SHIV SHAKTI
International Journal in Multidisciplinary and Academic Research (SSIJMAR)
Vol. 6, No. 4, August 2017 (ISSN 2278 – 5973)

A GLOBAL SCENARIO OF TREE DIVERSITY

Dr. DarshanKaurCheema, Professor, University of Delhi
KM Gunjan, Research Scholar, CMJ University

Tropical forests are distinguished from all other terrestrial ecosystems by a very high diversity on many levels (species, life-forms, *etc.)* and are the most heterogeneous of the world's ecosystems. They are acknowledged to harbour the greatest wealth of biological and genetic diversity of any terrestrial community (**Hubbell and Foster, 1983**). Most plant life-forms and especially trees exhibit a similar diversification on a local scale (**Wattenberg and Breckle, 1995**).

Consider, the mystery of tropical forests, plant ecologists have plunged into explorations to address the most obvious question: "Why are the tropical forests so rich?". The question continues to pose a difficult challenge to community theory (**Hubbell, 1980**) and evolutionary biology (**Ashton, 1969**). The mystery is further compounded by the fact that "not all tropical forests are rich in plant species"; indeed, some are very species-poor (**Connell, 1978**). Added to this complication in understanding tropical forest diversity, it is to be answered whether human-impacts on forests increase or decrease the plant diversity.

TREE DIVERSITY - A GLOBAL SCENARIO

Plant diversity inventories in tropical forests have mainly focused on trees than any other life-forms, *viz.* lianas, provide resources and habitat structure for almost all other forest species (Cannon *et* al., 1998). Besides being a pivotal and understory plants, *etc.* The reason behind this is that tree diversity is fundamental to total forest diversity and trees dominant life-form, trees are easy to locate precisely and count (**Condit *et al.*, 1996**) and are taxonomically a well-known group (**Gentry. 1992**). Thus tree diversity inventories gained impetus in the hands of plant ecologists and a plethora of literature exist for trees.

There are variations in the number and abundance of tree species between the world's three main tropical forest blocks - the American, the Asian and the African (**Ojo and Ola-Adams, 1996**). This variation is also present in the sub-regional blocks. There are several studies that support the contention that some tropical rain forests have more plant species on small areas of up to a few hectares than any other kind of vegetation on earth (**Whitmore *et al.*, 1985**).

Discussions on the patterns and trends of tree diversity in six continents (**Gentry, 1988a, 1988b**) and. a review on the tropical forest diversity and processes attributed to it (**Phillips et *al.*, 1994**; **Condit *et al.*, 2000**) are available. **Gentry (1988a,198813**) remarked that the highest alpha-diversity of trees in the world occurs in upper Amazonia, with record diversities of 275 - 283 tree species (> 10 cm dbh) per hectare at Yanamono and Mishana near Iquitos, Peru.

However, a strikingly high tree species richness of 473 species ha-lfor trees > 5 cm dbh, and 307 species ha-' for tees > 10 cm dbh in Amazonian Ecuador was reported by Vaiencia et (1994). The latter's finding is the world's highest record of tree species richness per hectare for stems > 10 cm. A wide range of sampling methods has been employed in tree diversity inventories over the years, specially the number, size and shapes of the plots besides the girth threshold of trees. While most of the studies adopt plot methods, plot less methods, such as point centred quarter method were also used.

Table 1.Summary of mature tree diversity) inventories for trees > 10 dbh or 30 cm gbh in 1 ha sample area across the tropical forests of the world.

	Location	Area (ha)	No. per ha or plots Trees species Family	Basal m²ha⁴	Reference
	THE ASIAN TROPICAL FORESTS				
1.	**Sabah**				
	• Sepilok	2	608* 198* --	37.8	Nicholson, 1965
	• Segaliud-Lokan	2.83	283 ----	--	Fox, 1968
	• Segaliud-Lokan	31.9	31 -- --	16.9	Fox, 1968
	• Danum Valley	1 8	431 124 --	42.8	Kamarudin, 1986
	• Danum Valley		470 248--	26.6	Newbery, 1992
2.	**Malaysia**				
	• SungeiMenyala	2.7	791* 210* --	32.9	Wyatt Smith, 1966
	• Jengka	1.09 2.7	2773* 37553*	24.2	Poore, 1968
	• Pasoh	2.63	2280* 328* --	--	Wong &Whitemore, 1970
	• Lempake	1	445 128 --	23.3	Kartawinata, 1981
	• Jengka	1	104 261* 42*	--	Ho et al, 1987
	• Pasoh	3.12	530 660*67*	29.13	Kochurmmen, 1990
	• Pason	3.82	546 -- --	25.2	Manokaran&Kochummen, 1990
3.	**The Western Ghats (India)**				
	• Devimane	2.7	1392*87*28*	--	Rai, 1981
	• Katlekan	1.09	379* 59* 27*	--	Rai, 1981
	• Malimane	2.72.63	1195* 77* 31*	--	Rai, 1981
	• Kodkani	1	1066* 77* 33*	--	Rai, 1981
	• Karnataka	1	333 -- --	61.9	Chandrashekara&Ramakrishnan 1984
	• Nelliampathy	3.12	49630 --	39.7	Parthasarthy, 1999
	• UppangalaKaranataka	3.82	1981* 91*31*	42.03	Sukumar, 1992
	• Mudamalai Game Reserve	50	2302* 90* 35 15417* 63*28*	28*	
5.	**The Eastern Ghats (India)**				
	• Shervarayan Hills	4	600 4533	34.8	Kadavul&Parthasarthy, 1999a
	• Kalrayan Hills	4	6004425	33.7	Kadavul&Parthasarthy, 1999b
	• Evergreen Forest	8	6305343.6	43.6	Chittubabu&Parthasarathy 2000a

