Chapter 1

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The Meghalaya state of India is gifted with the wealth of forest resources. Much of the area of the state receives an annual average precipitation of 7,000 mm or more and in certain parts, mostly the southern aspect facing Bangladesh, rainfall exceeds 10,000 mm per annum. Cherrapunji, the place known for the heaviest precipitation in the world is situated in this part of the state. The natural vegetation ranges from moist deciduous forest at lower elevation to subtropical broadleaved wet hill forest at higher altitude (Champion & Seth 1968). Of the total area of the state (72,490 Sq.km.), only 8,514 Sq.km. or 37.86 per cent is under forest cover. The State Forest Department owns only 0.48 per cent or 722.36 Sq.km. whereas 91.52 per cent or 7,791.64 Sq.km. is Community/Private forest. In addition to this, approximately 1,000 Sq.km. area is protected by the local tribesmen as 'Law-Lyngdoh' or sacred groves.

During a short span of time from 1975 to 1982, the forest cover in the state has depleted by about 9 per cent (National Remote Sensing Agency Report 1983). According to a recent estimate, approximately 4,746.72 Sq.km. or 21.11 per cent of the total geographical area of the state is in the form of wastelands (Centre for Science and Environment 1986). Abandoned Jhum-lands and barren hill ridges or rock outcrops form the major part of the wastelands in the state.

Exploitation and degradation of land in Meghalaya have
increased to alarming proportions. Awareness that the land resources are not infinite is not to the extent which could cause concern for protection and management of the life support systems. To meet the growing demands, the forest resources are being purportedly destroyed especially by Jhimmias (shifting cultivators), timber merchants and consumers of fuelwood. Human interference in various other ways such as mining and developmental activities have further accelerated the pace of forest destruction. The grasslands which occur in this region could be best described as representing degraded stages of forest ecosystems. Clearance of forest cover has exposed the soil to extensive wash-out losses and depletion of nutrients under the influence of high rainfall. Development of plant communities on such sites is arrested at varying seral stages depending on soil conditions and prevailing biotic interferences. Land which was once highly productive has been degraded and in certain areas totally destroyed or rather desertified. Ecological restoration of degraded lands or wastelands to their innate productive potential is not an easy task. It requires an overall understanding of the critical factors and their interactions with the structure and functioning of the ecosystem.

Plant communities growing on degraded sites such as abandoned Jhum fallows and eroded hill slopes in Meghalaya are composed largely of annual species and perennial grasses. N.L. Bor (1940) and later on Bor (1942), Champion & Seth (1968), Bor (1960) and Dabadghao & Shankarnarayan (1973) have described the floristic composition of these and other grassland communities from Assam state (the Assam of English ruled India) and have
grouped them under *Themeda-Arundinella* type cover. These grasslands owe their origin and existence to anthropogenic activities similar to their counterparts in other ecoclimatic zones of the country and represent a secondary seral stage (Whyte 1968; Yadava & Singh 1977; Misra 1983). On extremely degraded sites such as Cherrapunji and nearby areas, they are fairly stable. This is clearly evident from the fact that there is hardly any noticeable change in the floristic composition of southern aspect of Shillong plateau since the publication of the paper entitled *The relict vegetation of Shillong plateau* by N.L. Bor (1942). Rather, more forested area at higher elevation of Meghalaya has come under similar type of plant communities during past five decades or so.

Ecosystem is the unification of compartments and connecting fluxes that ensure transfers of energy and nutrients between the compartments (Bazilevich & Titlyanova 1980). The standing state of an ecosystem at a particular time is considered to be its structure whereas the functioning of the ecosystem is the change in its state with time. The functioning of an ecosystem may be of two kinds - *periodical* and *transitional* (Bazilevich & Titlyanova 1980). The former is characterised by periodic changes in flux intensities and matter reserves in compartments (e.g. from season to season) while the average values remain constant over a longer time scale. The climax ecosystems are closer to this kind of functioning. The latter type is characteristic of ecosystems that are passing from one regime to another, for example, from swamp to meadow or from meadow to steppe. The intensities of input and output fluxes and
the reserves in compartments are changing over a time scale in this kind of functioning. An ecosystem would be in recovering stage while the reserves in components and flux rates are increasing with time, and in degrading stage if the losses occur in the reserves and the fluxes reduce in time.

Nutrient cycling which involves complex and continuous interactions between biotic and abiotic components of the ecosystem plays a key role in the growth and development of plant community on the degraded sites. Nutrients from the available pool in soil enter into vegetation through root system and are partitioned in above- and belowground part. At the same time a certain amount of nutrients flows out from the aboveground green plant parts to the live belowground plant parts. In the process of dying-off of aboveground and belowground plant parts, i.e., litter. Subsequent transformations lead to mineralization of most of the dead organic matter, carbon being released to the atmosphere as carbon dioxide and minerals returning to soil nutrient pool; a small fraction remains in the soil humus during the course of humification. Some nutrients are washed out from aboveground plant parts by leaching through precipitation and a small quantity is lost to the soil via root exudates.

