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What Do Seedlings Like? The Relationship between Seedling Richness and Abundance with Abiotic Factors

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Abstract

Natural regeneration is the interaction of natural processes to restore the forest ecosystem. Its dynamics are influenced by the intensity and extent of a series of abiotic and biotic factors, which may be intrinsic or extrinsic. Knowing the importance of establishing natural regeneration within forest ecosystems, this work aimed to evaluate whether litter depth and trail distance influenced seedling abundance and richness in a forest fragment undergoing natural restoration. The hypothesis tested in this research was that abiotic factors influence the natural regeneration of this forest since they are factors that are directly linked to seed germination and seedling establishment. 30 plots of 1 m^2 were randomly analyzed within the forest located on the brown trail. A millimeter ruler was used to diagnose the litter depth and a measuring tape to measure the distance from the plot to the edge. In each plot the seedlings were morpho-specified and each morphospecies had the number of individuals counted. Linear regression tests were performed to assess the relationships between species richness and trail distance and litter depth. The same was done for species abundance. All results showed that there is no relationship pattern between any of the variables. Other factors also influence the regeneration of a forest, such as luminosity and seed bank. Furthermore, litter depth is related to the successional stage of the forest. It was concluded that the abiotic factors tested do not influence the regeneration of the study area.

Keywords

Abiotic Factors, Natural Regeneration, Forest Ecosystem

1. Introduction

Forest regeneration happens naturally and is part of the tree growth cycle. It involves the emergence of new plants that guarantee the continuity of species and the forest ecosystem. It is important that there are a sufficient number of young trees to ensure the survival of the species since a low population density can lead to replacement by other species due to natural disturbances or anthropic actions caused by man in the area [1]. The term "natural regeneration" can have two interpretations: the first refers to a part of the forest composed of a bank of seedlings and young individuals. The second interpretation is the regeneration process that occurs naturally in forests after disturbances, such as in clearings, abandoned crop fields, and other areas [2].

A study carried out by [1] on forest regeneration, shows that research in this area of knowledge is crucial for the protection, preservation, and recovery of these environments since regeneration represents the set of individuals capable of growing and developing, forming a healthy forest. The analysis of regeneration allows for diagnosing the state of the forest and assessing the response of conservation areas and forest management. Several intrinsic and extrinsic biotic and abiotic factors influence regeneration, making it an important indicator of forest health. For [3] seedling recruitment is an important obstacle to the survival of tree communities, since biotic factors, such as predation, competition, and physical damage, and abiotic factors, such as water availability, temperature, and luminosity, affect the organization of seedlings.

Such factors can influence the germination and development of seedlings from seeds, being invertebrates, rodents, pathogens, and precipitation, such factors that can affect the number of individuals in different subplots [4]. In this way, preserved natural environments contribute to the natural regeneration process taking place efficiently, contributing to the maintenance of forest communities [5].

However, in environments that suffer anthropic interventions, germination and establishment of seedlings may be limited due to the intensity of disturbances, which may compromise the regeneration process. Another important factor for the functional and ecological development of seedlings is the morphological variations of the cotyledons concerning their position, exposure, and function, since different morphological types of seedlings imply different adaptations of the species, due to variations in light absorption, protection of nutritious tissues and defense against herbivore attacks [6].

Since natural regeneration plays an essential role in the establishment and

evolution of forest ecosystems, this work aimed to evaluate whether the depth of the litter and the distance to the trail influence the abundance and richness of seedlings in a forest fragment undergoing restoration. The hypothesis tested in this research was that abiotic factors influence the natural regeneration of this forest since they are factors that are directly linked to seed germination and seedling establishment.

2. Material and Methods

The study was carried out in the Reserva Particular do Patrimônio Natural Reserva Ecológica do Guapiaçu (RPPN REGUA), located in the municipality of Cachoeira de Macacu, approximately 120 km away from the city of Rio de Janeiro, covering the basin of the upper Guapiaçu River, at geographic coordinates 22˚27'12"S and 42˚46'13"W (Figure 1).