Location	Area (ha)	No. per ha or plots Trees species Family	Basal m^2ha^4	Reference
THE AFRICAN TROPICAL FORESTS				
• Okomu, Nigeria • Akhilla • Cameroon • Khade, Ghana • Manogarivo Madagascar	1.5 1.5 1.2 49	582* 90* -- 423 87 31 551* 109* -- 550 87 30.9 728 90 38	-- -- -- 30.9 22.4	Richards, 1939 Richards, 1939 Richards, 1963 Swaine, 1987b D'amico& Gautier, 2000

Location	Area (ha)	No. per ha or plots Trees species Family	Basal m^2ha^4	Reference
THE AMERICAN TROPICAL FORESTS				
1. **Brazil** • Varzea Forest • Terra Firme Forest • Mocambo • Para • Breves • Manuas-Itacoatiann				Black et al, 1950 Cain et al, 1956 Pires et al, 1953 Pires 1966 Prance et al, 1976
2. **Peru**	--	--	--	--

Comment :- * - Value for the total plot , T - Includes Lianas

3. **Panama** • Bara Colorado Island • Bara Colorado Island • Bara Colorado Island	5 1.5 50	168 44 -- 768* 142* -- 7614* 186* --	-- 38.6 --	Thorington 1982 Lang & Knight 1983 Hubbell & Foster, 1983
4. **Amazon** • Rio Xingu • Jenaro Herrera • Central Amazon • Mare	3 9 5 1	500 150 33 524 -- -- 600 176* -- 645 201 34	29.34 -- -- 31	Campbell, 1986 Spichiger, 1989, 90 Rankin-de-Merona et al, 1990 Korning&Baslev, 1994
5. **Ecuador** • Terra Firme, Anangu • VarzeaAnangu • Amazonia • Cuyabeno Reserve	1 11 3.1	728238-- 41714944 693307 46 700 20050	-- -- 25.7 33.5	Balsleve, 1987 Balsleve, 1987 Valencia, 1994 Korning&Baslev, 1994

The girth threshold of trees considered in the quantitative plant diversity inventories does vary to a great extent. Generally, the girth at breast height (gbh) or diameter at breast height (dbh), usually measured at 1.3 m above the ground. is used as the criterion for tree inventories. Nevertheless, height of trees is also used in few inventories of this kind. For instance, trees 1 m tall were investigated in the Lower

Comment :-* - Value for the total plot , T - Includes Lianas

Rio Negro, Amazonia (**Rodrigues, 1961; Prance, 1979**). Regarding the tree girth measurements, minimum gbh or dbh used in various studies ranged from as small as 1 cm dbh (**Bongers*et al.,* 1988**; **Condit *et al.,* 2000**), through 2.5 cm dbh (Knight, 1975), 4.5 cm dbh (**Bunyavejchewin, 1999**), 5 cm dbh (**Pelissier and Riera, 1993**; **Valencia *et al.,* 1994**; **Johnston and Gilman, 1995**), 10 cm dbh (many authors, see Table 1) 15 cm dbh (**Prance *et al.,* 1976**), 30 cm dbh (**Nadkarni*et al.,* 1995**), 30 cm gbh (many authors, see Table 1) and 91 cm gbh (**Poore., 1968**; **Ho *et al.,* 1987**), to 152.4 cm gbh (**Fox, 1968**).

Though such a variation in girth threshold considered is common, the frequently used girth threshold has been either 10 cm dbh or 30 cm gbh (**Campbell *et al.,* 1986**, **1992**; **Gentry, 1988a**, **1988b**; **Lieberman *et al.,* 1996**; **Phillips and Gentry, 1994**; **Phillips, 1996**). The reason for considering the girth threshold of 10 cm dbh or 30 cm gbh by many ecologists in tree inventory is: this girth threshold is supposed to be a representative of mature trees with greater stability in forest structure and function than the lower girth threshold of trees (**Newbery *et al.,* *1992***).

