Rainfall Variation based on Forest Type

Matthew Whitley

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Introduction

Cloudbridge is located in a Tropical Montane Forest, and for that reason has a very wet climate. It rains almost every day at Cloudbridge, though the year can be divided into a rainy season and a drier season. At Cloudbridge we have extensive historical data on rainfall, but no data on variances within the rainfall based on different forest types. This experiment was set up to explore the difference between rainfall in Primary old-growth forest, mature Secondary forest, and areas of natural regrowth. Two sites were set up in each of these forest types, as well as a control with no tree cover.

Hypothesis

It was hypothesized that rainfall would vary according to forest type, in that the forest with the most leaf cover would intercept the most rain before the ground, and the forest type with the least leaf cover would collect the most rain. Thus, it was hypothesized that Primary forest would receive less rainfall on average than secondary forest and natural regrowth areas. Natural regrowth was hypothesized to receive the most rainfall of the forest cover, and a control set up on open ground was predicted to receive the most rainfall of all.

Background

Vegetation plays a key role in the hydrology of humid tropical forests, especially Tropical Montane Forests like Cloudbridge (Douglas 1977, Shuttleworth 1989, Grace et al. 1996). This is because of relatively high leaf areas and canopies that are essentially closed. Thus, virtually all water that reaches the forest floor comes into contact with vegetation. When rain falls in the forest, it can fall directly to the ground (called fall through) or can be intercepted by leaves in trees and plants, then fall off of the plant (this is called canopy drip). These processes are illustrated in Figure 1. Forest with denser canopies and more leaf surface area will intercept more rain than forest with larger gaps between leaves and smaller leaves. For this reason, I hypothesized the Primary forest to have a larger, denser canopy, and thus intercept more water. Secondary forest is not as mature as Primary forest, and thus have a smaller canopy. While areas of natural regrowth have much less of a canopy, as the trees are more spread out, and do not form any canopy per se.

The rain gauges set up in this experiment were somewhat crude (yet cheap), and only recorded the precipitation in the form of rain. So, the experiment was not able to account for the hydrological input from wind driven cloud water or any moisture collected by the vegetation. This input to the water system is not insubstantial, as it has been estimated that wind driven cloud water can account for 22% of the hydrologic input in this region (Nadkarni and Wheelwright 2000). Thus, the experiment could be recreated more accurately with better rain gauges and a cloud water collector.

The implications of this study are significant when assessing the utility of one forest type over another in terms of ground water recharge, erosion, landslides, and flooding. If one particular type of forest intercepts significantly more rainwater than another type of forest, then it would have profound effects in determining strategies for landslide protection, erosion control, or flood risk mitigation.

