IMPACT OF HUMAN ACTIVITIES ON PLANT BIODIVERSITY OF NOKREK BIOSPHERE RESERVE OF MEGHALAYA

By

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I, Ms. Swapna D. Prabhu, 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 other University / Institute.

This is being submitted to the North-Eastern Hill University, Shillong for the award of degree of Doctor of Philosophy in Botany.

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- Swapna D. Prabhu

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CONTENTS

List of abbreviations used

B	Bamboo groves
BR	Biosphere Reserve
CM	Coalmine spoils
J_1	1-yr. old jhum fallow
J_{12}	10-12 yr. old jhum fallow
J_3	3-4 yr. old jhum fallow
J_6	6-8 yr. old jhum fallow
L	Lowland forest
LM	Limestone mine spoils
M	Montane forest
O	Orchards
R	Riverain forest

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CHAPTER I

INTRODUCTION

Man is dependent on biological resources for his sustenance and survival. Over a long period of his existence on this planet, he has discovered several elements of biodiversity, which are useful for him in different ways. With increase in human population and over-utilization of biological resources by man, the biodiversity has been adversely influenced. Biodiversity can be studied at three hierarchical levels, viz. genetic, species and ecosystem. These three major components of biodiversity are recognized in the definition adopted in the Convention on Biological Diversity (CBD), which was a major outcome of the Rio Conference, 1992. The CBD defines the biological diversity as "the variability among living organisms from all sources, including *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and ecosystems'.

Genetic diversity refers to the variation of genes within population, species, variety or breed, which may not be expressed phenologically. It is the genetic diversity within a species, which allows a species an opportunity to evolve under changing environment and selection pressure.

Species diversity refers to the variety of species within a region and it is often referred to as taxonomic diversity. The species level is the most natural

level describing the organismic diversity and is the basis of evolution. The origin and extinction of species are the principal agents for the existence of biological diversity (UNEP 1992). Such diversity can be measured in many ways, and scientists have not settled on a single best method. The number of species in a region, i.e. species richness, is often used to measure the species diversity. The global diversity as mentioned in terms of the number of species, comprises about 1.7 million species, which are known and classified under different taxonomic groups. Some biologists feel that certain species are more important than others from taxonomic point of view or from conservation point of view and should be given higher weightage. Such species form an important component of taxonomic diversity and are categorised as keystone species, endemic species and threatened species.

Ecosystem diversity refers to the diversity among habitats, communities, and associations. It includes three major components viz., composition, structure and function of the biota within an area (Noss 1990). Many community characteristics such as relative abundance of species, pattern of communities in a region, changes in community composition and structure over time, population attributes such as the age structure of populations, and even ecological processes such as parasitism, predation and mutualism are important from biodiversity point of view.

The biodiversity values, human influences on biodiversity, as well as the measures for the conservation and sustainable use of biodiversity vary greatly within and between different cultures. Cultural diversity reveals the adaptations

of human societies in response to changing environmental conditions. Thus, cultural diversity becomes the fourth aspect of biodiversity, which recognises the important role of sociological, ethical, religious and ethnobiological values in human activities and cuts across all the three levels of biodiversity described earlier.

The global concern for the biodiversity is both, for its loss as well as its economic, social, aesthetic or moral values. The benefits of biological diversity can roughly be categorised into direct uses (e.g. biological resources), and indirect uses providing a wide variety of ecosystem services, and social benefits. Biological resources, which are a small portion of the biodiversity of actual or potential use, are being exploited since the time of human origin. One of the major causes of species loss is overexploitation of species serving as biological resources. These include species for food, medicines, and materials for shelter and for fuel. Social benefits cover recreation, cultural and aesthetic values of biodiversity. There is a need to manipulate the relationship between human being and this portion of biological diversity upon which his welfare depends.

Besides the direct benefits of the biodiversity, its significance lies in its role extended for the well being of an ecosystem, which in turn, provides a variety of ecosystem services to the human society. These include protection of water sources, nutrient storage and cycling, pollution breakdown etc. Though the exact relationship between the species diversity and the ecosystem stability is not yet thoroughly understood, a number of studies have been carried out to