Quantitative inventories of trees began with the pioneering investigation on stratification of trees (by clear felling method) in the tropical mixed forest in Moraballi Creek, Guyana (**Davis and Richards, 1934**). They measured all the trees, shrubs, herbs, climbers and epiphytes in two smaller plots, each 61 m x 7.6 m size, and one large plot of 122 m x 7.6 m. The trees, shrubs and herbs, individually formed two permanent plots in the Ituri forest at Edora in Congo, Africa, were excluded from the Table 1, as they are for trees 1 cm dbh.

While the Indian tropical forests, which have been inventoried for the past two decades starting from **Rai** (**1981**), showed a mature tree diversity ranging from 30 species ha^{-I} for trees 30.1 cm gbh in Nelliampathy in the Western Ghats (**Chandrashekara and Ramakrishnan, 1994**) to 80 - 85 species ha $^{-I}$ for trees 30 cm gbh in Kalakad forest of the Western Ghats (**Parthasarathy, 1999**).

Apart from the three main tropical forest blocks (the American, the African and the Asian) discussed above, a few studies are available from other tropical forests too (Table 1). They include those of Queensland (**Williams *et al.,* 1969**), New Caledonia (**Jaffre and Veillon, 1990**), La Reunion (**Strasberg, 1996**) and Papua New Guinea (**Wright *et al.,* 1997,Oatham and Beehler, 1998**).

Species diversity

The simplest measure of diversity is to count the number of species, and theresult is termed species richness. Though species richness and species diversity are often interchangeable, the latter should be regarded as involving the relative importance as well as the number of species in a community or stand (**Greig-Smith, 1983**). Species richness is the simplest measure to compare some 'patterns of diversity' (**MacArthur, 1965**). However, the disadvantage of species richness measure is that it does not take account of the abundance or biomass of plants (**Richards, 1996**).

It is increasingly clear that species (alpha) diversity of tropical forests variesdramatically from place to place (Table 1) and species richness is very much dependent on sample size: larger the sample, greater the expected number of species. This is evident from Table 1, where the- species richness is a whopping high for the large-scale plots, and especially the on plot values are looked into *(e.g.* **Kochummen*et al.*, 1990**; **Condit *et al*, 2000**). The most tree species rich forests of the world are Northwestern Amazonian rain forests (**Gentry 1988a**, **1988b**; **Valencia *et al.*, 1994**). For example, a single hectare of Amazonian forest can support 307 tree species with10 cm dbh (**Valencia *et al.*, 1994**). **Wright (2002)** has elaborately reviewed the tree diversity in tropical forests and hypotheses explaining the species richness.

Many causes for the gradient in species richness among the world forests (**Wallace, 1878**; **Pitman *et al.*, 1999**) and for the `mega-diversity' status of tropical forests have been examined (**Wallace, 1878**; **Duivenvoorden, 1996**; **Wright, 2002**). There might be several factors, climatic (**Pianka, 1966**), edaphic (**Hall and Swaine, 1976**; **Faber-Langendoen and Gentry, 1991**) and biotic (**Janzen, 1970**; **Connell, 1971**; **Phillips *et al.*, 1994**; **Terborgh*et al.*, 1996**), responsible for the species richness oftropical forests. Nevertheless, a satisfactory hypothesis is still awaited to get explanation on how the great species richness of tropical forests is maintained (**Richards, 1996**; **Duivenvoorden, 1996**).

Species diversity is also analyzed by statistical methods. Usage of diversity indices, such as Shannon (H'), Simpson (D), evenness index (E), Hill diversity (N_a),*etc,* to express the alpha diversity of a community gained popularity as they arewidely used (**Magurran, 1988**; **Krebs, 1989**). These indices take account of the relative density of individuals. Of late, nonparametric estimators of species richnessare computed using software *(e.g.* the Estimates 5 of **Colewell, 1997**). The latter computes diversity indices well as the Morisita-Horn index of biotic similarity between samples.

Species-area curve is a graph, which plots cumulative number of species against cumulative size of the area (**Brower *et al.*, 1990**). It is useful in evaluating species richness in a habitat. Where numerous species occur on a small area the curverises steeply. Where the minimum area is large the curve continues to raise a long way before flattening (**Whitmore, 1990**). These represent high alpha and beta diversity, respectively.

In ecological population studies, numbers of individuals are basic information. Abundance is the number of individuals in a given area, and density is that number expressed per unit area (**Brower *et al.*, 1990**). Frequency and basal area are the other two basic measurements used in describing populations and communities. Frequency refers to the number of samples in which a species occurs. This is expressed as the proportion of the total number of samples taken that contains the species in question. Basal areas of trees are determined from trunk circumferences measured at breast height above the ground.

