CHAPTER-2

REVIEW OF LITERATURE
"Vegetation Ecology" a term coined by Mueller-Dombois and Ellenberg (1974) includes the investigation of species composition and sociological interactions of species in communities from broad physiognomic formation to the very fine floristic pattern occurring on a small area. Further it is much concerned with correlation between environment and vegetation. According to Fosberg (1992) vegetation ecology implies a consideration of environmental relations and their influence on the plant cover.

Research in vegetation ecology is usually divided in to two broad areas, (i) the study of distribution of species and communities and (ii) the study of plant succession and vegetation dynamics. Distribution is a spatial/geographic concept. It relates to the classification and mapping of species and plant communities when it is done in relation to environmental gradients.

A new approach to the study of distributional dynamics called "landscape ecology", focuses on the dynamics of spatial vegetation patterns (Mueller-dombois 1992). A landscape is considered as a mosaic of patches interacting with each other. Landscape is defined as a heterogeneous area composed of a cluster of interacting ecosystems that are repeated in similar form throughout. Like other ecological units it is dynamic in structure, function and spatial pattern. Landscape ecology is the study of spatial variation in landscapes at a variety of scales. It
includes the biophysical and societal causes and consequences of landscape heterogeneity.

Preliminary investigations in field of vegetation ecology were mainly based on distribution of vegetation. Buttrick (1979) sampled vegetation of 151 sites in the alpine area of British Columbia, from which 16 plant communities were recognized. The local distribution of these communities was primarily controlled by topography, snow duration and moisture. Dawe and White (1982) identified nine vascular plant communities on the little Qualicum river estuary, Vancouver Island. Major factors affecting the distribution of the vegetation within the estuary appeared to be site elevation, soil type and texture and inundating water salinity.

Wilson and Bowman (1987) analysed 20 vegetation types characteristics of the coastal northern portion of the northern territory. The mangrove, grassland, forest and woodland communities form a complex-spatial pattern. Vegetation types appear to be principally determined by variations in dry season, moisture supply, wet season and soil aeration. The monsoon climate also influences vegetation distribution by providing conditions suitable for the ignition of dry season fires and generating cyclonic storms. Su (1987a & b) analysed data obtaining from 40 sample stands including 10 environmental factor through Detrended Correspondence Analysis (DCA) and confirmed that altitude and percentage of direct light sky space were important in plant and community distribution in forest vegetation in Central Taiwan.

Grabherr and Mucina (1989) analysed 105 phytosociological relieves of forest of differing vitality in the Vorarlberg region of Austria to determine some air borne pollution induced changes in habitats as well as in the floristic composition of natural woodlands.

Deall et al. (1989a) described the physiography, geology, soil and climate of a broad transect of Eastern Transvaal escarpment in the Sabie area.

Deall et al. (1989b) classified the indigenous vegetation of the Eastern Transvaal escarpment in the Sabie area with the aid of PHYTOTAB program package and found four ecological formation classes based on floristics, physiognomy and climate correspond to 4 data subsets. Floristic analysis of the same area showed the Compositae as the largest family followed by the Leguminosae, Graminae, Rubiaceae and Liliaceae (Deall and Backer 1989). Roberts (1993) described floristic classification of the vegetation of municipal Durban, Natal.
Laine and Vanha-Majamaa (1992) analyzed the plant communities of southern Finland in relation to environmental variables. Result showed that the post-drainage plant communities can be used in site classification.

Ash and Mueller-Dombois (1992) described the vegetation of Fiji island. Study revealed that about 25% of native vascular plant species were endemic out of 1769 native species. Vegetation was predominantly rain forest with mixed species composition Carleton and Arnup (1993) surveyed 170 natural, undisturbed stands of fire origin ranging from 50 to 300 years old using quadrat sampling of fixed area plots. They observed that white pine (Pinus strobus) regeneration was significantly higher on very shallow soils. Floristic composition was more strongly related to stand feature than to stand age.

Yang (1994) reported total of 101 families, 234 genera and 336 species, among which 27 species are rare including a new record Gardenia nutans S & Z from Chachayali Shane Nature Reserve, southern Taiwan. He found that altitude and direct light skyspace are the most significant factors affecting plant distribution and vegetation differentiation. Taft et al. (1995) studied the vegetation and soil data from six flatwoods remnants on the Illinoian till plain. They observed that ground cover, species richness and diversity were inversely related to tree and total woody stem density and tree diversity. Chen(1996) described the forest vegetation of Liukuei. The forest is a typical mountain forest
dominated by trees of Lauraceae and Fagaceae and forest vegetation comprised two major types with seven subtypes based on differences of species composition. The main environmental factor influencing differentiation in the vegetation was altitude.

