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The Effects of Altitude and Micro-Spatial Habitats on the Physiognomic Characteristics of Syzygium Guineense in Mazumbai Forest Reserve

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Acknowledgments

I would like to thank my mom for supporting me throughout life and especially for my study abroad program in Tanzania. Without her, I would not be here. I would also like to the thank Baba Jack, Oscar, and SIT for giving me the best classroom and learning experience and for helping me a great deal throughout ISP. I especially thank my guide, Msafiri for bestowing so much knowledge upon me, bushwhacking with me, and helping me collect my data. I am grateful to Sokoine University for allowing me to conduct my study in the Mazumbai Forest. Finally, I thank Kiparoo, Richard, and Davie at Mazumbai for taking care of and feeding me well while I conducted this study.

Abstract

In order to examine the affects that altitude and micro-spatial habitat have on the physiognomy of *Syzygium Guineense*; buttress sphere size, number of buttresses, relative size of the buttresses, DBH, and height were measured in three different altitudinal bands (1400 - 1500 m, 1500 - 1600 m, and 1600 - 1700 m) and three different habits portraying concave, convex, and intermediate landscapes. Micro-spatial habits showed to have weak to no effect on all measured physiognomic variables giving insignificant p-values according to ANOVA. However, correlation tests against leaf litter depth and slope showed to have some relation to the size and number of buttresses in certain vegetational zones, indicating that other micro-spatial factors likely affect these tree characteristics in complex ways depending on the vegetational community. Changes in the physiognomy of all dependent variables showed to strongly change with changes in altitude according to regression analyses. Both macro and micro-spatial heterogeneity showed to affect the physiognomy of *Syzygium Guineense*, however, combined, their affect is complicated, and thus more studies need to be done to better understand the extent and exactness of their influence.

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Introduction

Conservation is a growing concern throughout the world. As the human population increases, pollution and deforestation increase as well; effectively destroying important ecological and evolutionary processes across the globe. Tropical forests are especially important due to their vast biodiversity. Moist tropical forests comprise a small percentage of the earth's area yet contain approximately half of the world's species. As the destruction of tropical forests continue to occur, earth's biodiversity decreases at an alarming rate (Newark 2002)

The Eastern Arc Mountains are a unique mountain range stretching from southeast Kenya through south central Tanzania. They are comprised of thirteen separate blocks of mountain sustaining 3300 km^2 of sub-montane, montane, and upper-montane forest; or less than 30% of the estimated original forest (Burgess 2007). Due to their proximity to the Indian Ocean, elevation, and prevailing easterly winds, the Eastern Arc Mountains are easily able to capture precipitation making them the most moist montane tropical forest in Tanzania and Kenya. The mountains also contain an unusually high concentration of endemic species of animals and plants, making them the biologically richest area for their size in East Africa (Newmark 2002).

The Western Usambara Mountains, in Northeastern Tanzania, are an important block of the Eastern Arc Mountains due to their higher prioritization for biodiversity conservation (Burgess 2007). The destruction of forest in the Usambaras can largely be attributed to the local agricultural practices in combination with the growing population. Additional settlement areas and farmland are needed in order to sustain the growing population, which results in uncontrolled grazing, harvesting, and cutting (Kaneka 1994). According to Mrecha, the increased human settlement and farming activities are threatening the biodiversity of the Usambara Mountains, and therefore, must continue to be studied with growing urgency (Cohen 2006).

The plant diversity of tropical forest can be attributed to a vast array of factors. Aside from sunlight, soil nutrient levels, and rainfall - macro-spatial and micro-spatial heterogeneity also play an important role in the type of plants grown in an area and their success. Macro-spatially, altitude has been know to have an effect on vegetational communities (Iversen 1991). Plant growth is affected by altitude through temperature and rainfall. Temperature decreases with altitude; an average of approximately 4ºC with an increase of every 1000 m, while rainfall increases with altitude. However, runoff increases inversely with altitude. Lower elevations will often receive the water from higher altitudes giving lower elevations equal or greater moisture levels than higher altitudes (Richards 1996). Rainfall and temperatures also affect soil nutrient levels. With increased rainfall, nutrients are leached faster. As temperature decreases, the rate of decomposition and nutrient release in leaf litter is slowed . In the Mazumbai Forest Reserve, the temperature and rainfall gradient with the corresponding nutrient levels results in vegetational zones adapted to the particular conditions at each elevation (Cohen 2006).

On a smaller scale, micro-spatial heterogeneity also effects plant communities and growth. Micro-spatial heterogeneity says that no climate is absolutely monotonous; it is constantly changing. Vertical and horizontal stratification, leaf litter depth, gap dynamics, and slope for example all play some role in plant successfulness (Terborgh 1992). Since the soil nutrients within tropical forests are leached out of the soil due to the heavy level of rainfall, most soil nutrients are locked into the fallen leaves (Cohen 2006). Hence, leaf litter is an indicator of nutrient availability - the deeper the leaf litter, the more available nutrients for the residing plant life. The micro-spatial landscapes, such as concave, convex, and intermediate (uniform slope throughout) will cause different leaf litter depths to accumulate which will result in differing nutrient availability and ultimately affect the successfulness of the plant communities.

Syzygium Guineense, or Mshiwi in Kishambaa, is a species of tree found in the Mazumbai Forest. It is most ubiquitous in the lower altitudes of the forest from just below 1500 meters to approximately 1700 meters. *Syzygium Guineense* is unique because it displays buttressing on the lower trunk. Buttressing is a stability mechanism used by trees that tend to have porous interiors. This study involved examining how the physiognomic characteristics of *Syzygium Guineense* change with the macro-spatial and micro-spatial habitats. More specifically, how altitude and landscapes; such as the concavity, convexity, and intermediacy of the surrounding land effect the buttressing characteristics and size of *Syzygium Guineense*. It was hypothesized that the number and size of buttresses of *Syzygium Guineense* will decrease with increasing elevation and concave and convex landscapes, and increase with intermediate lands. It is also predicted that the DBH (diameter at breast height) and height of the tree will decrease with increasing elevation. Since the soil nutrient levels tend to decrease with increasing elevation, then it seems likely *Syzygium Guineense* will be smaller in size and height than at higher elevations. Also since more stability is needed on intermediate landscapes due to a steeper slope, then it is hypothesized that there will be more buttressing and larger buttresses in these areas than those trees in concave and convex areas. Furthermore, it is predicted that trees in concave areas will have be larger and taller than trees in convex and intermediate areas because of the likelihood of deeper leaf litter.