Population structure

Populations, whether plant or animal, vary in their proportions of young and old individuals (**Brower et al., 1990**). **Hutchings (1986)** described the plant population biology in detail. In the case of trees, the proportions of individuals belonging to the various girth classes in a forest stand will form the forest population structure. If the population structure is worked out for a species, it is called species population structure. Species population structure is useful in the interpretation of forest succession (**Finol, 1971**). Usually, most of the studies (**Knight, 1975**; **Kadavul** and **Parthasarathy**, **1999a**, **1999b**) use the uniform girth class categories to discuss the population structure of different species in a stand. However, usage of uniform girth class categories is discouraged (**Bongers*et al,* 1988**; **Condit *et al.,* 1998**) as species vary in their biology.

Knowledge on population structure is important, for the age distribution of a population affects its growth and dynamics. At stand level, a growing population willshow an increased proportion of young individuals (small-sized stems), a stable population will show no increase or decrease in the relative numbers in each age (girth) class, and a declining population will show an increase in the proportions ofthe population in the older age (girth) classes (**Brower *et al.,* 1990**).

From the knowledge of the forest stand population structure, a life-table canbe constructed using the size class proportions (Usher, 1966; Enright and Ogden,1979; Platt *et al.,* 1998; Newbery and Ganlan, 1996; Condit *et al.,* 1998) and with this, the future of the forest can be predicted (Lorimer, 1980; Knowles and Grant,1983; Ogden, 1985; Hart *et al.,* 1989; Franklin *et al.,* 1993; Read *et al.,* 1995).

Spatial dispersion patterns

Density alone gives an incomplete picture of how a population is distributedwithin a habitat, for two populations can have the same density but quite differentspatial dispersion patterns. There are three basic patterns of dispersion: uniform (or regular), random and contagious (also called clumped, clustered, or patchy). Contagious and uniform dispersion patterns are sometimes called over-dispersed andunder-dispersed (**Brower *et al.,* 1990**).

A consequence of the high species diversity that characterizes tropical forestsis the low density of most tree species and the large expected distances between con-specific trees (**Richards, 1996**; **Hubbell, 1979**). Recognizing the distantly locatedadult con-specific trees in most tropical forests, several studies have been conducted to examine the patterns of tree spatial dispersion. These studies (**Pires*et al.,* 1953**; **Ashton**, **1964**, **1969**; **Poore, 1968**; **Lang *et al.,* 1971**; **Greig-Smith, 1979**; **Hubbell, 1979**, **1980**; **Lieberman**, **1979**; **Forman and Hahn**, **1980**; **Fleming and Heithaus**, **1981**; **Thorington*et al.,* 1982**; **Newbery *et al.,* 1986b**; **Sterner *et al.,* 1986**; **Lieberman and Lieberman**, **1994**; **He, *et al.,* 1997**; **Condit *et al.,* 2000**) indicate that many tropical tree

As 13 diversity is the variation in species composition between areas of alpha(a) diversity, and by measuring 3 diversity, the degree of association or similarity of sites or samples is obtained (**Greig-Smith, 1983; Pielou, 1984; Southwood, 1978**). The simplest and easiest way to measure the p diversity of pairs of sites is by the use of similarity coefficients. Despite the availability of vast range of similarity indices (**Bray and Curtis, 1957**; **Clifford and Stephenson, 1975**; **Southwood, 1978**; **Janson and Vegelius**, **1981**; **Wolda, 1981**; **Taylor, 1986**).**Wolda (1981)** found versions of the Sorenson index and the Morisita-Horn index were among the most satisfactoryavailable.

A good representation) of 13 diversity especially when there are a number of sites can be obtained through cluster analysis. Cluster analysis begins with a matrix giving the similarity between each pair of sites. The two most similar sites in this matrix are combined to form a single cluster. The analysis proceeds by successively clustering similar sites until all are combined in a single dendrogram (**Pielou, 1984**). Several studies (**Poore, 1968**; **Whittaker**, **1972**; **Schmida and Wilson**, **1985**; **Magurran**, **1988**) have measured 13 diversity by using one or more of the several indicesavailable.

Quantitative plant biodiversity inventories of Indian tropical forests for tree inventories are available from various forests of Western Ghats (**Sukumar et al., 1992**; **Ganesh et al., 1996**; **Pascal and Pelissier, 1996**; **Ghate et al., 1998**; **Parthasarathy, 1999**; **Parthasarathy and Karthikeyan, 1997a**; **Ayyappan and Parthasarathy, 1999**) and on the Coromandel coast of India (**Parthasarathy and Karthikeyan, 1997b**; **Parthasarathy and Sethi, 1997**), but the Eastern Ghats is poorly studied for these aspects, except those of **Kadavul and Parthasarathy (1999a)** in the Shervarayan hills and **Kadavul and Parthasarathy (1999b)** in the Kalrayan hills.