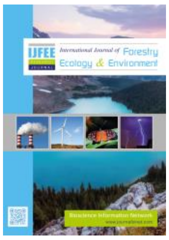
Journal BiNET
Scientific Publication

Published with Open Access at Journal BiNET
Vol. 03, Issue 01: 114-120
International Journal of Forestry, Ecology and Environment

Journal Home: https://www.journalbinet.com/ijfee-journal.html



The Dynamics of tropical forest ecosystem with special reference to gap dynamics, regeneration and succession

A. R. R. Menon

School of Environmental Studies, Cochin University of Science and Technology (CUSAT), Cochin-682 022, Kerala, India.

*Corresponding author: arrmenon@gmail.com (Menon ARR); Contact no: +91 9447239455
Article received: 14.11.20; Revised: 09.12.20; First published online: 30 January 2021.

ABSTRACT

The ecosystem stability in forests is highly dependent on ecological efficiency of species to the changed habitat. Thus, in forest ecosystems, the biodiversity change, interruption of migration patches, changes in soil profile, changes in habitat and watershed, and changes in wildlife status etc are the major impacts of climate change. The forest canopy is not homogenous and dense canopy cover is often interspaced with openings, where tree saplings along with shrubby vegetation co-exist. The species in the openings or fewer dens region determining the forest structure for a very long time because of the long span of tree maturity phase, sometimes centuries. New species seedlings occupy the canopy openings, most of them are light demanding, and establish the community at the risk of shade loving species present under dense canopy region. This building phase of forest is the most important part of the life cycle. The survival of seedlings and transformation to the sapling stage can be more complex due to long-term environmental factors. The regeneration dynamics of the tropical forest ecosystem is poorly understood. The details are discussed in the paper.

Key Words: *Gap dynamics, Species composition, Regeneration status, Tropical evergreen forests*

Cite Article: Menon, A. R. R. (2021). The dynamics of tropical forest ecosystem with special reference to gap dynamics, regeneration and succession. International Journal of Forestry, Ecology and Environment, 03(01), 114-120.
Crossref: https://doi.org/10.18801/ijfee.030121.12

I. Introduction

The Champion and Seth's (1968) systems of classification are followed in Kerala's Western Ghats region. This classification system is primarily based on climatic parameters. Both, macro and microclimatic conditions influence forests. The broadly divided forest climate into macroclimate and microclimate has a high influence in determining forest structure and function. The effect of climate change and its impact is critical, especially in tropical ecosystem, because of the highly fragile nature of tropical species. The ecosystem stability in forests is highly dependent on ecological efficiency of species to the changed habitat. Thus, in forest ecosystem, the biodiversity change (many species perish due to lack of adaptability); interruption of migration patches (by agriculture, urban and deforested area); changes in soil profile, change in habitat and watershed, change in wildlife status *etc.* are mainly

Published with open access at journalbinet.com.
EISSN: 2708-5430,

due to climate change. The existence of free atmosphere in forest canopy is the influencing factor of microclimate in forest ecosystem. The microclimate of forests are influenced by canopy opening, radiant energy exchange in the forest openings, direct solar flux, wind affecting convection and latent heat exchange, and rainfall. The forest canopy is having a profound influence on regulation of forest microclimate. A dense forest canopy often modifies the climate near the ground. Net radiation is usually diminished (inside closed canopy only 20% of heat observed). It is observed from the past studies, that the net radiation is more than 50% in open forest, when compared to the dense forest ecosystem. Similarly, relative humidity near the ground exceeds, than that of the canopy during daytime. In Indian forests, major economic species like, *Tectona grandis, Shorea robusta,* and Bamboo sp., are changed more than 75% of grids where they are currently existing (Ravindranath et al., 2006).

II. The Gap Dynamics

The forest canopy is not homogenous and dense canopy cover often interspaced with openings, where tree saplings along with shrubby vegetation co-exists. This building phase of forest is most important part of life cycle. After canopy closure, only the shade tolerant seedlings of the mature phase would maintain themselves beneath it. But in fact, such a static situation never arises, because forest canopy is continuously changing by disturbances. Thus, the forest is always functionally dynamic, in nature. The canopy changes are controlled mainly by two factors *viz*: 1. the immediate environment of a single tree and is caused by the collapse of branch or death and decay of the tree due to age or diseases. 2. Damage resulting from some natural calamity like storm, landslide or even anthropogenic interference. The consequent rupture of the canopy produces the opportunities for change. Owing to the intrinsic heterogeneity of the mature phase, canopy gaps are indeterminate. van- Steenis (1958a, 1958b) is of the opinion that chance plays a large role in many cases, and aggregates of one species result solely from the proximity of seedling parent to a newly created canopy gap. Poore (1964) suggested that regeneration in these gaps depends primarily on the establishment of seedling and sapling that are present when the gap is formed. The existence of particular seedlings and sapling is dependent on many factors like proximity of parent trees, efficient dispersal mechanism, seed dormancy, phenology aspects of trees and the degree of shade tolerance.