REGUA is a Brazilian non-profit organization that aims to protect and conserve the Atlantic Forest, promoting the area's ecological restoration, community interaction and visitation, and scientific research. REGUA is located in a rural area, where there are also other private properties in the surroundings, with access to all of them, both in the Reserve and neighboring ones, through dirt roads. Data collection for the current work took place on the brown trail, which has easy access, consisting of secondary vegetation with environments in different stages of restoration, resulting in a varying incidence of light within a few meters.

For the study, 30 plots of 1 m^2 were randomly established within the forest

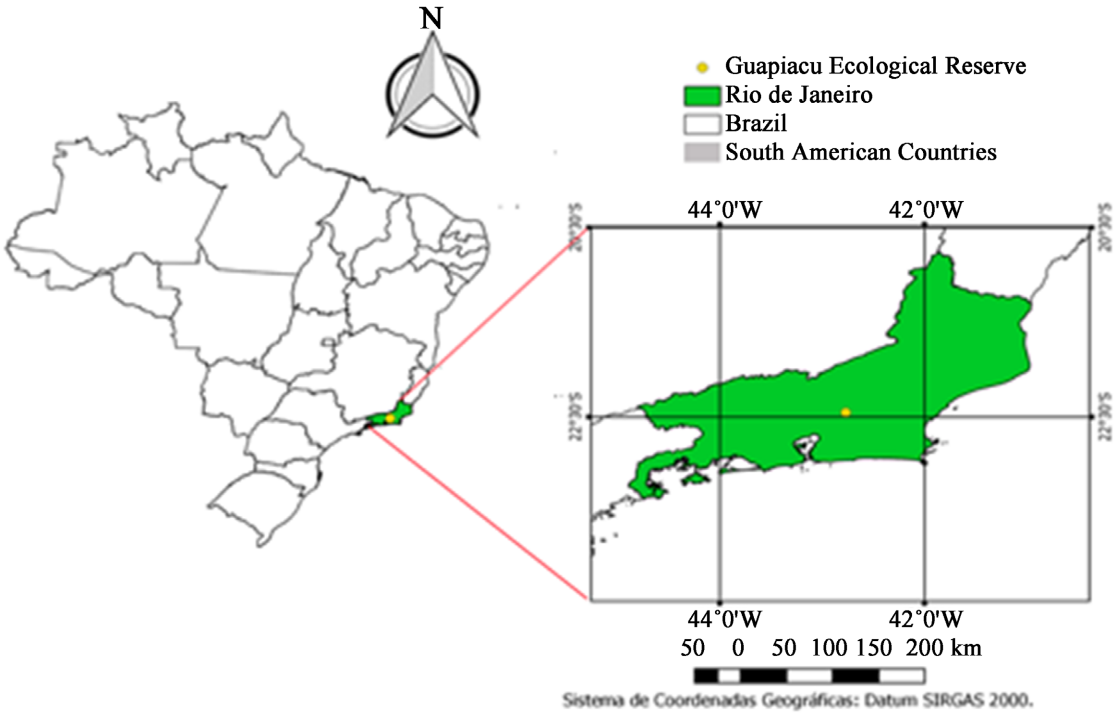

Figure 1. Geographical location of the Guapiaçu ecological reserve, located in the state of Rio de Janeiro, Brazil.

located on the brown trail. In each plot the seedlings were morpho-specified and each morphospecies had the number of individuals counted.

At the same time, we measured the litter depth at four points located at the vertices of the plots, with the aid of a millimeter ruler. For each plot, the distance from it to the edge of the trail was measured.

To test possible relationships between seedling richness and abundance and mean litter depth and distance from the edge of the trail, a simple regression analysis was used. Regression analyses were employed using richness and abundance values as dependent variables and trail distance (DT) and litter depth (SP) data as independent variables.

3. Results and Discussion

Richness values (S) of seedling morphospecies varied between one and seven in the sampled plots. The abundance value (N) was between 2 and 46 individuals of seedlings in the plots. There was no relationship between seedling morphospecies richness and trail distance (**Figure 2**), nor was there a relationship between species richness and litter depth (**Figure 3**).

As with richness, there was also no relationship between seedling abundance and trail distance and litter depth (**Figure 4** and **Figure 5**).

