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Original Article

Abundance of Evergreen Tree Species in a Disturbed Seasonally Tropical Dry Forest

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ABSTRACT

The study was conducted to determine the abundance of evergreen tree species in a seasonally tropical dry forest in Southern Ecuador. Systematic sampling approach was adapted for this study. Here we sampled twenty-five plots with a plot size of 530 m^2 in the disturbed forest. Our results revealed that there were only a few evergreen tree species recorded in the study area. The family Fabaceae was abundant among the recorded trees. An increasing pattern of stem density from low to high elevation was noted, and a decreasing pattern of the basal area was also observed. These results will serve as a baseline data in the decision-making process to carry out forest management plans especially in the management of the dry forest.

KEYWORDS: *Evergreen tree species, Ecuador, forest inventory, tropical dry forest*

1 INTRODUCTION

Tropical forests are threatened because of the multiple functions and ecosystem services. Of the 25 biodiversity hotspots, featuring several habitat forest types at a global scale, many of the identified hotspots are situated in the tropical forests (Myers *et al.*, 2000). Many scientific studies have been conducted globally in tropical rainforests in the context of climate change including carbon sequestration. However, a few research were available online on the ecological processes of seasonally tropical dry forests (TDFs). An online search conducted by Quesada *et al.* (2009), on the Institutes of Science Information (ISI) Web of Science database from 1900 until March 2009 for articles with the words ''succession'' and ''tropic'' in the title and summary, shows a big difference in the numbers of papers conducted in each ecosystem with 436 papers on ''rain forests'' versus 60 papers on ''dry forests''). They pointed that all TDFs are exposed to different threats, which largely result from human activities. Janzen (1988) supported the statement that this forest type is threatened as compared to other tropical forest types. Further, many studies showed that deforestation and forest degradation are the major threats to global change which leads to the rapid loss of tropical forest areas with significantly altered biodiversity conservation and ecosystem functioning (Stoner & Sanchez-Azofeifa, 2009; Portillo-Quintero & Sánchez-Azofeifa, 2010).

In the case of Ecuador, 1.4 percent of the total TDF in South America is represented. This figure does not seem significantly important compared to other South American countries, which have higher concentrations of dry forest distributions (Miles *et al.*, 2006). An analysis reported from the paper of Miles *et al.* (2006), Ecuador previously had an extent of dry forest of 25,275 km^2 which is according to the data derived from MODIS 500-m of Olson *et al.* (2001). Though, this figure was far below of the current analysis which resulted in only 6,443 km^2 showing about 75 percent of the said forest had been lost. A recent article published by Tapia-Armijos *et al.* (2015) at the Public Library of Science (PLOS) One, estimated that annual deforestation rates of the South Ecuador forest were 0.75 percent (1976–1989) and 2.86 percent (1989–2008) for two consecutive survey periods. The decreasing mean patch size and the increasing isolation of the forest fragments show that the area is under severe threat (Sánchez-Cuervo *et al.*, 2012). The authors further revealed that South Ecuador's original forest cover converted into pastures by approximately forty-six percent.

More knowledge on tropical dry forests will allow the scientific community to understand the dry forest distribution patterns and improve knowledge on the location of potential restoration areas or new reserves (Miles *et al.*, 2006; Portillo-Quintero & Sánchez-Azofeifa, 2010). The study was conducted to assess the abundance of evergreen tree species in a disturbed seasonally tropical dry forest. In addition, this information will serve as a baseline data in the decision-making process to carry out forest management plans especially in the management of the dry forest in South Ecuador.

2 MATERIALS AND METHODS

Study Area

The study area is located at Laipuna, Southern

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Ecuador from April to May 2015 (Fig. 1). The forest reserve is administered by the international non-government organization Naturaleza Y Cultura Internacional, which aims to promote conservation and sustainable resource use. The disturbed forest is adjacent to the Laipuna Forest Reserve, and mainly influenced by grazing of cattle and goats, and other agricultural activities such as farming. Average annual rainfall of the study area was 625 mm yr^{-1} with a strong interannual variability from 275 to 825 mm yr^{-1} (Peters, 2012). The mean annual rainfall ranged 64–218 mm month^{-1} from the month of January to February with little rainfall events from December to May. The dry season lasts for about eight months from May to December with rain from January to April (Peters, 2012).

