Floral Diversity & Ecosystem Function IN North-East India

Jenpuiru Kamei

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Preface

This work is based on my doctoral dissertation submitted to North-eastern Hill University, Shillong and approved in the year 2008. I worked under the able guidance of Prof. H. N. Pandey of Centre for Advanced Studies in Botany, NEHU and Prof. S.K. Barik of the same centre.

I worked in the village of Swer in East Khasi Hills district of Meghalaya state where there are well protected sacred groves of the indigenous Khasi people. I am lucky that the head man of the village, Mr. Orstar Swer extended full co-operation to me.

As is well known, Meghalaya is a part of ecosystem of northeast India which is a hot spot of biodiversity. I worked on the inter-relationship between tree diversity and ecosystem function.

I have already published three papers churned out of this work in the following journals: 1. *Canadian Journal of Forest Research,* 2009, Vol. 39-47. 2. *ANVEṢĀ Journal of Fakir Mohan University*, 2008, Vol. 3(1):1-10

I am grateful to the Editors of *Candadian Journal of Forest Research* and *ANVEṢĀ* for their kind publication of my papers. Simultaneously I express my gratefulness to *Canadian Journal of Forest Research* for their kind permission to reproduce the article in the present book. I was greatly

helped by my two teachers Prof. H.N. Pandey and Prof. S.K. Barik in the publication of these three papers.

In the preparation of this work, I got help from many of my colleagues in the Centre for Advanced Studies in Botany, NEHU. However, I would like to mention Dr. Krishna Upadhaya and Dr. N.J. Lakadong.

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Jenpuiru Kamei

Imphal
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Introduction

The most striking feature of the earth's biota is its extraordinary diversity, estimated to include about 10 million different species. Of the estimated 2,97,000–5,10,000 plant species of the world's biota (Schippmann *et al.* 2002), only 1,70,000 have been described to date (Groombridge and Jenkins 2000), and their distribution is highly uneven. About seven per cent of the world's total land area is home to half of the world's species, with the tropics alone accounting for 5 million.

India contributes significantly to this latitudinal biodiversity trend. A rich and varied heritage of biodiversity, encompassing a wide spectrum of habitats from tropical rainforests to alpine vegetation and from savanna to coastal wetlands is encountered in the country. There are nearly 47,000 species of plants, which includes 17,000 angiosperms (Trivedi 2002), accounting for 10.78% of the global total. Of the 17,000 species of flowering plants, 5,725 are endemic to the Indian subcontinent accounting for 33.5% of the total flora, of which, 2,532 are restricted to the Himalayas. The Red Data Books (Jain and Shastry 1984; Nayar and Shastry 1988–90) list 623 threatened species of which 550 are endemic including some valuable medicinal plants.

The vegetation of northeastern India has 1,63,799 km^2 area under forest accounting for 25% of the total forest cover of the country (FSI 1999), and harbours approximately 7,500 species of angiosperms. Meghalaya in northeast India with an actual forest cover of around 15,584 km^2 (FSI 2001) harbours about 3,128 species of flowering plants and contributes about 18% of the total flora of the country. It includes 1,237 endemic species (Khan *et al.* 1997) and 53 threatened plant species (Nayar and Sastry 1988). In Meghalaya, very few studies are available on endemic and threatened plant species. Most of these species are restricted to Biosphere Reserves, National Parks, Wild Life Sanctuary, community and reserved forest, and sacred groves.

Sacred groves are small patches of forest protected by local people out of reverence and respect, fear and sentiment. They are the home of the local flora and fauna. Tree felling and hunting of animals are strictly prohibited here. Leaves, fruits or roots may be removed only for medicinal purposes. Ecologically the sacred groves represent the climax vegetation of the area. In Meghalaya, it ranges from moist deciduous forests at lower elevation to subtropical semi-evergreen to evergreen forest in the precipitous zone at higher elevation between 1200–1900 m a.s.l.

Forests in India have been and are being exploited intensely for centuries (Veach *et al.* 2003). Although the degree of anthropogenic pressure varies in different parts of the country, human disturbances have become a wide spread feature in most of the forested areas throughout the Himalayas (Singh *et al.* 1984). In the northeastern region, dependence on forest for fuelwood as a source of energy, coupled with shifting cultivation has been causing deforestation (Ramakrishnan 1987). Due to the ever-increasing population, fuelwood consumption is also increasing rapidly in the region (Arunachalam *et al.* 2004). In Meghalaya, the main causes of biodiversity loss are shifting cultivation, deforestation, mining, habitat destruction, over extraction, fragmentation and land use changes (SoE 2005). Lately, the pressure on forests in the state has increased many folds leading to encroachment in sacred groves by the indigenous tribes themselves for their various needs.