Study Area

This study was conducted in the Mazumbai Forest Reserve on the eastern side of the Western Usambara Mountains in northeastern Taznania. The Eastern Arc Mountains were created by block faulting over a long period of time (Lovett 1996). They have been tectonically stable for around 25 million years, thus creating a relatively stable climate which contributes to the rich biodiversity of the tropical forest. The annual rainfall of between 1200 and 3000 mm, and the close proximity to the Indian Ocean also contribute to the biodiversity.

The Usambara Mountains are a part of the Eastern Arc Mountain chain. Mazumbai forest reserve is a 350 hectare tropical montane forest privately owned by Sokoine University. It was originally in the hands of a Swiss owner who eventually donated it to the University of Dar es Salaam with the stipulation that it remain unused for extractive purposes, and then later transferred to Sokoine University. The forest reserve is surrounded by numerous villages, the closest being Mazumbai, followed by Kizanda and Mgwashi. It is also surrounded by large deforested areas due to local agriculture and firewood collection (Cohen, 2006).

The reserve ranges in elevation from 1300 meters to 1900 meters. The forest has three vegetational communities divided by elevation. This study sampled *Syzygium Guineense* from all three communities. The lower and middle vegetational community is separated by a road that runs through the reserve. The lower elevations have thick and dense brush with trees that reach up to 50 meters, while the higher elevations have less dense brush with the highest trees only reaching 35 meters. While concave, convex, and intermediate micro-spatial landscapes can be found in all three vegetational zones, concavity is most prominent at lower elevations, intermediacy in mid-elevations, and convexity at higher altitudes. The lowest altitude (1400 -

1500 m) studied had the most human activity, with tea fields surrounding areas where plots were set up. The mid-altitude (1500 - 1600 m) contained a road and a stream running through the lower portion of the studied altitude range. Whilst the highest altitude had the least amount of human activity.

The forest contains two rainy seasons; October through December and March through May. This study took place in November, when it primarily rained in the afternoons with sunny mornings.

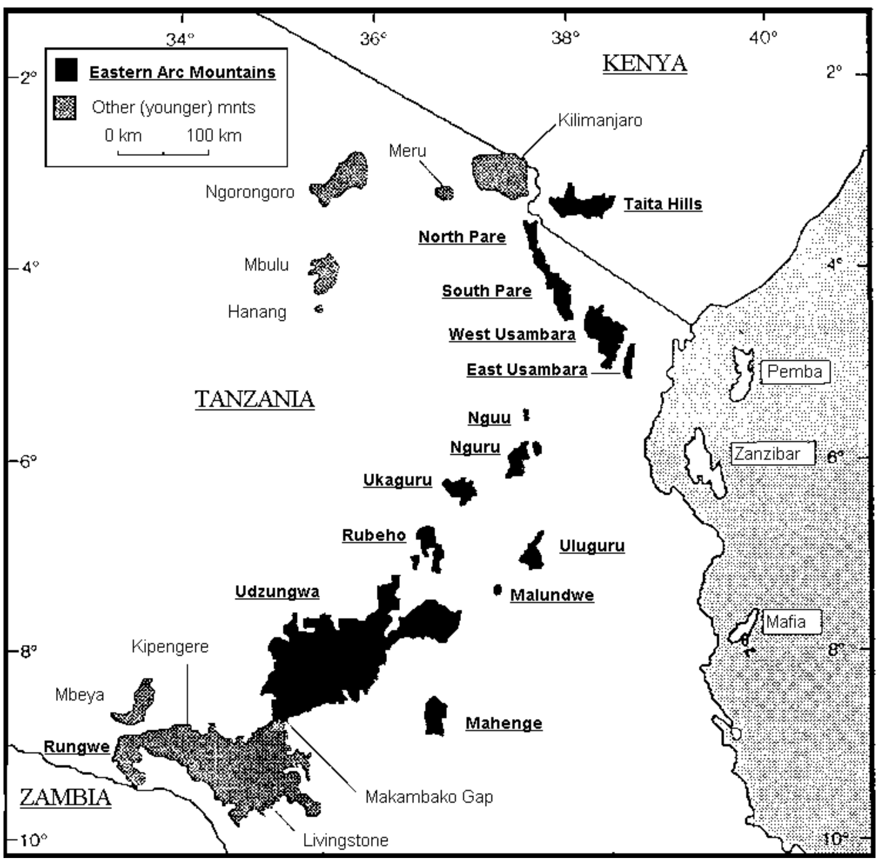

Figure 1: Map of the Eastern Arc Mountains. Source: Tanzanian Forestry Research Institute.

Methodologies

This study was conducted in Mazumbai Forest Reserve in Northeastern Tanzania from November 9th until November 23rd to determine the physiognomic effects that altitude and micro-spatial habitats have on the tree species; *Syzygium Guineense*. The sample population was *Syzygium Guineense*. The sample frame involved three bands of varying altitudes; 1400 - 1500 meters, 1500 - 1600 meters, and 1600 - 1700 meters, as well as three different micro-spatial habitats; concave, convex, and intermediate. 90 belt transects were non-randomly distributed among the altitudinal bands and micro-spatial habitats. 30 belt transects of 5 by 5 meters were set up at each altitude. 10 belt transects in concave areas, 10 in convex areas, and 10 in intermediate areas for each altitude.

Within each plot, the altitude, leaf litter depth, buttress sphere, number of buttresses, relative size of each buttress, DBH, and height of *Syzygium Guineense* was measured and recorded. A watch was used to measure the altitude, while a measuring tape was used to measure leaf litter, buttress sphere, and DBH. The slope, type of micro-spatial habitat, relative size of the buttresses, and height of each tree was estimated.

Data was collected over a period of 15 days. Each day one of the three altitude bands was visited, where six belt transects were set up; two plots were placed in micro-spatial habitats displaying concavity, two in convex areas, and two in intermediate. Concave areas were defined as areas with a close to 0° slope in the center and slopes on the edge of the plot being greater than 0° and slanting upward; analogous to a bowl. Convex areas were defined as areas with an approximate 0° slope in the center, but edge slopes slanting downward; comparable to the top of a hill. Finally, intermediate habitats involved nearly uniform slopes throughout the plot with angles greater than 10°. Within each plot, a five meter line was laid, with the apex or trough for convex and concave areas, respectively, in the center of each plot. Since intermediate areas displayed mostly uniform sloping throughout, the center laid randomly. The quadrate included 2.5 meters on either side of the five meter center line. Since the areas displaying the desired micro-spatial habitats needed to be larger than the plot itself, a five by five meter plot was chosen. A larger belt transect would have made it very difficult to find large enough areas displaying the preferred micro-spatial habitat.