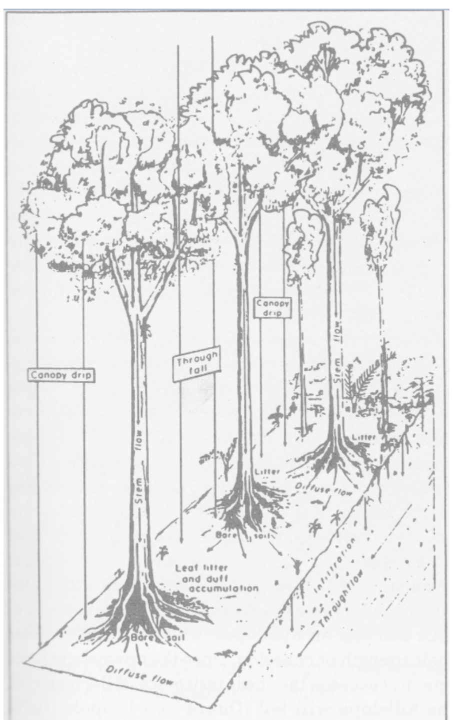
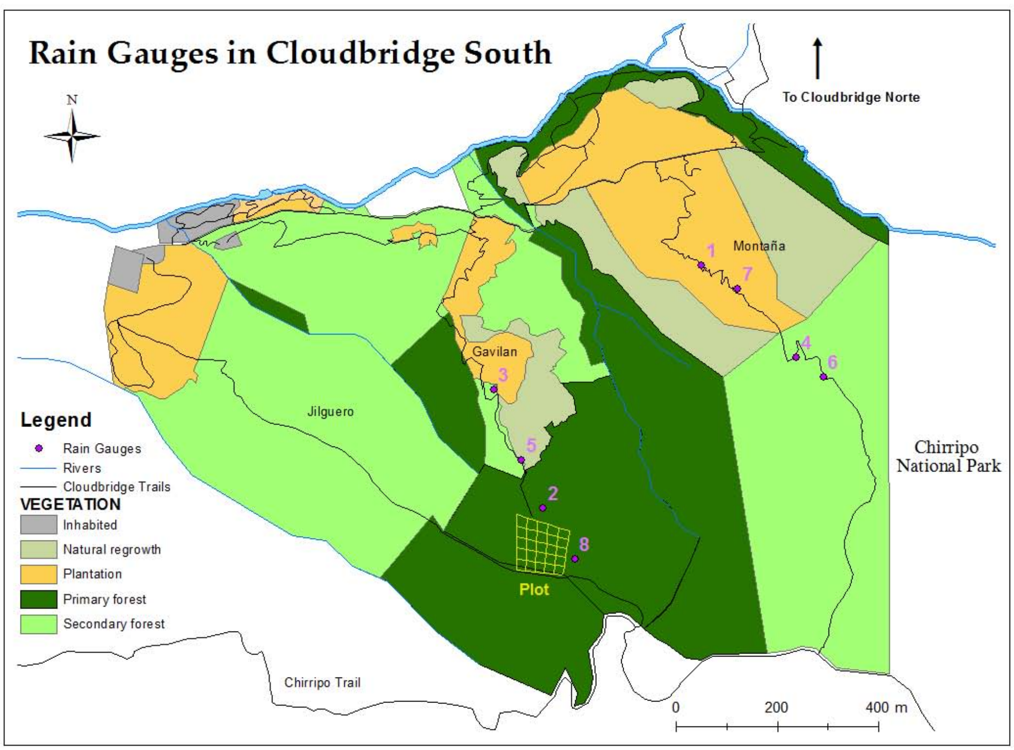


Figure 1. Canopy Drip and Fall Through

Methods

For this experiment I made eight rain gauges out of recycled water bottles by cutting the bottle in half and marking every 50 ml of volume with a sharpie. The rain gauges were then mounted onto a bamboo stake split at the top to hold the rain gauge, and planted in the field so that the lip of the rain gauge was 1m above the ground, see Figure 2. Two rain gauges were set up in each of the forest types, and two were set up as a control in an open tree plantation. The locations of each rain gauge can be seen in Figure 3.

Figure 2. Rain Gauge Planting



Created for Cloudbridge Nature Reserve by Matthew Whitley 2013

Figure 3. Rain Gauge Location in Primary forest, Secondary Forest, Natural Regrowth, and Plantation (Open).

The rain gauges were set up at roughly the same elevations ranging from 1,850 m to 1,998 m, going up the Montaña trail and coming down the Gavilan trail.

Rain measurements were collected roughly every four days, and then entered into an excel spreadsheet. Because the measurements were done in ml on the rain gauges, the data was then converted to mm (height) of rain using the diameter of the mouth of the rain gauge. Because the gauges were made out of recycled bottles and cut in different places, each rain gauge had a unique diameter. These diameters can be seen in Table 1.

Table 1. Diameter of Rain Gauges.