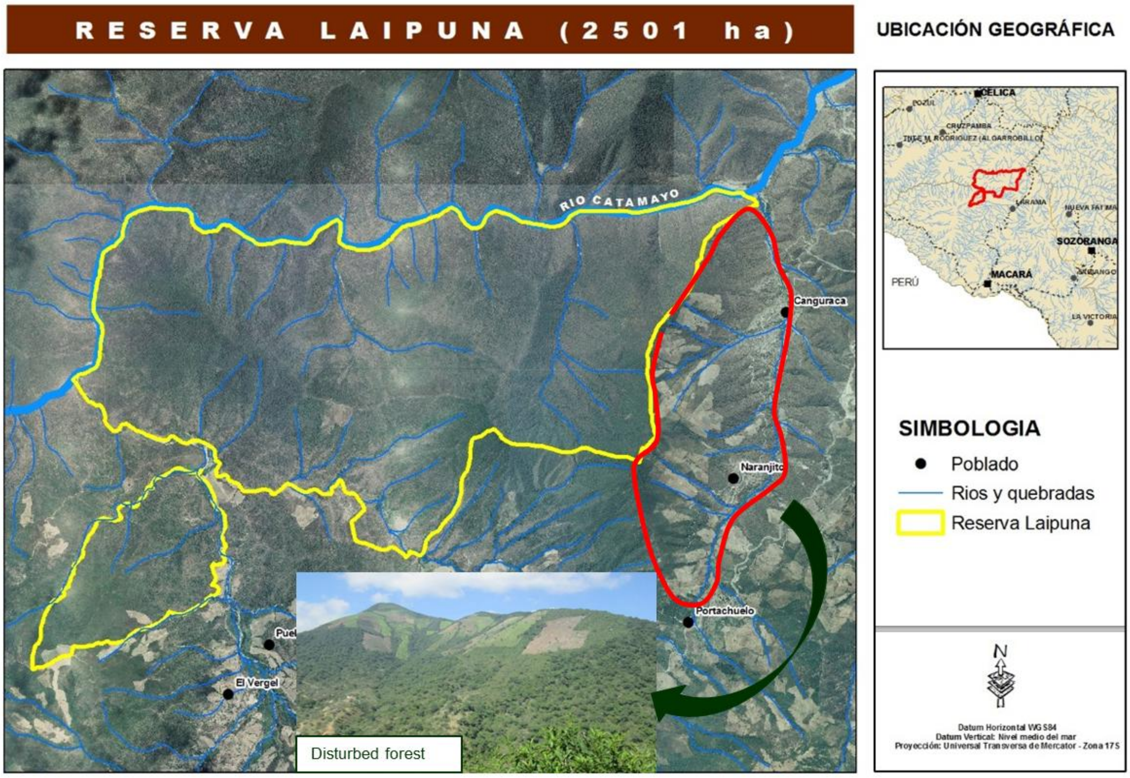

Figure 1. Disturbed forest in the study area

Sampling Design and Data Collection

A Google Earth image of the study area was digitized. Systematic sampling was performed in the open software Quantum Geographic Information System (QGIS). Kleinn (2013) explained the advantages of the difference plot shapes in conducting forest inventory. For this inventory, a circular plot size of 530 m^2 was adapted. There were twenty-five plots sampled along the disturbed forest. Elevation ranged from 600 – 760 meters above sea level (masl) for the lower, 760 – 880 masl for the middle, and 880 – 1080 masl for the upper elevation. The plots were traced according to the coordinates on the universal transverse mercator 17 South projection and the Global Positioning System. All evergreen tree species $\geq$ 10 cm DBH were recorded using the calibrated diameter tape. Unidentified trees were labeled and leaf samples brought for reference. Tree heights were measured using the vertex hypsometer (Vertex IV, Haglöf, Sweden). Tree heights difficult to measure were visually estimated.