After the plot was established, the altitude was recorded using a watch. Five measurements of the leaf litter were taken in the northwestern, southwestern, northeastern, southeastern corners of the plot, as well as one measurement in the center of the plot. The slopes were estimated for the same five areas within the plot. Then, the buttress sphere and DBH were measured using the measuring tape. The number of buttresses for each *Syzygium Guineense* were counted and each buttress was given a relative size of small, medium, large, extra large, or extra-extra large. The size of the buttresses were determined by an approximate percentage of the mass of the base of the tree being taken up by buttresses; small (<10%), medium (10 - 20%), large (20 - 30%), extra-large (30 - 50%), extra-extra-large (>50%). Then, the height of each tree was estimated. Finally, the position of each tree within the plot was measured, recorded, and mapped.

The data was divided into two categories and analyzed separately; 1) the effect of altitude and 2) the effect of micro-spatial habitats on the physiognomy of *Syzygium Guineense*. A regression analysis was used to compare altitude on buttress sizes, DBH, and height, while ANOVA was used to compare micro-spatial effects . Since altitude needed to be kept constant to more accurately study the effects of micro-spatial habitats on the tree species, 3 separate sets of data per micro-spatial habitat were analyzed, giving a total of nine separate sets of data that were run through ANOVA and given a corresponding p-value.

Results

In order to analyze the effects that altitude and micro-spatial habitat have on the physiognomic characteristics of *Syzygium Guineense*, the results have been separated into two separate sections. The first section will compare micro-spatial habitats to the four measured dependent variables (size of buttress sphere, number of bttresses, DBH, and height). The second will examine the effects of only altitude on the same variables.

I. Effects of Micro-Spatial Habitat

	Zone 1		**Zone 2**		**Zone 3**	
	Leaf Litter (cm)	Slope (deg.)	Leaf Litter (cm)	Slope (deg.)	Leaf Litter (cm)	Slope (deg.)
Concave	9.8 (R: 4 - 40)	29.3 (R: 0 - 50)	12.64 (R:5 - 40)	28.8 (R: 0 - 60)	21.84 (R: 12 - 40)	17.2 (R: 0 - 45)
Convex	11.9 (R: 6 - 33)	4.2 (R: 0 - 15)	15.74 (R: 6 - 37)	13.4 (R: 0 - 30)	22.92 (R: 12 - 47)	7.2 (R: 0 - 20)
Intermediate	8.74 (R: 4 - 24)	39.3 (R: 20 - 50)	16.98 (R: 11 - 25)	44.0 (R: 25 - 50)	18.02 (R: 11 - 32)	34.4 (R: 20 - 50)

Table 1 Micro-spatial Habitat Leaf Litter and Slope Averages: Average litter (cm) and slope (degrees) for the three micro-spatial habitats (concave, convex, and intermediate) with vegetational zones kept constant (Zone 1 = 1400 - 1500 meters, Zone 2 = 1500 - 1600 meters, Zone 3 = 1600 - 1700 meters). n = 50 for both leaf litter and slope per micro-spatial habitat per vegetational zone. A ruler was used to measure the leaf litter and the slope was estimated. Data was collected from 90 belt transects (10 per micro-spatial habitat for each vegetational zone) from November 9 - 23, 2014 in the Mazumbai Forest Reserve, Tanzania.

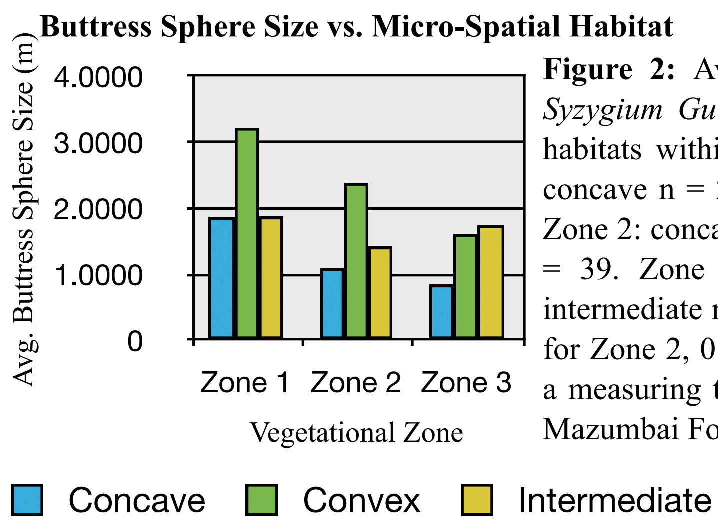

Figure 2: Average size of the buttress spheres for *Syzygium Guineense* amongst the three micro-spatial habitats within the three vegetational zones. Zone 1: concave n = 21, convex n = 25, intermediate n = 24. Zone 2: concave n = 28, convex n = 24, intermediate n = 39. Zone 3: concave n = 29, convex n = 34, intermediate n = 31. p-values = 0.12 for Zone 1, 0.007 for Zone 2, 0.07 for Zone 3. Data was collected using a measuring tape from November 9 - 23, 2014 in the Mazumbai Forest Reserve, Tanzania.