support the importance of diversity in the functioning of any ecosystem. Especially, the simple hypothesis stating that greater diversity leads to longer stability (MacAthur 1965) has provoked much research into this subject. Two important hypotheses about the significance of biodiversity for the stability of ecosystems have been put forward viz., the 'rivet hypothesis' (Ehrlich and Ehrlich 1981) and the 'functional redundancy hypothesis' (Walker 1992, Lawton and Brown 1993). The rivet hypothesis states that within an ecosystem there are a certain number of species that may disappear without making the system unstable. However, the next species that disappears will make the system unstable. Thus, every species has potential of becoming crucial to the functioning of the ecosystem (Mooney *et al.* 1995). The functional redundancy hypothesis is based on the division of the ecosystem into functional groups. In every functional group there is one species that is optimally adapted to the prevailing environmental conditions and attains highest abundance. Most other species become redundant. However, with changing environmental conditions, one of these 'redundant' species could be the one that is best adapted to those conditions and would take over as the most abundant species (Lawton 1997). Some species known as keystone species play a role in ecosystems that seems out of proportion to their number such that even small changes in their abundance may have great impacts on the ecosystems in which they live (Paine 1966). Functional importance of keystone species and the functional groups in ecosystem functioning is poorly known. However, biodiversity buffers changes

in environmental conditions and might be considered as a kind of insurance (Aarts and Nienhuis 1999) which leads to stability.

Anthropogenic disturbances operating at different scales cause destruction to the plant and animal habitats to varying degrees that bring about a number of changes in various ecosystem properties and processes including biodiversity loss. Disturbances caused due to various human activities play a major role in structuring ecological systems by producing a spatio-temporal mosaic of patches (Moloney and Levin 1996). The effects of diversity on ecosystem processes and the impact of disturbances on them have been the centre of focus of biodiversity research in recent years. Many recent ecological works have centred around the disturbance-diversity-stability debate and a number of observational, experimental and theoretical studies have contributed substantially towards our understanding of biodiversity- disturbance interface. To understand the accelerating effects of human activities and how the loss of biodiversity alters ecosystem functioning are two core issues that the recent ecologists are trying to address (Hobbs 1992, Davis and Richardson 1995, Lamont 1995).

Global Biodiversity Assessment (1995) of the United Nations Environmental Program (UNEP) has identified four major causes of decrease in biodiversity, which are land use, introduction of alien species, pollution and toxicity, and climate change. Of these four causes, change in land use pattern is the principal contributor to the habitat loss and fragmentation, which has ultimately resulted into the current decline in biodiversity. The pressure on

terrestrial resources and land depends very much on population growth and the demands of early stages of economic development. Moreover, land acquisition, especially for agriculture and development, focuses initially on those areas which have the most fertile soils and equable climates, and which are often the areas of greatest biological diversity. Globally, the rate of loss of tropical forests for the 1980s has been estimated at about 1% per year. The rates of extinction of local species that accompany these rapid changes in land cover may soon be far in excess of what is found today, reaching as high as 10,000 times the natural background extinction rate (Janetos 1997).

India comprises of two natural realms, Palearctic realm represented by Himalayan and Trans-Himalayan region and Indo- Malayan realms represented by the rest of the sub-continent (Udvardy 1975). Three biomes cover most of India viz., tropical humid forests, tropical dry deciduous forests and warm deserts and semi-deserts. Besides these biomes, coniferous forests and alpine meadows also form two additional biomes. The country is further classified into 12 bio-geographic provinces and three bioregions (Cox and Moore 1993).

It is estimated that about 17,000 vascular plant species (angiosperms, gymnosperms and pteridophytes) are present in India out of which as many as 5,725 species are endemic to it (Rao 1994). It contains 7% of the world's biodiversity and supports a number of major ecosystems, varying from alpine pastures to mangroves in coastal ecosystems. The country has established a network of protected areas including 89 National Parks, 495 Wildlife Sanctuaries (including 27 tiger reserves and 11 elephant reserves) and 13

biosphere reserves under Indian Wildlife (Protection) Act of 1972. The area covered under protected area network is 1,56,300 km^2 which accounts for 4.7 % of the total geographic area of the country (Anonymous 2003).

The northeastern region of India is important from biodiversity point of view, because of its floristic richness and high endemism. It is a unique transitional zone between Indian, Indo-Malayan and Indo-Chinese biogeographical zones as well as the confluence of the Himalayan region with peninsular India (Rao 1994). It is one of the 12 mega-centres of biodiversity and also one of the 25 hotspots in terms of threats to biodiversity. The undulating topography, high rainfall and varied altitudes are main factors that have contributed to its rich ecosystem diversity. The region represents about 50% of the floristic wealth of India and contains about 8000 species of flowering plants including several representatives of primitive or ancient angiosperms (Takhtajan 1969). It abounds in gene pool of cultivars and land races of crop plants. About 64 species of *Citrus* have been recorded from the north-east of which several most primitive species viz., *C. assamensis*, *C. indica* and *C. letipes* are concentrated in Nokrek area of Meghalaya giving a strong evidence that this region is the centre of origin of *Citrus* (Singh 1984).