Shen-Reichen (1996) studied the distribution and synecology of *Bretschniederia sinensis*, considered an endangered species in Taiwan. 117 species of vascular plants were recorded in sampling plots and 4 vegetation types were distinguished. Su (1996) classified tropical forest data set from the Tachiashi valley of central Taiwan using cluster analysis and two-way indicator species analysis.

A phytosociological analysis of the vegetation of the rocky outcrops of the southern free state is presented by Malan *et al.* (1998). TWINSPLAN classification, refined by Braun-Blanquet procedures resulted in 35 distinct plant units within the 2 major communities of Shrubland vegetation of hills and ridges and dwarf shrubland associated with flat area on hill plateau.

On the basis of a review of literature, the taxonomic position and geographical distribution of *Betula platyphylla* and the horizontal and vertical distribution of forest vegetation dominated by *Betula platyphylla* (and its variations) are discussed by Guan (1998). The landscape characteristics is based on an analysis of the landscape composition, fragmentation, patch size, frequency, density proportion, diversity, evenness and dominance are also discussed by Guan (1999).
Apart from this other notable contributions in field of vegetation ecology are of Harrington et al. (1984); Jensen (1997); Abs et al. (1999); Austin (1999) and Malan et al. (1999).

Major investigations related to vegetation ecology in India carried out by Kumar and Shankar (1985) who analysed the vegetation of dry tropical forest type of Guhiya catchments on the Aravalli ranges. The area covered by desert thorn forest. Out of seven grass covers type, three grass covers type higher in successional hierarchy exhibit specific edaphic affinities. Kumar and Shankar (1987) studied the vegetation of Bandi catchment of the upper Luni basin. The area divided into two distinct zones were a forest of Aravali ranges corresponding to the northern dry tropical forest and other two forests on the alluvia and hillocks to the desert thorn forest.

Shankar and Kumar (1988) reviewed the studies on vegetation of Indian arid regions in Rajsthan. Environmental factors, vegetation types and their successional status have been briefly discussed. Different classical approaches used for vegetation description and classification in India are reviewed. Based on a study of 26 interdunal plains in Jaisalmer district, it is shown that multivariate anlaysis and ordination techniques are most appropriate for summarizing spatial heterogeneity and temporal variability in plant communities. Sharma (1988) classified and ordinated the herbaceous and perennial woody species of Kailana catchments. TWINSPLAN showed 13 site classes and 25 species classes for herbaceous
vegetation and 30 site classes and species classes for perennial woody species. Kumar (1990) reviewed the vegetation ecology of the Indian deserts and different aspects related to their status and challenges.

Kunhikannan (1999), reported five forest communities from Tadoba National Park, Chandrapur, Maharashtra, reporting 741 plant species belonging to 427 genera and 115 families.

Oosting (1956) described phytosociology as one of the major aspects of vegetational study. In general, phytosociology is defined as study of composition, development, geographic distribution and environmental relationships of plant communities (Mueller-Dombois and Ellenberg, 1974).

Poore (1962) considered that vegetation is not a random assemblage of individuals of many species but these plants are associated in community with a definite structure and often in a regular specific composition. A plant community is understood to be a more or less stable combination of naturally occurring species which are in ecological equilibrium with one another and their environment.

Curtis and McIntosh (1950) worked out the mathematical interrelations of certain phytosociological characters by sampling an artificial population and degree of randomness of species on these interrelations. Curtis and McIntosh (1951) came out with the concept of importance value. They considered the floristic composition, layering, structure, physiognomy function, periodicity and inter-specific correlation as some of the more useful characteristics for vegetation
description at an extensive level. Total of importance values occupied by the most important species is a function of the amount of disturbance and are inverse function of species richness (Campbell, 1994).

There are several methods to identify the communities in a vegetation or stand. Mueller-Dombois and Ellenberg (1974) opined that identification of communities can be achieved through the variations in the homogeneity or uniformity of the vegetation cover.

Communities are mainly classified according to the difference in dominant species whose abundance, size, or other attributes exert a major influence upon other species occurring in same locality. Classification of communities is hierarchical, the highest level being the subdivision of world vegetation into recognizable physiognomic categories, or biomes (Weaver and Clement, 1938).

Some ecologists prefer Braun-Blanquet’s (1965) method for large scale survey. In this method, a sample is chosen subjectively within a community that includes all major species and that is as uniform and homogeneous in plant cover as possible. The major drawback of this method is the subjective selection of samples which gives no indication of heterogeneity in the vegetation and leads to the impression of distinct communities whether they exist or not because of selection criteria.

Whittaker (1962) and Walter (1971) preferred more objective techniques which involve the random selection of samples. The use of various statistical procedures is common to test the similarities between these samples and thereby identify and classify communities. These
techniques account for heterogeneity and commonly used more precise counting methods than does the Braun-Blanquet method.

