Spatial Distribution and Density of Lauraceae Trees: A Preliminary Assessment of Lauraceae Species in Primary and Secondary Tropical Premontane Wet Forest in Monteverde, Costa Rica

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Abstract
Recent climate change models predict that various plant species in Monteverde, Costa Rica will gradually move further up the mountains in response to the changing abiotic conditions. In order to protect the local avian frugivores that depend on these plant species (in this case, plants belonging to the Lauraceae family) it is important to first investigate how these plants are naturally distributed today and what factors might be affecting their density and distribution. To evaluate how the history of an environment can be an indicator of differential abundance and/or proportional distribution of plant species, specifically of Lauraceae species, six 50 m by 20 m transects (three in old-growth primary forest, and three in secondary forest) were established in a wet premontane forest in Monteverde, Costa Rica. Given how the Three-Wattled Bellbird (Procnias tricarunculatus) has a tendency to disperse Lauraceae seeds at the edges of treefall gaps, we hypothesized that in this case the abundance of Lauraceae juveniles in secondary forests (where gaps in the canopy are more frequent) would be higher than in primary forests as well as affect the proportional distribution of the species. While on average more juveniles were found within the secondary forest transects, this difference was not found to be statistically significant. Furthermore, the difference in proportion of Lauraceae species found between forest types was found to be statistically significant.

Introduction
How tropical plant species are distributed in nature has been a subject of debate in the recent decades. (Janzen 1970, Connell 1971, Hubbell 1979, Clark & Clark 1984). One popular model of spatial distribution follows the predictions of the Janzen-Connell Hypothesis, which predicts that plants will be afflicted by pest pressure in a negative density-dependent manner that would prevent a few number of species from dominating a particular ecosystem and would partially explain how species coexistence in species-rich communities can persist (Janzen 1970, Connell 1971). Evidence for the Janzen-Connell hypothesis has been recognized in various natural communities (Clark & Clark 1984, Gilbert et al. 1994, Comita et al. 2014), but it has also been recognized that several other factors including topography and species rarity contribute to the density and distribution of species in nature (Fangliang et al. 1997). A good example is Guariguata & Ostertag (2001)’s review on neotropical forest succession where they detail how site-specific factors and land use can affect the recovery of an ecosystem’s biophysical properties following disturbance.

Which factors contribute to the natural distribution of plant species is of particular interest in Monteverde because various beloved avian species depend on plant species (particularly those within the Lauraceae family) for food and in turn the plants depend on the birds for seed dispersal (Nadkarni & Wheelwright 1999). Furthermore, Gasner et al. (2010) predict that as a result of climate change, these avian frugivores will have an elevation-based shift in range as the Lauraceae species they depend on move higher up the mountains (Gasner et al. 2010). Given this likely scenario, it is indispensable to investigate how Lauraceae species are naturally dispersed and distributed in Monteverde in order to track density and distribution changes brought about by climate change, and to investigate how sites with different land use history differ presently in terms of species density and distribution.

Locally, it is well known that several Lauraceae species are dispersed by avian frugivores like the Three-Wattled Bellbird (P. tricarunculatus), the Resplendent Quetzal (Pharomachrus mocinno), and the Emerald Toucanet (Aulacocynus prasinus) (Wheelwright et al. 1984). However, these birds do not all have the same effect on the seed dispersal and subsequent distribution of these species’ juveniles. For instance, P. tricarunculatus disperses over 52% of the seeds it ingests on the edges of treefall gaps over 25 m away from the fruiting tree, while other bird species have a tendency to disperse the seed very close to the fruiting tree. How these differences in seed dispersal distance are reflected in the distribution of the Lauraceae species has been investigated in the past (Wenny 2000), but how these effects vary between the primary and secondary premontane wet forests of the region remains to be investigated.

In this paper we present a preliminary assessment of the abundance and spatial distributions of Ocotea, Cinnamomum, and Beilschmiedia (Lauraceae) species in six 50 m x 20 m transects established in a tropical premontane wet forest characterized by a distinct primary and secondary forest division in Monteverde, Costa Rica. Species from these genera were chosen for this study because their relationship with the avian frugivores has been well documented and we could identify them in the field. The questions we seek to answer revolve around how the densities of Lauraceae juveniles and the forest composition of Lauraceae species differ between primary and secondary forests. Given how prominent light gaps are as secondary forests form, we predict that a greater concentration of Lauraceae juveniles will be present in secondary forest transects despite the effects brought about by negative density dependence. In addition, we also hypothesize that secondary and primary forests will differ significantly in forest composition of Lauraceae species.

