Project Update: December 2010

Introduction

The decrease of similarity of any two observations with distance was first explained by geographers and referred to as the "first law of geography" (Tobler, 1970). However, ecologists recognized this phenomenon for several decades (Whittaker, 1960; 1972; Preston, 1962). Nekola & White (1999) made it popular for describing the biodiversity patterns in ecological communities. Distance decay relationship is a very successful and useful relationship in ecology. Ecologists use this relationship most widely to visualize the spatial patterns of biodiversity in different ecosystems (Morlon et al., 2008; Soininen et al., 2007; Palmer, 2005; Condit et al., 2002; Nekola & White, 1999). This relationship is a novel perspective for investigating the alpha and beta diversity across landscapes (Ferrier et al., 2007; Bryant et al., 2008). It explains the variation in similarity in species composition between two communities with respect to distance that they have (Morlon et al., 2008). Distance decay may happen due to different reasons: environmental heterogeneity   (Duque et al., 2009; Miller et al., 2002; Tuomisto et al., 2003), dispersal limitation (Duque et al., 2009; Harms et al., 2000; Selmi et al., 2002), disturbances (La Sorte et al., 2008; Moloney et al., 1992), animal behaviour (Oliva and Gonzalez, 2005; Wilkinson & Edds, 2001; Lichstein et al., 2002), neutrality (Chave & Leigh, 2002; Condit et al., 2002; Hubbell, 2001). Here, I used this distance decay relationship to visualize the effects of land use changes and anthropogenic disturbances on biodiversity in a protected area of Bangladesh

Hypothesis

I test the hypothesis that species distribution and abundance patterns of plant species (alpha-diversity) as well as do biological heterogeneity (beta-diversity) vary with respect to the land use and disturbance regimes.

Materials and Methods

I conducted the study in one of the protected areas of Bangladesh, where spatially explicit assessments of biodiversity patterns at the landscape level are lacking as in many tropical countries. I applied a representative, rapid, unbiased and systematic sampling procedure on plant species diversity combined with information on land use, soils and disturbances. I used digital elevation models, satellite images, and systematic sampling techniques to locate the sampling sites throughout the study areas based on terrain attributes, land uses and land cover classes.

I collected two types of data at each plot. One is the floristic occurrences i.e. which plant species are present (plant diversity) and another is disturbance data i.e. which types of anthropogenic disturbances are present (e.g. fire, logging etc.). Then the present disturbances were characterized by the following disturbance descriptors:

    i.   Size e.g. large and small relative size to the size of ecosystem (large scale=>50%, small scale=<50% area of the plot);

    ii.   Effect of each disturbance on vegetation e.g. high, medium, low (high=breakdown/destruction of whole ecosystem; medium= shift biomass, destruction of trees; low=phonological plasticity),

    iii.   Selectivity e.g. all and few i.e. the specific disturbance affect all the species in the ecosystem or specific species

    iv.   Form e.g. linear, laminar and puctiform

             Distribution e.g. homogeneous and heterogeneous

    v.   Seasonality e.g. wet and dry season i.e. at which season of the year the specific disturbance occur

    vi.   Frequency e.g. 1x/yr, 2x/yr, >2x/yr, /2yr, /5yr, /10yr, / 20yr, non predictable i.e. how many times this disturbance occur

    vii.   Duration e.g. <1day, <1week, <1 month, <1year, >1year i.e. how long the disturbance exists

Thirdly, I used the selected and collected disturbance descriptors in different land uses as explanatory varibales