The concept of importance value index has been developed in order to express the dominance and ecological success of any species in single value. Forest with a tree species whose dominance is 40 or more is called single dominant forest.

Data for phytosociological analysis can be obtained from different methods of sampling. All methods are specific to objectives of the study, topography, types of vegetation etc. (Mishra 1968, Curtis and Cottam, 1956, Mueller-Dombois and Ellenberg 1974, Barbour et al. 1987 and Kent and Coker 1992). Because of the obvious relationship of species to area, several investigators have attempted to standardize the size of quadrat used for different layers of vegetation where certain species dominate. Cain (1932) has suggested different sizes of study units in ecological studies. Quadrat sizes are 0.01 or 0.1 sq.m (For soil layer i.e. cryptogams dominated layer), 1.0 to 2.0 sq. m (herbaceous Layer), 4.0 sq.m (Low Shrubs), 16.0 sq m (tall shrubs and low trees) and 100.00 sq.m. (Superior layer of forests). The minimum size of quadrat may vary according to the objective of the study or type of vegetation. Nautial et al. (1987) standardized the quadrat size for deciduous forest as 400-900 sq. m. for trees, 9.25 sq.m. for shrubs and 0.25-1 sq. m. for herbs.

Phytosociological investigations in forest of India have been carried out by a number of workers. Studies on various aspects of sal forests in different parts of India were done by a number of workers (Tewari, 1967;

Phytosociological studies of different forest vegetation were conducted by Vyas, 1964; Gaur and Satyanarayan, 1967; Menon and Shah 1982; Singhal et al., 1986; Singnal and Sharma, 1989; George and Varghese, 1986, 1989 and Sanjayan et al., 1995.

Forests of Garhwal Kumon and Central Himalayan have been investigated for the structure and composition by a number of workers (Saxena and Singh, 1982; Tiwari and Singh, 1985; Rana et al. 1985; Joshi and Tiwari, 1990; Agarwal et al., 1991; Nayak et al., 1991; Rajwar and Gupta, 1992; Rajwar and Dobhal, 1991; Pathak et al., 1993 and Raizada et al., 1998).


Phytosociological analysis of mines of Solan district was performed by (Panwar et al., 2000a&b).

A plenty of literature on different aspects of M.P. forest is available. Pandey et al. (1988) carried out ecological study of grasses in relation to phenological stage in Kanna National Park. Lal (1988) studied forest communities in Bandhawgarh National Park and Tala forest range.

Saxena et al. (1992) analysed the vegetation of fourteen forest site of Panna in Kaymore plateau along an altitudinal gradient. They identified three forest types on the basis of IVI. Rao and Mishra (1994) studied floristic composition, species diversity and some quantitative characters of various constituent tree species of Chitrakoot and Ghunghuti forest.

Forest of Sagar district have been investigated by a number of workers. Mishra and Joshi (1952) recognized seven types of forest communities from Patharia hill, Sagar. They described sociological data for the tree, shrub and herb layers together with the habitat factor for each type and a scheme showing the succession in the forests is also discussed. Pandey (1954) studied grasslands of Sagar. He observed that exchangeable calcium to some extent determine the distribution of associations of grasses. Themeda caudata occupies soil with moderate amount of exchangeable calcium. Eulalia-Cymbopogon appear to love lime rich soil, whereas Heteropogon contortus appear to evade them.

Bhatia (1958) analysed the vegetation of a mixed deciduous teak forest of Central India at Sagar. He recognized 4 types and 11 sub types of forests on the basis of co-dominant species.

Mishra (1961) has studied the forest communities of five different forests of Sagar in relation to the underlying rock and soil type occupying
different physiographic units. Athaya (1980) analysed the vegetation of eight forest sites around Sagar and found it heterogeneous in their vegetational composition, density and extent due to extreme biotic interferences. Khare (1981) studies on structure and composition of Gopalpura forest and natural regeneration of forest trees at six forest sites around Sagar.

**Species diversity**

Diversity is considered as one of the important community characteristics. Simpson (1949) introduced a concept of diversity index to indicate vegetation abundance. Shannon and Wiener (1963) emphasized diversity index as a proportional abundance of species out of total species. Index of diversity based on information theory was introduced by Margalef (1963). McIntosh (1967) desired that an index of diversity, based on different reasoning closely related to Simpson Index. Peet (1974) quoted that Shannon index accorded more than general concept of diversity. However, the opinion of Hill (1973) was that different measures of heterogeneity would differ in their response to change in relative abundance of rare and common species.

On the basis of plant community, stand position and composition, Whittaker (1960) distinguished three types of diversities. Alpha (α) diversity refers the species diversities within individual communities or habitats; Beta (β) diversity refers to relative extents of differentiation of communities along topographic gradients; and Gamma (γ) diversity is
diversities of vegetation patterns, resulting from both alpha and beta diversities.