The biodiversity declines are already pronounced in many areas. Such local declines are often even more dramatic than global declines, and the beneficial effects of many organisms on local processes are lost long before the species become globally extinct (Naeem *et al.* 1999).

Human modifications to the living community in an ecosystem as well as to the collective biodiversity have a strong potential to alter ecological properties, ecosystem goods and services which they provide to humanity. Therefore, ecologists have raised concern about how a change in species diversity alters functioning of the ecosystem such as productivity and processes leading to transfer of C and nutrients within the ecosystem and its stability.

An understanding of the relationship between biological diversity and functioning of ecosystems can help improve a wide range of policies involving agriculture, forestry, fisheries and land use, transcending traditional conservation-based policies (Mooney *et al.* 1995). Although every organism contributes to ecosystem processes, the nature and magnitude of individual contributions vary considerably. An understanding of the ecosystem level consequences of individual species is also essential to examine the interactions between biological diversity and ecosystem function. If we cannot establish that individual species are significant, we are unlikely to be able to detect the much more subtle and complex effects of species diversity. Individual species matter, or at least some of them do, and the loss or gain of those species alters the net effects of terrestrial ecosystem on the atmosphere, the hydrosphere or the long-term fertility of soils (Ehrlich and Mooney 1983).

When discussing the effects of biodiversity on ecosystem function it is important to be specific about which components of biodiversity are affecting which components of functioning. Variation in ecosystem properties can result from fluctuations in the environment from year to year, directional changes in conditions, abiotic disturbance or biotic disturbance. There is no a priori reason to expect that different ecosystem properties have a single pattern of response to changes in different components of biodiversity, or that change in either direction is inherently "good" or "bad" (Hooper *et al.* 2005).

The natural forest is never homogenous in structure; it is always an irregular mosaic of developing and developed stages of community, often called as gap, building and mature phases. The young, mature and senescent individuals of most tree species are unevenly distributed and cause patchiness in the forest structure and composition (Richards 1996). The forest vegetation produces a complex 3-dimensional mosaic of microclimates varying vertically from canopy top to the forest floor and horizontally from point to point beneath the canopy. At a larger scale, microclimates vary between canopy gaps of different sizes, between building and mature phases, and between different forest types. Each of the contrasting microclimates has a role to play in accounting for biology of individual plants and animals in the forest.

The structure and function of forest ecosystem is determined by the plant component more than any other living component of the system. The importance of plant control at the ecosystem level lies in driving nutrient cycling back to the plants. This is possible due to the high proportion of total stock of nutrients that is held in shoot system and the "leak-proof" efficiency of the forest floor and soil compartments of the ecosystem (Richards 1996).

The flow of nutrients within the forest ecosystems occurs through: 1) root nutrient absorption via the processes of uptake and assimilation, 2) nutrient allocation to biomass construction and maintenance, 3) nutrient translocation from senescent tissue, 4) return of nutrients in above and below ground litter and 5) microbially mediated release of inorganic nutrients into soils solution i.e. mineralization during organic matter decomposition (Barnes *et al.* 1998).

Nutrients entering forest ecosystem from mineral weathering, atmospheric deposition and biological fixation can enter soil solution where they are absorbed by plant roots. Within the plant, absorbed nutrients participate in a wide array of physiological processes, and in some cases, nutrients are mobilized (i.e., translocated) prior to the shedding of some plant tissues. Plant litter on the forest floor plays a critical role in determining soil properties and substrate supply for microorganisms. Most of the nutrients leaving the aboveground biomass as litter or as leachates reach the forest floor rapidly, where soil microorganisms decompose them. The decomposition of litter by microbes into inorganic ions and turnover of labile soil organic matter is affected by the litter quality and timing of litter input, besides microenvironmental conditions on the forest floor. During the process of decomposition, soil bacteria, actinomycetes and fungi assimilate the organic compounds contained in plant litter into their cells for biosynthesis i.e., growth and maintenance. In humid tropical forest dense networks of fine roots, which are concentrated on the forest floor and the underlying mineral soil layer, rapidly absorb ecosystem nutrients released during decomposition of litter. Thus, the rate at which nutrients flow within the forest ecosystems is controlled by the physiological activities of plants and soil microorganisms, and their requirement for growth.