Methods
Study site
This study was conducted within the Dwight & Rachel Crandell Memorial Reserve at 1480 meters above sea levels (84°48” W, 10°16” N) from June 12, 2014 to June 30, 2014. This reserve is found in premontane wet forest on the Pacific slope of the Tilarán Mountain range in Monteverde, Costa Rica (Fig.1). The ecosystem in this area is an evergreen forest dominated by Lauraceae, Moraceae, Euphobiaceae, Fabaceae and Sapotaceae species, all which are usually found with various epiphytic species on their branches and trunks (Nadkarni & Wheelwright 1999; Wenny 2000). Mean annual rainfall is ca. 2500 ml (Nadkarni & Wheelwright 1999).

Marking and measuring
Three 50 m x 20 m transects were established in secondary forest and another three in primary forest. Due to time...
constraints, we decided to focus only on the following species: Ocotea monteverdensis, O. floribunda, O. londuzii, O. whiteii, Beilschmiedia brenesii, B. costaricacense, Cinnamomum paratriplenerve, and two unknown Cinnamomum species or varieties, quite possibly close relatives of C. costaricanum, C. paratriplenerve, or C. triplenerve. In order to distinguish between these two unknown types, we gave them common names, “bulgy veins” and “flat glossy” to each based on differences in leaf morphology. In each transect a handheld Garmin GPSMAP 60CSx was used to mark all individuals of each target species. Information such as height and DBH was recorded. Individuals with DBH > 25 cm were classified as “adults,” while those with DBH < 25 cm were classified as “juveniles”.

Mapping and statistical analysis—ArcGIS® was used to map the distribution of the trees within the six transects. Given how our GPS points regularly had about 3 m of error, a 3 m long buffer zone around each transect was added to the map.

To test mean differences in juvenile abundance between forest types, a Student’s t-test was used. To compare the variance in forest composition between forest types (using O. whiteii, B. brenesii, C. paratriplenerve, “bulgy veins”, and “flat and glossy”) found across most transects), a Fisher’s exact test of independence was applied. The X2 test of independence was used to investigate the difference between the observed frequencies of C. paratriplenerve and O. whiteii (the two most abundant species) and the expected frequencies between forest types. Finally, to test whether the transects within each forest type have identical distributions, goodness of fit tests were run for both forest types. All Statistical analyses were conducted using the software program R (R Development Core Team, 2010).

Graphs were created using the software program RStudio (RStudio, 2012).

**Results**

Data was collected on a total of 325 individuals. In the primary forest transects, 48 individuals belonging to four species and two unknowns (O. whiteii, C. paratriplenerve, “B. brenesii”, B. costaricacense “bulgy veins”, and “flat and glossy”) were found, while in the secondary forest transects, 277 individuals belonging to six species and two unknowns O. whiteii, O. floribunda, O. monteverdensis, C. paratriplenerve, “B. brenesii”, B. costaricacense “bulgy veins”, and “flat and glossy”) were found. The most abundant species, C. paratriplenerve, accounted for 64.31 percent of all individuals found (illustrated as the yellow dots on Fig. 1).

**Juvenile abundance: Primary vs. secondary forest**

The mean number of juveniles found in primary forest (13 ± 9.85) did not significantly differ from that found in secondary forest (90 ± 30.80); (t test(2) = 1.41, p = 0.29).

**Forest composition of Lauraceae**

The five species found across most transects in primary forest (9.4 ± 7.3) and secondary forest (50.4 ± 82.71) were found to vary significantly (f test, p = <0.001). There was also a significant difference in the proportion of C. paratriplenerve to O. whiteii between primary and secondary forest. (X2 = 55.82, df = 1, p < 0.001). Within the primary forest, the proportion (20 to 11) of C. paratriplenerve to O. whiteii was not found to be significantly different across transects (X2 = 2.61, df = 1, p = 0.106), while the proportion (198 to 21) of C. paratriplenerve to O. whiteii was found to be significantly different across secondary forest transects (X2 = 143.05, df = 1, p <0.001).