Tropical forests are regarded as the richest in biodiversity because conditions for evolution is generated by species interaction such as competition and niche diversification, which are greatly manifested in the tropics due to high humidity and temperature. Higher rainfall and temperature which are features of tropical environment have been said to be responsible for diversity of tropical forests (Richards, 1952). Deshmukh (1986) reported that variation in temperature and rainfall has direct effects on species diversity. Gentry (1982) observed in neotropics that tree species richness declines from around 150 species at 3000 mm to 50 species at 1000 mm mean annual rainfall.

Studies on plant diversity have been conducted by various workers in different forest ecosystems throughout the world. Monk (1967), Risser and Rice (1971) reported diversity indices ranging from 2 to 3 for temperate forests. Knight (1975) estimated diversity index values for tropical forests ranging from 5.06 to 5.40. Hubbell (1979) summarized the patterns of tree abundance and dispersion in a tropical dry deciduous forest. Whittaker (1975) proposed the niche preemption hypothesis for dominance-diversity curves, showing to the geometric forms of the dominance-diversity curve by vascular plant communities of low diversity. Elton (1958) mentioned that species rich ecosystem are more resistant to invasion than species poor ecosystem. Removal or loss of
some key stone species collapses the ecosystem functioning (Ellenberg, 1988).

In recent years the important contributions in this field are those of Austin (1999), Vasander et al. (1997), Myers et al. (2000), Pachepsky et al. (2001) and Burslem et al. (2001);

'Species diversity and vegetation structure in tropical dry deciduous forest ecosystem in India have been studied in detail by several workers (Shah et al. 1978; Shah and Bhatt, 1980; Verma and Das, 1981; Banerjee and Lal, 1985; Sharma et al., 1986; Agrawal et al., 1991; George and Varghese 1993). Khare et al. (1989) studied the plant communities in Central India with two level ordination. They observed the difference in spatial distribution of plants are due to underlying rock formation and soil conditions. Gogate and Anmolkumar (1993) reported that species diversity is higher in teak plantation at Chandrapur than in an adjacent natural forest (Tadoba National Park).

Srivastava (1986) measured the species diversity and their dominance in two man made forest viz., Chir and teak plantations in demonstration area of F.R.I., Dehra Dun. There was inverse relationship between concentration of dominance and species diversity. Agrawal (1992) stated that the species diversity is very useful parameter for comparison of two stands or communities especially to study the influence of biotic disturbance and/or state of succession and stability in the community. Singh and Singh (1985) found lower diversity and
consequently greater concentration of dominance in montane temperate vegetation of Himalayas.

According to Parthasarathy and Karthikeyan (1997) mostly species richness, diversity and density decreased with increasing girth-class, except for the greatest girth class. Pandey and Shukla (1999), studied plant diversity and community pattern along the disturbance gradient and found the relative density of leguminous shrub decreased along the gradient and the trends of dominance and $\beta$ diversity were reverse to that of $\alpha$-diversity along the gradient. Semwal and Bhatt (1997) quantitatively analysed woody vegetation of central Himalaya and found that the diversity and concentration of dominance to total vegetation varied from 1.457 to 2.955 and 0.131 to 0.648 respectively.

Analysis of species diversity of plantation raised on degraded Bhataland was done by Verma (2000). Khatri (2000) analysed species diversity of trees, shrubs and herbs in three plant communities corresponding to different elevation ranges in Satpura National Park. Diversity analysis of tree species carried out by Chauhan et al. (2001), showed that the species diversity (H) ranged between 0.09-2.27 and evenness ranged between 0.02-0.84 in sal forests of Doon Valley. Pandey et al. (2001) studied species diversity in moist temperate forest of Kedarnath forest division (Garhwal Himalaya). They observed range of Shannon-Winher index as 1.26-2.09 for trees : 0-2.49 for shrubs and 1.45-3.0 for herbs.
Kushwaha and Kumar (2002) compared species diversity and index of evenness for eight protected areas of M.P. The maximum value (2.505 and 2.511) was found for Madhaw National Park and the minimum value (1.717 and 1.763) for Panchmarhi Wildlife Sanctuary. Singh (2002) summarized the different aspects of biodiversity.

Pandey et al. (2002) studied species diversity in a western Himalaya forest of Chakrata forest division (Uttaranchal). They observed that Shannon-Wiener diversity Index was higher for trees which belong to higher altitudinal zone. Murthy et al. (2002) compared diversity index in less disturbed and disturbed forest and plantation in Uttara Kannada district, Western ghats. Arunachalam (2002) studied species diversity in two different forest types of Western ghats and observed that Shannon-Wiener index was greater for trees followed by ground vegetation and shrubs in evergreen forest.