Data Analysis

To determine the most abundant evergreen tree species in the disturbed forest, species listing was applied using the pivot table (Microsoft Excel, 2013). Descriptive statistics were conducted to explore the data. In addition, a non-parametric test Kruskal-Wallis test (Minitab, 2013) was conducted to determine the significant difference of the stem density and the basal area between elevation (lower, middle and upper). No other statistical analysis was performed for this study.

3 RESULTS AND DISCUSSION

Species composition

Results showed that there were seven evergreen tree species recorded in the disturbed forest (Table 1) where *Capparis scabrida* was the most abundant (28 percent). *Geoffrea spinosa* (23 percent) was the second most abundant trees species that occurred nine times in all the plots sampled. The least species occurred in the disturbed forest was *Prosopis juliflora* with only one count (3 percent). We calculated the average DBH (cm) with corresponding standard error and showed that the biggest DBH among the species was *Caesalpinia glabrata* under the Fabaceae family with SE + 5.7. The second biggest tree species was *Geoffrea spinosa* also under the family Fabaceae (SE + 3.4).

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Table 1. The abundance of evergreen tree species in the disturbed forest.

No.	Species	Family	DBH (cm + SE)	Count	Percent
1	*Capparis scabrida*	Capparaceae	19.43 + 3.1	11	28.21
2	*Geoffrea spinosa*	Fabaceae	25.17 + 3.4	9	23.08
3	*Caesalpinia glabrata*	Fabaceae	28.48 + 5.7	6	15.38
4	*Zyzyphus thyrsiflora*	Rhamnaceae	21.93 + 7.9	6	15.38
5	*Prosopis juliflora*	Fabaceae	24.78 + 6.1	4	10.26
6	*Agonandra excelsa*	Opiliaceae	13.10 + 0.2	2	5.13
7	*Albizia multiflora*	Fabaceae	10.10 *	1	2.56
				39	100

**only one species observed in the study area*

On the other hand, the smallest tree species was *Albizia multiflora* also belonged to Fabaceae family. This data suggests that majority of the evergreen tree species in the study area belonged to Fabaceae family. A similar result was found of the study conducted in the undisturbed forest where they found that Fabaceae was the most dominant tree family in the neotropical dry forests (e.g. Romero-Duque *et al.*, 2007; Gillespie *et al.*, 2000; Álvarez-Yépiz *et al.*, 2008). Further, a study reported that low species diversity and mortality of regeneration were mainly caused by high levels of disturbance such as grazing and harvesting (Keddy, 2005; Kalacska *et al.*, 2006; Chaturvedi *et al.*, 2012). Molina *et al.* (2007) as cited by Ochoa *et al.* (2016) revealed that population growth and livestock grazing in extensive areas were the cause of land use change in Ecuador. In our study, a few number of species was observed as it was clearly influenced by grazing activities. In addition, the change in species composition can be explained by the adaptability of the species on the disturbance. The study area was severely disturbed by agricultural expansion and cattle grazing (Fig. 1). The information can be confirmed from the paper of Ochoa *et al.* (2016), where they estimated the stocking rates of 0.22 cattle and 0.33 goats per hectare in the study area. Further, according to information taken from the villagers, this type of land use was very common in the middle of the last century. At the time of the data collection, disturbance on the forest was clearly visible through the planting of agricultural crops and raising of livestock.

Table 2. Plot characteristics based on an altitudinal gradient in the disturbed forest.

Altitude range (m asl)		No. of plots	No. of tree species	No. of families	Ave. DBH (cm + SE)	Ave. height (m + SE
Low	600-760	10	7	4	23.42 + 3.4	8.82 + 1.7
Middle	760-880	8	4	3	21.09 + 3.5	7.85 + 1.2
High	880-1080	7	4	3	22.89 + 3.3	11.13 + 1.9