Depending on the gap formation factor, the canopy gap in forest ecosystem varies in different size from a few sq. meters to many hectares. The small gaps are normally due to death and decay of mature trees and large due to natural catastrophe or anthropogenic influences. The small canopy openings due to death and decay of mature trees, will automatically occupied by the seedlings present in the ground strata, mainly the light demanding species, which are in dormant condition due to lack of light, and later form the building phase forest. In the large gaps created by the natural calamities like storm, landslide *etc,* the microclimatic condition will suddenly change, resulting a total or partial change in the ecosystem. The large gap is then occupied by external seed source, through wind or animal dispersion system. In small gaps, the sapling rapidly responds to the increased light and height increment, apical dominance is maintained until the leader emerges from the main canopy, leads to the development of mature crown shape. By competitive self- thinning, the number of individuals growing in the gap reduced. Fast growing species (*eg*. *Shorea robusta, Macaranta peltata etc*.), have the competitive advantage and the more growing shade tolerant species make their way up to the main canopy under it shade. These small gaps do not create any substantial change in the floristic composition of the canopy.

The continuous regeneration of the shade tolerant species in small canopy gap has been described as diffuse regeneration, resulting two types of formations, *viz.* shade-tolerant or shade loving, and shade-intolerant or light demanding. These pioneer or climax species will often change to a group of secondary species during the process of succession, transforming the climax forests to secondary forests, where species composition is a mixture of all species. This type of directional shift with time in floristic composition is a common phenomenon in Western Ghats. The large gap formation is caused by natural factors had cumulative impact, leading to gradual change in climate.

III. Forest Regeneration Changes

The term regeneration refers to the sustenance processes, including seed dispersal, germination and establishment of seedlings. Regeneration involves the inherited genetic and physiological

Published with open access at journalbinet.com.
EISSN: 2708-5430,

development, as well as the development due to environmental factors. The seed production of a tree is dependent on many factors, *viz*. age, vigor, seed mast years *etc*. and is deterministic. The seed dispersion and germination are stochastic process, where external climatic factors are more significant, in the regeneration process. The forest regeneration is immediately affected by changed microclimate. The sudden shooting up of light demanding species in canopy openings and the luxuriant growth of shade lovers in closed canopy region, thus changes forest structure and status, in due course. Change of primary species to secondary species due to openings, the forest edge effect and impact on transition zone *etc.* are also notable, due to microclimatic variations. Mortality in the regeneration phase of forests is usually high; only a few individuals that germinate become seedlings and only a few seedlings grow into saplings (Botkin, 1992).

IV. The Succession changes

The succession is the normal growth and development of existing forests (Kimmin, 1987) and disturbance is the change or removal of existing forests, partially or completely through natural calamities (Spurr and Barnes, 1980). These are the two major patterns of silvicultural changes. That is; succession and disturbance are opposing but complementary forces. The formation of canopy gaps during the developmental stages of forests create a mosaic of young and mature vegetation assemblage, which in due course form an array of gaps of different age group formation, thus forming an uneven canopy. This can be observed as rough texture in aerial photographs during photo-interpretation. According to Hely et al. (2000) such a gap creates an uneven canopy, changing the nutrient status, because of the resource quality change, and finally, affects the regeneration status of the forests. Gap sizes vary according to the severity of the disturbance. The microclimate of the gaps varies as in relation to tress as well as latitude. Due to the influence of the gap size on dispersal probabilities and gap microclimate, it is found that many tree species are specialized according to the size of the gap in which they are likely to regenerate (Denslow, 1980).

