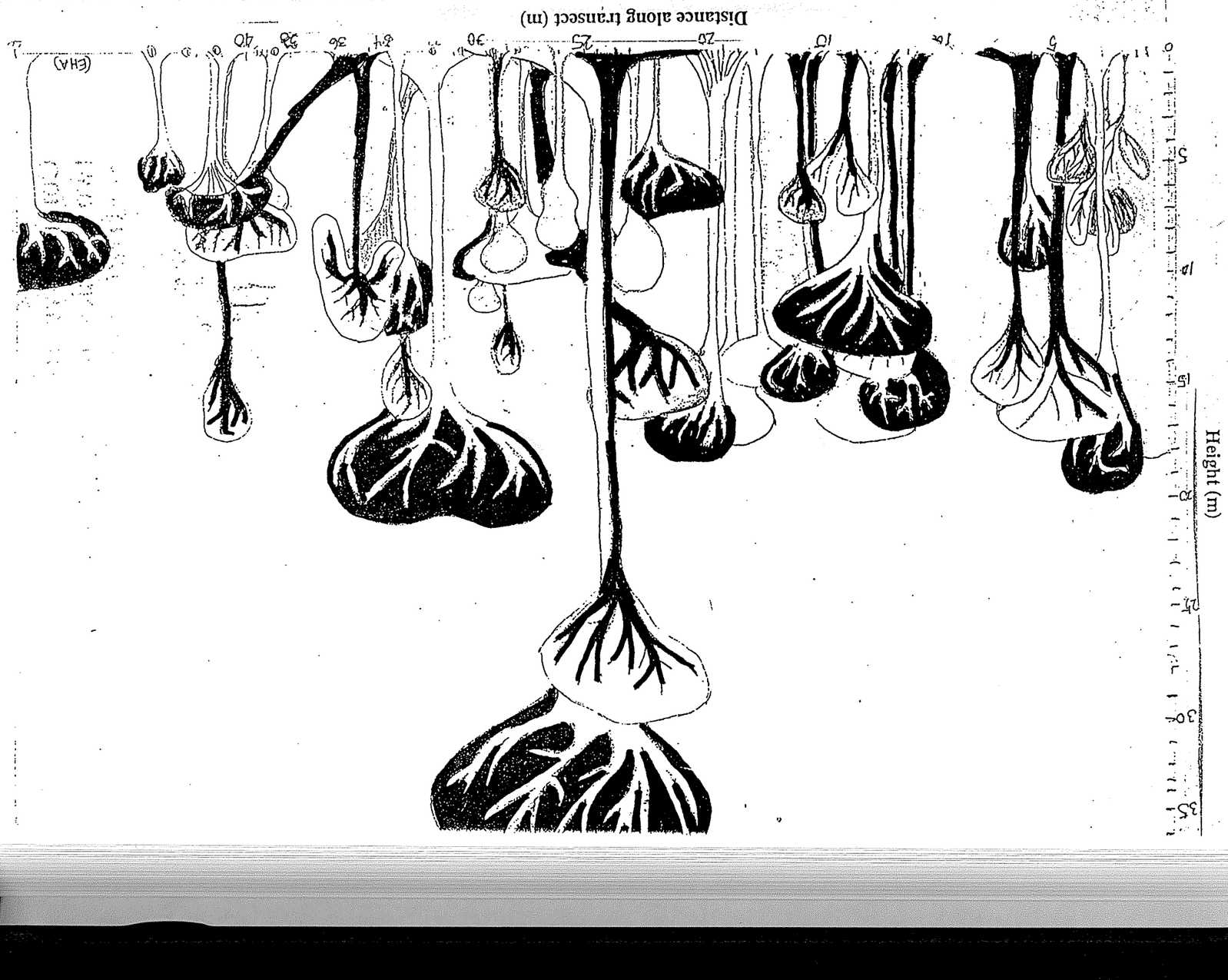
Appendix 2. Profile of primary forest at Cerro Cacao, Costa Rica.

Appendix 1. Profile of primary forest at Palo Verde National Wildlife Refuge, Costa Rica.





Appendix 4. Profile of primary forest at La Selva Biological Station, Costa Rica.



Appendix 3. Profile of secondary forest at Corcovado National Park, Costa Rica.