Studying Forest Edge Effects on Lepidoptera at Finca Las Piedras, Madre De Dios, Peru

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Abstract

Deforestation in the Madre de Dios region has increased drastically in the last decades due to an increase in gold mining and agriculture activities, both accounting for the most important exports of the region. Until local communities have better ways to support their lives, extractive-based deforestation on local ecosystems can provide insights into biodiversity resilience and how we can promote diversity to persist in the thralls of habitat degradation. This project will use butterflies as the study group as they are very diverse within insects and regulate plant communities. They are also ideal due to the ease at which they can be collected and monitored. The objective of the study is to quantify the effects of deforestation, specifically the forest edge, on butterfly diversity and species richness using data collected at Finca Las Piedras, Madre de Dios. Butterflies were collected using baited ground traps located in the forest edge and interior. For each treatment, number of species, abundances, and diversity indexes were calculated, as well as non-metric multidimensional scaling plot was produced to compare species composition. While the diversity indices showed that the population of butterflies was more diverse within the forest interior, a t test concluded that these results were not significant. While the diversity index results were not found to be significant, I hypothesize that future studies with more traps for prolonged study periods will produce significant results. This study represents one of the few studies exploring forest edge effects at Finca Las Piedras.

Introduction

Up until a few years ago, the Peruvian Amazon in the Madre de Dios region was virtually untouched by human-caused forest degradation. But due to a drastic increase in land use changes regarding gold mining and farming practices, the forested areas are being destroyed in favor of these money generating activities (Praeli 2019). When forested areas are cleared away for practices such as agriculture, a forest edge is created which in turn creates a microclimate within proximity of the forest edge due to factors such as increased sunlight and elevated wind speed. In addition to climate related changes, increased predation pressure comes as a result of the open spaces at the forest edge as well (Koh & Menge 2005). Edge effects are in continuous study among ecologists given the increased rate of deforestation and the diversity of target groups.

Lepidoptera was chosen as the study group because they represent a very diverse and populous group of specimens to sample. Additionally, data from trap collections from the Lepidoptera project conducted by the Alliance for a Sustainable Amazon research team will be utilized to establish the control of

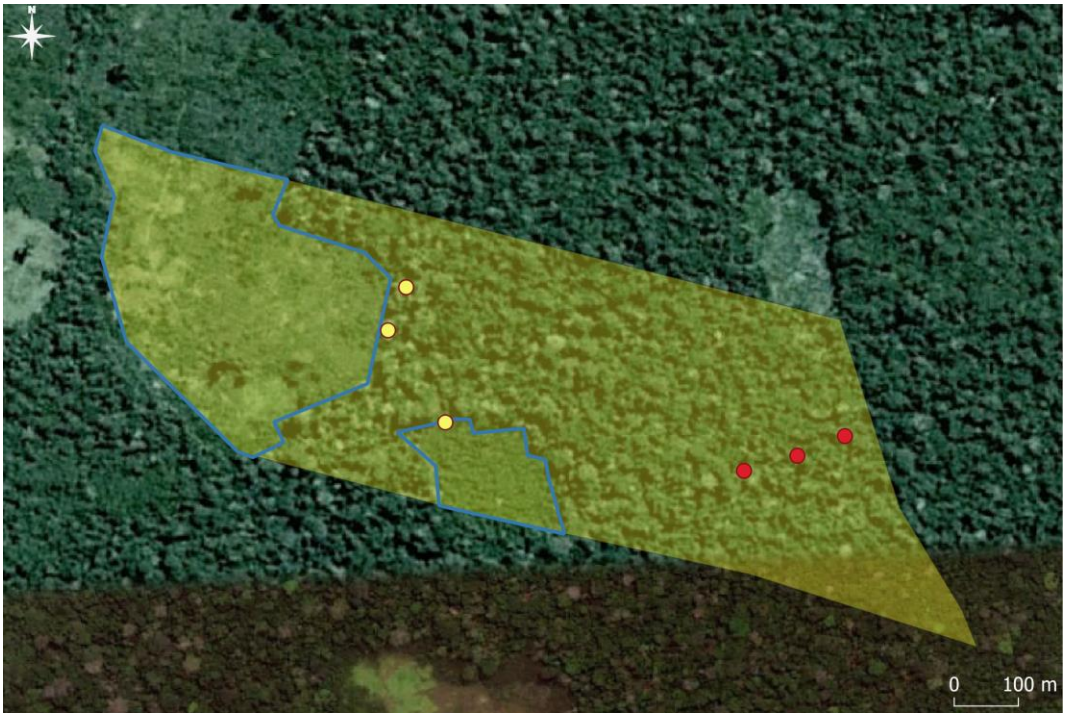

Figure 1: Property boundary of Finca las Piedras with the blue line indicated forest edge and the dots representing the forest edge traps (yellow) and the traps within the forest interior (red).

butterfly diversity within the forest interior. Their methods consisted of setting butterfly traps within the forest and collecting data for five consecutive days. For the ASA data collection, traps were set in both the understory and the canopy, but for this study, only data collected from the understory will be utilized.

