body in a nearby vertical position. He fluttered his tail from front to back covering approximately a 30° angle that was a little to the right of vertical. Both wiggled their tails and bodies slightly from side to side. After approximately 15sec of this behavior, the male flew behind the female and mounted for less than one second. He flew in front of the female and the courtship behavior began again. After about 10sec he flew behind the female again and mounted for less than one second. They flew away in the same direction. No vocalizations were heard during any of this behavior.

It seems likely that the male was bird C because the female was perched in his territory. Furthermore, he was present on his usual perch immediately before and after the copulation, but not during this time.

The female was perched on a horizontal branch about 1m high. It was fairly well covered by foliage from a liana and a bush. The mating took place at 0830 in overcast weather with a slight mist in the air.

A COMPARISON OF FOREST STRUCTURE IN PALO VERDE, MONTEVERDE, AND CORCOVADO

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Abstract. We compared forest structure of stands in Palo Verde National Park, Corcovado National Park, and the Monteverde Cloud Forest Reserve, Costa Rica, to examine the relation between forest structure and climate. In Palo Verde, where there is a pronounced dry season, the forest was shorter, less dense, and had lower basal area per hectare. The stands in Corcovado and Monteverde, which are subject to less seasonal climate change, were both much taller and had greater basal area than Palo Verde. The Corcovado stand had taller emergent trees, a taller main canopy, and a greater basal area and volume per hectare than the stand at Monteverde. Climate seems to affect forest structure, in that seasonality which limits growth results in less complex forest structure. In this study, moisture limitation seems to have had a greater effect than temperature variation. (JMH)

INTRODUCTION (JAR)

Palo Verde National Park, Corcovado National Park, and the Monteverde Cloud Forest Reserve each have distinctive climates, resulting in different forest types at each site. Palo Verde is classified as tropical dry forest, Corcovado as lowland tropical wet forest, and Monteverde as tropical cloud forest. Both Palo Verde (annual precipitation 1000-1500mm) and Corcovado (annual precipitation 5800mm) have distinct dry seasons, Palo Verde's being much more extreme than Corcovado's. Monteverde has little seasonality, receiving precipitation throughout the year (Janzen 1983).

Since the structure of a forest is partly determined by its climate, obvious differences should exist between profiles of the three forests. In the wetter areas (Corcovado and Monteverde), we expected the canopy to be taller and denser than in the seasonally dry area (Palo Verde). Reduced productivity during the dry season should result in lower biomass in seasonal sites, all else being equal.

The turnover rate in a forest affects biomass as well; slower turnover rates allow for more growth between disturbances, and thus, higher biomass. Turnover rates, however, are not known for the sites, so we could not include them in our analysis.

Based upon the climate differences between the sites and qualitative observations of the amount of regrowth in gaps (assumed to be indicative of productivity) at each site, we made the following predictions: (i) the forest at Palo Verde should have the lowest biomass and the shortest canopy of the three sites and (ii) the forests at Corcovado and Monteverde should have similar structures, with the biomass at Monteverde being higher due to the lack of seasonality which allows for continual growth.

METHODS (JVK)

Forest structure data were taken from three permanent plots estab-

Table 1. Range of heights and dbh for trees >10cm dbh at the three sites. At Monteverde and Corcovado, the area sampled was 7.5m x 50m. At Palo Verde, the area sampled was 10m x 50m.

	number of trees in sample	height range (cm)	dbh range (cm)	mean height (m)	mean dbh (cm)
Palo Verde	10	7.9-25.0	10.5-103.5	12.7	35.1
Monteverde	22	2.0-40.0	10.0-126.0	15.5	33.4
Corcovado	21	4.0-48.0	10.0-194.0	15.4	26.8

Table 2. Basal area and volume index of trees >10cm dbh at the three sites.

	basal area of plot (m^2)	volume index of plot (m^3)	basal area of forest (m^2/ha)	volume index of forest (m^3/ha)
Palo Verde	1.76	37.92	35.24	758.32
Monteverde	2.89	86.56	77.06	2308.35
Corcovado	3.62	155.37	96.24	4143.23

lished by Dartmouth College at Palo Verde, Monteverde, and Corcovado (Dartmouth FSP, 1991). The plots had been selected based on absence of gaps and representation of typical forest structure in these sites. We ran a 50m transect through the middle of each plot. At Palo Verde, trees within a 10m wide belt transect and minimum 5cm dbh were measured. At Monteverde, trees were measured within a 7.5m wide belt transect and minimum 5cm dbh. At Corcovado, we used a 7.5m wide belt transect and measured trees over 10cm dbh.

For each tree, we measured dbh, distance along the transect line, distance perpendicular to the transect line and canopy width along the direction of the transect. At each site, a few representative trees of the canopy, sub-canopy, and understory were accurately measured with a clinometer for height of tree top and height of crown base. We then estimated the heights of the remaining trees in comparison to these "standards". From these data, basal area and an index of tree volume were calculated.