Finally, I used multivariate statistics and geostatistics to the gathered bioinformation to find out the most prominent factors for biodiversity as well as to identify the major drivers of biodiversity loss.
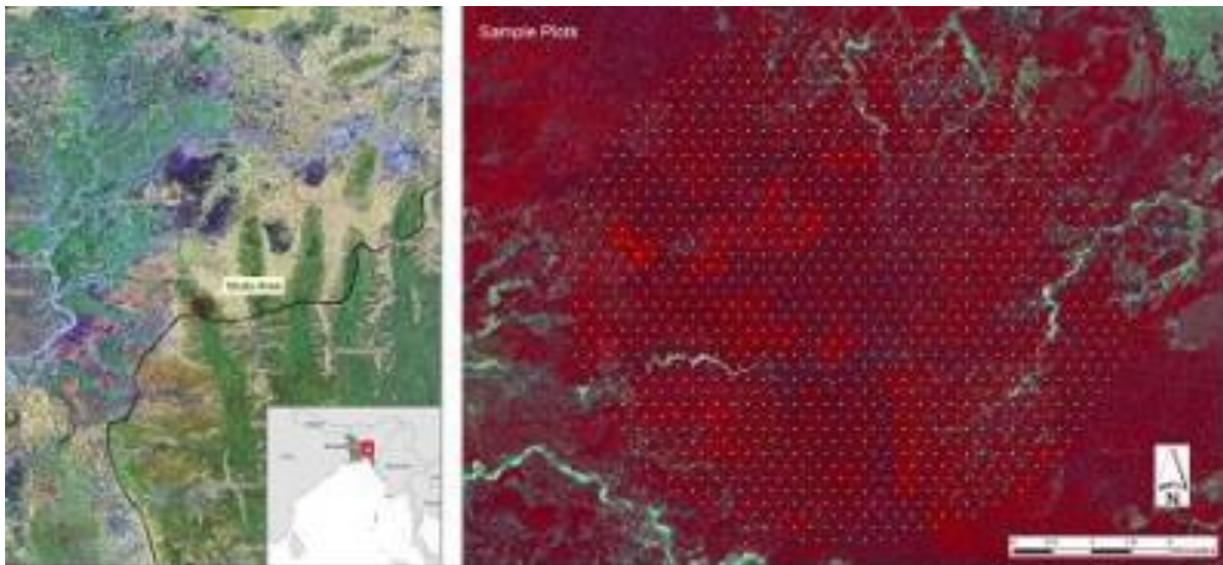
Figure 1: Study area with mainly forested landscapes in eastern Bangladesh (a) and systematic spatial arrangement of plant records (b).

Results and Discussion

Floristic similarity decreased significantly with distance in case of Sørensen similarity (P<0.001) but insignificant (P<0.157) while using Euclidean distance (Figure 2). The decline indicated by Sørensen similarity was much steeper than that of Euclidean distance. The distance decay model using Sørensen function showed an initial rapid rate of decline, smoothing its slope around a similarity value of 0.2. After 4000m, the similarity constantly decayed at slower rates with much more gentle and regular fashion. The distance decay model predicted the similarity up to ca 7000m very well (Figure 2), maximum distance covered in this study. Both the linear regression models for distance decay in Sørensen similarity and Euclidean distance provided a poor fit to data, explaining just 0.023% and 0.001% of the variation in floristic similarity with distance, respectively.

The DCA indicated that the distribution of species as well as diversity was closely related to the disturbances and land uses (Figure 3). I also divided the whole study area into four distinguished classes subjectively based on the disturbances as tea garden, fallow land, plantation and forest to prove my hypothesis more deliberately (Figure 3). The numbers of disturbances were strongly correlated with the plots in surrounding areas. Surrounding areas of Satchari protected area which consists mainly of fallow lands and tea gardens and these areas receive high amount of disturbances. Therefore, the predicted distribution of species and diversity was largely driven by these disturbances. The right sided plots were dominated by surrounding areas (i.e. tea gardens and fallow lands) with more number of disturbances and consequently fewer portions of species i.e. less diverse while left sided by national park and reserved forest with fewer numbers of disturbances and accommodate more portions of species indicating high biodiversity in the ordination diagram (Figure 3).