**Floristic composition**

Floristic composition is one of the important analytical characteristics of vegetation. Floristic richness of an area gives the design and functioning to the natural communities and also add to complete understanding of the pattern and process of their structure. The richness of an area however, depends upon the type, quality and stratification of its vegetation. Thus floristic richness of a region is closely related to its vegetational diversity (Whittaker 1972). According to Dansereau (1960), each species in a community has its own ecological amplitude and has particular relationship to the environment and also to the associated
species as well. Bliss (1962) reported that nature of a plant community is determined by the species that grow and develop in that particular environment.

Hooker and Thompson (1855) investigated the floristics and distribution of various taxa of India and divided the flora into 17 botanical provinces. Champion and Seth (1968) recognized 16 major forest types in India considering climate as the main factor.

In India, a total of 15000 species of flowering plants have been identified but only a few thousand species have been studied to a reasonable extent (Thomas, 1992; Jain 1990). Floristic diversity of India is very rich and about 30 per cent plant species being endemic. The largest number of endemic and endangered species occur in 24 critical plant sites which may be termed as micro hot spots (Nayar, 1997).

Important contribution regarding floristic and distribution of various taxa have also been made by Haines 1916; Collet 1921; Osmaston 1927; Bor 1953, 1966; Cooke 1967; Talbot 1976; Oomachan 1976; Shah and Yadav. 1979; Rajwar and Gupta 1981; Stebbing 1982; Dhar and Kachroo 1983; Sharma 1990. Uma Shankar (2001) identified 959 species belonged to 42 families in Mahananda Wildlife Sanctuary, Darjeeling.

Ganeshaiah et al. (2002) compiled the data on floral resources of Karnataka. They showed that Karnataka harbours 4758 species from 1408 genera and 178 families and accounts for about 27 per cent of the country's floral diversity.
Biological spectrum

Plants are classified taxonomically into families, genera, species, varieties, etc. This however, is not the only way to classify plants. Species and individuals can be grouped into life form or growth form classes on the basis of their similarities in structure and function. A plant life form or growth form displays an obvious relationship to important environmental factors.

The composition of life forms in addition to the composition of species in a plant community is of special interest as it may give information on the response of a community to particular environment.

The concept of life form was formulated by Humboldt (1806) and he used the term vegetational forms for it. However, many different classifications of plant life forms, 'growth forms' or 'basis forms' have also been developed. Lacza and Fekete (1969) and Fekete and Lacza (1970) have reviewed this aspect. Detailed extension of Humboldt's scheme was presented by Ginzberger and Stadlmann (1939). The dependence of plant form upon climate was proved by Grisebach (1844). Life form classification system of Drude (1897) and warming (1909) contributed many of the essentials for modern systems. Rubel (1930) has introduced the relation of plant behaviour characteristics in favorable season. In vegetation research, Raunkiaer's life form system (1934,1937) and its further extension by Braun Blanquet (1928) and Ellenberg and Mueller-Dombois (1967), has found widest application. Raunkiaer's system is ecologically oriented and based primarily on the position of buds or
organs from which new shoots or foliage develop after an unfavorable season.

Raunkiaer (1934) believed that the flora of a given tract of a country is an exact indicator of its climate. He distinguished three main types of phytoclimates on the earth, which include phanerophytic climate in tropics, therophytic in desert and hemicyrtophytic in greater part of cold temperate zone.

Meher-Homji (1964) proposed five criteria viz., climate, ephemonic, floristic, vegetational and agronomic, based characteristic of aridity or humidity of a region. Meher-Homji (1981) compiled the life form spectra from different parts of India and suggested possible relation with the environment of those regions. He observed that the life forms of different regions of the country are reflected by the bio-climates of the area and accordingly he found the flora as phanerophytic in humid regions, therophytic in arid regions and therio-chamaephytic in semi-arid regions. Barucha and Dave (1944) pointed out that high percentage of therophytes is an indicator of the amount of influence of men and animals. Mishra and Puri (1954) also stated that the intense human exploitation reduces phanerophytic flora into therophytic one. Thus a kind of biological spectrum is a general guide to the degree of biotic exploitations. Singh (1995) studied biological spectrum of Munger district where therophytic forms were found abundant. Pandeya (1954, 1964) employed the biological spectrum to estimate the intensity of grazing in the grassland of Sagar. He observed that the life form of each association
is maintained by extent of grazing; the percentage of geophytes and therophytes is about four times higher than in normal spectrum; and the highly therophytic character of the grassland is not only due to periodic climate but also due to grazing which makes vegetation open for further invasion of animals.

Verma and Das (1980) used the relative values of quantitative vegetational characters (R.F., R.D. and R. Dom) to compute the spectrum and yielded fruitful results with better expression of vegetation rather than the spectrum prepared according to Raunkiaer's system. Shrivastava et al. (1981) while studying the marshy grassland reported that the grassland is dominated by hemicryptophytes and chamaephytes. The higher percentage of formar may be due to the abundance of moisture which is more congenial to perennial growth of species. According to them, the higher percentage of therophytes may be due to the biotic interference in the marshy grassland like grazing by animals and scarping by man.

