BULL. BOT. SURV. INDIA
Vol. 4, Nos. 1-4; pp. 113-118, 1962

THE SCIENCE OF VEGETATION WITH REFERENCE TO INDIA

R. MISRA
Banaras Hindu University, Varanasi—5

ABSTRACT

Pt. I

Vegetation is the sum total of plant population covering a region and its descrete units circumscribed by characteristic environment, are communities. The species content is the flora. The physical and the biological surroundings characterise the environmental complex. Both plants and their environment are dynamic systems interacting within and with each other. The amplitude of variations in the environment is generally met with synchronised adaptive responses of the plants in time and space. Differentiation of ecads and ecotypes within the plastic species is the result. However, many forms and invaders may get eliminated also if the situation goes beyond their range of tolerance set by the genetic organisation as the factors may become critical at different stages of the life-cycle. The species around provide the genetic material for recruitment and ecesis within the community.

Pt. II

Migration of species involving mobility of disseminules, their germination, aggregation, competition and final ecesis—ever continuing processes lead to colonisation and invasions. All these plant phenomena react upon the environment introducing changes therein. Thus newer community—environment—complex equilibria are set up in the dynamic system. The whole process is called, succession in relation to time and the series of succeeding communities for a given area, a sere. When it happens 'de novo' with no trace of plant present originally in the area, it is prisere as a result of primary succession and subsere with disturbed communities in which secondary succession is the rule. The mechanism of succession is driven by the reacting and changing environment consequential largely either to the plant processes themselves or to extraneous forces succession is autogenic in the former and allogenic in the latter case. In every case succession terminates into a more stable climax community generally dependant upon the climate and soil. The taxa used for classifying communities differ widely among ecologists but association is the basic unit accepted by all, though with varying concepts. The concept of ecosystem in relation to energy and matter within the community is the most acceptable basis for comprehending vegetation types in India.

Pt. III

Since vegetation evolves out of the flora floristic regions of India should form the basis of its main divisions. For this purpose three main latitudinal belts viz. (1) Eastern and Western Himalayas, (2) Assam, Gangetic Plains and Rajasthan, and (3) Deccan and Malabar are recognised. The seven provinces with their distinct climate including photoperiod can be individually considered for the description of vegetation types along gradients of altitude, humidity-aridity, history and proximity of human settlements and soil fertility. Along these gradients closed, open and desert types of structure within forests, scrub and grass can be described with their combinations wherever necessary. Physiognomy, structure, function, composition, dynamics, habitat relations and history are the important diagnostic criteria of vegetation types. Size, texture and seasonal behaviour of leaves of dominant species may also be given. The hydrophytes can be described in each place as floating, suspended, submerged anchored, floating-leaved anchored and emergent anchored.

PART I

GENERAL PRINCIPLES

The collective and continuous growth of plants in space is called vegetation. Discrete units of vegetation known as plant communities are recognised by their physiognomy, structure, flora and environmental characters. The phenomena of vegetation are studied in ecology and plant geography. Synecology and plant sociology explain the origin, development, structure, reproduction and environmental interrelationships of plant communities and autecology deals with the ecological life-history of the component species. The history and principles of migration of species are studied in plant geography.

Vegetation is the totality of plant growth including large or small populations of each species intermixed in a region, whereas *flora* is the species content of the region irrespective of the numerical strength of each species. Plant communities are described and flora is listed. Flora and vegetation are interdependent through the environment and are mutually reactive.

The environment is a complex system of physical and biological factors operating in the media of plant growth. The elements of the climate, viz., temperature, light, rainfall, humidity, wind, etc., the physiographic factors of exposure, erosion, deposition, silting, etc., the edaphic factors of mineral and organic particles, salt solution, soil air and microorganisms and the biotic factors of human, animal and plant to plant relations are in constant flux throughout days, nights, seasons and years. The various factors are inter-linked and their temporal and spatial variations always present newer situations. The dynamic environmental complex works as a sieve selecting plants for growth from a bewildering array of plant forms on account of one or other factor becoming critical at critical stages of the life-cycle of the plant or vegetation. Nevertheless, the factors work conjointly and the environment is to be considered as a whole. This is the holocoenotic approach of understanding the environment. The temporal and spatial differences in the environment may present separate sets of microenvironments to the different plant organs or parts of vegetation.