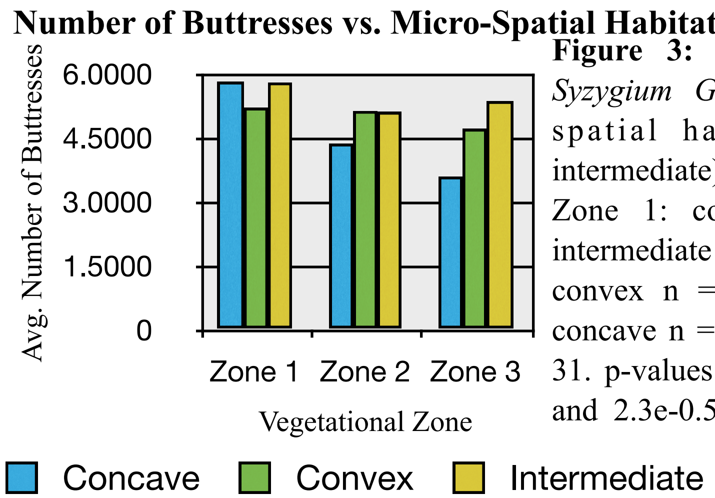

Figure 3: Average number of buttresses for *Syzygium Guineense* amongst the three micro-spatial habitats (concave, convex, and intermediate) within the three vegetational zones. Zone 1: concave n = 21, convex n = 25, intermediate n = 24. Zone 2: concave n = 28, convex n = 24, intermediate n = 39. Zone 3: concave n = 29, convex n = 34, intermediate n = 31. p-values = 0.52 for Zone 1, 0.10 for Zone 2, and 2.3e-0.5 for Zone 3. Data was collected by count from November 9 - 23, 2014 in the Mazumbai Forest Reserve, Tanzania

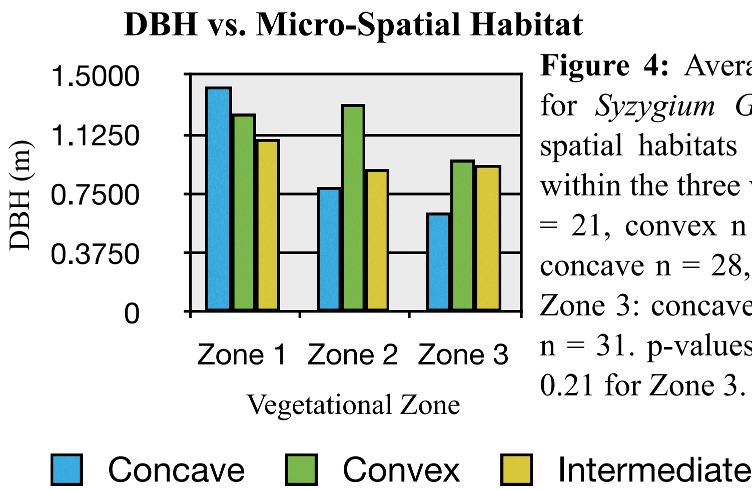

Figure 4: Average DBH (diameter at breast height) for *Syzygium Guineense* amongst the three micro-spatial habitats (concave, convex, and intermediate) within the three vegetational zones. Zone 1: concave n = 21, convex n = 25, intermediate n = 24. Zone 2: concave n = 28, convex n = 24, intermediate n = 39. Zone 3: concave n = 29, convex n = 34, intermediate n = 31. p-values = 0.51 for Zone 1, 0.11 for Zone 2, 0.21 for Zone 3. Data was collected using a measuring tape from November 9 - 23, 2014 in the Mazumbai Forest Reserve, Tanzania.

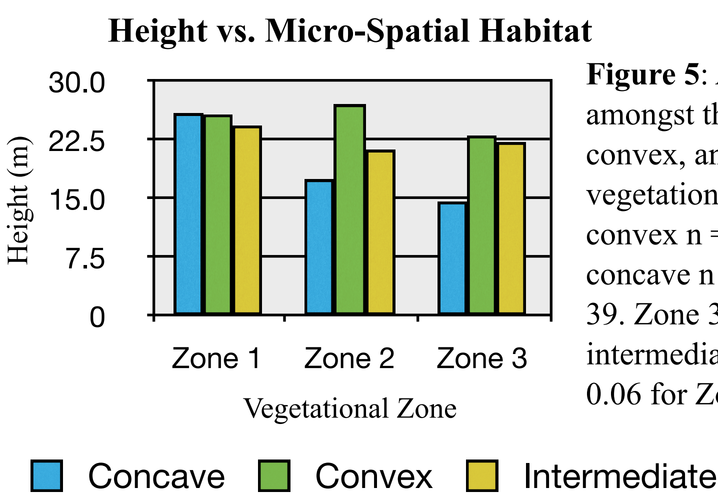

Figure 5: Average Height for *Syzygium Guineense* amongst the three micro-spatial habitats (concave, convex, and intermediate) within the three vegetational zones. Zone 1: concave n = 21, convex n = 25, intermediate n = 24. Zone 2: concave n = 28, convex n = 24, intermediate n = 39. Zone 3: concave n = 29, convex n = 34, intermediate n = 31. p-values = 0.93 for Zone 1, 0.06 for Zone 2, and 0.03 for Zone 3. Data was collected by estimation from November 9 - 23, 2014 in the Mazumbai Forest Reserve, Tanzania.

	Zone 1		Zone 2		Zone 3	
	Leaf Litter	Slope	Leaf Litter	Slope	Leaf Litter	Slope
Buttress Sphere	0.942	-0.96	0.470	-0.720	-0.435	0.285
# of Buttresses	-0.935	0.954	0.953	-0.029	-0.631	0.499
DBH	0.309	-0.256	0.433	-0.749	-0.222	0.633
Height	0.697	-0.656	0.601	-0.604	-0.221	0.062

Table 2: Correlation Coefficients vs. Variables vs. Leaf Litter and Slope: Correlation coefficients for leaf litter and slope versus buttress sphere (in meters), number of buttresses, DBH (in meters), and height (in meters) in the three vegetational zones. Zone 1 is 1400 - 1500 m, Zone 2 is 1500 - 1600 m, and Zone 3 is 1600 - 1700 m. A coefficient of 0.75 - 1.0 indicates a strong correlation. A coefficient of 0.25 - 0.75 is a weak correlation, and a coefficient of 0 - 0.25 is no correlation. A negative correlation indicates the variables are inversely related.

