Forest Structure and Epiphytes of Serranía de los Churumbelos

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Note: for the purposes of this ecological assessment, SS4a refers to the Villa Iguana plateau, and SS4b refers to the Alto Cagadero meseta landform.

Sumario
Se realizó un monitoreo de la biomasa de epífitas con el propósito de evaluar los niveles de perturbación en cada localidad de trabajo y para utilizarlo como indicador de clima y de clasificación de bosques. Las epífitas son importantes indicadores en los ecosistemas montanos tropicales; su presencia indica la incidencia de niebla en la superficie; también son de gran importancia para los ciclos de nutrientes. En cada sitio la biomasa de epífitas se midió utilizando una combinación de medidas físicas y de técnicas a escala, para evaluar la biomasa total, la cual osciló entre 0.2 toneladas/Ha en el SS1 hasta 7,9 toneladas/Ha en el SS4a. El epifitismo indica que los sitios SS1 y SS2 son estrictamente LRF, el SS3 es un tipo de bosque de transición y los sitios SS4a y SS4b exhiben un alto epifitismo típico de sistemas montanos tropicales.

Summary
A survey of epiphyte biomass at SS1 to SS4 was made (i) assess the levels of disturbance at the study sites, and (ii) to use epiphytism as an indicator of climate and forest classification. Epiphytes are an important bioindicator in montane tropical ecosystems, with their presence indicating the incidence of cloud at ground level as well as being important for nutrient and hydrological cycling. At each site, the epiphyte biomass was estimated using a combination of physical measurements and scaling technique to calculate overall epiphyte biomass. This was found to range from 0.2 tons/ha at SS1 to 7.9 tons/ha at SS4a. The epiphtism indicated that SS1 and SS2 were strictly LRF, with SS3 presenting a transitionary forest type, and SS4a and SS4b exhibiting high epiphyte biomass typical of montane tropical ecosystems.

Introduction
The presence of epiphytes clinging to tree barks typifies the vegetation in a Tropical Montane Cloud Forest (TMCF). Epiphytes are an important bio-indicator of air quality, but also can be used to measure forest disturbance, age and type. The slow rate of colonisation and growth of epiphytes means that that their abundance and stratigraphy can be used to assess the age of a tropical forest, and to ascertain past disturbances. Further, the hydrological properties of epiphytes means that they can be used in analysing forest structure and classification. Epiphytes have been shown to be extremely efficient at cloud scavenging (the condensation of water directly from cloud to vegetation), forming both an important nutrient flux as well as hydrological pathway (Jarvis, 1999). Without regular cloud events, the water and nutrients that epiphytes require is restricted, supporting a lower biomass. An analysis of epiphyte biomass can thus be used to assess whether or not a forest constitutes Lower Montane Cloud Forest (LMCF), as a requirement of LMCF is that it experiences cloud for a significant portion of every day.

Table 1: Epiphyte biomass in the literature

Source	Location	Altitude (m)	Dryweight Mass (Tons/Ha)
Veneklaas *et al*. 1990b	Cordillera Central, Colombia	3370	12
Pocs 1982	Tanzania Uluguru Mts: Mossy Elfin Forest SubMontaneRainforest	 2120 1415	 13.65 2.13
Tanner 1980 (in Brujinzeel and Proctor 1995)	Mor Ridge, Jamaica Mull Ridge, Jamaica	1550 1550	2.8 0.5
Hofstede *et al*. 1993 (in Wolf 1996)	Eastern Cordillera, Colombia	3700	44
Nadkarma 1984 (in Brujinzeel and Proctor 1995)	Monteverde, Costa Rica	1700	4.73

Epiphytic vegetation consists of angiosperms, pteridophyta, bryophytes, lichens and algae (Wolf, 1996), though the former and latter are excluded from this study. It is bryophytes that are of most interest hydrologically, as their large surface area and 'mossy' structure makes them supremely adapted to maximise cloud deposition.