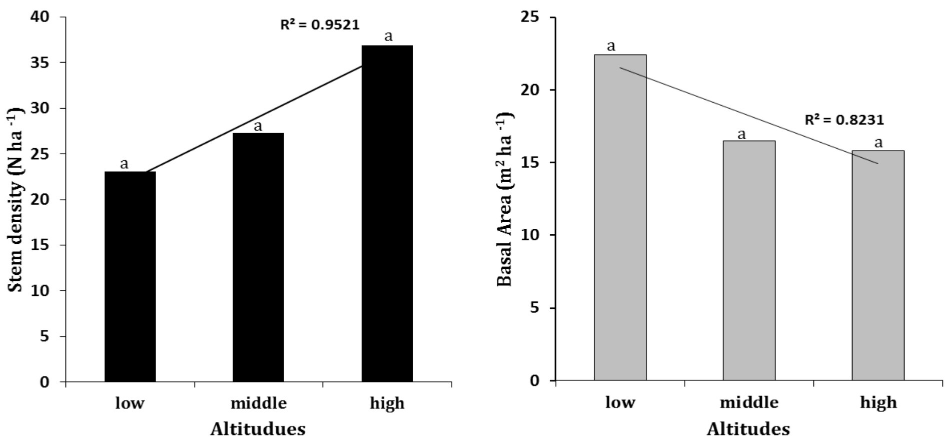

Figure 1. Stem density and basal area based on an altitudinal gradient. Similar letters indicate no significant differences (p > 0.05) in the Kruskal-Wallis Test

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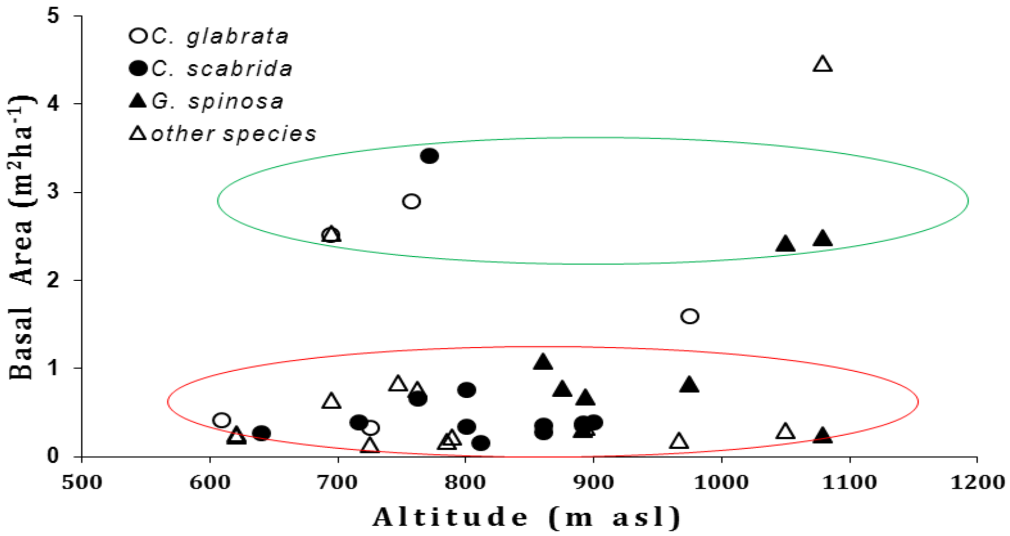