Now turning to the habit and behaviour of plants towards the environmental factors we have to analyse discrete plant populations recognised as species. The species is a uniform interbreeding population spread over time and space. The uniformity in structure, function, reproduction, growth and development is maintained by the genes located within the chromosomes and hence the species preserves its own stock of genes. The system within the population reacts to the environment through the protoplasm and adjusts itself structurally and physiologically according to the degree of its plasticity set by the genic constitution (Fig. 1). The various forms arising by virtue of somatic plasticity as reaction to environmental changes are called 'ecads'. But the critical conditions of the environment limit the distribution of the species either on ecological or geographical level. Thus within the ecological amplitude of the species there is an area or regime of easy life and a marginal area of not so easy life wherein ecads may arise. The concept of habitat is based on the most favourable factors of the environment such as moist and shaded substratum for a moss.

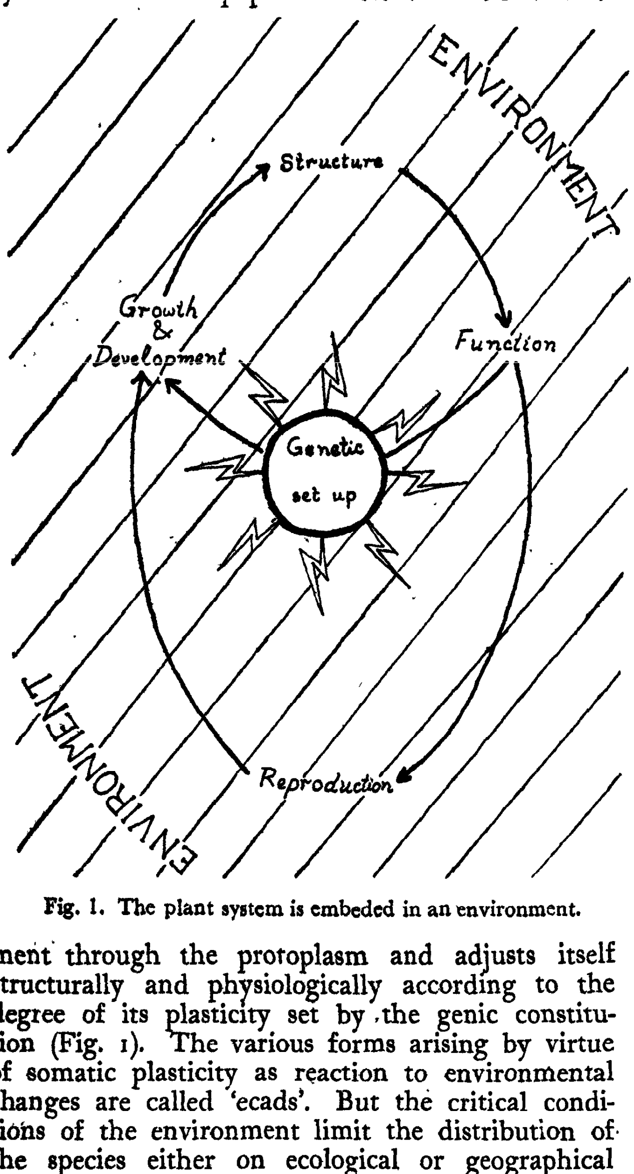

Fig. 1. The plant system is embeded in an environment.

The requirements of germination, growth, flowering, fruiting, leaf fall, etc. of the species are met with at the same place, but at different times of the year. There is so much synchronisation of the phenological behaviour of the species and the several elements of the environment that the plants are spoken of as biological clocks (Fig. 2). If we can comprehend the number of possible combinations of the two variables, i.e. plants and environmental effects, we may have some possible estimate of the number of species that may be accommodated in an area. Perhaps the saturation point is nowhere reached.