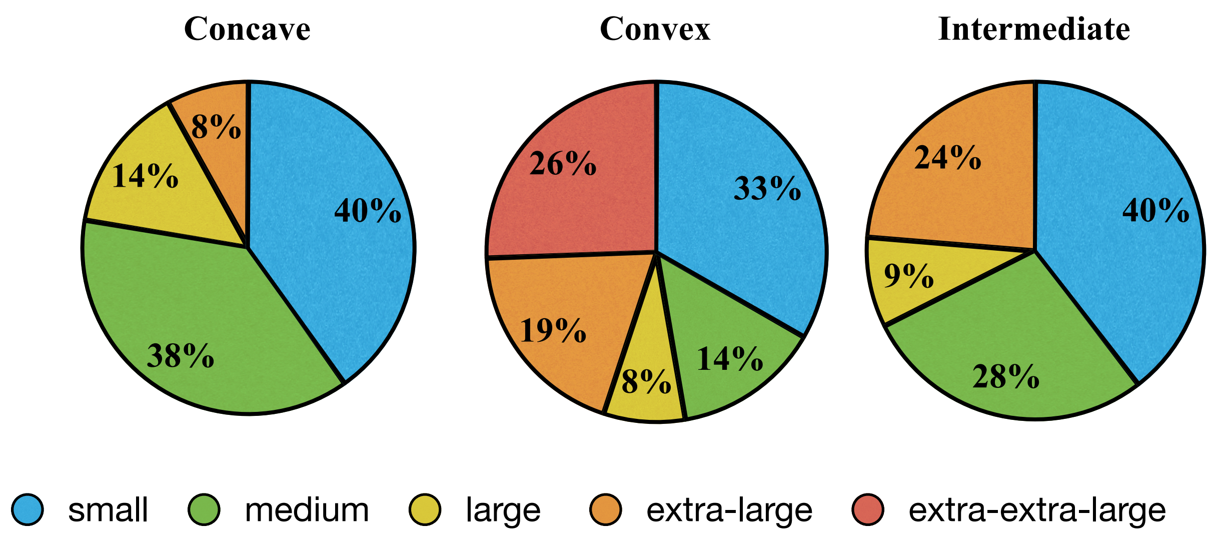

Figure 6: Zone 1 Size of Buttresses vs. Micro-Spatial Habitat: Percentage of buttress sizes in the first vegetational zone for each micro-spatial habitat (concave, convex, and intermediate). n = 21 for concave, n = 25 for convex, and n = 24 for intermediate. Data was collected by estimation from 30 belt transects; 10 transects per micro-spatial habitat from November 9 - 23, 2014 in the Mazumbai Forest Reserve, Tanzania.

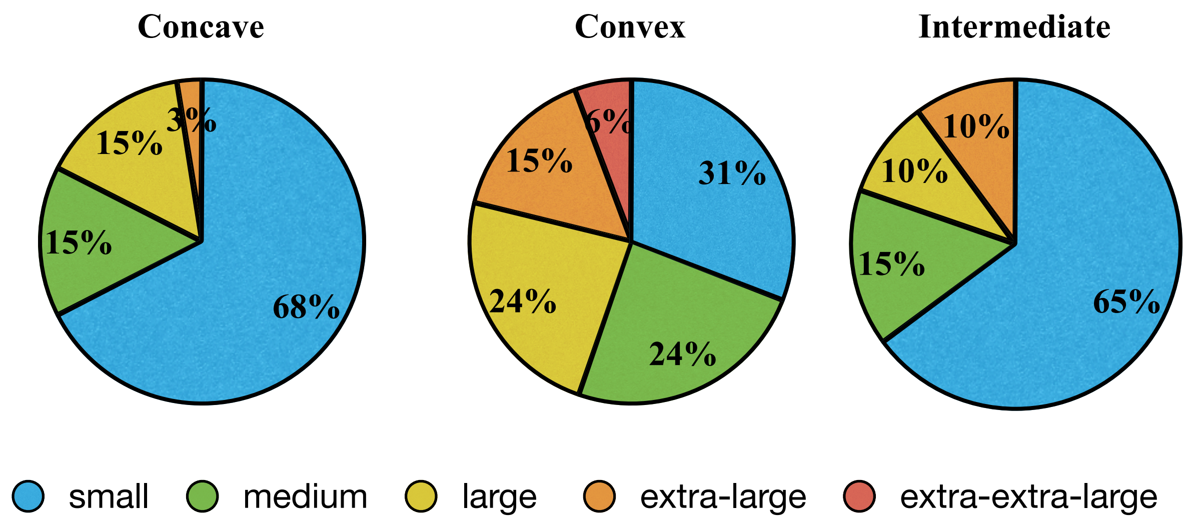

Figure 7: Zone 2 Size of Buttresses vs. Micro-Spatial Habitat: Percentage of buttress sizes in the second vegetational zone for each micro-spatial habitat (concave, convex, and intermediate). n = 28 for concave, n = 24 for convex, and n = 39 for intermediate. Data was collected by estimation from 30 belt transects; 10 transects per micro-spatial habitat from November 9 - 23, 2014 in the Mazumbai Forest Reserve, Tanzania.

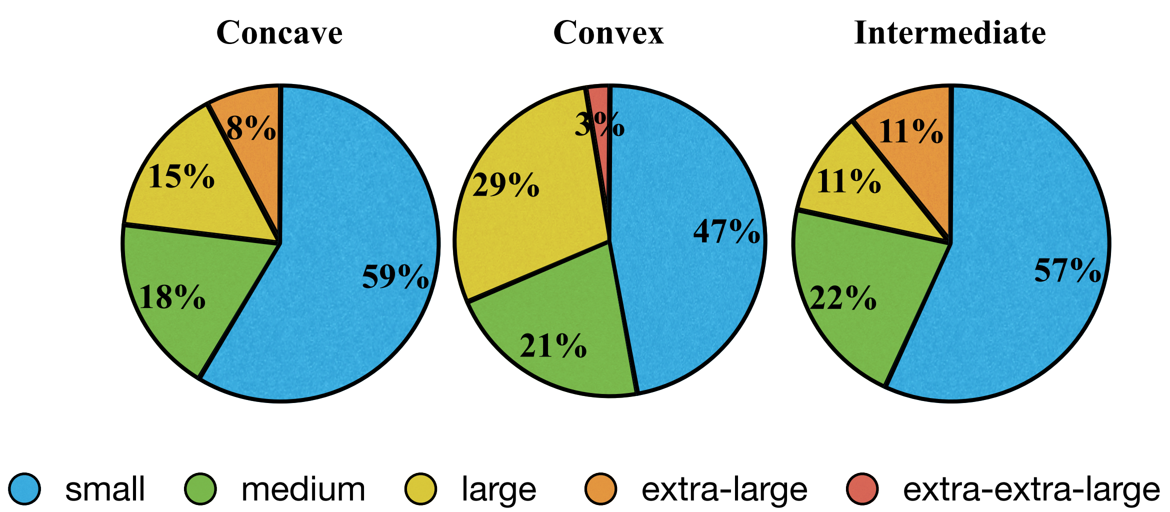

Figure 8: Zone 3 Size of Buttresses vs. Micro-Spatial Habitat: Percentage of buttress sizes in the third vegetational zone for each micro-spatial habitat (concave, convex, and intermediate). n = 29 for concave, n = 34 for convex, and n = 31 for intermediate. Data was collected by estimation from 30 belt transects; 10 transects per micro-spatial habitat from November 9 - 23, 2014 in the Mazumbai Forest Reserve, Tanzania.