In addition to the increase of sunlight at the forest edge, elevated wind speed and increased predation pressure has the potential to affect the populations of butterflies at the forest edge (Koh & Menge 2005). In this study, I examined the effect that the forest edge has on the butterfly community in Fincas Las Piedras, Madre de Dios region, in terms of number of species, abundances and diversity indices between forest edge and forest interior as the control. To that aim, butterflies' traps were set up in both treatments and the individuals identified to the species level when possible. Butterfly diversity and species richness was expected to decrease as proximity to the forest edge increases.

This study will expand ongoing long-term research on Lepidoptera diversity in a disturbed forest. Studying the effects of the forest edge on organisms like butterflies will give more perspective on how they respond to landscape change and perhaps represent an indicator for insect and plant community's resilience in the face of degradation.

Methods

Data collection and curation

The data for this study was collected at Finca las Piedras in the Madre de Dios region of Peru (Figure 1). Finca las Piedras is a research facility that is located on a plot of land that was previously logged on but has experienced immense forest regrowth in the

past 25 years. To establish a control dataset, I utilized butterfly data collected by the ASA Lepidoptera team. The data comes from three butterfly traps set within the forest interior and was collected a week before this study was conducted. The traps were set at 7am on Monday August 2nd and data was collected from the traps every day between 2pm and 4pm until Friday August 6th. The data from their collection represents what butterfly populations in the Madre de Dios region might look like in a regenerated forest farther away from the forest edge.

For data collection specific to the forest edge, three butterfly traps were set up 100m apart from each other along the forest edge. Two were situated at the beginning of two different trailheads and the third was set up in a clearing where a food forest is being cultivated. The traps were limited to the understory and were hung from tree branches about 1.5m off the ground. The traps were comprised of a cylinder mesh net capped with a tarp flap to deter rain and a cardboard bottom with a hole cut out of the center which is where the bait was positioned. A fermented banana mixture was used as bait and was placed in plastic cups that were situated in the cardboard placeholder at the base of the nets. The banana mixture was switched out daily during each data collection.

The traps were set at 7:30am on Sunday August 8th and butterfly collections occurred at 3pm that same day and continued at that same time for five consecutive days until Thursday August 12th. During data collection, the butterflies from the traps were placed in envelopes and taken back to the field lab for identification. This collection method follows the collection method of the ASA Lepidoptera team.

Data analysis

Species richness was determined for both areas using the species richness index. This index is an indicator of the level of biodiversity present in a sample based off of the variety of species present in a sample (Jayaraman 1999).

$$\text{Species richness index} = \frac{S}{\sqrt{N}}$$

To quantify the diversity at each trap, I conducted a Shannon-Weiner diversity index. The Shannon-Weiner diversity index occurs on a scale where 0 indicates no diversity and 1 and above indicates significant diversity presence. The Shannon-Weiner index takes into account evenness of the species present as well as abundance.

Shannon-Weiner diversity index formula:

$$H = -\sum_{i=1}^{S} p_i \ln p_i$$

After the Shannon-Weiner diversity scores were calculated for the forest edge and the forest interior, a t test was performed between the scores to determine if there was significance between the two areas.

Inputs for the Shannon-Weiner diversity index t test formula:

$$\nu = \frac{(Var(H_1) + Var(H_2))^2}{(Var(H_1))^2 / N_1 + (Var(H_2))^2 / N_2}$$

$$Var(H) = \frac{\sum p_i (\ln p_i)^2 - (\sum p_i \ln p_i)^2}{N} + \frac{S-1}{2N^2}$$

Shannon-Wiener t test formula:

$$t = \frac{\left|H_1 - H_2\right|}{\sqrt{Var(H_1) + Var(H_2)}}$$

An additional t test was conducted to determine the significance between the number of individuals and the number of species between the forest edge and forest interior. The t test was conducted within Excel. To calculate the degree of overlap between the diversity at the forest edge and within the forest interior, a Morisita's overlap index was be conducted.
Morisita's overlap index formula:

$$C_D = \frac{2\sum_{i=1}^{S} x_i y_i}{(D_x + D_y)XY}$$

R studio was used to create an NMDS of species abundance (Figure 4) for both treatment areas in order to visually display where concentrations of butterfly species were occurring with regards to the forest edge and within the forest interior (R Core Team 2020). QGIS was used to plot the coordinates of the traps on a map of Finca las Piedras (Fig. 1).