Ecological processes such as disturbances (e.g. anthropogenic) might have the impact on the distance decay model (Cassey et al., 2007; La Sorte et al., 2007, 2008). According to the abundance-occupancy relationship (Gaston et al., 2000), both occupancy and abundance of species tend to increase in a similar way. However, we passed through the whole study area as we used unbiased and systematic sampling procedure, the biodiversity in the study area is facing a noticeable threat from anthropogenic disturbances mainly deforestation (Figure 3). Within the study area, if species benefit from anthropogenic activities, this abundance-occupancy relationship might provide a more comprehensive explanation of lower ß diversity and higher compositional similarity in Bangladesh forest ecosystems.
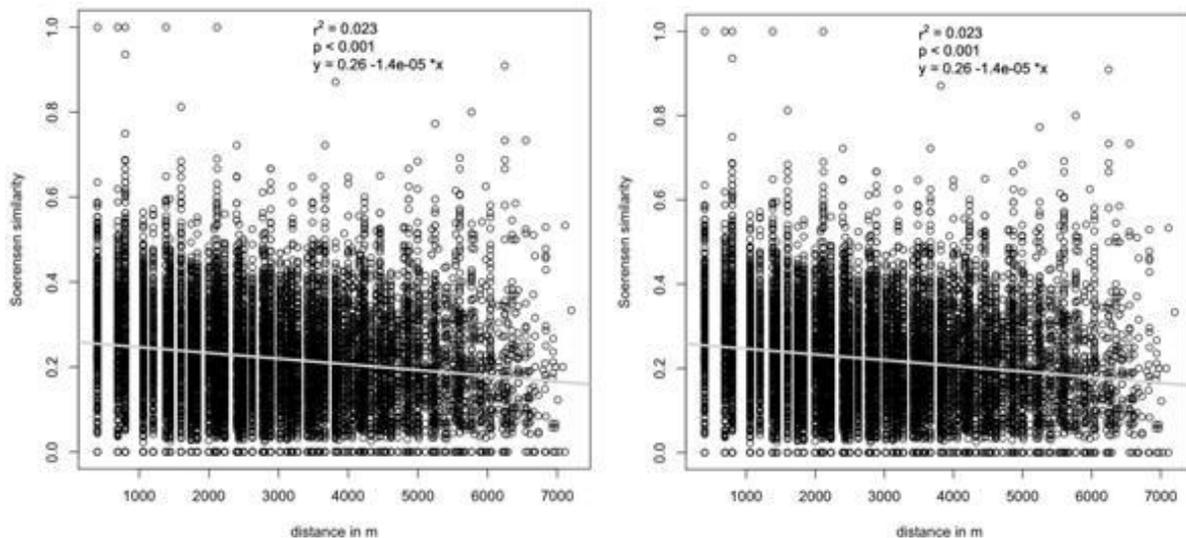

Figure 2: Distance decay analysis (DCA) relating disturbances to species distribution
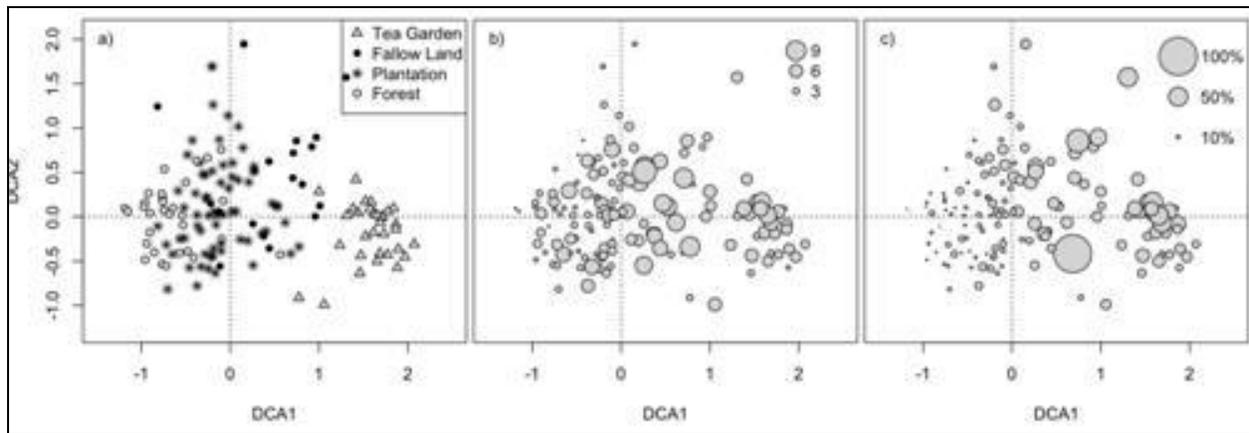
Figure 3: a) Land use categorization, as subjectively classified in the field, is differentiated by the first axis of a DCA. This indicates an increasing anthropogenic influence on vegetation composition against the first DCA axis. b) The number disturbances are highest at plots with medium intensive human use. c) The percentage of disturbances is increasing with anthropogenic influence.

Conclusion

As the forest ecosystems of Bangladesh are under the intensive anthropogenic and natural disturbances, the high species turnover emphasizes the importance of nature protection in the study area as it indicates a large variety of species on the landscape scale. Since different anthropogenic pressures affect biodiversity in protected areas, the outcomes of this study would be helpful to make a fruitful plan which will ensure conservation through the sustainable use of forest biodiversity. Finally, it is enhancing to ensure both nature conservation and local livelihoods in protected areas in the developing countries. Moreover, more exploratory studies are in need to identify the predictors of biodiversity patterns in forest ecosystems of Bangladesh.

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