II. Effects of Altitude

	Leaf Litter	Slope
1400 - 1500 m	10.1 (R: 4 - 33) cm	24.2º (R: 0º - 50º)
1500 - 1600 m	15.1 (R: 3 - 40) cm	30.3 (R: 0 - 60º)
1600 -1700 m	21.9 (R: 7 - 47) cm	19.6 (R: 0º - 50º)

Table 3: Altitudinal Bands Average Leaf Litter and Slope: Average leaf litter (cm) and slope (degrees) for the three altitudinal bands; 1400 - 1500 meters, 1500 - 1600 meters, and 1600 - 1700 meters. n = 150 for both leaf litter and slope measurements per altitudinal band. A ruler was used to measure the leaf litter and the slope was estimated. Data was collected from 90 belt transects (30 per altitudinal band and 5 measurements of leaf litter and slope per plot) from November 9 - 23, 2014 in the Mazumbai Forest Reserve, Tanzania.

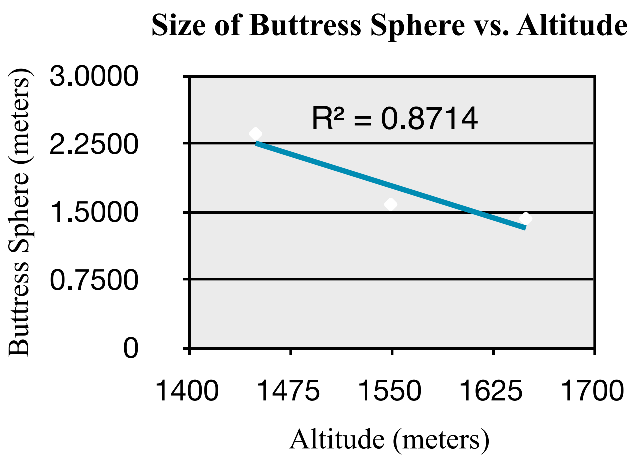

Figure 9: Average Size of the Buttress Sphere of *Syagium Guineense* amongst the three altitudinal bands (1400 - 1500 m, 1500 -1600 m, and 1600 - 1700 m). 1400 - 1500 meters n = 70, 1500 - 1600 meters n = 89, 1600 - 1700 meters n = 94. $R^2 = 0.924$. Data was collected using a tape measure from 90 belt transects; 30 transects per altitudinal band from November 9 - 23, 2014, in the Mazumbai Forest Reserve, Tanzania.

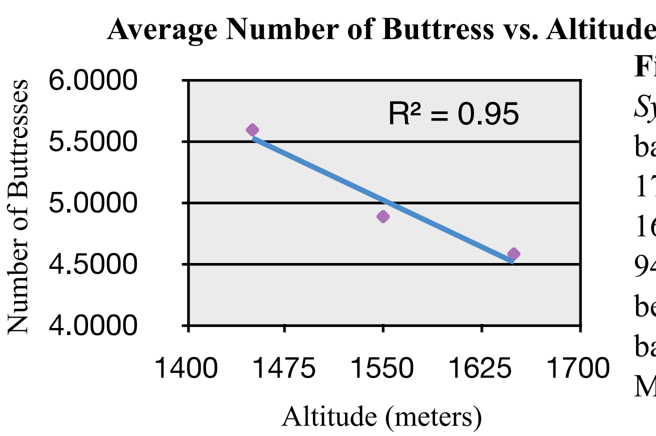

Figure 10: Average number of Buttresses per *Syzygium Guineense* amongst each altitudinal band (1400 - 1500 m, 1500 - 1600 m, 1600 - 1700 m). 1400 - 1500 meters n = 70, 1500 - 1600 meters n = 89, 1600 - 1700 meters n = 94. $R^2 = 0.95$. Data was collected from 90 belt transects; 30 transects per altitudinal band from November 9 - 23, 2014 in the Mazumbai Forest Reserve, Tanzania.

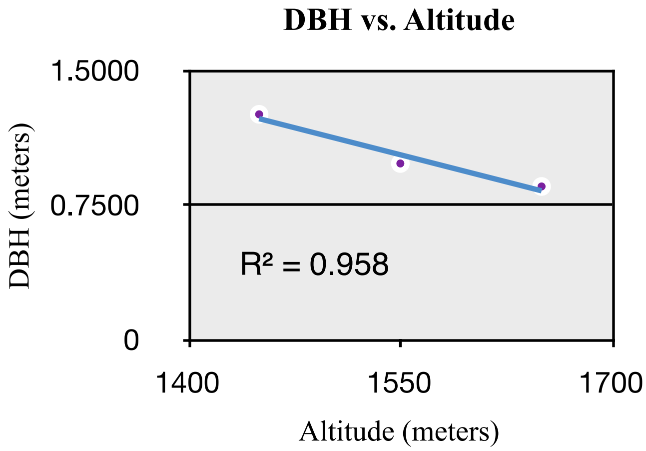

Figure 11: Average DBH (diameter at breast height) per *Syzgium Guineense* amongst each altitudinal band (1400 -1500 m, 1500 - 1600 m, 1600 -1700 m). 1400 - 1500 meters n = 70, 1500 - 1600 meters n - 89, 1600 - 1700 meters n = 94. $R^2 = 0.958$. Data was collected using a tape measure from 90 belt transects; 30 transects per altitudinal band from November 9 - 23, 2014 in the Mazumbai Forest Reserve, Tanzania.