Results

Species richness and overlap

At the conclusion of the study, there were 115 individuals collected from 21 species. Comparing the datasets of butterflies collected at each area, the traps at both the forests edge and the forest interior contained 16 different species. Out of the 16 species that were collected at each area, 11 species overlapped and were found at both areas.

When calculating Morisita's overlap index, a score of 0.543 was derived which indicates that the two areas have a moderate overlap of species. While there appears to be significant overlap between the two study areas, there were differences in terms of the total number of butterflies collected as well as outlier species that occurred at higher quantities. At the forest edge, 76 total butterflies were collected, and the number of butterflies caught per species ranged between 1 and 17. Within the forest interior, 39 total butterflies were collected, and the number of butterflies caught per species ranged between 1 and 6.

The species that appeared the most in the traps at the forest edge were *Satyrinae*, *Archaeoprepona demophon*, and *Taygetis* with *Satyrinae* and *Taygetis* both appearing 17 times and *Archaeprepona demophon* appearing 10 times. The rest of the species that were found at the traps along the forest edge did not appear more than 6 times.

While the same number of species were found at the forest edge and within the forest interior, the Shannon-Wiener diversity index indicate that the forest interior had slightly higher diversity of butterfly species. This was influenced by the level of species evenness found at each trap (Table 1).

Table 1. Summary of butterfly diversity and abundances at the forest edge and interior.

Treatment	Species	Max. # of species per trap	Min. # of species per trap	Mean # of species	Mean # of individuals	Shannon-Weiner
Edge	16	10	9	9	25.33	0.987
Interior	16	12	7	9.667	13	1.129

