Ecological Succession of Disturbed Areas in the Peruvian Amazon; Testing Biodiversity at Different Distances to Intact Primary Forest

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Abstract

Primary tropical rainforests hold the most biodiverse plant communities in the world. Deforestation has increased in tropical rainforests in the past two decades, causing reduced carbon sequestration, a loss in biodiversity, and land degradation. Many countries have initiated reforestation efforts in the tropics to help mitigate these issues. Regenerative forests in the tropics are less diverse than primary forests, however, they still assist in sustaining the overall biodiversity of plant and animal life in the tropics. Knowledge on reforestation efforts correlates to the diversity a regenerative forest can achieve. This study focuses on the effects of distance from a primary forest to a regenerative forest. Samplings were conducted in a regenerative forest growing after a fire in 2016 at Finca Las Piedras, a field station in the Madre de Dios region in Peru. The plant diversity of the regenerative forest was measured at two different distances from the primary forest border. Here I show that the distance from a primary forest tested in this study does not influence the plant diversity of a regenerative forest in this region. By studying the ecology of flora, this paper shed light on the community dynamics of a regenerative forest.

Introduction

The Madre de Dios region in Peru contains some of the most biodiverse areas in the world (Goodman, S., 2013). Deforestation causes a loss in biodiversity and contributes to climate change via a large release of carbon (Nunez, C., 2022). Over the past decade, deforestation has increased in the Madre de Dios region due to illegal gold mining, illegal logging, slah-and-burn agriculture, and burning for cattle grazing (Goodman, S., 2013). This is reflected in overall forest loss of the country. Peru has shown a steady increase in primary forest loss over the past two decades, of which more than 90% is due to deforestation (Fig 1). When areas used for cattle ranching or agriculture are abandoned, regenerative forests will grow slowly without any human intervention (Gunter, S. et al. (2007) Their overall biodiversity, however, is often lower than that of a primary forest. Many of the original plant species of a primary forest may not be able to grow there, changing the overall species composition of the regenerative forest (Piotto D, et al., 2019). Although the species composition may differ, they can still be sustainable for wildlife and keep biodiversity of nearby primary forests intact by acting as a corridor (Goodman, S., 2013). To increase the efficiency at which a corridor via a regenerative forest can be attained, reforestation efforts such as replanting, fertilizing, and invasive species clearing can be put in place (Woodford, R., 2000). Species, and where they are planted in a regenerative forest, should be considered in the reforestation process. Wind dispersed and pioneer species are more likely to grow naturally in a regenerative forest (Piotto D, et al., 2019), and species abundance of a regenerative forest has been found to decrease with increasing distance to a primary forest border (Gunter, S., 2007). This study will determine the effects of distance, from a regenerative forest plot to a primary forest plot, on the diversity and abundance of species in the forest of Finca Las Piedras. 20 transects were evaluated: 10 within 10 meters of a primary forest border and 10 within 70-100 meters. Knowing what

