Characterization of Throughfall Heterogeneity in a Transitional Cloud Forest in Costa Rica

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Introduction

- Understanding the water budget in tropical forests is essential because of its role in ecosystem health, drinking water supply, land, and resource management.
- Characterizing throughfall (TF) is a key component to understanding the water budget of this tropical pre-montane transitional cloud forest in Costa Rica.
- TF is precipitation that falls through a forest canopy and is intercepted and redistributed heterogeneously before reaching the forest floor.
- Our study focuses on quantifying this spatial heterogeneity and investigating the ecological and meteorological drivers influencing this variability.

Study Site

- Our study sites were focused in and around a 2.2 ha watershed at the Texas A&M University Soltis Center for Research and Education in San Isidro de Peñas Blancas, Costa Rica (Fig. 1).
- 164 fixed rain gauges were deployed across 5 sites
  - 1 extensive network (10 m grid spacing)
  - 4 hyper-dense networks (2 m grid spacing), including 1 control site.
  - Each site had a portable Onset HOBO weather station

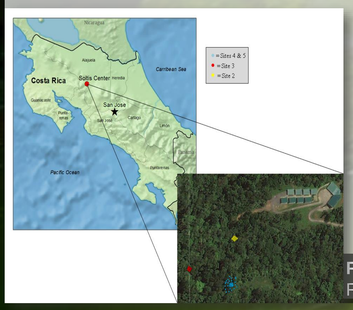


Figure 1. Location of the study watershed in Costa Rica, with the location of sites within the watershed.

Methods

- Precipitation and TF were measured daily at all sites.
- The canopy was quantified by using hemispheric photography to calculate LAI and visible sky above each gauge.
- Evaporation gauges were set up to account for evaporation.
- Meteorological data from HOBO stations was used to analyze the effects of rainfall intensity, duration, and drop size on TF.
- A random sampling analysis in MATLAB® was conducted to determine optimal sample size for minimal error.

Results

Effect of sampling population on accuracy

- 126 randomly-selected gauges would be needed to estimate TF within 1% of the true mean at the 95% confidence level.

Precipitation events

- 39 rainfall events ranging from 1.2 mm to 101.2 mm were sampled.

Throughfall variability

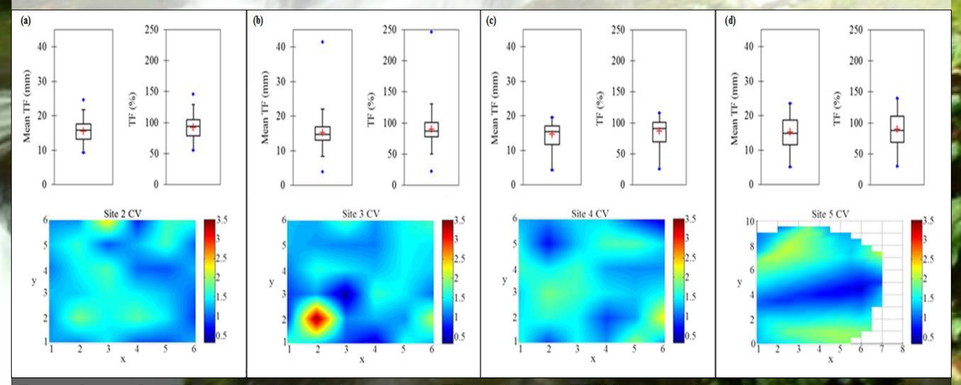


Figure 2. a-d: Site TF characteristics including mean TF (mm), mean TF (%), and surface plots showing mean CV.

- The mean TF observed under the canopy was 89.5%.
- Site 3 showed the greatest spatial variability, with CV=0.36 (Fig. 2).
- Our extensive network showed the 2nd greatest variability, with CV=0.29. TF variation patterns appeared to correspond with the site's terrain (Fig. 2).

Canopy Cover

- No correlation between LAI and TF was observed (R^2 = 0.007, Fig. 3).

Precipitation

- TF variability decreases as total event precipitation and rainfall intensity increase (Fig. 4 and Fig. 5).
- High intensity events generally receive a higher percentage TF (~90%) than low intensity events (~85%).

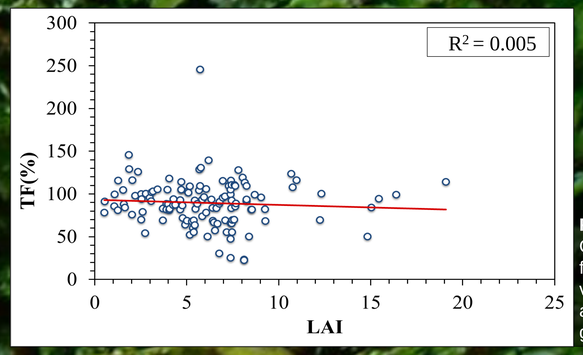
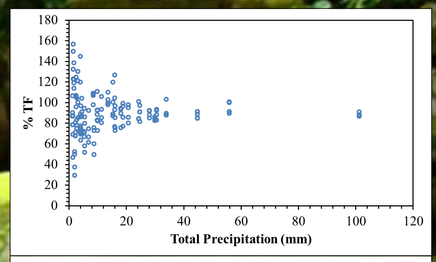


Figure 3: Overall TF(%) for all gauges versus LAI above each gauge.



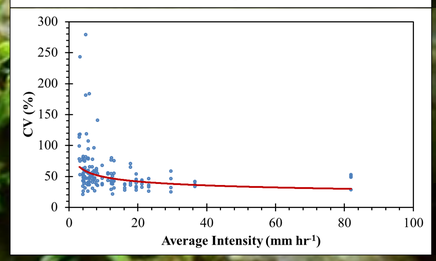


Figure 5: CV (%) of each site (n=148) for each event compared to the average intensity per event.

Figure 4: TF(%) plotted against the total amount of precipitation received in each event (n=148).

Conclusions

- Our findings suggest that the spatial and temporal patterns of TF are complex and transient in tropical forests.
- Using high-density sampling resulted in no evidence of independent drivers of TF redistribution through the canopy, regardless of the degree of canopy closure considered.
- While our study showed that TF(%) and TF variability decreased with increasing precipitation intensity, our data showed no correlation between TF(%) or TF variability and canopy cover.
- This study suggests that microscale spatial heterogeneity of TF is not correlated to specific drivers; rather, it is likely the result of compounding effects of a number of independent conditions.