Although microbial biomass represents a relatively small standing stock of nutrients compared to soil organic matter and above ground biomass of trees, but act as a labile source of nutrients for plants, a pathway for incorporation of organic matter into the soil, and a temporary sink for nutrients. The soil microbes associated with tree species differing in quality of leaf litter often have variable amounts of microbial biomass (Bauhas *et al.* 1998), rates of decomposition of organic matter (Melillo *et al.* 1982), mineralization (Vitousek *et al.* 1982, Zak and Pregitzer 1990) and nitrification (Finzi *et al.* 1998a, Lovette and Reuth 1999). The phenological diversity of trees in the forest helps reduce nutrient loss from the system by allowing plant uptake to take place concurrently with microbial mineralization (Baillie 1996).

In forest ecosystems, major pathways of nutrient losses are through leaching and denitrification. Leaching of growth limiting nutrients like N and P in particular occurs when precipitation exceeds the amount of water lost through transpiration and evaporation from the soil surface. Nutrients eventually enter ground or surface waters where they then become a nutrient input for aquatic ecosystems. Denitrification, on the other hand, is the microbially mediated reduction of nitrate to nitrous oxide or nitrogen, which returns N to the atmosphere (Tiedje 1988). This results in the loss of limiting nutrients, potentially influencing the productivity of terrestrial ecosystems.

The focus of ecological research over the past decade has been on the study of relationship between biodiversity and ecosystem functioning (Schulze and Mooney 1993). However, ecologists have different views on the importance of species diversity in ecosystem functioning because empirical studies have not demonstrated any consistent relationship between the number of species in a system and the rates of ecological processes. Several studies have provided clear evidence that biological communities do indeed regulate ecological processes (Tilman *et al.* 1997, Tilman 1999, Hooper and Vitousek 1997, Zak *et al.* 2003a, Spehn *et al.* 2005, Jonsson 2006, Lanta and Leps 2006), but these studies have often reached different conclusions about the contribution that species diversity itself make to ecosystem functioning. Interpretation of the experiments on the relationship between species and ecosystem processes has been controversial (Loreau *et al.* 2002). Most of these studies were undertaken under controlled conditions where species diversity in the experimental design was manipulated by altering either their composition or abundance or both.

The present study though is an attempt in the same direction, but differ significantly in its approach since it has been carried out in an undisturbed humid subtropical forest ecosystem characterized by high tree diversity showing highly uneven distribution pattern in the community. The relationship between tree diversity and N and P dynamics on the forest floor was investigated in the permanent plots dominated by different tree species by collecting data on production and decay of litter and fine roots, soil microbial biomass dynamics and nutrient mineralization. The following specific aspects were studied at monthly/ seasonal intervals, to achieve the objective:

1. Tree species composition and their phytosociological attributes,
2. Microclimatic condition and physico-chemical properties including N and P status of soil,
3. Accumulation, production and decomposition of tree litter,
4. Accumulation, production and decomposition of fine roots,
5. N and P input, accumulation and release through litter and fine roots and
6. N and P mineralization and soil microbial biomass C, N and P dynamics.

Interpretation of the experiments in the relationship between diversity and ecosystem process has been controversial. Most of these studies were undertaken under controlled conditions where species diversity in the experimental design was manipulated by altering either their composition or abundance or both.

The present study is an attempt in the same direction, but differs significantly in its approach since it has been carried out in an undisturbed humid subtropical forest ecosystem. The study was carried out in a sacred forest of Swer in East Khasi Hills district of Meghalaya in northeast India. It is a closed canopy forest characterized by high tree diversity of vascular plants, complex community organization and high spatial heterogeneity in species distribution and forest microenvironment.

This study will be of interest to the ecologists who are studying the ecosystem of northeast India.

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Dr. (Ms.) Jenpuiru Kemei is a research scholar who was educated in Imphal and Shillong. She graduated from D.M. College of Science under Manipur University. She did her M.Sc. in Botany in North-Eastern Hill University, Shillong. She was awarded PhD in 2008 from the same university.

Dr. Jenpuiru Kamei is now working in Institute of Bioresource and Sustainable Development under Department of Biotechnology, Goverment of India at Imphal.

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