It has been accepted that for regeneration of trees to get established, the greatest cause of seedling mortality and subsequent poor growth was mainly ascribed to herbaceous competition (Zobel et al., 1987). Species relation studies conducted Menon and Balasubramanyam (1985) confirm that facilitative interactions among plants play a crucial role in species co-existence, species diversity and even species productivity. The effect of one species on the other species through interaction, either directly (*competition*) or through gradual environmental modification (*allelopathy*), brings about, not only growth and establishment of the plants but also, vegetation changes and successions. The interaction between two species can be described as, facilitative, inhibitive or tolerant of each other (Connell, 1978; Connell and Slatyer, 1977). The species relation study with respect to co-existence is to be critically examined in this regard. This will also give an idea regarding the preferential species for forestation in the selected micro-habitat.

The evergreen forest dynamics are less explored and very few systematic studies are made in tropical rain forests with respect to secondary vegetation formation (Richards, 1936). The secondary succession processes are complex and differ from place to place, because the changed environmental situations are not similar (site specific changes). Several authors have referred to the rain forests as being a stable community. The stability seems to be apparent and the system is not static; continuously changing from primary succession stage to secondary succession stage, thus gradually replacing the primary species to large number of secondary species. When we say that the tropical rainforest is stable, we are not thinking of a static situation, but one in which the community, over a large area is continuously adjusting, so that it maintains essentially the same overall status, both structural and functional. This is because the resiliency of the community, which can withstand minor perturbations of climatic and habitat changes. The vegetation is very close to a state of dynamic equilibrium, when the overall changes during the observation intervals are so small, and not affecting the basic nature of the community. Thus the observer feels a static appearance even though the community is continuously changing. Because of this phenomenon very little studies are done on these types of vegetation changes. Ecosystem stability depends on two important factors: *viz.*1.the forces acting on the system that do not exceed certain threshold values; 2. that the environmental conditions are themselves relatively constant. In some cases, small disturbances can lead to progressive alteration to the dynamic balance. This relative stability is different from the massive anthropogenic changes, where the community has been destroyed and replaced by entirely different land use

Published with open access at journalbinet.com.
EISSN: 2708-5430,

patterns, or where the disturbances has exceeded self-maintain capacity of the system; where the dynamic equilibrium is altered or destroyed in total. Most of the present environmental problems are of these types effecting such destruction of dynamic equilibrium. Thus, the apparently stable system in which the flora and fauna represent a '*climatic climax*' has therefore a pre-requisite, that the system is left undisturbed or the disturbance are light such as normal death and fall of mature trees. Heavier, disturbances of the system will lead to the other changes and this in turn will result in a succession, which may or may not build up a system like original because of the multi directional succession as in *polyclimax theory* of succession. Such successions are called "*secondary*" a term which includes forests resulting from repeated major disturbances. The erratic climate variation will accelerate this process of secondary forest formation. In tropical system the secondary compositions are normally different to that of primary composition, due to various factors influencing the changes. Hence the preponderance of secondary species is an indication of disturbance in forest ecosystem.

Two main approaches are practiced in the study of secondary succession. The sequential examination of sites over a long period leading to the description of changes on one plot after the major disturbance (establishment of permanent preservation plots) is the first approach in the study. Secondly, several plots/sites of different age may be examined together, assuming the initial ecological conditions are similar in all plots/sites, and the information can be calculated. The first method requires a larger time scale for getting the required information and is the major limitation. In the second method, it is difficult to obtain reliable data on successions older than 30 years. The continual sampling of '*permanent plots'* established by forest departments and various research organizations are a good example of this type of evaluation. It is necessary to use both methods for analysis of the earlier sequence of succession in any tropical forest type. In India, as a result of human occupations from early times and shifting cultivation, most of the forests have been degraded and have reverted to that has been called '*predo-climax*', '*peni-climax*' or '*plesio-climax*'. Researchers are of the opinion that there is no '*primary forest*' left in India, Bangladesh and Srilanka, except to that of small units in the Andaman Islands.

The status of forest vegetation of Kerala is well studied in the past (Chandrasekharan, 1962a; 1962b and 1962c). The distribution status of species in different canopy layers is well described for Kerala region of Western Ghats. The bio-edaphic nature of secondary vegetation, with different species association, ultimately changing soil condition of selected sites is noted.

The study conducted at Kerala Forest Research Institute (KFRI) in the latter period (2000-2005), and that of Chandrasekhara (1992), confirm very little compositional changes in evergreen forests of Kerala except to that of selection felled area.