Measurement of epiphyte distribution and biomass is limited due to the unsatisfactory methods involved (McCune, 1994), but preliminary studies point to a total biomass in the order of 5-15 Tons per Hectare (Veneklaas 1990b, Wolf, 1996) in neotropical cloud forests. **Table 1** presents a summary of epiphyte biomass studies.

The distribution and structure of epiphyte biomass is clearly highly variable between sites, and indeed between trees (Hietz and Ursula, 1995). Tanner (1980) (in Brujinzeel and Proctor, 1995) attributed the large difference in biomass between ridges due to exposure to cloud and aspect, with sunlight and the regular presence of cloud being important factors.

With increasing altitude, the relative contribution of epiphytic bryophytes with respect to other epiphytesgenerally increases (Wolf, 1996). Where biomass is analysed in the local altitude (from ground lelvel to the canopy), it is found to be highest at the crown of the trees (van Leerdam *et al,* 1990; Hofstede *et al* in Wolf, 1996), with a greater predominance of lichens with increasing height (Wolf, 1996).

The aim of this study was to make a basic sample of epiphyte biomass at each site in order to ascertain a basic forest classification, as well as to assess disturbance levels.

Methodology

An efficient method for the measurement of epiphyte biomass is notoriously lacking. McCune (1994) used epiphyte litter at the ground surface to estimate biomass, but this method requires taxonomical knowledge of epiphyte species. In an ecosystem where epiphyte diversity is comparable to LRF tree and herb diversity combined (IUCN, 1997) this method is very restrictive.

To solve these problems a two step measuring technique was devised. A subjective index was created to estimate epiphyte biomass per tree based on the tree dimensions and 'epiphytism'. Termed the Epiphyte Biomass Index (EBI), this index allows rapid spatial measurement of biomass around the canopy. The EBI for a tree is used to predict the biomass per square metre of trunk, which can then be scaled up based on the tree dimensions. Each tree is assigned a number on the EBI scale of between 0 to 10, and is estimated using the descriptions in **Table 2**.

Table 2: Determination of EBI

EBI	Description
0	No epiphyte coverage
1	1-2cm thick 33% partial cover on bark only
2	1-2cm thick 66% partial cover on bark only
3	1-2cm thick full cover on bark only
4	1-2cm thick full cover on bark and crown only
5	1-2cm thick full covering on barks and stems
6	2-3cm thick full covering on barks only
7	2-3cm thick full covering on barks and stems
8	3cm+ thick full covering on barks and stems
9	3cm+ thick full covering on barks and stems, with epiphyte coverage on lianas
10	3cm+ thick full covering on barks, stems and leanas with hanging growth forms

Figure 1: Calibration of EBI with Biomass per Square Metre of Bark

The EBI has been used in a similar study in Colombia, and has been calibrated through the physical measurement of epiphyte biomass for 42 trees. This calibration is shown below.

For each site, the botanical plot (see "Botany" above) was assessed for epiphyte biomass through approximation of EBI. For each tree of diameter greater than 8cm, EBI and height were noted. Numerical up-scaling methods were then used to calculate the total epiphyte biomass per tree. Combined with understorey biomass, this gave an approximate total biomass for each site.

Results
Table 2 gives the final epiphyte biomass for each of the study sites.

Table 2 Results of epiphyte biomass study

Study Site	Epiphyte Biomass (dry weight tons/ha)
1	0.2
2	0.8
3	2.6
4	7.9
5	7.6

Conclusions
The low epiphyte biomass at SS1 and SS2 indicates LRF, along with levels of disturbance (particularly at SS1). SS3 has an increased biomass of 2.6tons/ha, showing the beginning of a transition into LMCF, with occasional cloud presence. SS4a and SS4b both have a very high epiphyte biomass of 7.9 and 7.6tons/ha respectively indicating frequent cloud events and high levels of cloud deposition. The slightly lower biomass at SS4b is due to the lower forest canopy reducing available surface area. A biomass of this magnitude presents a huge hydrological pathway in the order of 2000-3000mm of deposition per year, with potentially high nutrient fluxes.