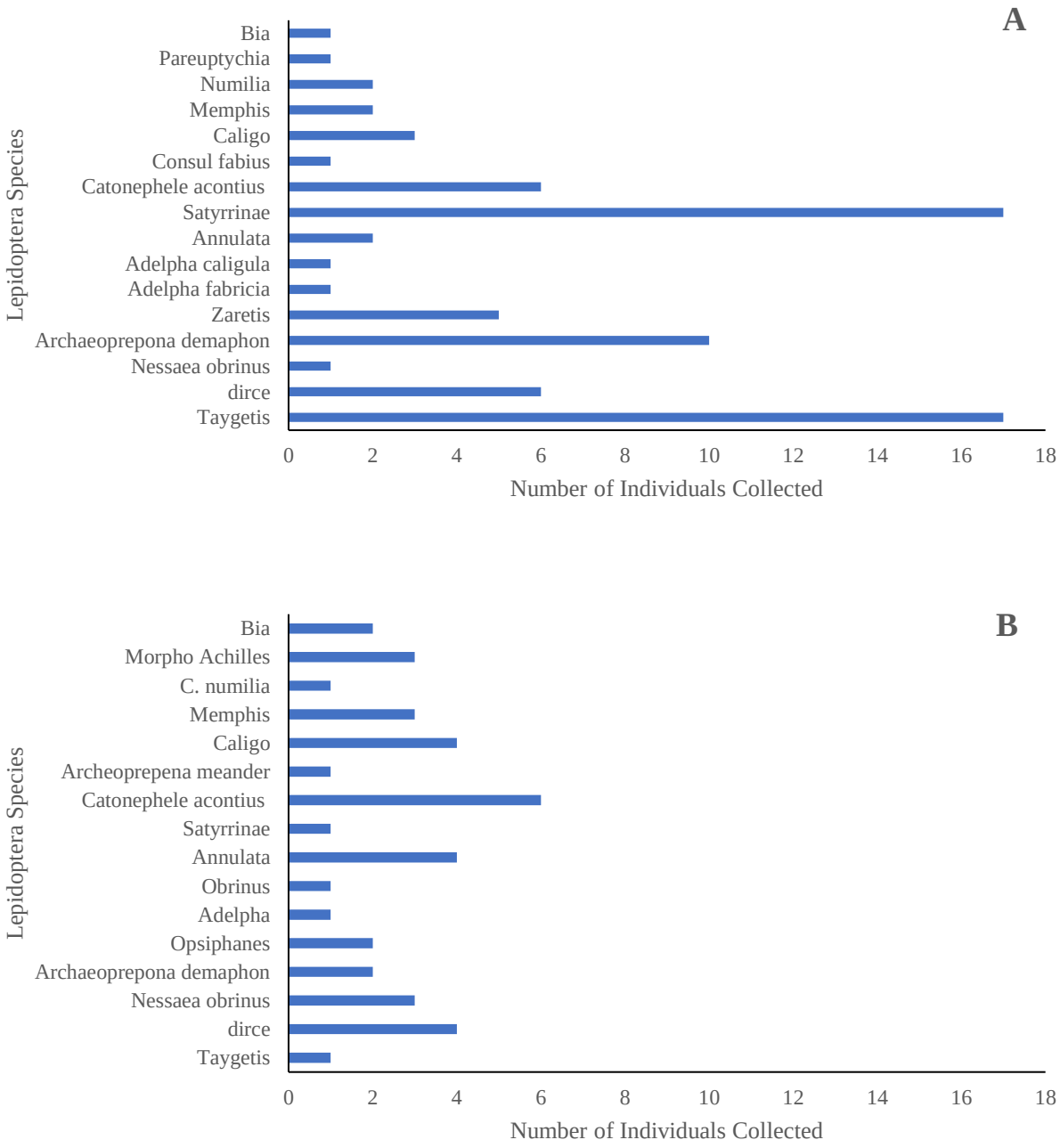

Figure 2: Species abundance at the traps at the forest edge(A) and within the forest interior (B).

Diversity indices

For the data collected at both the forest edge and the forest interior, a Simpson's diversity index and a Shannon-Weiner diversity index were conducted. For the Simpson's diversity index, it was found that the traps within the forest interior had greater diversity with a score of 0.939 while the traps along the forest edge had a diversity score of 0.872. These scores indicate that the

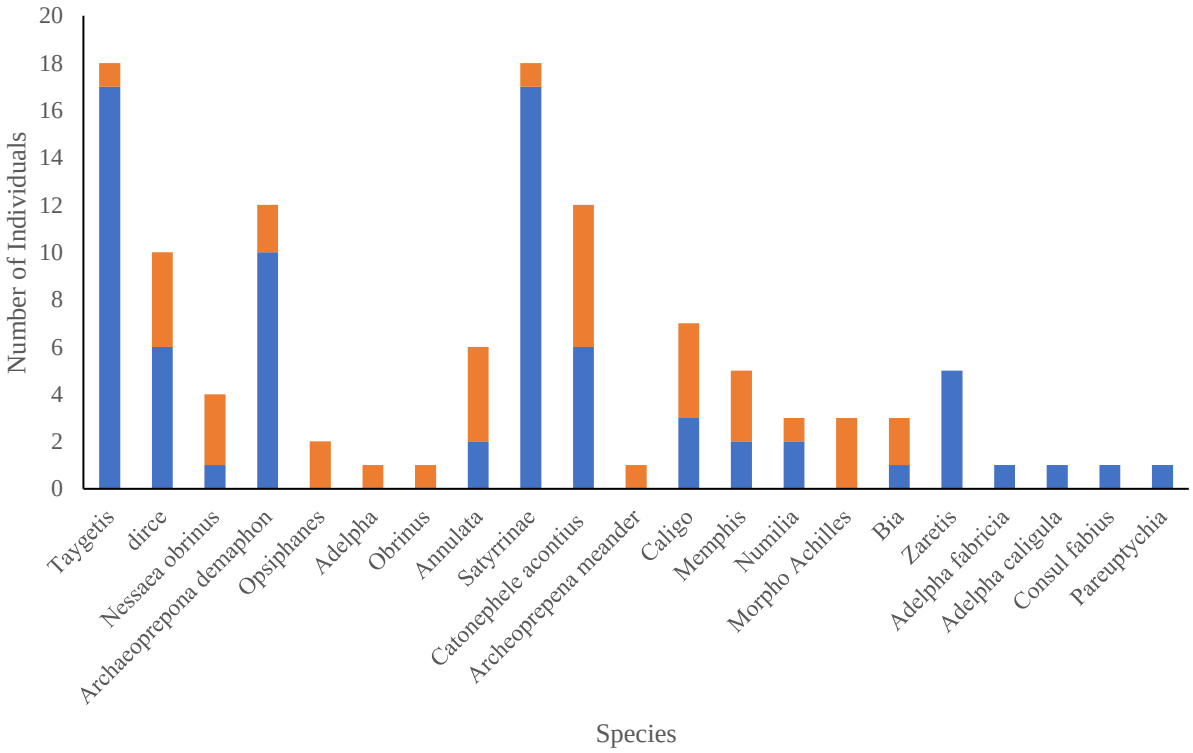

Figure 3: Species comparison between the forest edge (blue) and forest interior (orange).