Besides this, within a given landscape, the tribal farmers of north-east India practice a variety of land use systems contributing towards biodiversity at all levels ranging from the sub-specific, through the species, population and the ecosystem. However, this biodiversity is dwindling at an alarming rate due to high population pressure and injudicious exploitation of the available natural

resources. Consequently *ca.* 700 taxa of plants in this region have fallen under different categories of threat (Jain and Sastry 1980). Loss of biodiversity in the form of crop varieties is near zero significance in terms of overall global diversity, but genetic erosion in these populations is of particular human concern in so far as it has implications for food supply and the sustainability of locally-adapted agricultural practices. For domesticated populations, loss of wild relatives of crop or economically important plants is of special concern for the same reason. Thus, the protected areas become the only refuges of the relic pristine vegetation harbouring precious biodiversity of the region.

The Khasi, Jaintia and Garo hills of Meghalaya have long been a focal point of botanical attention. As many as 3331 vascular plant species have been recorded from the state, out of which 1236 (37.11%) are endemic (Khan *et al.* 1997). According to Champion and Seth (1968), Assam sub-tropical hill savanna, Khasi sub-tropical hill forests, Assam sub-tropical pine forests and Assam sub-tropical pine savanna are the major forest types in the state of Meghalaya. Haridasan and Rao (1985-87) described the vegetation of Meghalaya as follows: tropical evergreen forests in low-lying areas, with high rainfall; tropical semievergreen forests (up to elevations of 1200 m) where annual rainfall is 1500-2000 mm; tropical moist and deciduous forests in areas with less than 1500 mm rainfall; grasslands and savanna on the tops of Khasi, Jaintia and Garo hills.

Isolated patches of temperate forests are found at higher altitudes in Khasi and Jaintia hills. Sub-tropical pine forests are also found at higher

altitudes in such areas where the original broad-leaved forests were felled or disturbed otherwise. A large network of legally protected areas including two National Parks, three Sanctuaries and more than twenty-five reserved forests has been established in the state. Besides, there are several sacred groves, which are protected by the local communities.

In the tropical world, biodiversity concentrations are largely tied up with regions where traditional societies live. These traditional societies by their very nature of the livelihood activities are part of the ecosystem/ landscape functions rather than being external players (Ramakrishnan 1992). Biodiversity is not only an important regulator of ecosystem functioning in a biological sense, but is also crucial for satisfying a variety of social needs and functions. Such an integrated approach is necessary for developing strategies for sustainable management of biological resources and conservation of biodiversity. Biosphere reserves, having the human beings as the major integral component of their concept provide an excellent example for exploring the impact of anthropogenic activities on the vegetation and biodiversity.

In 1968, United Nations Educational, Scientific and Cultural Organisation (UNESCO) organized the "Biosphere Conference" in Paris, as a result of which, UNESCO's Man and Biosphere Programme (MAB) was initiated in 1971. Currently, the International Biosphere network includes over 350 reserves in more than 80 countries. Biosphere reserves are protected areas, which serve to provide scientific knowledge, training and human values needed to support sustainable development. They are multipurpose areas identified by

the respective National Committees of Man and Biosphere (MAB) Programme, designated by the respective governments and endorsed by the UNESCO. These sites serve as demonstration areas for cooperation in building harmonious relationship between human activities and the conservation of ecosystems and biological diversity. Each biosphere reserve exemplifies the characteristic ecosystem of one of the worlds major bio-geographic regions. These are land areas and/or coastal marine areas involving human communities as integral component with objectives ranging from complete protection (core zone) to intensive yet sustainable use of resources. Thus, the biosphere reserve concept is a key to achieving MAB's objective of striking a balance between conserving biodiversity, encouraging economic and social development and preserving cultural values (UNESCO 1971). Specific objectives of the establishment of the biosphere reserves are:

- In-situ conservation of biodiversity (genetic resources, species, ecosystems) of natural and semi-natural ecosystems and landscapes
- Contribution to foster sustainable economic development of the human population living within and around the biosphere reserve
- To provide facilities for long-term ecological studies, environmental education and training, and research and monitoring related to local, national and global issues of conservation and sustainable development.

The National Biosphere Reserve programme in India was initiated in 1986 broadly following UNESCO's guidelines. As a result, 13 Biosphere Reserves have so far been established all over India (Table 1.1).

Table 1.1 The details of biosphere reserves established in India.