Trees were identified to species if possible and it was noted if lianas and epiphytes were present. We also sketched each tree's profile including canopy shape and angle of leaning, as viewed perpendicular to the transect dragline. Later, an accurate profile of the 50m transect line was drawn to scale using the measurements taken.

Results (SLS)

The trees at Palo Verde greater than 10cm dbh ranged in height from 7.9m to 25.0m (Table 1). The canopy was mostly continuous with no emergent trees (Figure 1). The canopy trees included *Pseudobombax*, *Pithecellobium*, and several other leguminous species. Many of the trees were at least partly deciduous, one within the belt transect was completely bare of leaves. The ground vegetation was thick, dry and tangled. Lianas were present but not abundant. The estimated basal area was 35.24 m^2/ha (Table 2).

The canopy at Monteverde was unbroken, with one emergent tree attaining a height of 40.0m (Figure 2). The species were diverse including tree ferns, palms and a *Cecropia*. A number of trees had broken stems and

stumps were present. The ground vegetation was thick, and lianas, aroids, and epiphytes were all abundant. The estimated forest basal area was 77.06 m^2/ha (Table 2).

The tallest tree at Corcovado reached a height of 48.0m with a dbh of 194cm (Table 1). The canopy (mean height=15m) was continuous except for a tree fall area within the first 15m of the plot (Figure 3). There were many aroids and lianas and the ground vegetation, though substantial, was not as dense as at the previous two sites. The estimated basal area was 96.24 m^2/ha (Table 2).

The volume index at Monteverde was more than double that of Palo Verde while Corcovado's volume index was nearly two times Monteverde's (Table 2).

Discussion (JLB)

Compared to Monteverde and Corcovado, Palo Verde's lower, more open canopy, and lack of epiphytes and lianas, suggest that seasonality does affect the forest canopy. Palo Verde's pronounced dry season means harsher conditions for trees on an annual basis, whereas Corcovado and Monteverde experience much less pronounced seasonality and show similar more developed canopy structures. Our predictions of greater canopy height and biomass at Monteverde did not take into account the higher temperatures at Corcovado. Temperature seems to influence canopy height, perhaps allowing a higher growth rate, resulting in greater biomass. Basal area and estimated volumes support the visual representations given by these diagrams, offering further evidence for the predicted effects of seasonality and temperature on forest structure.

These profiles offer a fairly accurate visual representation of canopy height and structural complexity. However, different plot sizes, different minimum dbh measurements and the exclusion of fallen trees in the diagram makes comparison of detailed forest composition between sites difficult.

The emergent tree (*Anacardium*) at Corcovado accounted for 82% of basal area and 91% of volume in the belt transect. The inclusion of the tree in the sample could be misleading in terms of basal area and volume as trees of this size are infrequent in the forest. However, its inclusion is appropriate for visual representation of the Corcovado canopy structure. In the other sites, in contrast, emergent trees do no reach such extreme sizes.

Although the uses of forest canopy profiles are limited (because of the small plot size and lack of replicates, no accurate measure of biomass or turnover rate could be obtained) the profiles provide a useful means of visual comparison between sites.

