STUDIES ON PLANT BIODIVERSITY AND ECOSYSTEM FUNCTION IN SACRED GROVES OF MEGHALAYA

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I, Mr. Krishna Upadhaya, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any University/Institute.

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CHAPTER 1

INTRODUCTION

The term 'Biological diversity' draws together concepts that had preoccupied Ecologists and Geneticists for some time prior to 1980's. The concept of biodiversity was introduced by Lovejoy (1980) to express the number of species present in a community. Norse and McManus (1980) included genetic diversity and ecological diversity and Norse *et al* (1986) further expanded the usage of the term 'biological diversity' to include genetic (within species), species (species numbers) and ecological (community) diversity.

The contracted form – 'biodiversity', was coined by Walter G. Rosen in 1985 (cf. Wilson 1988). But the notion of the term was brought to the attention of scientists and others by Wilson (1988). The term was clearly defined in the Earth Summit (1992) at Rio De Janeiro, Brazil, which closely mirrors the concept of Norse *et al* (1986).

"Biological diversity means the variability among living organisms from all sources including, *inter*, *alia*, terrestrial, marine and other aquatic systems and the ecological complexes of which they are part, this include diversity within species, between species and of ecosystem" (UNEP, 1992 cf. Harper and Hawksworth 1995).

Biodiversity is by no means evenly distributed on the earth; some areas are very rich in overall diversity than the others. Biodiversity is high in warm and wet areas and low in drier and cooler areas. Diversity decreases with the increase in altitude and latitude. The tropical rain forests are non-seasonal ecosystems with high species diversity of both plants and animals, their structure is very complex and they are relatively stable (Richards 1986). Their stability is only in a relative sense and they are subjected to short-term changes due to natural and man-made causes. Even the least disturbed tropical rain forest consists of both seral and climax tree species, and is characterised by patchwork of gap, building and mature phases. They are the richest diversity areas on the earth containing more than 50% of the plant species, out of the estimated 3,00,000 flowering plants (Myers 2000). It is estimated that the tropical moist forest occupies an area of 1510 million ha, within which lowland rain forest covers 715 million ha (Whitmore 1998).

One of the severe and unlike any environmental threats is the accelerating and potentially catastrophic loss of biotic diversity. In the tropics the most important cause of biodiversity loss is shifting cultivation and logging for timber based industries. The overall global loss of all tropical moist forests during 1981-1990 was estimated to be 13.1x 10^6 ha year $^{-1}$ or 0.9% (FAO cf. Whitmore 1998). Therefore, conservation of biodiversity has attained immense importance in the recent time. From conservation point of view, a promising approach is to identify areas, which harbour far greater concentration of biodiversity then others and exhibit high level of endemisms and at the same time most severely threatened. This has led to identify priorities or species- rich areas on the earth (Myers 1988,1990). These areas are referred to as '*Hotspots*' of biodiversity. Myers *et al* (2000) identified 25 hotspots supporting 44% of all vascular plants in just 1.4% of land surface of the earth. Out of the 25 hotspots, 15 are predominantly tropical forests, which largely mean developing countries where threats are greatest and conservation resources are scarcest.

Species richness, their dispersion, density and dominance in relation to the co-existing species are major determinants of community structure. According to Richards (1996) the structure and function of forest ecosystem is primarily determined by the plant component than any other living component of the system. The species composition of communities express their relationships to one another as well as to their physical environment than dominance or any other community characteristics. Therefore, Whittaker (1975) emphasized that classification and interpretation of communities should be based on their floristic composition. Clement (1916) viewed community as a 'super organisms' with successional development from pioneer stage to relatively stable climax stage. Tansley (1935) pointed that in a community certain populations are independent as they can establish themselves well in other communities while others are strongly dependent. Gleason (1926) claimed that community depends for its existence on its particular environment, which changes constantly in space and time. The individualistic concept of Gleason (1926) provides a framework for examining plant community in greater detail as a dynamic unit.