Cycling of nitrogen in the ecosystem is rather complex. The basic or internal cycle as described above may be influenced by diverse peripheral processes (inputs and outputs) especially in case of nitrogen. Nitrogen inputs to grassland are primarily by symbiotic and nonsymbiotic nitrogen fixation, ambient precipitation, animal immigration and wind and surface water import. In managed grasslands fertilizers and sown legume-grass
mixtures are responsible for the major inputs. Nitrogen losses from the grasslands may occur by denitrification, volatilization, leaching, wind and water erosion of particulate matter, and in harvest or animal export.

Clark (1977) studied internal cycling of nitrogen in blue grama grassland using tracer nitrogen ($^{15}$N) and recognized four nitrogen supplying mechanisms: i) internal translocation whereby nitrogen stored over winter in belowground plant parts move to new growth in the next growing season, ii) mineralization of easily decomposable organic nitrogen compounds, such as certain herbage compounds, root exudates and exfoliates, and short-lived unsuberized roots, iii) mineralization of organic nitrogen synthesized by micro-organisms subsisting on energy rich materials, and iv) polymerization of a part of microbially synthesized organic nitrogen to humic nitrogen which slowly releases it to the available nitrogen pool. Further improvement of the basic pathway of nutrient flow, particularly nitrogen, suggests that microbes subsisting on the decomposing organic matter (litter and root) and energy rich materials immobilize a part of inorganic nitrogen and synthesize it in the organic compounds (Clark 1977). After microbial death and decay nitrogen again becomes available for reuse by plants.

The phosphorus cycle in most grasslands is closed, with no significant gains or losses even in the areas of heavy precipitation (Clark et al. 1980). Thus it differs from nitrogen cycle which is open both to atmospheric fluxes and losses through leaching. Unlike nitrogen and phosphorus cycles, potassium cycle is characterised by its mode of return to the soil. Potassium
from organic matter is released not primarily by decomposition but rather by physical weathering processes collectively called leaching. Leaching is the removal of substances from plants by the action of aqueous solutions associated with rain, dew, mist and fog (Tukey 1970).

In brief, cycling of nutrients in the grassland ecosystems may be considered as a combination of biological cycle and abiotic processes. The biological cycle consists mainly of processes of matter transformation, i.e., the synthesis of organic and organomineral compounds, their transformation, resynthesis and degradation to simpler compounds. All the transformation processes together contain the movement of chemical elements within a single ecosystem. Abiotic processes (inputs and outputs) are basically transport processes and play a major role in the movement of materials between ecosystems. Since water is the transporting medium in abiotic processes, the extent of abiotic processes depends on the hydrologic cycle. The relative importance of biological cycle and abiotic processes varies with ecosystems.

Nutrient cycling in temperate grassland ecosystems has been studied extensively and most of the work done on this aspect have been reviewed by Jones & Woodmansee (1979), Clark et al. (1980) and Bazilevich & Titlyanova (1980). Recently, Coleman et al. (1983), Macduff & White (1984), Ulehlova (1985), Ruess & McNaughton (1987), Jackson et al. (1988), Chapman et al. (1989) and Bobbink et al. (1989) have also contributed to the knowledge of nutrient cycling in grasslands. Similar works on tropical grassland ecosystems are relatively less (Dommergues 1963;
Bazilevich & Rodin 1966); Rosswall 1980; Robertson & Rosswall 1986). In India limited work has been done on nutrient cycling aspect of the ecosystem as compared to the phytosociological and productivity measurements (Pandey 1976; Billore & Mall 1976, 1985; Mishra 1979; Yadava 1980; Tiwari 1985; Agrawal & Tiwari 1987; Chaturvedi et al. 1988; Pandey & Singh 1990). Most of these studies are from the semiarid and subhumid regions. However, similar studies on the humid grasslands are few and far between.

Not much attention has been paid towards the study of nutrient cycling in humid grassland ecosystems of Meghalaya, although distribution of various grass species has been recorded by Bor (1940, 1960), and taxonomic studies were conducted by Neogi (1980), Myrthong (1980), Haridasan (1982) and Kumar (1984). Some work has also been done on grass-legume interaction in relation to soil nitrogen (Pradhan & Tripathi 1980, 1984, 1985), trampling (Pradhan & Tripathi 1983) and nitrification potential (Ramakrishnan & Saxena 1984). Ram (1986) studied the ecosystem structure and function of seral communities of degraded environment at Cherrapunji and data are now available on hydrology, soil fertility (Ram & Ramakrishnan 1988c, 1989) and productivity (Ramakrishnan & Ram 1988). However, no attempt has been made to understand the nutrient cycling in these grasslands of Meghalaya occurring at varying topography and exposed to markedly different climatic conditions and biotic stresses.

Considering the aforesaid facts, cycling of three major nutrients, viz., N, P and K which have strong influence on plant growth and productivity, was studied at three different sites which are distributed along an altitudinal gradient between 100
and 1,900 m altitude running across north-south direction in the state. At one of these sites, effects of prevailing biotic disturbances such as annual burning and mild cattle grazing were also studied. Data collected on storage of N, P and K in soil and vegetation components, their uptake by vegetation, transfers between different above- and belowground producer compartments and input to soil through decomposing litter and belowground parts during 1988-1989 are presented in this dissertation.