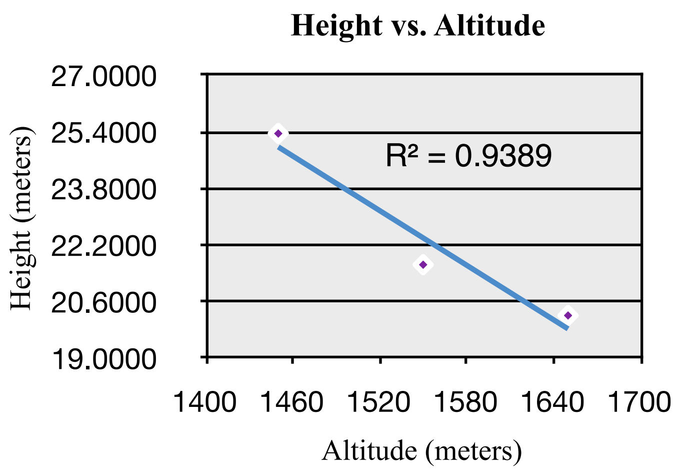

Figure 12: Average Height per *Syzygium Guineense* amongst each altitudinal band (1400 -1500 m, 1500 - 1600 m, 1600 - 1700 m). 1400 - 1500 meters n = 70, 1500 -1600 meters n = 89, 1600 - 1700 meters n = 94. $R^2 = 0.9389$. Data was collected by estimation from 90 belt transects; 30 transects per altitudinal band from November 9 - 23, 2014 in the Mazumbai Forest Reserve, Tanzania.

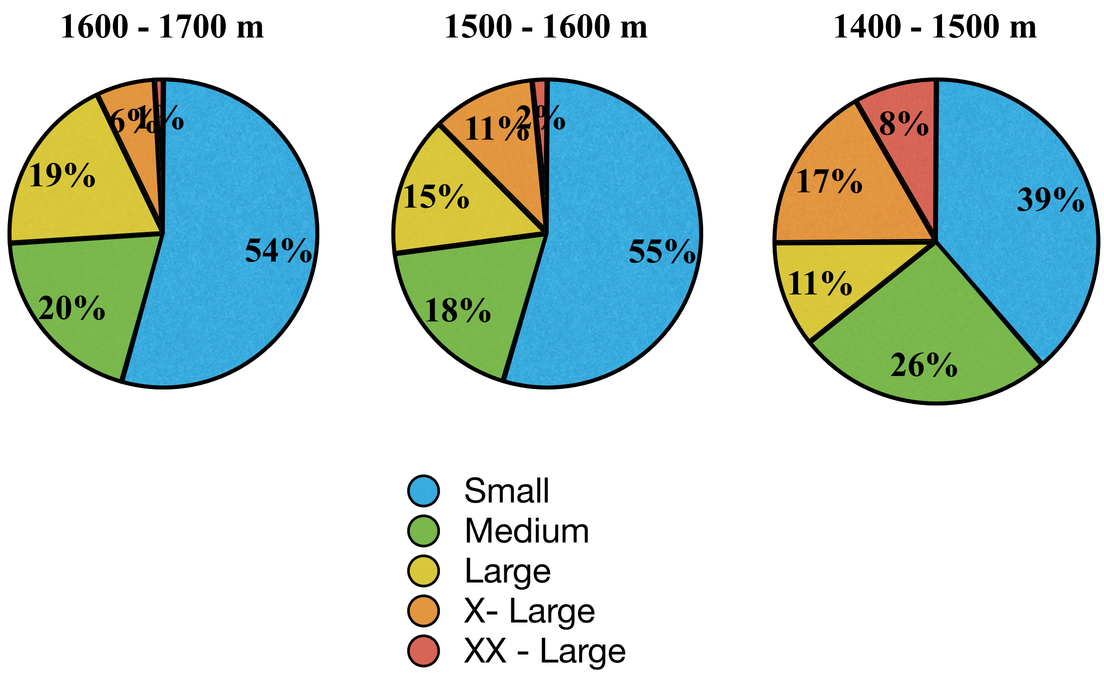

Figure 13: Size of Buttresses vs. Altitude: Percentage of buttress sizes per altitudinal band (1400 - 1500 m, 1500 - 1600 m, 1600 - 1700 m). n = 70 for 1400 - 1500 meters, n = 89 fro 1500 - 1600 meters, n = 94 for 1600 - 1700 meters. Data was collected by estimation from 90 belt transects; 30 transects per altitudinal band from November 9 - 23, 2014 in the Mazumbai Forest Reserve, Tanzania.

Discussion

I. Micro-Spatial Effects

Micro-spatially, it was hypothesized that *Syzygium Guineense* will display more buttressing characteristics in intermediate areas than in concave and convex areas due to the steeper slope, and that the trees in concave areas will be larger in general because of the likelihood of a deeper leaf litter. However, according to ANOVA, buttress sphere size, number of buttresses, DBH, and height varied differently for all three micro-spatial habitats; showing almost no significant differences between the habitats (p-values were greater than 0.05), except for buttress spheres in zone 2, number of buttresses and height for zone 3 (p-values for these measurements were less than 0.05). The data showing significant differences between the means of the variables measured could be interpreted that micro-spatial habitat plays a more important role in determining the physiognomy in these zones. In other words, the concavity, convexity, and intermediacy of the landscape likely effected the size of the buttress sphere in the 1500-1600 m vegetational zone, and the number of buttresses and the height in 1600-1700 m vegetational zone.

However, for the rest of the vegetation zones that showed no significance between the means of the measured variables within each micro-spatial habitat; there could be other factors contributing to the size of the buttress sphere and DBH, number of buttresses, and height. Even though p-values for these vegetational zones show no significant differences between the means of the four measured variables for each habitat, when running a correlation test comparing the buttress spheres, number of buttresses, DBH, and height for each vegetational zone against leaf litter and slope, the results show that there is some correlation to leaf litter and slope depending on the vegetational zones. (**Table 2)**. As discussed in the introduction, micro-spatial heterogeneity effects tree growth and success and covers a multitude of factors aside from the concavity, convexity, and intermediacy of the landscape surrounding the trees. Hence, there could be other factors (such as sunlight and water availability, surrounding vegetation, canopy cover, temperature etc.) effecting the physiognomy of *Syzygium Guineense.* This would explain the lack of conclusive data regarding micro-spatial habitats effect on the physiognomy of *Syzygium Guineense*.

The strong positive correlations for leaf litter and slope versus buttress sphere and number of buttresses for the first vegetational zone suggest that the slope and leaf litter are strongly related to the size and number of buttresses on *Syzygium Guineense*, while the height and DBH of Zone 1 are only weakly related to the slope and leaf litter. Zone 2 primarily showed weak correlations for all variables and Zone 3 showed weak to no correlations. This could suggest that more and more factors are effecting the physiognomy of *Syzygium Guineense* as vegetational zones are moved across. It was hypothesized that the lowest altitude would have the largest trees because of more soil nutrient availability and higher temperatures. Perhaps the data is inconclusive for micro-spatial habitats because not all possible variables effecting they physiognomy of the examined tree species was taken into account. For example, soil nutrients were not wholly considered (aside from leaf litter depth), and temperature was not measured at all. Since soil nutrient availability and temperature decrease with increasing elevation, and thus affect plant success negatively as the mountain is ascended, micro-spatial habitats in Zones 2 and 3 would show less correlation to leaf litter and slope because there are other factors effecting plant success more strongly at the higher altitudes.