There is a vide variation in secondary communities of rain forests. The forests exploited for timber or cultivated and abandoned are considered as a secondary forest type (Richards, 1952). The major features of this type are smaller average dimensions of the trees, though scattered large trees may remain from the original stand the often regular and uniform structure of the very young stages and the very irregular structure of older stages with many lianas. Formations of secondary forests consist of different species assemblage, which in due course, form a dominant community of mature trees, similar to climax forest. Hence old secondary forest is almost similar to the primary forests. The weak representation of small trees as compared to the number of large trees of given species observed at times, may be explained by the forest being an old secondary community. The typical secondary forest species are light demanding, requiring light intensity of at least 75% of full day light. Most of the species are even unable to regenerate under their own shade due to rapid growth in height, (1- 4m/a) and diameter (2- 4 cm/a). Most of the trees have early flowering and efficient propagule dispersal. The species are mostly short lived, fast growing, often dying at 15-20 years. The species are frequently gregarious with light timber, soft and not very durable (Richards, 1952; CTFT, 1974).

Secondary species appear to be more selective, regarding the soil, than the primary species. According to Kellman (1969) secondary species are more efficient in the process of bio-geo chemical cycling, than the primary species and species like *Trema orientalis* and *Melastoma polyanthum* can even restore phosphorous. Because of their efficiency in biochemical cycling and soil enrichment, the secondary species can easily establish, even in poor soils and adverse site conditions. Most of the

Published with open access at journalbinet.com.
EISSN: 2708-5430,

exotic species are of this nature. The virulent growth and the colonization of exotic species in forest areas can be looked on these lines.

The accumulation of soil nutrients with succession is largely associated with an increase in humus derived from litter fall. The rate of humus increase depends on the level of humus characteristics with respect to species composition of the mature system and the terrain features. The geomorphology of the landscape and the terrain features has a crucial role in humus accumulation in forests. The rate of carbon to nitrogen does not change greatly during succession, the increase in nitrogen being thought to be mainly derived from non-symbiotic nitrogen fixation. The buildup of plant biomass and consequently nutrient storage may be rapid. The initial occupation of the site by a given set of species appears random. The full recovery of the ecosystem requires hundreds of years. The recovery follows a repeatable, predictable sequence of life forms and the functional characteristics of ecosystems are reestablished rapidly (Golley et al., 1975). The secondary succession stage is often marked by species of *Trema*, *Vismia, Macaranga, Mussanda, Ceropia, Leea,* and *Scleria*. The species with rapid growth and good means of seed dispersal, with high ecological efficiency to withstand the adverse condition, thus facilitate a temporary foothold in the disturbed site. Repeated cultivation, burning and other activities changes the status of succession; and certain selected species take advantage, leading to the formation of different cover types. This is in tune with the '*polyclimax theory'* of succession. This may lead to the change of forest towards grassland, simulating closely, to an '*edaphic climax*' (Richards, 1952). In moist deciduous forests, the succession trend is often towards semi-evergreen type, with deciduous light demanding species gradually crowded out by shade bearing evergreen species under which the former cannot regenerate. The trend is accelerated during fire management activities (FAO, 1973).

V. Discussion

The regeneration with respect to Gap dynamics is an aspect of interest of ecologists. Micro-sites factors are important in forest regeneration affecting the seedling establishment (Harper, 1977; Grubb, 1977). Regeneration from seeds, which is natural regeneration of high forests, depends almost entirely on the micro-site characteristics, such as moisture content and light infiltration (Kozlowski, 2002). The specific microclimate of a given micro-site within which a propagule is trapped or landed may be one of the most critical factors for plant germination and growth. The early establishment phase is more complex and germination of seeds depends on micro site qualities, than the soil type itself (Robert, 2003). Hence micro-site characteristics, with respect to micro-climate, are to be studied thoroughly.

No comparative information on germination and establishment in different forest types is available. No significant differences in fruit biology are known between different forests on average and well-watered fertile sites. According to Chen and Popadiouk, (2002) light intensity is more crucial than soil condition in gap dynamics of tropical forests. Time and periodicity of the gap formation also affects the species that is growing in the forests (Denslow, 1980; Runkle and Todd, 1985). The vegetation growths of an ecosystem are highly depended on soil condition, especially in the initial stage of germination of seeds and establishment of seedlings. The geological formation and subsequent soil type development is also important, since physical and chemical characteristics of soil substratum is a controlling factor of vegetation development. Thus, the edaphic condition of Moist Deciduous forests of tropics can be linked with regeneration factors.

