Effects of fragmentation on plant diversity and microclimate in premontane tropical forests

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Tropical forest in South and Central America are being lost at the alarming rate of more than 2 million hectares of forest annually (Achard et al., 2002). This deforestation creates extensive landscapes of isolated forest fragments in a "sea" of disturbed habitats such as pasture and agricultural lands. Therefore, to better manage these forests, we need to understand the dynamics of the plant community in fragmented forests.

Fragmented landscapes have been studied using two main approaches: testing predictions of the equilibrium theory of island biogeography (ETIB), and the examining effect of edges on abiotic conditions and species composition. The ETIB (MacArthur and Wilson, 1967) predicts a positive relationship between island size and species richness, and a negative relationship between isolation distance and species richness (Figure 1). Studies of fragmentation in lowland tropical forest have shown not only lower species richness in smaller or more-isolated fragments, but also a change in species composition with invasion of species that favor pasture habitats into smaller fragments (Arroyo-Rodriguez et al 2006).

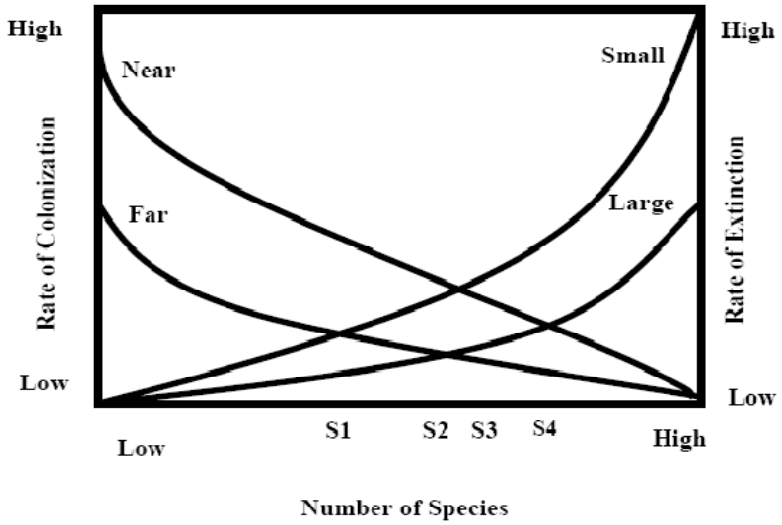

Figure 1. Colonization and Extinction Curve. S1-S4 show equilibrium species richness for islands experiencing different rates of immigration and extinction. For example, S1 shows low species richness on small islands that are isolated (far).

Research on edge effects shows fragmented forests may not experience a consistent environment or regular species composition throughout the fragment. Gradients exist from the forest edge into the interior. Higher air temperature and lower relative humidity is detected in the first 40m from the edge compared to the forest interior in Amazonian fragments (Kapos 1989). In these fragments higher tree mortality is also observed within the 60m nearest to the edge (Laurance et al 1998).

Fragmentation studies have mainly focused on lowland tropical habitats. We do not know whether the response of premontane forest to fragmentation is similar. Premontane forests experience less seasonality but greater wind disturbance than lowland forests, and may respond differently. Therefore, we will examine how plant diversity and microclimate respond to fragmentation in premontane. Premontane forests in two regions in Costa Rica, San Luis de Monteverde and San Vito de Coto Brus, provide model landscapes for investigating these responses. Figure 2 shows an aerial photograph of the landscape in the San Luis region.

Objectives and Methods

Our research will focus on four main objectives.

1. *Determine the relationship between plant diversity and fragment size and isolation distance.*
    a. Is there a difference in the response of woody and herbaceous species richness to fragment size or fragment isolation?
    b. Does the abundance of trees of different size classes differ among fragments of different of different sizes?

    We will measure species richness in fragments of different sizes and distances from large forest stands. Within each fragment, herbaceous species will be recorded and tree species greater than 10cm in diameter will be measured in three 20x20m plots. Tree diameter will also be measured.
2. *Characterize the edge-interior gradients in premontane fragments.*
    a. -Does microclimate vary along the gradient from forest edge to interior, and how far do edge-like conditions penetrate into the fragment?
    b. Does tree diversity also vary along that gradient?