Biosphere Reserve	State	Date of notification	Total area (sq. km)	Area of the core zone (sq. km)
Agasthyamalai	Kerala	12/11/2001	1,701.00	1701.00
Dehang Debang	Arunachal Pradesh	02/09/1998	5111.50	4094.00
Dibru-Saikhowa	Assam	28/07/1997	765.00	340.00
Great Nicobar	Andaman and Nicobar Islands	06/01/1989	885.00	520.00+185.00
Gulf of Mannar	Tamil Nadu	18/02/1989	10500.00	---
Kangchendzonga	Sikkim	07/02/2000	2619.92	1784.00
Manas	Assam	18/03/1989	2837.00	520.00
Nanda Devi	Uttaranchal ~~Uttar Pradesh~~	18/01/1988 (Revised on 07/02/2000	5860.69	624.62+87.50
Nilgiri	Karnataka, Kerala, Tamil Nadu	01/08/1986	5520.00	1240.00
Nokrek	Meghalaya	01/09/1988	820.00	47.48
Pachmarhi	Madhya Pradesh	03/03/1999	4926.28	524.37
Similipal	Orissa	21/06/1994	4374.00	845.00
Sunderbans	West Bengal	29/03/1989	9630.00	1700.00

In the state of Meghalaya, Nokrek was designated as National Park (NP) on 11th November 1986. While making attempts to identify suitable areas in Meghalaya for conservation and maintenance of genetic diversity, the Indian Council of Agricultural Research through its National Bureau of Plant Genetic Resources identified this area as a reservoir of a large variety of wild relatives of *Citrus* species cultivated throughout the north-eastern India. Thus, in order to conserve the Citrus gene pool, the concept of Citrus Gene Pool Sanctuary within the network of Nokrek NP came up, with a view to develop a national-scale Citrus improvement programme. However, various anthropogenic stresses especially jhum cultivation, coal mining and limestone extraction, were posing serious problems for the conservation and management of the Nokrek NP. Considering the importance of Nokrek NP from the biodiversity point of view, the Nokrek NP was recommended as a biosphere reserve by a committee established by the MoEF (Ministry of Environment and Forests, Government of India), with the objectives of striking a balance between conserving biodiversity, encouraging economic and social development at local level and preserving cultural values. The vegetation of the BR is comprised of tropical and subtropical evergreen forests, semi-evergreen forests, deciduous forests, bamboo patches, grasslands and riverain forests. The area harbours great variety of plant communities of economic, medicinal and botanical significance.

Shifting cultivation is the major means of subsistence for a majority of the local people (85%). It is widely practiced in the buffer zone of the BR. The

total land area under shifting cultivation within BR is *ca.* 31400 ha. (38 % of the total land area). Orchards, tea gardens and valley cultivation are the secondary land use systems, which occupy *ca.* 3500 ha. area, within the buffer zone. Unscientific surface coal mining and lime stone extraction activities are being operated in the southern part of the BR leading to the land degradation and loss of biodiversity of the area. The factors like poverty, inadequate educational facilities for the locals, and absence of location-specific sustainable eco-development programme with community participation have contributed to the forest fragmentation and loss of biodiversity.

Effective management is required to halt the continued decline of the species in the wild and to restore their populations and habitat against the threat of destruction due to various anthropogenic activities. A sound understanding of biology of the species and their population dynamics in response to the anthropogenic activities is a prerequisite for their conservation. The identification of species, communities and ecosystems that are likely to be damaged by human activities forms an essential part of any nature conservation management (Nilsson and Grelsson 1995).

The present study was carried out in the core as well as buffer zones of the Nokrek Biosphere Reserve to study the biodiversity in different ecosystems of the Biosphere Reserve and to determine the impact of human activities on the plant diversity. To achieve this goal, the study was carried out with the following specific objectives:

1. Inventorying the plant diversity of different ecosystems found in the Nokrek biosphere reserve
2. Assessing the impact of human activities on plant diversity of the Biosphere Reserve
3. Identification of biodiversity-rich vegetation patches containing endemic, rare, endangered and medicinal plant species.

The data collected on above-mentioned aspects have been dealt with in detail in chapters IV to VII. The chapter II i.e. "Review of Literature" gives an overview of research work done on the aspects related to the present study. A brief introduction about the study area, which includes location, climate, geology, soil, demographic features, and vegetation types and fauna of the study area, has been given in chapter III (Study Area and Methods). It also gives an account of the methodology adopted to achieve the research objectives. Chapter IV includes the characterization of different ecosystems of the BR. Chapter V deals with the biodiversity and community characteristics of the undisturbed ecosystems of the BR, while impact of human activities on these attributes of disturbed ecosystems of the buffer zone have been discussed in the chapter VI. A detailed account of endemic, threatened and rare as well as medicinal plants of the BR has been given in the chapter VII. The results of chapters IV to VII are critically discussed in an integrated manner in the "General Discussion". In the end are appended the "Summary" and "References".