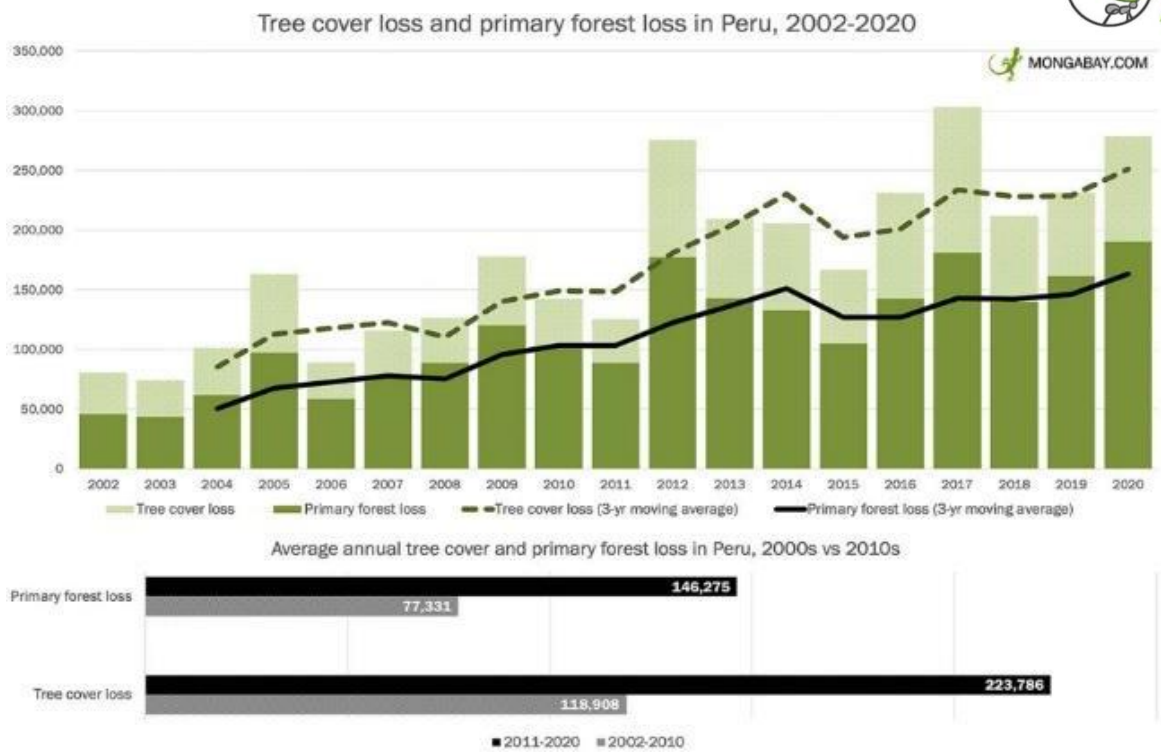

Figure 1: Details of forest loss in Peru over the past two decades (MONGABAY)

areas of regenerative forest to focus on could greatly improve the efficiency of the reforestation process. Increasing reforestation efficiency will be a crucial component in maintaining the biodiversity of the Amazon rainforest.

Methods

This study was done in the Peru Madre de Dios region at the Fincas Las Piedras research station (FLP). The site is located on the edge of a lowland tropical rainforest, known as terra firme, which was selectively logged about 25 years ago. This is the "primary forest" I refer to in this study, although the forest is defined as disturbed (Geoff Gallice, 2022). The plot borders Brazil nut concessions, agriculture fields, cattle pastures, and selectively logged forests. The degraded areas of land in the study are also on this property and were burned in 2016. It is now owned and protected by the NGO Alliance for a Sustainable Amazon (ASA). To determine the species richness and relative abundance in relation to distance from intact forest, a total of 20 transects were studied. These transects were split into two categories: edge areas having their nearest point 0-10 meters from intact forest, and far areas having their nearest point 70-100 meters away from intact forest. The transects were chosen using aerial photos and pseudo-random method of selection. Each transect was 20 meters long, and all species present along 5 meters on either side of the transect were measured. African Cattle grass (*Brachiaria brizantha)*, one of the main grass species present in the plots is an invasive species introduced for cattle grazing. The abundance of this species, along with other grasses, was not measured as it does not pertain to this study. Due to a lack of time and resources, lianas were also not counted for this study. What was measured, however, is every other plant species present. Plants were put into numbered categories. Each category represents the same type of plant off the basis of the following: leaf shape and structure, bark texture and shape, color of flowering if present, and branching patterns. When a new category of plant was found, photographs and

notes were recorded to recognize future plants within the same category. The biodiversity along the transects is what was compared. To determine this, a Shannon diversity index was used (Nolan, K. & Callahan J., 2006). This relates both species diversity and abundance using the following equation:

$$D = -\sum_{i=1}^{s} p_i ln(p_i)$$

$$p = \frac{n}{N}$$

Where n is the total number of organisms within a category, N is the total number of organisms within that transect, and D represents the biodiversity (the higher the value, the more biodiverse the area). A one tailed paired t-test was used to determine if the differences in biodiversity among the two plot types is statistically significant or not.