Ghildiyal and Srivastava (1990) reported that the marshy grassland of Rishikesh is dominated by therophytes, cryptophytes (hydrophytes and geophytes) and chamaephytes. They assigned reasons for more number of therophytes which are due to biotic disturbances like grazing, browsing, lopping and felling of tree by man. The dominance of phanerophytes in normal spectrum, which is characteristic of tropical vegetation (Raunkiaer, 1934) occupies the second position in Rishikesh,
higher percentage of cryptophytes may be due to higher availability of moisture in that area.

Dayama (1987) reported 54% therophytes, 27.7% phanerophytes, 13.3% chamaephyte and 4.4% hemicryptophytes in Bichoone area of Jaipur. Agrawal and Paul (1996) reported dominance of phanerophytes and geophytes in Chhotanagpur flora. Sharma and Dhakre (1993) studied the biological spectrum of Shahjahanpur district U.P and reported that the therophytes and nannophanerophytes showed maximum divergence from the normal spectrum. The phytoclimatique of the area may be called as theroph-nanophanerophytic. Therophytes constitute half of all life forms in the area. Rajendra Prasad et al. (1998) reported that the biological spectrum of Sacred groves of Kerala coincide with normal spectrum of tropical rain forest, except in the case of therophytes indicating that the vegetation actually stands as a relic of the tropical evergreen forest. Reddy et al. (2002) reported that biological spectrum of Marriguda Reserve Forest is phanerophytic. The dominance of phanerophytes is due to high rainfall, temperature and low biotic pressure.

Biological spectrum from the deciduous forests of central Indian region has not been worked out in detail. However, Khatri (2000) has examined the vegetation of Panchmarhi Hills which shows a mixed vegetation of dry, moist and subtropical climates.
Vegetation profile

Profile diagram is a pictorial representation of the structure and vertical stratification of the vegetation (Misra, 1968). Profile diagram is used to illustrate details in vertical spacing of species, which are not representable in layer diagrams (Mueller-Dombois and Ellenberg 1974). Davis and Richards (1933) were the first to present a systematic method for profile construction by the single plot method. Their profiles were based on the measurement of trees within the suitable plot, usually 200x25ft (61x7.6m) or 400x25ft. (122x7.6m) in size and selected as representative of the forest. In addition to tree size it was possible to obtain other structural data from these plots, e. g. the per cent of tree species or individuals with buttresses, thorns, mesophyll leaves, evergreen leaves and other morphological features. Another method for construction the profile diagram and obtaining structural data is the distance method described by Knight (1963).

The usefulness of profile diagrams and structural-functional data has been recognised by several ecologists (Beard, 1941,1955; Burges and Johnson, 1953; Dansereau and Lems, 1957, Keay, 1957; Webb, 1959; Fosberg, 1961; Legris, 1961). The length and width of the plots used in the construction of profile diagrams depends on the size of the dominant plants, their density and their structural variability. Loveless and Asprey (1957) found that a plot 30x5m (99x16.5ft) was adequate for the scrub thicket vegetation of Jambia and even smaller plots or line transects may be used in shrub and grassland vegetation. Beard (1946) used an actual
typical strip of forest, 200 ft (61m) long and 25 ft (7.6m) deep to show the structure of Mora forest.

Ralhan et al., (1982), prepared the profile diagram of forest vegetation of Naini Tal. Sharma and Shankar (1990) constructed the profile diagram of watersheds at Kailana catchment of Thar desert in India. Visalakshi (1995) made profile sketches of two tropical forests viz. Marakkanam Reserve Forest (MRF) and Puthupet Sacred Grove (PSG) in the Coromandel coast of India and showed that the canopy trees are few. The forest formation is almost open in MRF, whereas in PSG the forest showed overlapping growth pattern of various trees. Cao et al., (1996) constructed the profile diagram (100x10m) of the seasonal rain forest in Xishuangbanna southwest China. Studies on vegetation in Indian forests mostly lack the vegetation profile and therefore literature on analysis and interpretation on the above aspect is meagre.

**TWINSPAN (TWO-WAY INDICATOR SPECIES ANALYSIS )**

Looking to the complexity of data analysis and increasing number of variables it is very difficult to find out the grouping of sites as well as species. In this context, a number of programmes have been developed. Among these, TWINSPAN is one of the most popular analytical one.

TWINSPAN is a computer program developed in Cornell Ecology Programs series (CEP-41), by Hill (1979). TWINSPAN is a FORTRAN program for two-way indicator species analysis, which is an improvement upon the original indicator species analysis. In Hill et al., (1975) species
are classified so are the samples. New program is much more flexible than previous program.