Bottle #	Diameter (mm)
1	93
2	93
3	91
4	70
5	91
6	71
7	93
8	92

Results and Conclusion

The results of this experiment were hard to analyze, but so far have not supported the hypothesis. Figure 4. shows each rain gauge's recorded rainfall over the time I was here to conduct the experiment. As seen from Figure 4., Rain Gauge (RG) 2 consistently had the highest rainfall collection, and on a number of occasions was overflowing, suggesting an even higher amounts of rain. Likewise, RG 5 had a consistent low collection of rain. When these numbers are taken in aggregate, they show us the total rainfall over 3 months (Figure 5.).

From Figure 5. we can see that the Open and Secondary forest follow the trend of the hypothesis in that the Secondary forest receives less rain than the Control, and thus supports the idea that the vegetation in the forest is indeed intercepting rain. This is further supported by the low standard error, meaning that the rain collected was fairly uniform and predictable. However, the Primary and Natural Regrowth both have very large standard error, and are not comparable even within the same forest cover. This leads to the conclusion that these data are not representative of their forest cover, and thus contain outliers.

This is supported by Figure 6 and Figure 7. which show the daily average rainfall by forest type. Figure 6. shows Primary forest including RG 2, while the Figure 7. shows Primary forest not including RG 2. This supports the fact that RG 2 is an outlier because when it is removed from the dataset, the Primary forest conforms to the pattern of rainfall.

Problems with this experiment are extensive. First of all, the rain gauges were not very accurate, as well as the fact that we did not have any cloud water collectors. Furthermore, four days may not have been adequate enough, as seen by RG 2 overflowing consistently. Ideally checking the rain gauges everyday would provide a larger and more robust dataset, which could be achieved more easily with remotely monitored rain gauges. Overall, the sample was probably too small, as eight rain gauges were not enough to adequately describe each forest type. Because there were only two rain gauges in each forest type, the outlier in the Primary forest skewed the data considerably. Finally, the experiment was only running for three months so only a quarter of the year can be compared, notably excluding the dry season.

However, we can conclude that rain interception from plants does reduce rainfall in the Secondary forest compared to the open sites with no forest cover. We can also conclude that the Primary Forest and the Natural Regrowth data are erratic, and not representative of the forest type. All of these findings lead to the conclusion that the experiment should be conducted again, with more rain gauges and perhaps a cloud water collector.