Results

Among the 10 edge transects studied, there was a mean biodiversity of 1.84, and among the 10 far transects studies, there was a mean biodiversity of 1.65 (Fig.2). After conducting a t-test assuming unequal variance, the Shannon diversity values for the two habitats had a P value of 0.189, so the null hypothesis is accepted. Therefore, there is no significant difference of biodiversity between the two habitats studied. Plant abundance (Fig.3) and total species present were also observed. The edge habitats had a total of 213 individuals with 54 different species, and the far habitats had a total of 152 individuals with 35 different species. The plant abundance for the two transect types has a P value of 0.105, so the null hypothesis is accepted. Similar to the diversity among the habitats, the plant abundance had no statistically significant difference. Certain species were more abundant than others. Some were prevalent in only edge habitats,

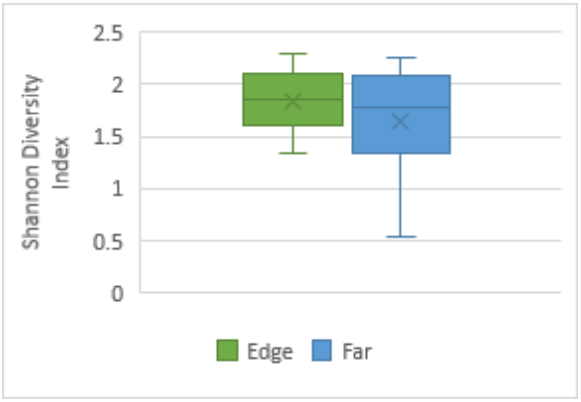

Figure 2: Box plot of the Shannon diversity index among the two different habitats studied

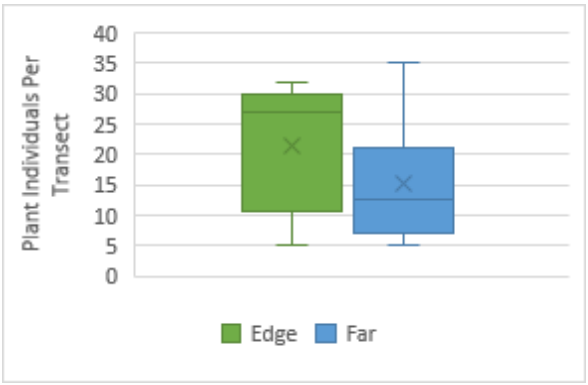

Figure 3: Box plot of the plant abundance among the two different habitats studied

Table 1: Species with 10 or more individuals found in either of the habitats.

Category	Edge	Far
1	24	0
8	7	12
11	3	10
17	3	22
19	24	4
26	17	24
28	11	13

while some were only prevalent at far distances or both (Table 1).

Discussion

Due to the lack of a statistically significant difference between the edge and far habitats, it cannot be inferred from this study that difference in biodiversity between the two plots studied is substantial enough to alter reforestation efforts. It should be noted that, due to a small sample area, there were other factors that may have influenced the results of this study. Edaphic factors are known to have an effect on forest succession in the tropics (Villegas, S. E., 2019), and the soil type on five of the edge transects is a lighter color and sandier texture than that of the rest of the study (Geoff Gallice, 2022). Other studies have shown that distance from a mature forest negatively impacts the plant diversity of a regenerative forest (Piotto D, et al., 2019). There are other factors, however, that are important to the success of a successional habitat. Even if the biodiversity among the two habitats was found to be completely even, there are still reasons to have reforestation efforts be focused on further distances from intact forests. Fewer seeds will be dispersed as the distance from a seed source or perching site increases (Piotto D, et al., 2019). The difference in species abundance and total species present shown in this study would then indicate that habitats closer to an intact forest need less assistance in regeneration. Repeating this study at a larger scale could be very beneficial, and edaphic factors would be less influential on the results. The methods used in this study could be easily repeated and used as part of a longer term, or larger scale study. They could also be repeated to determine other important aspects of regeneration, such as specific species present in regenerative forests. Identifying prevalence of certain species at different distances to a mature forest (Table 1) could allow reforestation efforts to be focused on specific species or plant groups. By evaluating the diversity of flora in regenerating areas, this paper has provided a small scale understanding of influence that distance to a mature forest has on a degraded area of land.

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Supplementary Materials

Appendix 1: Common species (Table 1)

Category

1

8

11

17

19

26

28