The area in which the study was developed presents an initial phase of a restoration process, we observed during the data collection in the field that the cover of the canopy of the fragment did not have a great variation, both close to the trail and inside the fragment, be an explanation for why the relationships between the variables analyzed were not significant for the richness and abundance of seedlings in the area. [7] found a relationship between small litter removals for transposition and the development of degraded areas, which generate stimuli for natural regeneration, through seed germination and seedling establishment. These results, however, differ from our data presented in **Figure 2** and

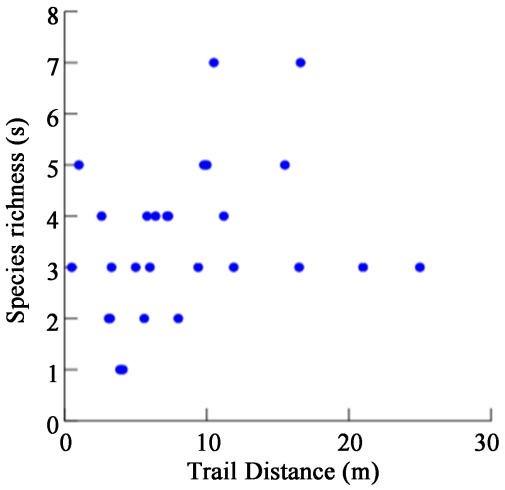

Figure 2. Simple regression analysis graph between species richness and trail distance. X-axis: Track distance (m); y-axis: Species richness (s).

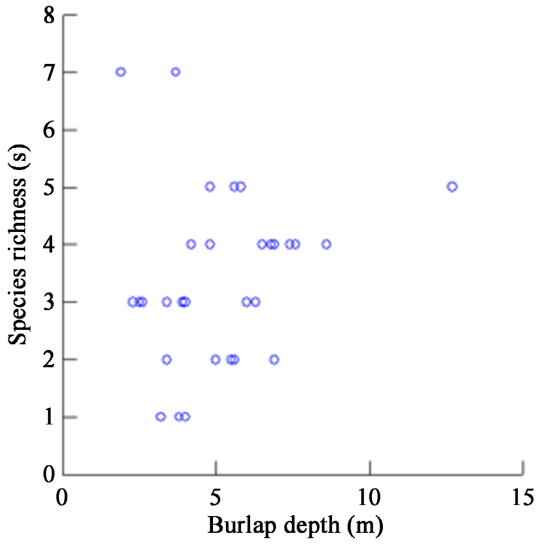

Figure 3. Graph of simple regression analysis between species richness and litter depth. X-axis: Burlap depth (cm); y-axis: Species richness (s).

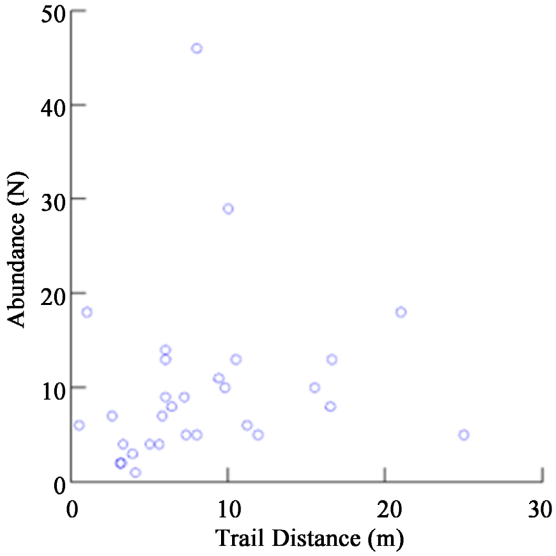

Figure 4. Graph of simple regression analysis between species abundance and trail distance. x-axis: track distance (m); y-axis: Species abundance (N).

Figure 3, where they demonstrate that the depth of the litter does not have a great influence on the regenerative process of the forest, as this forest possibly does not undergo processes of environmental disturbances because it is preserved under legal protection.