But the species are known to extend over diverse habitat and territories by reorganisation of the genes during the process of sexual reproduction. Combinations and recombinations of genes, mutation and polyploidy are conjuring up variety of genotypic forms within the species population. Of the various biotypes thus produced and dispersed in different habitats, some may be better equipped to utilise the available resources of the environment. A part of the complex population may thus be isolated by specific habitat factors giving rise to 'ecotypes'. Ecotypes of the species growing together on marginal areas interbreed and produce fertile offsprings of intermediate characters. Since differentiation of ecotypes results from the discriminating selection offered by unlike habitats, the ecological amplitude of the species as a whole becomes much extended through them. Ramakrishnan (1961) has shown by transplant and breeding experiments such ecotypic differentiation in *Euphorbia thymifolia*, *E. hirta* and a number of other plants. These genetically distinct races may be isolated by one or more of habitat factors thus giving rise to climatic, edaphic and biotic ecotypes.

The ecads and the ecotypes extend the range of plant tolerance and by their migration and invasion to newer areas they change the character of the vegetation in time. Many of the species seem to possess populations preadapted for wider distribution. This would explain the introduction of many plants in India in recent times such as *Croton sparsiflorus*, *Xanthium strumarium* (through its photoperiodic ecotypes —Kaul and Misra—1957), *Euphorbia species* (through edaphic and biotic ecotypes—Ramakrishnan—1958) and many of the weeds. Some of our wide-spread trees may have a number of latitudinal or photoperiodic ecotypes.

PART II

THE DEVELOPMENT OF VEGETATION

During their migration the disseminules of species from neighbouring areas colonise fresh areas provided habitat conditions are suitable. If the fresh area is completely devoid of plant life, the colonists happen to be the pioneer species which by their growth react upon the habitat factors and change

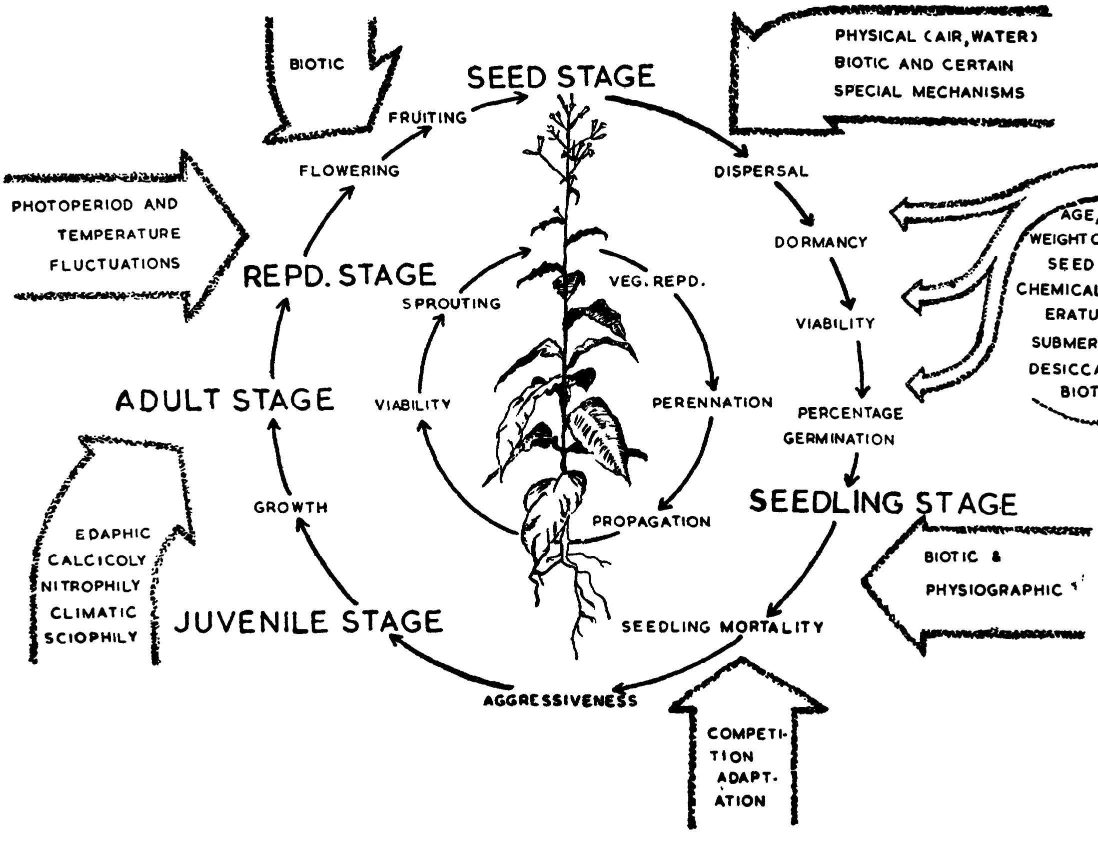

Fig. 2. Ecological life history of the plant. A biological clock.

the latter. Now the changed habitat becomes unsuitable for the growth and perpetuation of the pioneer species and promotes the growth of other invading species suited to the conditions. The process is repeated in time and, at any time, the old lingering species can be seen growing side by side with the more aggressive invaders. This phenomenon of community development is called plant succession.