The role of patchy understory vegetation in the growth and establishment of seedlings in forest is substantial. The effects can be both positive and negative, *i.*e. understory vegetation helping in the survival of the seedlings is positive, whereas, competing for resources such as light and nutrient is negative. Competition from other plants, herbaceous as well as shrubs, in the understory is one of the major factors affecting regeneration of forests. The evaluation of understory vegetation in different season can also be linked to the regeneration of the cover type. Thus, the study will be an insight to the structure and dynamics of Tropical forests of Kerala.

The highest mortality in the life cycle occurs between flowering and seedling establishment and its appreciation is crucial in the development of suitable methods of natural regeneration of logged forest (Wyatt-Smith, 1963), nevertheless it is not known to what extent mortality is probabilistic rather than

Published with open access at journalbinet.com.
EISSN: 2708-5430,

assignable to specific selective factors. The specialized nature of initial establishment may be the major factor for preventing their return after forest clearance (Gomez-Pompa et al., 1972). There is often considerable inter-specific variation in moisture requirement for successful germination; this may help to explain both intrinsic spatial pattern and extrinsic spatial variation in forest floristic.

VI. Conclusion

The regeneration dynamics of the tropical forest ecosystem is poorly understood. The complex nature of tropical forests with high species diversity, different geomorphic terrains, and the special climatic condition.are to be studied thoroughly. More attention is required, in the study of germination and mortality rate of evergreen species in different environmental conditions of evergreen species. The tropical evergreen species are highly eco-sensitive and the ecological efficiency of adaptation is much lower to that of arid and temperate species. The study of gap dynamics in tropical forest is more significant on this respect.

Acknowledgment

The author acknowledges the academic support from the School of Environmental Studies, Cochin University of Science and Technology, and the logistic support for field data collection, rendered from Kerala Forest Research Institute and Kerala Forest Department.

References

[1]. Botkin, (1992). In: The Myth of Nature's Constancy – Preservation, Protection and Ecosystem management. (Authors- Richard M. Degraaf and William M Haley) 58th North American wildlife and nature resource conference transactions, pp.17-28.
[2]. Champion, H. G. and Seth, S. K. (1968). A revised study of the forest types of India. Manager of Publications, Government of India, Delhi. p.404.
[3]. Chandrasekhara, U. M. (1992). Studies on the gap-phase dynamics of a humid tropical forest. (Doctoral dissertation), Dept. of Environment Science, Jawaharlal Nehru University, New-Delhi, p.148.
[4]. Chandrasekharan, C. (1962a). Forest types of Kerala State (i). Indian Forester, 88, 660-674.
[5]. Chandrasekharan, C. (1962b). Forest types of Kerala State (ii). Indian Forester, 88, 731-742.
[6]. Chandrasekharan, C. (1962c). Forest types of Kerala State (iii). Indian Forester, 88, 837- 847.
[7]. Chen, H. Y. H. and Popadiuk, R. V. (2002). Dynamics of North American boreal mixed woods. Environ. Rev. 10, 137-166. https://doi.org/10.1139/a02-007
[8]. Connell, J. H. and Slayter, (1977). Mechanism of species interaction, co-existence and dynamics. Esajournals. Online library. Wiley. com/doi/10.1890/10-1323.1#i0012.
[9]. Connell, J. H. (1978). Diversity in tropical rainforests and coral reefs. Science, 199, 1302-1310. https://doi.org/10.1126/science.199.4335.1302
[10]. CTFT (Centre Technique Forester Tropical). (1974). Carecteres des especes forestieres secondaris. Nogent- Sur- Marne, Publ. Multigr (Unpublished).
[11]. Denslow, J. S. (1980). Gap partitioning among tropical rain forest trees. Biotropica, 12, 47-55. https://doi.org/10.2307/2388156
[12]. FAO, (1973). Manual of forest inventory with special reference to mixed tropical forests. Food and Agricultural Organization, Rome. p.200.
[13]. Golley, E. B., Mc Ginner, J. T., Clements, R. G., Child, G. I. and Duever, M. J. (1975). Mineral cycling in a Tropical moist forest ecosystem. Athens, Georgia Univ. Georgia press. p.248.
[14]. Gomez-Pompa, A., Vazquez-Yanes, C. and Guevara, S. (1972).The Tropical Rainforest: a non-renewable. Science, 1972. https://doi.org/10.1126/science.177.4051.762
[15]. Grubb, P. J. (1977). Control of forest growth and distribution on wet tropical mountains: with special reference to mineral nutrition. Annual Review of Ecology, Evolution, and Systematics, 8, 83-107. https://doi.org/10.1146/annurev.es.08.110177.000503
[16]. Harper, J. L. (1977). Population biology of plants. New York, NY Academic Press, p.892.
[17]. Hely, C., Bergeron, Y. and Flannigan, M. D. (2000). Effects of stand composition on fire hazard in mixed wood Canadian boreal forest. Jour. Vegetation Science, 11(6), 813-824. https://doi.org/10.2307/3236551
[18]. Kellman, M. C. (1969). Some environmental components of shifting cultivation in Upland Mindanao. Journal of Tropical Geography, 28, 40-56.
[19]. Kimmin, J. P. (1987). Forest ecology. Macmillan, London. p. 531.