When comparing the relative sizes of the buttresses for each micro-spatial habitat within each vegetational zone, a common trend was that concave and intermediate habitats showed a larger percentage of small and medium sized buttresses, while trees in convex landscapes showed a higher percentage of larger buttresses (**Figures 5, 6 and 7)**. This trend occurred in all three micro-spatial habitats, which does not support the hypothesis that larger buttresses would be found in intermediate areas. Perhaps this is still a result of strain on the tree. In convex areas, the tree sits on a hill, and therefore must be able to support itself on all sides, whereas intermediate ares just need to support itself on one side. While concave and intermediate landscapes closely matched each other on percentage of small buttresses, intermediate areas still show a greater percentage of larger buttresses although only slightly greater. This does support the idea that the landscape that provides the flattest and least strenuous habit for *Syzygium Guineense* would show trees with the greatest amount of small buttresses.

II. Altitude Effects

Conversely, altitude showed to have a strong effect on the physiognomy of *Syzygium Guineense.* A scatter plot of buttress sphere size, number of buttresses, DBH and height versus altitude showed obvious trends. Running regression analyses on each of these variables versus altitude gave large R^2 values. For buttress sphere versus altitude, $R^2 = 0.87$ showing that buttress sphere size is heavily dependent on altitude. R^2 for number of buttresses versus altitude was even higher, with a value of 0.95. R^2 for DBH versus altitude was 0.958 and for height was 0.9389. Thus, all four measured variables are affected by altitude. It was hypothesized that the number of buttresses, buttress sphere size, DBH, and height will decrease with increasing elevation. This hypothesis proved to be correct.

Relative buttress sizes did not show any obvious trends, except that the lowest altitude had the greatest percentage of larger buttresses, while 1500 - 1600 m and 1600 - 1700 m had roughly similar percentages of buttress sizes.

The findings are consistent with the idea that lower altitudes provide a more advantageous environment for plant species due to temperature and water availability. Even though higher altitudes receive more rain than lower elevations, the lower altitudes obtain runoff from higher elevations giving them the same or greater moisture level than higher elevations. Furthermore, higher rainfall gives higher nutrient levels in the soil because nutrients are leached faster, but lower temperatures slow the rate of nutrient release in the leaf litter. Therefore, the higher temperatures at lower altitudes combined with runoff creates a more advantageous environment for trees because it provides more water and nutrients. In an environment where water and nutrients are more readily available and accessible, trees are able to invest more resources into their structure. This makes sense with the data obtained; showing larger overall structure for *Syzygium Guineense* at the lowest altitudinal band, and decreasing with increasing elevation.

Limitation & Recommedations

Methodological

- short amount of time given to conduct study. A larger set of data would have given more reliable and accurate results.
- heavy reliance on estimation as a form of measurement; slope, height, and relative size of buttresses.
- difficulty reaching high heights to appropriately measure the DBH above the buttress.
- difficulty accurately meausring the buttress sphere in intermeidate habitats because the slope of the terrain would hide a portion of the buttress.
- Accuracy of the altimeter on the watch
- The uneven amount of trees in each plot did not give the same amount of measurements when running ANOVA. ANOVA is better with equal sample sizes.

Observational

- Finding areas that definitely displayed the desired micro-spatial habitats. Some vegetational zones had more defintive habitats, while others were more obscure and slightly questionable.

Recommendations for the Current Study

I would highly recommend collecting more data if possible; i.e. setting up more than 90 plots if time permits. A larger data set could give more insight into micro-spatial habitats effect on *Syzygium Guineense*. I would also recommend keeping the plots small - at least 5 by 5, if not even smaller. Since the micro-spatial habitat changes greatly within small distances.

Recommendations for Future Studies

Since there have been several studies done on altidue's affect on tree physiognomy, and most come to a similar conclusion as my study did, then I would highly recommend that the next study looks explicity at micro-spatial habitats. My data did not give great insight into how concavity, convexity, and intermediacy affect *Syzygium Guineense*. There are a multitude of micro-spatial heterogeneous factors that could be effecting trees. Thus, I would recommend that another study measures other factors in addition to the sloping of the landscape. Such as temperature and canopy cover.

Conclusion

Syzygium Guineense, a species of tree found in the Mazumbai Forest, was studied at three separate elevations; 1400 - 1500 m, 1500 - 1600 m, and 1600 - 1700 m and three micro-spatial habitats; concave, convex, and intermediate in order to exmaine macro and micro-spatial affects on the physiognomy of the species. Micro-spatially, it was hypothesized that the trees would have larger and more buttresses in intermediate areas, but larger DBHs and heights in concave areas due to slope strain and nutrient availability. However, according to ANOVA, most of the data was insignificant (p values greater than 0.05) But when comparing the measured variables to leaf litter and slope; there appeared to be some correlation indicating that the landscape of the habitats most likely does not play a major role in the physiognomy of *Syzygium Guineense (*except for the 3 sets of data showing significant p-values) and other micro-spatial factors can affect the physiognomy more or less depending on the vegetational zone.

Macro-spatially, it was hypothesized that the size and number of buttresses, DBH, and height would decrease with increasing elevations due to the temperature and rainfall gradients up the moutain. This hypothesis was supported by the data comparing all the measured variables to the altitude and regression analyses indicating R^2 values greater than 0.85 indicating a strong change in the physiognomy of *Syzyguin Guineense* with altitude.

The purpose of this study was to examine macro and micro-spatial functions inside of a the Mazumbai Forest, and calls attention to the complexities of tropical forests. It highlights the need for more research in order to further understand biodiveristy within these forests and it's impact on a global scale. As deforestation increases along with the population, the threat to tropical forests becomes greater. Therefore, a better understanding of their function globally could effectively save them.

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Appendix A: Example of Data Collection Sheet

	Conc.	Conc.	Conv.	Conv.	Intm.	Intm.
Altitude						
Leaf Litter Depth						
Slopes						
Buttress Sphere Size						
# of Buttresses						
Buttress Sizes						
DBH						
Height						

5 x 5 meter belt-transect