The process just described as beginning with a region devoid of any plant is primary succession. If it takes place in a pre-vegetated or partially denuded area, it is secondary succession. The species which occupy the maximum space within the community are the dominant species. By virtue of their bulk, they control the factors of the environment and thereby growth of the subordinate species.

Succession of plant communities and consequently that of the corresponding environment in a given space terminates into relatively stable communities which are known as climax communities. Clements (1916) believed in only one climax of which the population of species attains equilibrium with the climate. The climatic climax can yield to another climatic climax in geological epoch only on change of the climate. Since the dominant species play the key role in the mechanism of succession, it is regarded by him as a biotic phenomenon and the resulting system of the community is compared with an organism which takes birth, develops and dies yielding place to successive organism. The climax community extending over a large tract of uniform climate and characterised by a number of dominant species was recognised by him as formation of which regional climatic types with one or more dominant species form the association. The procession of communities in time culminating into the climax was recognised as 'Sere' and the relative successional communities were regarded by Weaver and Clements (1938) as seral communities. The seral community corresponding to the stable association unit was named as associes. In fact, these authors built up a complete hierarchy of subordinate taxa of vegetation such as consociation and consocies, faciation and facies, society and socies, etc. Thus the coherence and logic involved in the concepts gave the students of vegetation a perfect system of recognising plant communities and classifying them according to their status on successional level.

The concepts of succession and climax vegetation outlined above have been applied in the study of Indian vegetation with some success. Dudgeon (1920) gave the first clear account of succession in the Upper Gangetic Plain, but unfortunately he included the recurrence of seasonal meadow flora as part of the developmental succession. Misra (1946) has shown by his studies on meadow and low-lying land vegetation how the real successional trend can be demonstrated in relation to time by taking into account the same season year after year.

There are some ecologists who believe in regression as the opposite of succession in which vegetation is gradually reduced by biotic and other disturbances. Some of them called the process even as retrograde succession. But this way of describing the destruction or denudation of plant communities is not acceptable since secondary succession is always initiated by the causative factors, the continuity of which may lead to termination of succession within the community.

Further, the ecologists all over the world have shown that there are too many examples of stable vegetation wherein succession has terminated into communities, which are as stable as the climatic climaxes in different areas since the causal factors of stability are continuously operating upon them. Thus there may be edaphic, biotic, fire, etc. climaxes. Considering the span of human life, there are numerous examples of relatively stable vegetation in the same climatic zone. Thus arose the polyclimax hypothesis.

Plant geographical and autecological studies undertaken in different parts of the world soon revealed that species behave as individuals and associate freely with other species in several communities. They grow in varying ranges of habitat conditions and come together wherever the range of tolerance for critical factors overlap each other. The dominant species may have a wide amplitude of tolerance with or without ecotypes so as to be present in diverse habitats and are themselves affected by the subordinate species. Thus, in community organisation, the role of dominant species was overemphasized by Clements and there can be no similarity between a plant community and organism. In fact Gleason (1936) believes in the individualistic concept of the community wherein chance of incidence of species is the reality in view of the complexity of environment and the amplitude of species tolerance. No two stands of a plant community are identical. Tansley (1941) further showed that plant succession is not necessarily autogenic as there are too many examples of allogenic succession, that is, the mechanism of succession involves in it too many factors and forces which are extraneous to the biotic community. Thus the concrete association concept is challenged in conformity with the European ecologists who believe in abstraction of the unit from numerous stands having characteristic species of the association. Thus not dominance but the fidelity of the species to the association is decisive.