Published with open access at journalbinet.com.
EISSN: 2708-5430,

[20]. Kozlowski, T. T. (2002). Physiological ecology of natural regeneration of harvested and disturbed forest stands: Implications for forest management. Forest Ecology and Management, 158(1), 195-221. https://doi.org/10.1016/S0378-1127(00)00712-X

[21]. Menon, A. R. R. and Balasubramanian, K. (1985). Species relation studies in Moist Deciduous Forests of Trichur Forest Division (Kerala). K. F. R. I., Res. Report No. 32, P.194.

[22]. Poore, M. E. D. (1964). Integration in the plant community. Jour. Ecol. 52: (suppl), 213-226. https://doi.org/10.2307/2441

[23]. Ravindranath, N. H., Joshi, N. V., Sukumar, R. and Saxena, A. (2006). Impact of climate change on forests in India. Current Science, 90(3), 354-361.

[24]. Richards, P. W. (1936). Ecological observations on the rain forests of Mount Dulit; Sarawak. Jour. Ecology. 24(1): 1-37. https://doi.org/10.2307/2256268

[25]. Richards, P. W. (1952). Tropical rainforest: an ecological study. Cambridge Univ. Press. 1952. p. 450.

[26]. Robert, T. W. (2003). Climate Change: The Political Situation. Science, 302(1):1925. https://doi.org/10.1126/science.1093160

[27]. Runkle, J. R. and Todd, C., Yetter. (1987). Tree falls revisited: Gap dynamics in the Southern Appalachians. Ecology 68(2), 417-424. https://doi.org/10.2307/1939273

[28]. Spurr, S. H. and Barnes, B. V. (1980). Forest ecology. 3rd edition. John Wiley and Sons Inc. New York, 1980.

[29]. Van Steenis, C. G. G. J. (1958a). Rejuvenation as a factor for judging the status of vegetation types: the biological nomad theory. In: Proc. Kandy Symp. pp. 212-218. Paris. Unescop.

[30]. Van Steenis, C. G. G. J. (1958b). Commentary on the vegetation map of Malaysia (1/50,000) UNESCO. Humid Tropic Research Projects.

[31]. Wyatt-Smith, j. (1963). Manual of Malayan silviculture for inland forests. History (part1); Environmental factors (part2), Silviculture and forest management (part 3). Malayan For. Rec. 23: p 400.

[32]. Zobel, B. J., Wyk, G. and Stahl, P. (1987). Growing exotic forests. cabdirect.org.

HOW TO CITE THIS ARTICLE?

MLA
Menon A. R. R. "The Dynamics of tropical forest ecosystem with special reference to gap dynamics, regeneration and succession". International Journal of Forestry, Ecology and Environment, 03(01) (2021): 114-120.

APA
Menon, A. R. R. (2021). The Dynamics of tropical forest ecosystem with special reference to gap dynamics, regeneration and succession. *International Journal of Forestry, Ecology and Environment*, 03(01), 114-120.

Chicago
Menon, A. R. R. "The Dynamics of tropical forest ecosystem with special reference to gap dynamics, regeneration and succession". International Journal of Forestry, Ecology and Environment, 03(01) (2021): 114-120.

Harvard
Menon, A. R. R. 2021. The Dynamics of tropical forest ecosystem with special reference to gap dynamics, regeneration and succession. International Journal of Forestry, Ecology and Environment, 03(01), pp. 114-120.

Vancouver
Menon ARR. The Dynamics of tropical forest ecosystem with special reference to gap dynamics, regeneration and succession. International Journal of Forestry, Ecology and Environment, 2021 January 03(01): 114-120.

Published with open access at journalbinet.com.
EISSN: 2708-5430,