There are other factors that, according to the literature, also directly interfere with natural regeneration, such as the incidence of light in the areas. In agreement with [8] when we observe the luminous environment of a forest, the structure of the canopy and the distribution of leaves above the ground play a crucial role in determining the quality of available light. The solar radiation that is absorbed, transmitted, and reflected by the canopy directly affects the survival,

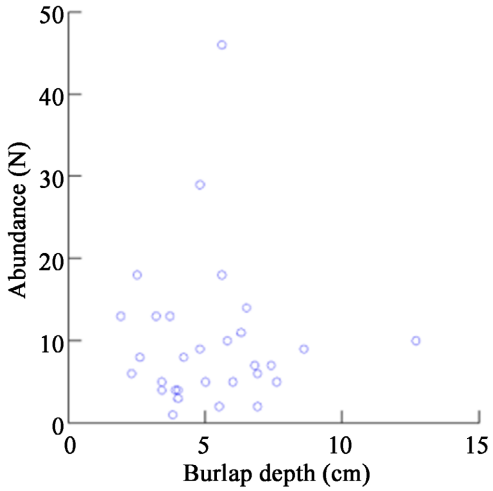

Figure 5. Graph of simple regression analysis between species abundance and litter depth. X-axis: Burlap depth (cm); y-axis: Species abundance (N).

growth, shape, and reproduction of trees that live in this environment.

When analyzing soil and relief characteristics, [9] reported that most forest species are not demanding in soil chemical quality, except for the group of species listed as possible phosphorus accumulators. On the other hand, the external morphological characteristics related to the strong wavy relief, slope, and canopy cover, for the forest composition, showed the importance of forest succession.

Another extremely important factor described by [10] is that pioneer plants have larger leaves and grow faster than non-pioneer plants. This happens because their leaves are able to capture a greater intensity of light, which allows them to grow faster. However, in nutrient-poor areas, non-pioneer plants have an advantage as they are able to better use available nutrients and invest fewer resources in their leaves. According to [8], the availability of light and the presence of mature trees affect the variation of the regenerative component. This emphasizes the importance of the quality of the luminous environment for the initial phase of establishing natural regeneration. Epiphytes are an example of bioindicator plant species present in forests that can indicate environmental disturbances [11], accumulate chemical elements taken from the atmosphere and absorb moisture directly from leaves and stems, become more exposed to pollution, and are useful for assessing the damage caused by pollutants, in addition to being sensitive to burning and deforestation [12].

Another condition that is important to point out is that degraded soils or those without vegetation cover have a lower capacity to retain and absorb water, increasing the risk of erosion and silting up of rivers. The restoration of the forest cover and the formation of litter help to reduce degradation, reducing the risk of erosion, improving the soil with the accumulation of organic matter, and increasing the supply of groundwater and consequently positively affecting the fragments that are still found. In a primary formation, the cycling of nutrients and the accumulation of organic matter are still not abundant [5].

In addition, factors such as a still unstructured seed bank and the low number of dispersing animals may be related to seedling development and the dynamics of natural forest regeneration. The formation of a seed bank in the soil of a forest can be decisive for the establishment and perpetuation of species, in addition to dispersing their seeds spatially by different dispersing agents, many seeds can be stored for a long period close to the mother tree, making this bank is an indicator of the resilience of a degraded ecosystem [6].

A study by [13] reports that seed rain is an important mechanism for the establishment of new plant species and is crucial for the healing of gaps and continuity of succession. It is defined as the set of propagules that reach the soil through dispersion mechanisms for forest regeneration and recovery of degraded areas. In addition, seed rain plays a key role in the recruitment of individuals and the colonization of new habitats. It is worth noting that there are several factors that may be related to the entry of seeds into an area, whether degraded or not, among which we can highlight: species abundance, distance from propagule sources, dispersing agents, and also specific characteristics of each propagule.

4. Conclusion

Thus, we can conclude that the depth of the litter and the distance from the trail do not influence the abundance of species and the bank of seeds and seedlings. However, it is possible to see the great interference of abiotic factors with the development and regeneration of the forest. It was possible to observe that factors such as luminosity, humidity, the structure of the canopy, and precipitation are essential for the good development of the seedlings, directly affecting the absorption of nutrients, restoration, and conservation of the soil and plant growth.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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