Perhaps the truth lies in the middle course and it is safe to think of abstract associations of ecologically interrelated species forming a loose combination with enough freedom of variations within. The degree of interdependence of the species within the community is not as great as Clements would make us believe and neither as loose and individualistic as Gleason (1936) thought of. The association in reality assumes the abstract form with sufficient degree of floristic and environmental similarity between its stands isolated by major factors. Whittaker (1953) therefore considers the issue on population pattern hypothesis in relation to time and space.

Clements and Shelford (1939) have developed the concept of biome wherein all plants and animals are related to each other by their coaction and reaction on the environment. Tansley (1935), on the other hand, emphasizes the role of the environment in his comprehensive term ecosystem involving all physical and biotic factors working in a complex. The ecosystem concept has found favour with most of the ecologists. According to Evans (1956) the ecosystem involves the circulation, transformation and accumulation of energy and matter through the medium of living things and their activities.

PART III

CAUSATIVE FACTORS OF DIFFERENTIATION OF VEGETATION TYPES

The foregoing discussion clearly shows that the participants of the vegetation are recruited from the flora of the region and hence floristic considerations are of foremost importance in any scheme of vegetational analysis. There seems to be sufficient justification for treating the vegetation types separately for each floristic region of the country. The floristic regions described by Chatterjee (1940) may be accepted for this purpose with the elimination of the Central Himalayas which indeed merge into the Eastern and the Western Himalayas. Besides the two regions of the Himalayas which lie more or less in the same latitudinal belt, the Rajasthan arid area, the Indo-Gangetic plains and Assam occupy another latitudinal belt with the Malabar and Deccan regions in the south. Thus the seven floristic regions of India lie in three distinct latitudinal belts.

A consideration of the latitudinal gradient becomes self evident in light of newer knowledge relating to photo-periodism and plant distribution. Instances have already been given in this regard. The tropical, the sub-tropical and the temperate regions which are mainly considered in terms of latitude were often equated with temperature regimes until the effects of photoperiod on plants were discovered. Now the position is changed and altitudinal gradients of the tropics cannot be compared with those of the temperate regions. Kodaikanal and Ootacamund temperature for instance may be nearly as much as that of Mussoorie and Simla in the summer yet the latter show stronger seasonality on account of very low winter temperature, distance from the ocean and longer summer photoperiods. Therefore, it is not correct to designate the flora or even a part of it on the top of the southern hills as temperate. The genera and the species which happen to be common to the Northern and the Southern mountains may belong to different ecological races, being either day neutral or short day in the south and long day plants in the north. The *Rhododendron* of the Sholas is quite distinct from *R. arboreum* of the Himalayas. Several such examples are awaiting detailed investigations.

The altitudinal gradient within each botanical region affects the flora and vegetation not only by virtue of corresponding temperature gradients but also because of air pressure, humidity, light intensity and ultraviolet rays. The first two decrease with height and the other two increase. The latter, as is well-known, bring about dwarfening effect on plant growth.

The next in importance is the humidity and aridity gradient within a region. The Himalayan and the central floristic regions show in general progressive aridity from the East to the West. The Malabar region is wet and the Deccan shows great variations in its area. But it is not the total annual rainfall which matters. Most of the workers have reached to the conclusion that the pattern of rainfall in its intensity, duration and seasonality together with the duration of aridity, is important. Nevertheless, the physiographic features and the soil of the terrain are decisive in retention or loss of moisture in the rooting regions of the plants. Hence the edaphic gradients within the humidity gradients should always be considered in vegetational analysis. The fertility gradient is of local importance.

The antiquity of man and growth of civilization in India have modified the biological and physical environment everywhere. Hence the biotic gradient in vegetational analysis should be understood in terms of history and proximity to settlements.

We may sum up that for the study of vegetation of India the following sequence of factors may be followed: (1) Division of the country into seven floristic provinces which fall in tropical, sub-tropical and temperate latitudinal belts. (2) Altitudinal gradient within a region in terms of plain, submontane and montane regions. (3) Biotic gradients in terms of history of the vegetation and proximity to settlements. (4) Moisture gradients in terms of frequency and duration of rainy and non-rainy days and retention of moisture by the soil. (5) Fertility gradients in terms of nutrient and aeration levels of the soil. The environmental factors of each of the types of vegetation should be described in effective way.

As far as the vegetation itself is concerned, a system of classification has been developed recently by Fosberg (1962) which appeals for wide applicability.