Biodiversity renders several environmental services also known as ecosystem services including regulation of climate, biogeochemical cycles, hydrological functions, soil protection, crop pollination, pest control, recreation and ecotourism (Myers 1996). In recent years, the effect of biodiversity on ecosystem processes has received much greater attention because of growing concern that loss of biodiversity may impair ecosystem functioning (Ehrlich and Wilson 1991, Schulze and Mooney 1994, Vitousek *et al* 1997, Chapin *et al* 1997). With the current rate of species extinction there is growing interest in determining how the loss of biodiversity might alter the rates of ecological processes like productivity, decomposition, elemental cycling etc. that are vital to the functioning of the ecosystems. Several studies have provided clear evidence that biological communities do indeed regulate ecological processes (Naeem *et al* 1994, Tilman *et al* 1996, 1997, Hooper and Vitousek 1997, Mc Grady-Steed *et al* 1997, Wardle *et al* 1997, Symstad *et al* 1998), but these studies have often reached very different conclusions about the contribution that species diversity itself makes to ecosystem functioning.

The classification of species into functional groups has been suggested as a way to simplify the examination of species effects on ecosystem properties and of the effect of global change on species interactions (Korner cf. Schulze and

Mooney 1994). Functional groups' are defined as groups of species with similar response to a given factor (Gitay and Noble 1997). Within an ecosystem plants can be divided into groups with common features according to quality criteria such as life form, over all size, rooting depth, symbiotic associations, fire resistance, spatial distribution of plants and plants organs etc., (Lavorel *et al* 1997, Korner 1994). Functional grouping of components of vegetation have been done by earlier workers on the basis of morphological (Raunkiaer 1934), physiological (Ellenberg 1974, Kinzel 1983) and physio-morphotype characteristic (Turesson 1930, Pisek 1965, Schulze and Hall 1982). Functional groups have been identified in response to disturbance on the basis of extensive sets of traits. Life form has been considered to have largest effect because this trait is correlated with other functionally important traits such as plant size (Lavorel *et al* 1997).

Forest clearance not only destroys community organization and causes biodiversity loss, it results in exposure of topsoil leading to increased erosion and decrease in total soil organic matter (SOM). The carbon loss from the system is gradual and is not easily detectable. One of the current models of SOM dynamics divides SOM into three fractions with different turnover rates; the active (0.14 yr), slow (5 yrs) and passive (150 yrs) fractions (Parton *et al* 1989). The active fraction with short turnover time appears to contain primarily living soil microbial biomass and microbial products.

Information on changes in microbial biomass following vegetation removal is valuable not only because it provides information on slower, less easily detectable SOM changes but also because microbial biomass contributes to soil fertility (Henrot and Robertson 1994). The change in microbial biomass carbon after conversion of virgin rain forest to pasture in an Amazonian soil has been reported by Luizao *et al* (1992). Microbial biomass carbon accounts for 3.5–5.3% of the total carbon in Amazonian Pastures and forests, (Luizao *et al* 1992), 0.27–5.0% in cultivated soils (Anderson and Domsch 1986) and 1.8- 2.9% in forests soils (Vance *et al* 1987). It acts as medium through which all organic material that enters the soil must pass (Jenkinson 1977).

Bolton *et al* (1993) demonstrated that plant cover determines the amount and activity of the soil microorganisms. Root biomass and aboveground plant biomass are considered to be the main source of SOM and the latter is highly correlated with microbial biomass (Schnurer *et al* 1985). Srivastava and Singh (1991) reported that the conversion of dry tropical forest into savanna resulted in a decrease in the amount of plant biomass leading to decrease in soil nutrients and microbial biomass. The effect of disturbance such as tree cutting and shifting cultivation in the humid tropical forest causes depletion of soil nutrients by lowering microbial biomass and microbial activity (Arunachalam *et al* 1999).