    We will measure microclimate variables along transects beginning in the pasture and continuing at least 100m into the forest. Measures will be taken at several intervals along transects extending from 20m in pasture to 100m into the forest interior. Measurement will be taken over 6 weeks.

    Along these transects, we will also measure tree diversity using the point-quarter method. Each point along the transect will divided into quadrants. The nearest tree will be identified and diameter will be measured in each quadrant.
3. *Examine whether animal dispersed species have lower species richness than wind-dispersed species in smaller fragments compared to larger fragments or continuous forest.* Animal-dispersed seeds may experience reduced dispersal if dispersers show restricted movement among fragments due to threat of predation or unsuitable environment of the surrounding landscape.

    Dispersal mode will be assessed for each species using, a) Dispersal modes reported in scientific literature, b) Dispersal syndrome as inferred from fruit morphology and c) Interviews with local researchers and landowners familiar with the flora.
4. *Determine the generality of responses of plants to fragmentation in two separate but similar premontane habitats.*

    We will examine these questions at two sites in Costa Rica with similar elevation, climate, soils, vegetation and fragmentation history a) Las Cruces Biological Station on the south pacific slope and b)the UGA San Luis Research Station in central montane region.

Figure 2. Aerial Photo of San Luis de Monteverde, Costa Rica and surrounding regions

Preliminary Results

Preliminary sampling shows a positive relationship between fragment size and species richness for woody species (Figure 2). This relationship is not observed in herbaceous species

and may be due to the presence non-forest interior species (e.g. grasses, *Zebrina spp*. which are found in smaller fragments with more edge-like habitat), in addition to typical forest interior species.

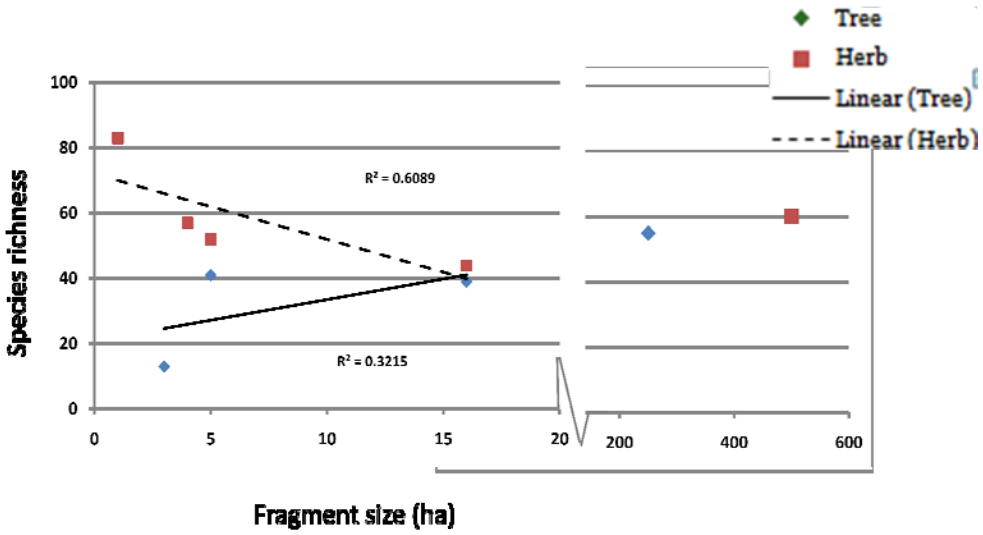

Figure 3. Change in species richness with fragment size

Research Significance

Plant responses to fragmentation are influenced by i) fragment characteristics, such as area, isolation, and microclimate and ii) plant traits, such as habit (woody vs. herbaceous) and dispersal modes. Understanding species response to fragmentation is important for conservation measures such as reserve design, and identification of species vulnerable to local extinction. In both the San Luis and Las Cruces areas, local conservation agencies are designing corridors to connect coastal forest to montane forest by connecting fragments along the Pacific slope. Our research will determine fragment characteristics which support the greatest plant diversity and thus, will identify fragments best suited for reserves and other conversation measures.

To our knowledge, no fragmentation study has encompassed more than one area. Las Cruces and San Luis have similar climates, vegetation and land use history and offer comparable sites that may provide evidence as to the generality of the size –diversity relationship and other fragmentation impacts.

References

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Field Work Photographs, October 2010.

Climate Station

Herbaceous Layer