Impacts of Precipitation Variability on Throughfall in a Tropical Transitional Forest

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I. Introduction

Understanding the water budget in tropical forests is important for ecosystem health and for supply of human drinking water, irrigation, and hydro-electric power operations. To understand the spatial variability of throughfall precipitation in a tropical transitional forest at the Texas A&M University Soltis Center in Costa Rica, a network of rain gauges and weather stations was installed, including 3 hyper dense and 1 extensive gauge network, as well as a control network outside the forest. This research is focused on understanding how precipitation characteristics such as event magnitude, event intensity, and rain drop size distributions (DSD) impact throughfall.

Fig. 1. Site 3 showing HOBO weather station and portion of surrounding gauge network.

II. Data & Methods

- Precipitation and throughfall measured daily from June 18 - July 18, 2012 and June 12 - July 17, 2013
- Event size defined by total daily precipitation at control site
  - -Large and small event threshold of 10 mm determined from frequency distribution in Figure 2
- Intensity determined using tipping bucket gauge
  - -High and low intensity event threshold of 7.5 mm/hr determined from frequency distribution in Figure 3
- Throughfall amount and spatial variability characterized by the throughfall percentage (TF%) and coefficient of variation (CV%) in the equations below:

$$CV\,\% = \frac{Standard\ Deviation}{Mean\ Precip.} x\ 100\% \qquad TF\% = \frac{Mean\ Precip.at\ Site}{Mean\ Precip.at\ Control} x\ 100\%$$

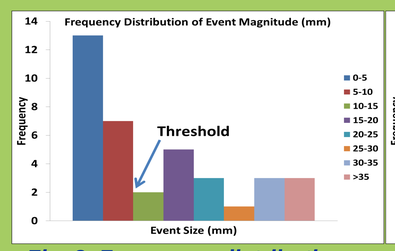


Fig. 2. Frequency distribution of event size.

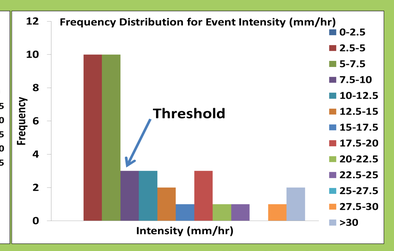
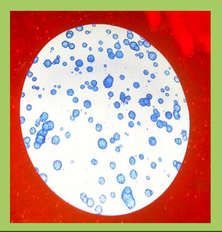


Fig. 3. Frequency distribution of event intensity.



- DSD measured for select events using dye and filter paper method
- Characteristics of the DSD related to throughfall

Fig. 4. DSD measurement using dye and filter paper.

III. Event Magnitude & Throughfall

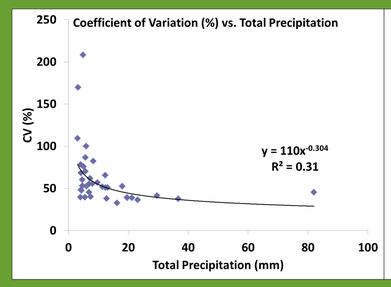


Fig. 5. Overall CV as a function of event sizes.

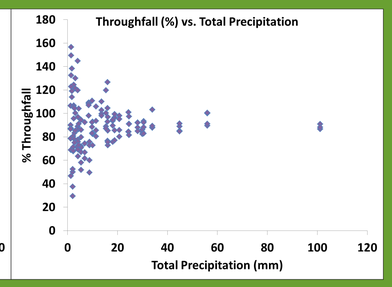


Fig. 6. TF% as a function of event size.

- Throughfall variability decreases with gross precipitation (Fig. 5)
- Throughfall percentage varied from 30%-150% for small events, but only from about 70-110% for large events (Fig. 6)
- Throughfall percentage approaches 90% as gross precipitation increases (Fig. 6)

IV. Event Intensity/DSD & Throughfall

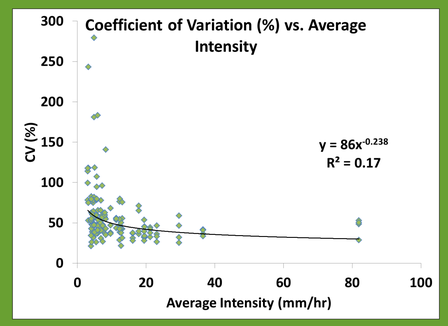


Fig. 7. RR of each event at each site as it relates to throughfall variability

- Throughfall variability decreases with increasing event intensity (Fig. 7)
- CV values as high as 280 were observed with low intensity events showing that less intense events are more spatially heterogeneous(Fig. 7)

Table 1. DSD for three sampled events.

Event	D_{max}	D_{min}	D_{mean}	D_{median}	Total Precip.	RR	%TF	CV (%)
29	4.6	0.3	0.9	0.6	30	21.2	85	39
31	2.6	0.3	1.3	1.2	1.4	3.2	70	170
39	3.2	0.3	0.9	0.7	5.4	5.9	76	100

- As expected, events with larger drop sizes correspond to higher intensity events (Table 1)
- Events with larger drops had a higher TF% and lower CV%

V. Event Throughfall Comparisons

Fig. 8. Throughfall comparisons for large and small events at each site.

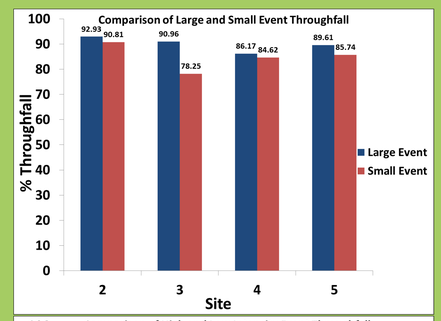
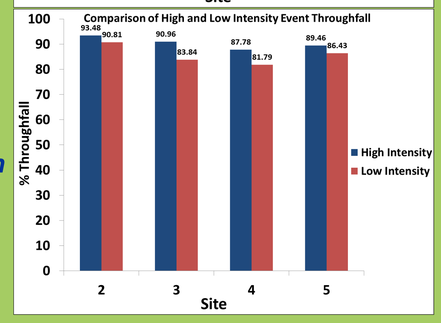


Fig. 9. Throughfall comparisons for high and low intensity events at each site.



- A T-test shows that CV% is statistically significantly different above and below size threshold
- A T-test shows that high and low intensity events have statistically significant different CV%
- Larger events received approximately 90% TF whereas TF for smaller events is 85% (Fig. 8)
- More intense events had about 89% TF whereas average TF for less intense events only had 84% TF (Fig. 9)
- The fact that different sites differ in variability can be attributed to the different canopy structure at each of the sites

VI. Conclusions

- Throughfall is consistently influenced by precipitation event size, event intensity, and event DSD
- Event size: larger events are likely more able to saturate the canopy, resulting in higher throughfall and reduced variability
- Intensity: as precipitation intensity increases, the canopy can saturate more quickly which can reduce throughfall variability
- DSD: Large drops associated with higher intensity events and greater kinetic energy, likely allowing them to penetrate the canopy more easily