Microbial biomass can provide one of the most satisfactory estimates of the effect of disturbances. Though the soil biomass measurements are not uniform across systems and is highly debatable, relative biomass change over time should be sufficient for predicting the ecosystem recovery after disturbance. The microbial biomass measurement may provide the information needed for ecosystem level monitoring of disturbances and recovery (Smith and Paul 1990).

Nitrogen and Phosphorus are the two most important limiting nutrients in soils. A major challenge to ecologists and land managers is to increase agricultural and forest productivity, which is largely dependent on the availability of these two essential macronutrients. The availability of N and P in soil is largely controlled by biologically mediated processes such as mineralization and immobilization.

Mineralization is a process of nutrient release from the organically bound materials into inorganic or plants-available forms. Mineralization of organic soil N is therefore, fundamentally linked with forest productivity and attention is being shifted from static measures of N- availability to more dynamic measures of N release (Keeney 1980).

Many studies have reported increased loss of N and other elements from forest ecosystem following tree felling. Recognition of the effects of disturbance on elemental cycling and loss in terrestrial ecosystems has increased in recent years. This emphasizes the continuation of a longstanding concern among forest scientists over the possibility that forest clearing causes nutrient losses, which could affect the long–term productivity of a site (Likens *et al* 1970). To characterize the degree of homeostasis in forest biogeochemical cycles, elemental losses following disturbance have been used and has been suggested as a useful measures of ecosystem-level stability (Bormann and Likens 1979).

In the north-eastern India the state of Meghalaya having an area of 22429 sq. km and is botanically rich and interesting area which has attracted the attention of a large number of taxonomists in the past. The state has about 15,769 sq. km of tropical and subtropical forest cover, of which only 11% is under the control of the state government and the rest belongs to the people (Tiwari *et al* 1999).

The rich floristic diversity of the state is confined mainly to moist tropical and humid subtropical forests, which are exposed to various types of forces leading to their destruction. The major factors responsible for deterioration of forest wealth are shifting cultivation or *jhum*, forest fire, over exploitation of medicinal and ornamental plants, encroachment for developmental activities and permanent agriculture. The state lost 845 sq. km of forest cover during 1987-1997 and 24 sq. km during 1997-1999 (FSI 1987, 1997, 1999). Therefore, the biological diversity of the state is preserved mainly in the Biosphere reserves, Wildlife sanctuaries and National parks and forests protected by the different tribes of the state. All three major tribes of the state - Khasi, Jaintia and Garo, have an age-old tradition of preserving small patches of old growth forests as a part of their culture and religious beliefs. These are popularly known as '*sacred groves*'. These are forest communities and composed of large number of endemic and rare taxa of the region and harbour a good number of medicinal and other plants of economic importance. The sacred grove gives a glimpse of the virgin climax vegetation that might have covered the hills and valleys in the past (Kanjilal *et al* 1934-40). About 79 sacred groves covering an area of about 1,00,00 ha has been reported by Tiwari *et al* (1999) from Meghalaya. The vegetation of these groves varies from tropical moist deciduous to sub-tropical wet hill broad leaved forest (Champion and Seth 1968).

Loss in forest cover and destruction of climax tropical and humid subtropical forests are of major concern for plant diversity conservation. Even the sacred forests, which were protected for centuries, are being encroached upon for various reasons, causing destruction of the complex community organization and loss of plant diversity. Therefore, the present study was undertaken in the two well preserved sacred groves and their mildly disturbed portion in Jaintia Hills of Meghalaya with an objective to assess floristic richness, study community structure and to evaluate the effect of disturbance on phyto diversity certain ecological processes within the ecosystem.

The major objectives of the study were as follows:

i) To study the plant biodiversity status of the sacred groves.

ii) To analyse the structural organization of the sacred grove communities.

iii) To assess the effect of cultural disturbance in the grove on plant diversity, certain soil biological process such as temporal and spatial dynamics of microbial biomass carbon and N mineralization.