lepidoptera diversity was greater within the forest interior than at the forest edge. The forest interior also had a greater Shannon-Weiner diversity score at 1.129 while the traps at the forest edge had a score of 0.987. While the scores from the indices indicate that

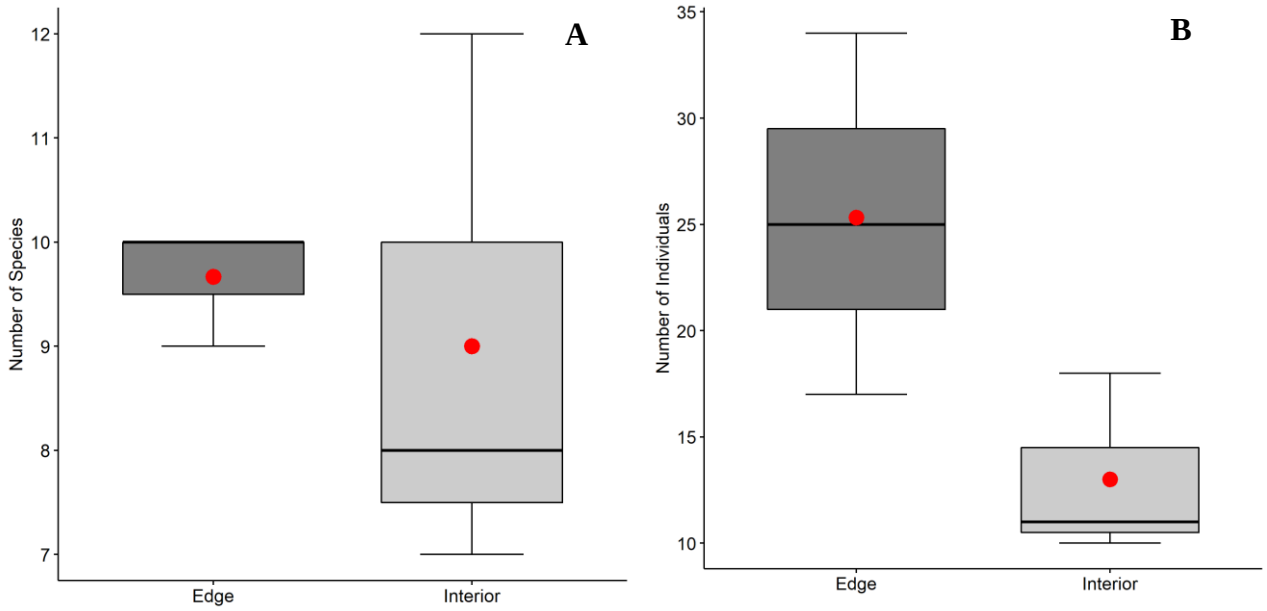

Figure 4: Boxplot representing species count (A) and individuals count (B) in the forest edge and interior.