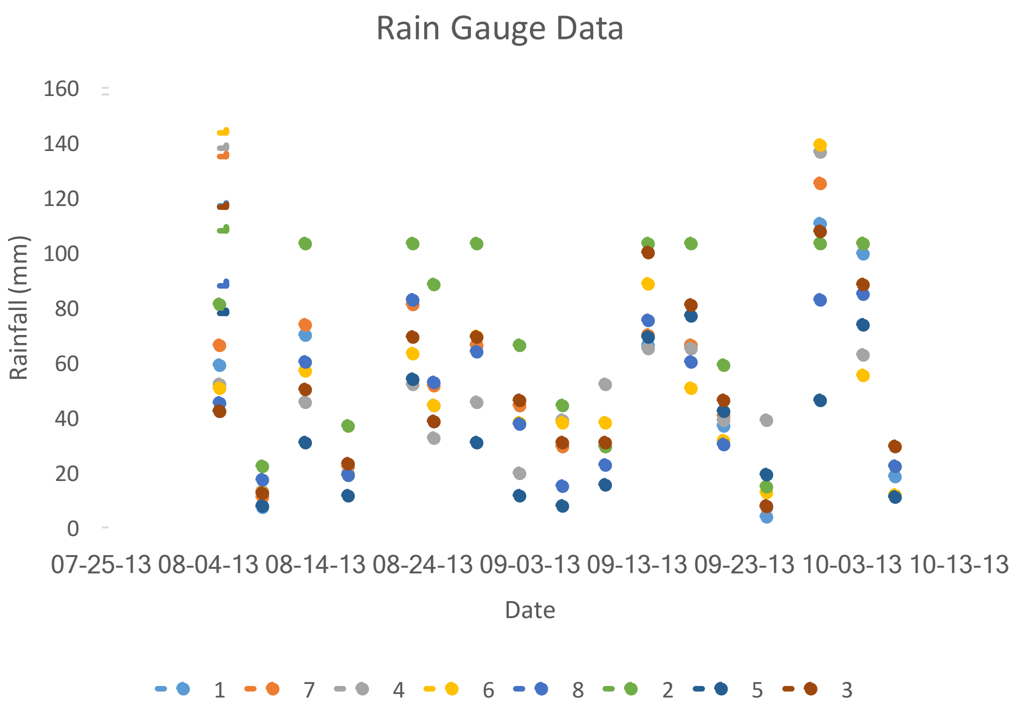


Figure 4. Rain Gauge Data.

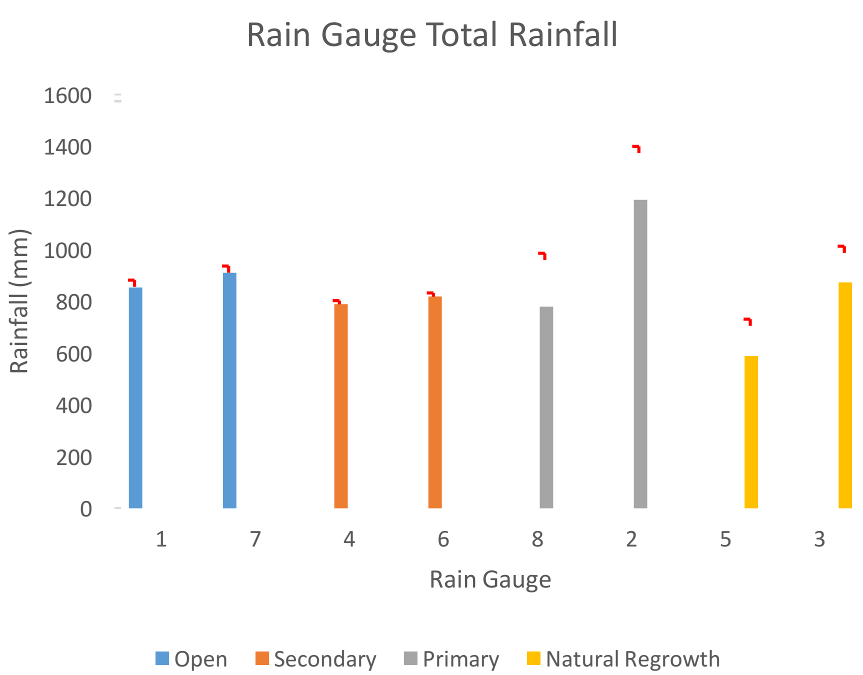


Figure 5. Total Rainfall by Forest Cover.