Figure 2. Basal area based on altitudes of selected evergreen tree species

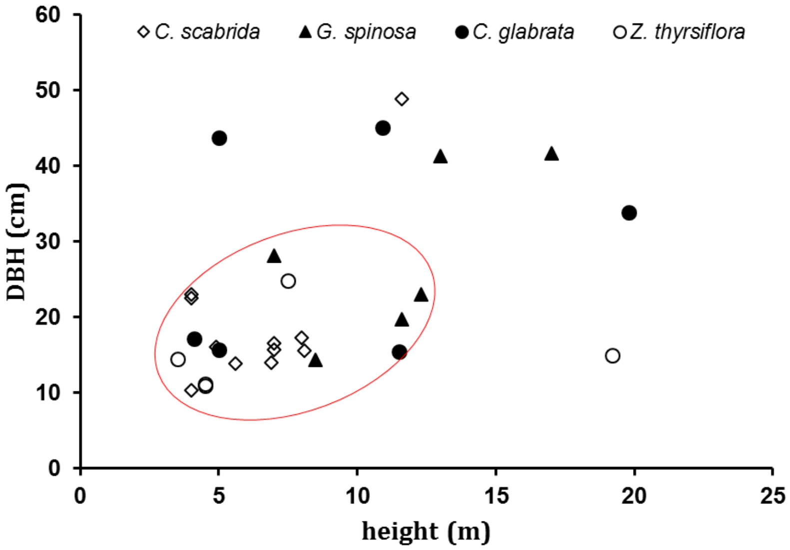

Figure 3. DBH- height relationship of four selected evergreen tree species

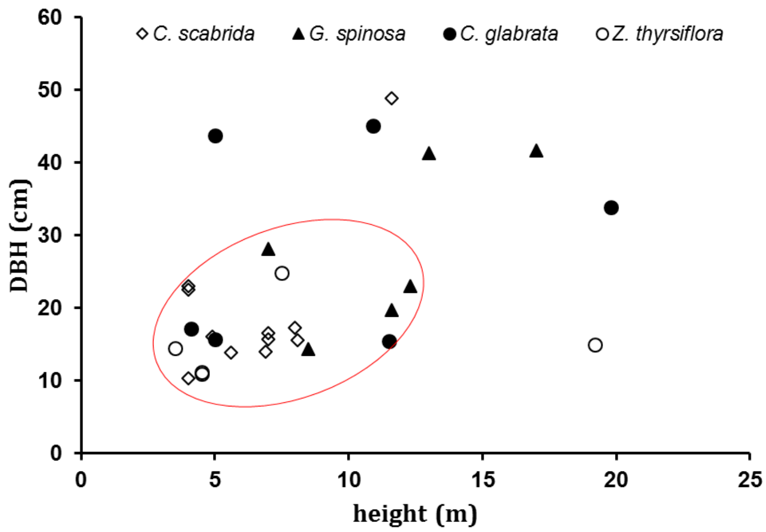

Figure 4. DBH- height relationship of four selected evergreen tree species

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Stem density and basal area

In our study area, an increasing pattern of the stem density was noted ranged from lower to upper elevation (Fig. 2). On the other hand, a decreasing pattern of the basal area (m^2ha^{-1}) from lower to upper elevation was observed. No significant differences were found between the stem density and basal area based on the Kruskal-Wallis non-parametric test, although differences based on the basal area was around to seven m^2ha^{-1}. A study conducted in northwestern Mexico showed that several old-growth forest where thick trunks contributed a lot to the highest mean basal area in the studied forest (Álvarez-Yépiz *et al.*, 2008). This information confirms our results that at the lower elevation had high basal area because it has more big-sized diameter trees, thus contributes to the basal area.

In comparison with each evergreen tree species, we plotted the relationship between the basal area in response to elevation (Fig. 3). It shows that majority of the tree species based on the basal area were less than 1 m^2ha^{-1}, which is considered low compared to the tropical dry forest conducted in Coromandel Coast, South India where they found 29.48 m^2ha^{-1} and 15.44 m^2ha^{-1} from the two completely different vegetation (Parthasarathy & Karthikeyan, 1996). Although, the studied forest revealed that some of the basal area of the tree species was visible at 2 – 3 m^2ha^{-1}. On the other hand, we also plot the DBH and height relationship and it shows that majority of the tree species was clustered at DBH between 10 to 20 cm, and the height at 5 to 13 m (Fig. 4). The DBH and height were comparable to the tropical dry forest in India where the study recorded ca. 6 m and 10 m from the two studied forests (Parthasarathy & Karthikeyan, 1997). (Fig. 3 and Fig. 4).

4 CONCLUSION

The study recorded seven evergreen tree species in the disturbed forest which *Capparis scabrida* was the most abundant tree. The biggest tree species based on the average DBH were *Caesalpinia glabrata* and *Geoffrea spinosa*, which both are under the Fabaceae family, while, the smallest tree species was *Albizia multiflora* also belonged to family Fabaceae. In addition, many small-sized trees occurred at lower elevation, and tall trees occurred at the upper elevation. This study showed that disturbance clearly influences the composition and structure of a tropical dry forest. Urgent planning of the conservation strategies of this forest type is recommended to prevent further deforestation and forest degradation. Further, it is suggested that inventory during dry season should be conducted to determine the difference in the forest structure.

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