The most significant feature of new program is that it first constructs a classification of the samples, and then uses this classification to obtain a classification of the species according to their ecological preferences. The two classifications are then used together to obtain an ordered two way table.

The use of TWINSPLAN program has been done by various workers for the classification of vegetation throughout the world. Shankar and Kumar (1988) studied on vegetation of 26 interdunal plains in Jaisalmer district. TWINSPLAN revealed 9 site classes and 6 species classes. Kumar (1992) sampled 251 sites for analysis of perennial vegetation, TWINSPLAN revealed three site classes and four species classes, both arranged along a gradient of soil texture. Vegetation of 127 sites on different aspects of dune-interdunes in the Indian Thar Desert was classified using TWINSPLAN by Kumar (1996). The TWINSPLAN classified 127 sites into 26 site classes and 29 species of these sites into 11 species classes. Khan (1996) classified tropical dry deciduous vegetation of Gir Lion Sanctuary and National Park Gujrat. The vegetation was sampled at 240 sampling points and TWINSPLAN produced 23 groups of plant species for whole of Gir. Dixit (1997) analysed the vegetation on proposed Narmada Sagar project in Khandwa district of M.P. which will submerge 403.32 km² of forested area after its completion. From this area 11 species associations were identified using multivariate classification technique, TWINSPLAN.
Rawat and Bhainsora (1999) studied the woody vegetation of Shivaliks and outer Himalaya using stratified random plots. The TWINSPLAN analysis segregated 17 groups of tree associations with eigen values ranging from 0.216 to 0.279 which largely follow increasing rainfall and moisture gradient.

**Physico-Chemical properties of soil and soil plant relationship:**

A lot of literature is available on physico-chemical properties of soil and soil plant relationship.

Soils developed on the same parent material under similar climatic conditions have marked variation in morphological characteristics due to topography. Red soil are always situated at the top of landscape and black soils in valley with transitional yellow and brown coloured soil between them (Gawande 1963). Similar observations on slope soil relationship are also reported by Jyotyprakash (1968), Bhattacharjee et al. (1971) and Gaikwad et al. (1974). Physiographic position of the land play very significant role in the formation of soil profile. In an undulated landscape where the parent material and climate are more or less the same, topography and consequently the external and internal drainage conditions may largely change the properties of soils as a result a very conspicuous difference in soil profile on ridge top, on the slope and on the valley floor may result. In fact the characteristics of soil profile have clearly shown the effect of toposquence on the physical and physico-chemical properties of the soil and the mineralogy of clays on ridge top, slope and in the valley (Biswa et al., 1966; Gawande and Biswas, 1977).
Singh et al. (1993) studied the soils in the toposequence of central Himalaya and observed that physiography was the major soil forming factor affecting physical, chemical and mineralogical properties. Minchas and Bora (1982) studied the effect of altitude on the soils and reported that with the increases in the altitude, the organic carbon and the total available ammonium and nitrate increased, while pH and CaCO$_3$ of the soil decreased. Gaikwad et al. (1986) reported that the land form and elevations affect the depth, colour, slope erosion, physico-chemical properties of soil and thereby the land use. It was observed that different types of land forms have pronounced effect on soil properties. Change in slope affects runoff, erosion, drainage, vegetation and land use which indirectly affect soil properties like texture, pH, electrical conductivity (EC) and base saturation. Kumar and Tripathi (1987) reported that with decrease of elevation and slope, the soil texture become finer and there was increase in water retention capacity and infiltration rate.

Level of organic matter in soil is influenced by climate, topography, parent material, vegetation, organism and time (Jenny 1941). Organic matter in soils has a pronounced beneficial effect on soil management and crop production (Allison 1973).

Pandhare et al., (1974) studied soil moisture characteristics in different soil and observed that available soil moisture range is low in sandy clay loam and is high in clayey soils.
Khare and Mishra (1981) studied on effects of three soil types on seedling performance in *Butea monosperma* and observed that growth performance better in pure black soil.

Changes in soil characteristics influence the growth of many plant species. A striking relationship between vegetation cover, soil and geomorphology was noticed in DehraDun valley (Dhar and Jha, 1977). Sal thrives best on soils derived from Shivalik sediments whereas khair, shisham and bamboo grow on gravel stream beds. General distribution of sal in M. P. is governed by climate and rainfall (Khan 1953). Bhatnagar (1961) reported that local distribution of sal may be governed largely by condition of geology and soil. Totey et al., (1986) attempted to study performance of sal on soils derived from different parent material/rock in Shahdol forest division Madhya Pradesh. According to phytosociological consideration communities like *Shorea-Madhuca, Shorea-Terminalia, Terminalia-lagerstroemia* and *Terminalia-Boswel*ia were found on sandstone, deccan trap and lime stone respectively. *Shorea robusta* has maximum frequency, density, basal area and also IVI on soil derived from sandstone and minimum on soil derived from lime stone. Sal prefers soil low in pH (5.4 to 6.5), electrical conductivity (< 0.1 mmhos cm⁻²), exchangeable Ca (3 to 10 m g/ 100g. ), exchangeable Mg (1 to 4 m g/100 g) and low in CEC (6 to 20 meq/100g ).