Fosberg (1962) considers physiognomy, structure, function, composition, dynamics, habitat relations and history as important criteria according to the gradients of which vegetation can be scientifically classified. He recognises closed, open (steppe) and desert (sparse) types as major structural features of the vegetation and bases the formation on growth form with emphasis on seasonality, leaf structure and such ephormonic features as thorniness, succulence and graminoid habit. Seral or denuded stages contiguous with developed forms are treated parts of the latter and stated accordingly.

If the height of the dominant plants is more than 5 metres, the community is a forest; it is a scrub if they are between 5 and 0.5 metres high and a dwarf scrub if the height is less than 0.5 meter. The vegetation may then be described as for example: open forest with closed lower layer, closed scrub with scattered trees, dwarf scrub with closed ground cover, open scrub with closed ground cover, open dwarf scrub with closed ground cover, etc.

Savanna is very often confused for open wood or scrub, but its main feature is the presence of closed grass or other predominantly herbaceous vegetation with widely spaced woody plants. It is a tall savanna if the height exceeds one metre and low one if less. If the woody species are shrubs, it is a shrub savanna. In the absence of these the vegetation is either tall grass (more than one metre) or short grass (less than one metre). Sometimes we come across extensive broad leaved herb vegetation which should be described as such. The marsh and aquatic vegetation are best described as per Daubenmire's (1947) scheme. It differentiates floating hydrophytes, suspended hydrophytes, submerged anchored hydrophytes, floating leaved anchored hydrophytes and emergent anchored hydrophytes. These descriptive terms can be effectively combined to describe the aquatic vegetation of any situation.

Within the types of the terrestrial plant formations as outlined above, it is important to take into account evergreen, semi-evergreen, deciduous and seasonal habits of the component species. The size and character of the leaves such as micro, meso, macro and megaphyllous, and orthophyllous and sclerophyllous texture are also important.

Thus it is possible to describe any vegetation with sufficient precision and objectivity in relation to its ecosystem by combining the terms suitably.

LITERATURE CITED

CHATTERJEE, D. Studies on the endemic flora of India and Burma. *J. Roy. Asiat. Soc. Bengal*, 5 : 19-67, 1940.

CLEMENTS, F. E. Plant Succession : An analysis of the development of vegetation. *Carn. Inst. Wash. pub.* 242. 1916. (Reprinted W. H. Wilson Co., 1928).

——AND V. E. SHELFORD. *Bio-ecology*, John Wiley, New York. 1939.

DAUBENMIRE, R. F. *Plants and Environment*. John Wiley & Sons, Inc., New York. 1947.

DUDGEON, W. A contribution to the ecology of the Upper Gangetic Plain. *J. Indian bot. soc.* 1 : 296-324, 1920.

EVANS, F. C. Ecosystem as the basic unit in ecology. *Science*, 123 : 1127-1128, 1956.

FOSBERG, F. R. A classification of vegetation for general purposes. *Trop. Eco.* 2 : 1-28, 1961.

GLEASON, H. A. The individualistic concept of the plant association. *Torrey Bot. club Bull.* 53 : 7-26, 1926.

KAUL, V. N. AND R. MISRA. Studies in germination and photoperiodic behaviour of *Xanthium strumarium* L. *Modern developments in plant physiology*. Bot. Dept. Delhi University ; 49-53, 1957.

MISRA, R. A study in the ecology of low-lying lands. *Indian Ecol.* 1 : 27-46, 1946.

RAMAKRISHNAN, P. S. Ecotypic differentiation in some plants of Varanasi. *Proc. Nat. Acad. Sci.* 28B : 68-76, 1958.

——Calcicole and Calcifuge problem in *Euphorbia thymifolia* Linn. *J. Indian bot. soc.* 40 : 66-81, 1961.

TANSLEY, A. G. The use and abuse of vegetational concepts and terms. *Ecology*. 16 : 284-307, 1935.

——Note on the status of salt marsh vegetation and the concept of formation. *J. Ecol.* 29 : 212, 1941.

WEAVER, J. E. AND F. E. CLEMENTS. *Plant ecology*. McGraw-Hill Book Co., New York. 1938.

WHITTAKER, R. H. A consideration of the Climax Theory : The climax as a population pattern. *Ecol. Monogr.* 23 : 41-78, 1953.