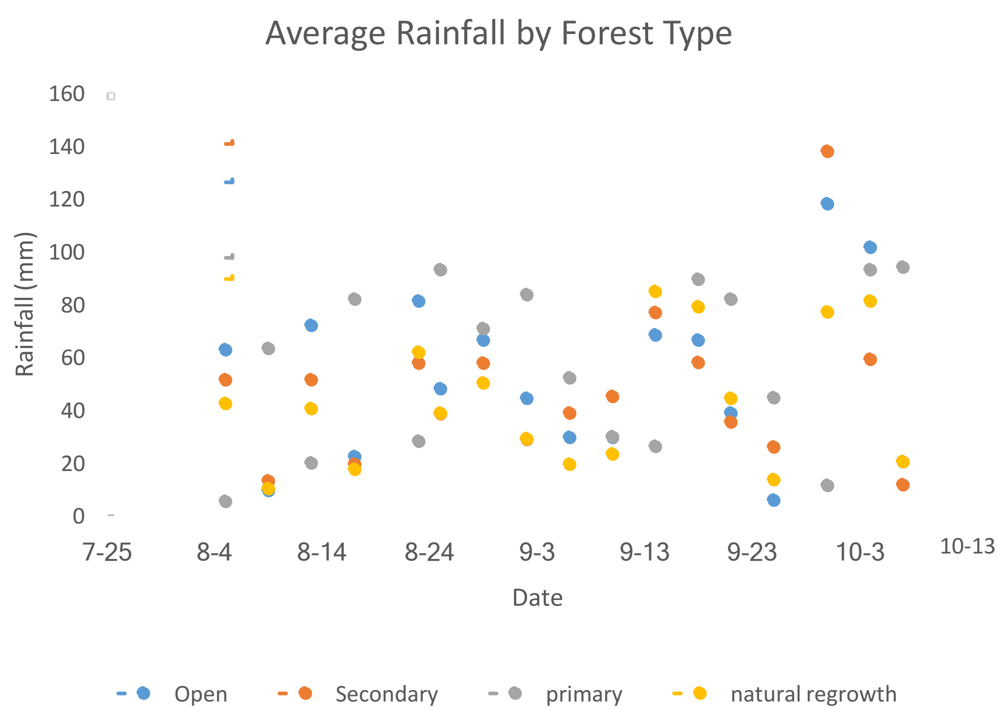


Figure 6. Average Rainfall by Forest Type.

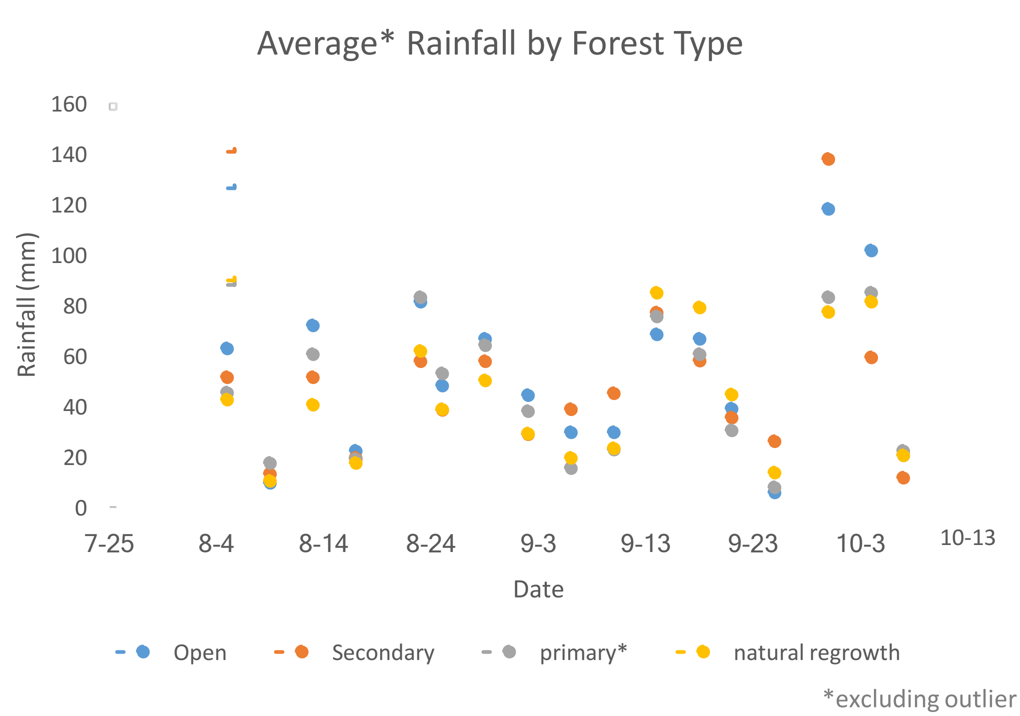


Figure 7. Average Rainfall by Forest Type, Excluding Primary Forest Outlier

References

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