**Introduction**

Climate change and anthropogenic disturbances (i.e. selective logging and deforestation) has increased the rates of tree species extinctions (Johnson et al., 2018), being 1000 times higher than natural extinctions rates (De Vos et al., 2015). One possible consequence of tree species loss is the erosion in the forest tree composition, decreasing diversity and thus making forest vulnerable to unexpected climatic events (Cardinale et al., 2012; Reich et al., 2012).

Resilience can be defined as the capacity of a forest to absorb a disturbance without losing its functioning (Holling, 1973) and could depend on how fast a locally extinct species is replaced by another with similar characteristics (Mori et al., 2013). In tropical forest ecosystems, how fast a species can be replaced by another might be determined by the degree of functional redundancy and functional diversity within each community. Thus is expected that forests with high functional redundancy and high functional diversity could maintaining their function under unexpected disturbances (Elmqvist et al., 2003; Naeem, 1998; Yachi & Loreau, 1999)

Functional redundancy can be defined as the number of species that performed a similar function in an ecosystem and shared the same parts within the functional space (Naeem, 1998). This can be quantified as the distance between two species in a dissimilarity matrix and is measured with the index proposed by Ricotta et al., (2016). On the other hand functional diversity can be defined as the functional trait variability in a community and can be measured with an index called FDis propose by Pavoine & Bonsall, (2011).

The overall goal of this research is to understand how landscape-level processes determine forest resilience in mature wet forests. Specifically I want to determine how space, climate, and soil characteristics determine functional diversity and functional redundancy across an elevation gradient in Costa Rica.

**Materials and Methods**

*Data Sources*

For this project I will used already published data. Forest species composition of the wet forest comes from data collected by Sesnie et al., (2009) while for the soil and climatic characteristics of each plot I will use the data collected by Chain-Guadarrama et al., (2018). Finally, for calculating the functional redundancy and functional diversity I will use the data collected by (Chazdon et al., 2010).

*Study area*

The study area is located in the northern part of Costa Rica (Figure 1), specifically in San Juan- La Selva national park. This study area goes from 0 to 2881 meters above the sea, the mean temperatures vary between 10.8°C to 26,2°C while the annual mean rainfall vary between 2134 mm and 4932 mm. Within the landscape, it is possible to find three main forest types that are mainly defined by the dominance of one specie. The first type of forest is located in the most norther part of the landscape and is mainly dominated by *Qualea Paraensis* (Q. *Paraensis*). The second type of forest is located mostly in the center of the landscape and is dominated by *Pentracleta Macroloba* (P. Macroloba) while the foothills forest is located at the beginning of the mountain range, and it is dominated by multiple species.

*Sampling design and environmental factors*

Across the elevation gradient a total of 127 plots with a size 0.25 hectare were established between 30 and 1200 meters above the sea (Sesnie et al., 2009). The distance between each plot varies between 0.3 km to 61 km covering a total area of 6166 km2 across the landscape (Chain-Guadarrama et al., 2018).

In each plot all trees with a diameter larger than 10 cm were identified at the level of species. A total of 4801 trees were measured representing a total of 257 species. At each plot, soil pH, soil Ca, Mg concentration were measured alongside the soil clay and sand content (measured as percentages) and the soil organic material.

In terms of climatic variables, six predictors were used; mean annual temperature (temp), the lowest temperature of the coldest month (tempmin), mean annual precipitation (prec), precipitation of the driest month (precdriest), the coefficient of variation of the precipitation (preccv) and the standard deviation of the temperature (tempsd). Each of these variables were interpolated from meteorological stations and represent the average climatic conditions from 1950-2000 with a resolution of 1 km2 (Chain-Guadarrama et al., 2018)

*Biodiversity indexes*

Functional redundancy for each of the 127 plot was calculated by index proposed by (Ricotta et al., 2016). This index is defined as:

where D is the Simpson index and Q represents the quadratic Rao index while functional diversity was estimated using the FDis (Pavoine & Bonsall, 2011). Both indices were calculated using the FD R package (Laliberté & Legendre, 2010).

*Dataset description*

The full dataset have dimensions of 127 rows (that represent each plot in the landscape) and 18 columns. I will use as response variables the functional redundancy and functional diversity of each plot and as independent variables I will use 6 climatic variables, 7 soil variables, the elevation and the latitude and longitude of each plot.

*Statistical Analysis*

The main challenge for the analysis of the dataset is dealing with the high multicollinearity between the independent variables thus before building the models, I will have to address this issue (Figure 2).

For determining how the climatic and soil characteristics affect the functional redundancy and functional diversity across the landscape I will build a model using stochastic partial differential equations for modeling the spatial correlation across the landscape, including the climatic and soil characteristics as covariates.

*Preliminary results*

Functional diversity and functional redundancy indices seem to have a spatial pattern that seems to go from south (Foothills forest) to the northern part of the landscape (Figures 3 and 4).

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*Map

Description automatically generated with medium confidence*

Figure 1. Location of the 127 plots across the landscape. The number of plots within each forest type is unbalanced.

*Chart, scatter chart

Description automatically generated*Figure 2. Correlation plot showing the high collinearity between climactic variables lowest temperature of the coldest month (tempmin), mean annual precipitation (prec), precipitation of the driest month (precdriest), the coefficient of variation of the precipitation (preccv) and the standard deviation of the temperature (tempsd) and the soil characteristics pH, Ca, Mg, clay, and sand content (measured as percentages) and the soil organic material (OrganicMatter).

A picture containing map

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Figure 3. Functional redundancy distribution across the landscape showing a spatial pattern that goes from south (high values of redundancy) to north (low values of redundancy)

Figure 4. Functional diversity distribution across the landscape showing a spatial pattern that goes from south (low values of diversity) to north (high values of diversity)

Map

Description automatically generated with low confidence