![Figure 1. Location of juvenile and adult Lauraceae trees in Rachel and Dwight Crandell Reserve; illustrated by large dots representing adults (DBH >25 cm) and small dots representing juveniles (DBH < 25 cm); Species indicated by colors.](image1)

**Figure 1.** Location of juvenile and adult Lauraceae trees in Rachel and Dwight Crandell Reserve; illustrated by large dots representing adults (DBH >25 cm) and small dots representing juveniles (DBH < 25 cm); Species indicated by colors.

**Figure 2.** Mean number of Lauraceae juveniles found in primary (N=3) and secondary (N=3) forest transects. Error bars represent +/- one standard error of the mean.

**Figure 3.** Stacked percent of total Lauraceae individuals found in the primary and secondary forest transects. Graph A illustrates the proportion of five species (In primary forest: Total = 47, B. brenesii = 2, “bulgy veins” = 11, C. paratriplenerve = 11, “flat and glossy” = 3, O. whiteii = 20; In secondary forest: Total = 252, B. brenesii = 7, “bulgy veins” = 17, C. paratriplenerve = 198, “flat and glossy” = 9, O. whiteii = 21); Graph B illustrates proportion of two abundant species (C. paratriplenerve and O. whiteii).
DISCUSSION
In this study, the differences between primary and secondary forests in relation to Lauraceae were addressed with two different questions: (1) is there a difference of Lauraceae juvenile incidence between primary and secondary forest? and (2) do the distributions of Lauraceae species differ between forest types and/or according to transect? While we did find more juveniles in our secondary forest transects, statistical analysis demonstrated that there was no significant difference among juvenile means (Fig. 2). However, distributions of the Lauraceae species studied were found to be significantly different between forest types and within the secondary forest transects (Fig. 3A-B) Therefore, we cannot support our alternative hypothesis that a greater concentration of Lauraceae juveniles are present in secondary forest transects. However, our findings reveal that secondary and primary forests differ significantly in forest composition of Lauraceae species. As for variation across transects within forest type, in primary forest we cannot support our alternative hypothesis that the transects differ significantly in forest composition of Lauraceae species, but in secondary forest we can reject the null hypothesis.

Before establishing concluding remarks with these findings, it is important to highlight the issue of sample size; due to time limitations, only three transects per forest type were created. Furthermore, in one of the secondary forest transects (Transect 1), we found 157 C. paratriplenerve – the other two secondary transects only had 27 (Transect 6) and 14 (Transect 4) individuals of this species. Because of the exploratory nature of this study and the lack of a sufficient sample size to conclude this transect’s composition as atypical, we decided to include this transect in all analyses to retain as much information as possible until further studies suggest otherwise. Likely as a result of the variation in this species abundance between secondary transects, findings indicated significant differences between the secondary transects proportion of C. paratriplenerve to O. whiteii. As a result, we cannot conclude that the three secondary transects in this study appropriately represent how Lauraceae are distributed in a secondary forest. More transects are required in order to accurately compare the distribution and density of Lauraceae species between forest types.

Understanding how plant biodiversity differs between old growth forests and disturbed landscapes can offer insight into which species are more at risk of extinction by climate change and deforestation (Guariguata & Ostertag 2001, Guariguata et al. 1997). Chazdon and Coe (1999) found that the abundance of trees, saplings, and seedlings of species with ethnobotanical uses did not differ significantly between old-growth, second-growth, and logged forests. However, the density of certain species was found to differ significantly across forest types, a difference the researchers attributed to the low density of the mature canopy in secondary forests. As was aforementioned, in one of our secondary forest transects, we found a high density of C. paratriplenerve (156 juveniles, 1 adult); this finding if coupled with more transects reflecting the same phenomenon would offer evidence contrary to the predictions of the Janzen-Connell Hypothesis (Connell 1971, Janzen 1970). Moreover, if one or two Lauraceae species dominate the understory of secondary forests this may prove problematic in the future as species that depend on the other Lauraceae species are inevitably forced to remain secluded to the old growth forests of Monteverde. Understanding which Lauraceae species have more difficulty growing in disturbed areas can guide restoration movements into focusing on these plant species so as to protect the animal species that have a relationship with them. It is thus imperative to continue onwards with this transect-based spatial distribution and density study and to include other plant families within it so as to gain a better understanding of how to properly protect the fauna and flora of this region.

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References