Dolui et al., (1985) studied physico-chemical characteristics of some laterite soils under forest floor in toposequence of west Bengal. Chemical composition of these soils has been influenced to a great extent
by drainage condition, differential transport of eroded material, leaching
translocation and redeposition of mobile soil constituents. Das et al.
(1980) studied genesis of red and lateritic forest soils of West Bengal.
These soils were found to be related to the elements of landscape,
microclimate, water table, vegetation, erosion, deposition or combination
of these influenced formation of these soils.

Singh and Totey (1985) studied the physico-chemical properties of
bhata soils of Raipur. They observed that there is a maximum increase in
exchangeable cations and organic matter in the soil under miscellaneous
plantations followed by Tectona grandis, Emblica officinalis and
Eucalyptus hybrid. Maximum girth in the study area was attained by
Cleistanthus collinus, followed by Emblica officinalis, Azadiracta indica,
Tectona grandis and Eucalyptus hybrid etc.

Singh et al., (1987) studied soils of lateritic belt of four ecosystem
in West Bengal supporting different vegetation communities. A significant
positive relationship was observed between organic carbon and calcium,
organic carbon and magnesium, calcium and magnesium under the
forests dominated by Tectona grandis.

Rawat et al. (1987) studied vegetation and soil relationship in the
community forest of Machhland subwatershed, Garhwal. They observed
silty to silty loam soil texture in the community forests having temperate
species and silty to silty clay loam in Shorea robusta forest. The highest
values of exchangeable Mg were found at site dominated by Shorea
robusta followed by Cupresus torulosa and Cedrus deodara whereas no
significant variation was observed in the level of exchangeable Mg in the site dominated by *Pinus roxburghii* forest and monospecific forest of *Quercus leucociphora*. Exchangeable K was high in site dominated by *Pinus roxburghii*.

Sundriyal *et al.* (1987) studied vegetation composition of grassland of Garhwal, Himalaya as related to soil profile and seasonal variation. The composition of grassland changed with altitude. Biotic factors like grazing, cutting and burning had considerable impact on the grassland.

Totey *et al.* (1988) studied impact of forest cover on soil of Risgoan range, Raipur. Soil pedon under pure sal, sal with mixed tree species and only mixed species covers, were studied. Soils formed under pure sal forest were very deep in nature having intensive weathering activity. The soils were poor in exchangeable Ca, organic matter but high in exchangeable potassium and sodium. Weathering activity was not of intensive nature under sal with mixed cover and purely mixed cover. These soils were found to be moderately deep to deep with higher organic matter content. Both the soils were found to be rich in exchangeable Ca, Mg, total exchangeable cations and cation exchange capacity but poor in exchangeable potassium.

Influence of teak plantation on soil studied was by Namdeo *et al.* (1989). Soils under teak plantation were found to contain high level of organic matter, pH, electrical conductivity, exchangeable Ca, Mg, Na, K and total bases. Teak soils showed high degree of base saturation. They concluded that soil nutrient status was improved under teak plantations.
Sharma and Shankar (1990) have studied vegetation habitat and soil variations in GS (gentle slope) and MS (Moderate slope) group of watersheds at Kailana catchment. The watersheds in SS (steep slope) group were almost devoid of soil cover. Soil texture in GS group was sand to loamy sand while in MS and SS group in middle and upper slopes it was fine sand to silty clay loam and rich in organic content. *Euphorbia caduifolia*, *Grewia tenax* and *Barleria acahanthoides* were most common woody species recorded from all the watersheds.

Distribution of organic matter in some representative forest soils of Bangladesh was studied by Hassan and Mazumdar (1990). Organic matter was found to be high in forest soil of terraces and hills as compared to esturine flood plain soils and agricultural lands. Further, in the well drained profiles of terraces and hills, organic matter had undergone homogenization to a greater depth and decreased regularly from surface downward.

Ram et al. (1993) studied the physico-chemical attributes of the soils under different forest stands. Soils under natural forest and teak were distinctly superior in structural stability to soils under sal. The physico-chemical properties of soil were found to be greatly influenced by vegetational growth at their respective sites and vice versa.

The inter-relationships of geology, soil and vegetation of Kansar range in Chakrata division were studied by Raina et al. (1994).
Investigation revealed that basal area of *Cedrus deodara* increased with increasing calcite content and decreased with increasing dolomite content.