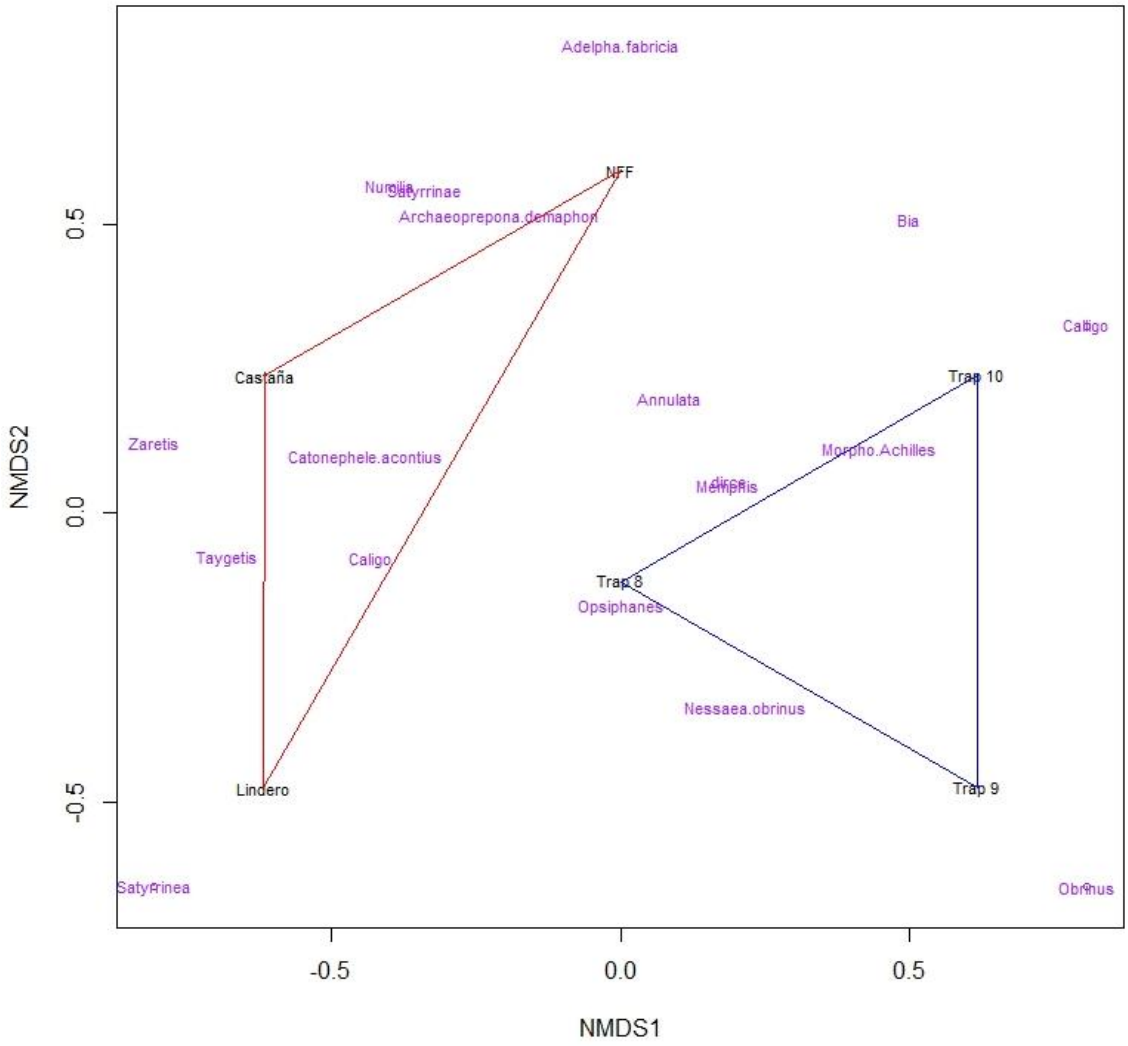

Figure 5: NMDS concentration of diversity of butterfly species at the forest edge (red triangle) and within the forest interior (blue triangle). This graphic depicts how various species are more common to certain treatment areas.

lepidoptera diversity was greater in the forest interior, the difference between the two areas is not significant (t = 1.45, df = 78.51, p >0.05, n.s)

Diversity and abundances of butterfly species are presented where a total of 21 species were found, 16 at each treatment. There was a maximum of 10 species present at the edge traps and 12 species present at the traps within the forest interior.

Discussion

Although it was found via the Shannon-Weiner diversity index that the forest interior contained a higher diversity score than the forest edge, the findings were not significant. I hypothesize that if the study were to be continued over a longer period of time and with more traps, that the difference in diversity composition between the forest edge and the interior would be significant.

In addition, the results showed that there was a significant difference in the number of individuals found at each treatment, which indicates that even though the diversity appeared less at the edge, there were far more butterflies found. These butterflies could be edge specialist creatures and could potentially thrive in edge environments. In a further study, I suggest focusing on these potential edge specialists as a way to investigate the ways in which some species may actually benefits from deforestation and the edges it creates.

Both treatment areas experienced overlap with a Morisita's score of 0.543 indicating that the diversity of the samples collected were more similar than not. While the two treatment areas do seem to have overlap, I feel as though prolonged trap exposure will produce an overlap score that is closer to 0 indicating less overlap in species diversity related to the two treatment areas. This is because longer exposure would increase the likelihood of rarer species to occur in traps.

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