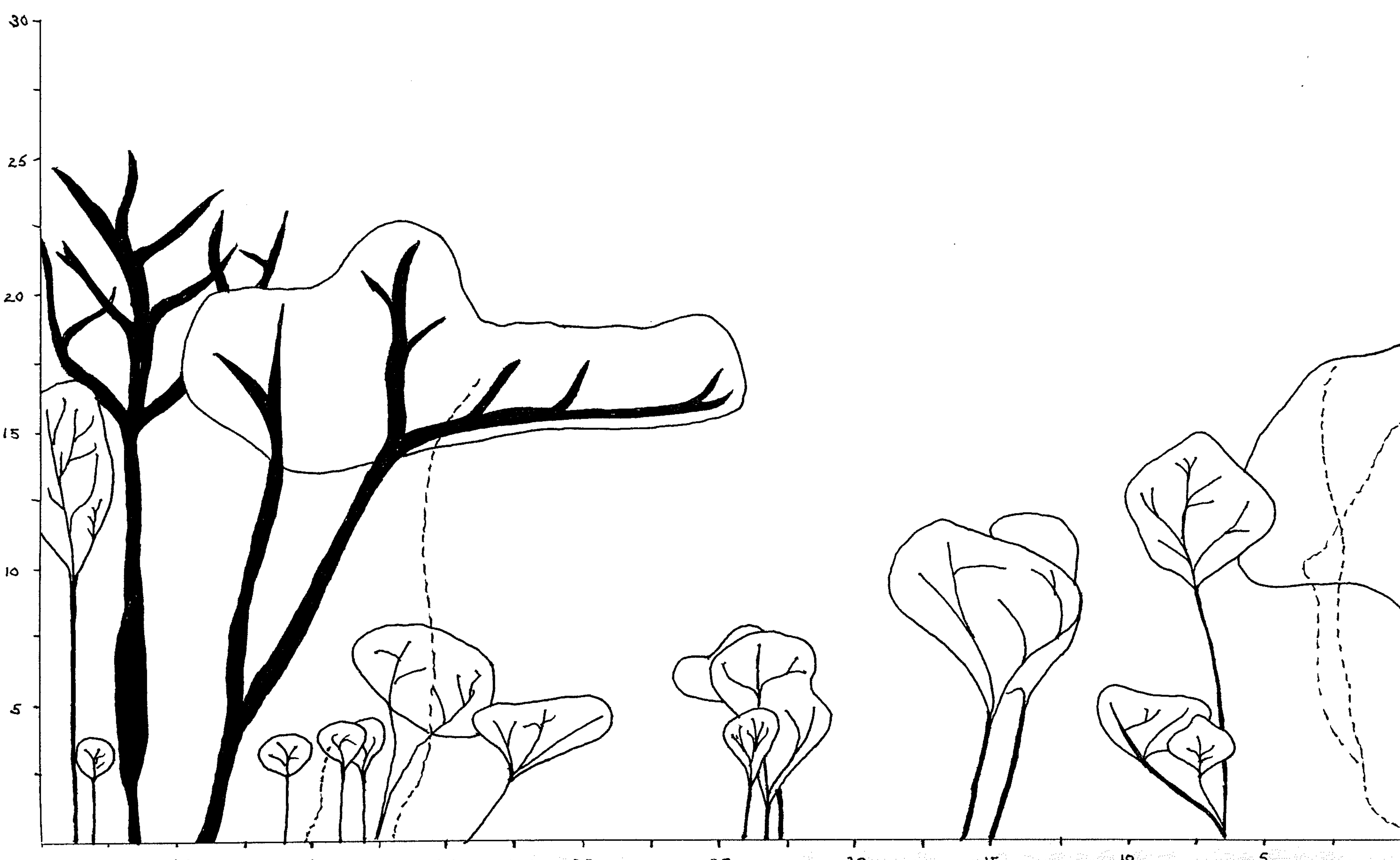

FIGURE 1: PALO VERDE PLOT TRANSECT

FIGURE 2: MONTEVERDE PLOT TRANSECT

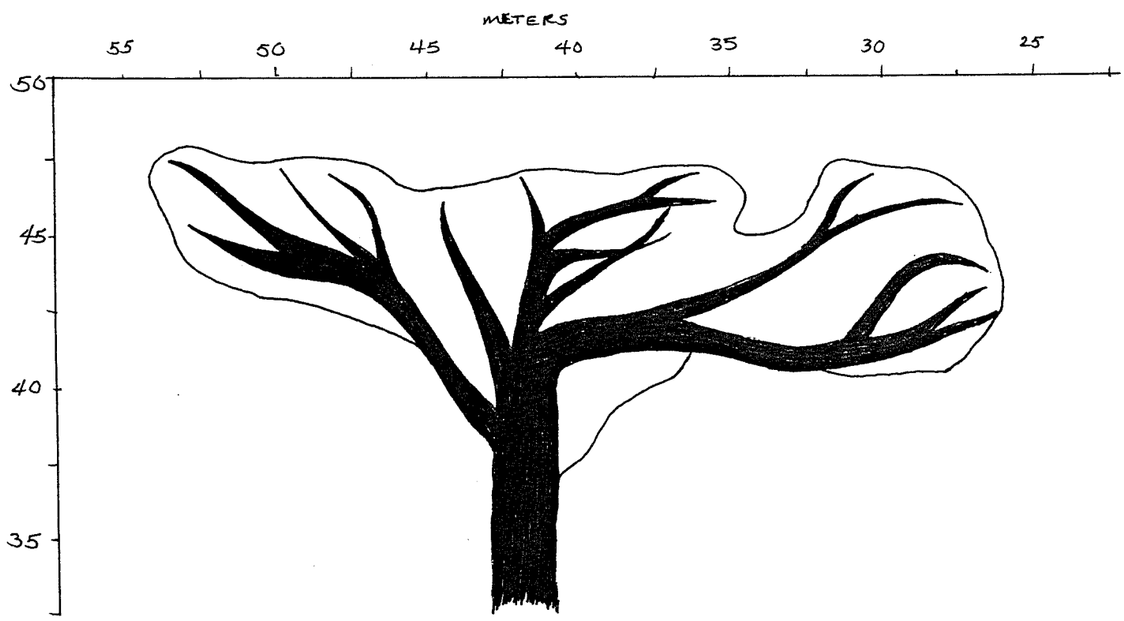

FIGURE 3 CONTINUED; CROWN OF ANACARDIUM