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Floristic Diversity in the Tropics: Ensuring Sustainability of This Natural Heritage is a Matter of Life and Death: A Review

Echereme, Chidi Bernard*and Mbaekwe, Ebenezer Ike
Department of Botany, Nnamdi Azikiwe University, P.M.B. 5025, Awka, Nigeria

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****Corresponding Author***

Chidi Bernard

Abstract

The consequences to the tropical forest ecosystem structure of man's cultural progression from a predator to a domesticator and farmer, and the associated diffusion of agricultural concepts in the region, have of course, been profound. The conversion of tropical forests to crop land and other uses typically entails the replacement of systems rich in biodiversity with systems poor in biodiversity. We reviewed regional occurrences of floristic diversities of tropical forest on the planet and how man has led to gradual and progressive removal of the rich natural resource. Agricultural activities and timber harvest are used to discuss ways human contribute to loss of floristic diversity in the tropics. Since it is obvious that the population must usually obtain the majority of its food and other resources locally it is therefore of the utmost importance to plan a reasonable pattern of land-use to take account of present and future requirements. Thus, understanding how human activities influence the forest is a milestone in developing effective management and conservation principles.

INTRODUCTION

The sheer bulk of energy-laden materials in tropical forests, coupled with the progressive increase by photosynthesis, ranks tropical and subtropical forests in a unique position as a global natural resource (Table 2). Ensuring increase in yields of these yields of this natural heritage is a human and economic problem, indeed it is not too much to say that it is a matter of life and death to many of the people of the tropics, and yet so many attempts have ended in failure.

In the tropical forests, where both species diversity and anthropogenic pressures on the natural environments are high, biodiversity is threatened by human-driven, land-use changes (Gibson et al., 2011). Loss of natural habitats to human land-use, particularly agriculture, is predicted to be the major driver of biodiversity loss in the 21st century (Sala et al., 2000), and this is particularly true in tropical forest ecosystems. Rapid deforestation of tropical forests for agriculture, timber production, pasture, firewood, construction of roads and dams, and other uses, have dire consequences on the tropical biodiversity along with the products (Lamb et al., 2005; Ravikanth et al., 2009; Gibson et al., 2011; Uma Shaanker et al., 2003, 2004). Deforestation continues at an alarming rate, mostly in tropical regions (Ghazoul and Evans, 2001). The 2005 Global Forest Resources Assessment by the Food and Agriculture Organisation of the United Nations (FAO, 2004) estimates the deforestation at 13 million hectares per year. As tropical forests contain at least half the earth's species, this represents enormous loss

Current interest in sustainable forestry based on managing entire forest ecosystem is generating a need for increased understanding of the effects of forest management on floristic diversity pattern at the landscape-, stand-, and plant levels (Roberts and Gilliam, 1995; Lindenmayer et al., 2006; Reader and Bricker, 1992). Research efforts have begun to focus on the long-term effects of forest management on the spatial and temporal distribution of forest under-storey floras. Some of the earlier studies that attempted to draw a direct link between timber management and floristic diversity point to clear cutting, logging damage, disruption of competitive dynamics, rapid micro-and macro-environmental changes and short harvest rotations and negative influences on herb populations (Duffy and Meier, 1992; Meier et al., 1995). Although forest management certainly affects floristic diversity patterns, the magnitude and trajectory of those effects are not well known for the variety of silvicultural techniques that managers have at their disposal, or across the multitude of forest types currently under management (Ellum, 2009).

The diversity rate of human population in the developing countries, where most of these forests are located, has triggered a greater demand for timber and other forest products, making sustainable management of these remnant forests a major challenge (Wright and Muller-Landau, 2006). Human disturbances often lead to altered environmental conditions, which influence the process that can both augment and erode species diversity in the tropical forest community (Kennard et al., 2002; Sapkota et al., 2010).

Species Diversity of Tropical Forests

From the gene level to the habitat level, tropical forests have the most terrestrial biodiversity on the planet (Myers, 1988). More than 50% of known plant species grow in tropical forests. A single hectare (ha) of tropical forest typically contains well over 100 species of trees. The tropical forest is thus an outstanding example of a complex biocoenosis; there is closely integrated community of different species. Nowhere in the world is the diversity and the interdependence of plants and animals more obvious: shade-tolerant plants germinating and developing under the canopy of trees; lianas reaching the upper layers by utilizing trees as scaffolding; stranglers surrounding big trunks; epiphyllous liverworts overgrowing leaf blades; lichens covering the bark; orchids growing in the crown-humus; fungi and bacteria decomposing wood and litter; ants feeding from floral and extra floral glands; insects pollinating flowers; birds disseminating seeds; rodents feeding on fruits; herbivores grazing on seedlings; leopards preying on smaller mammals; and so on (Longman and Jenik, 1974).

It is clear from much of the foregoing that there are very numerous life forms and species in tropical forests, at least as far as the climatic climax vegetation is concerned. The total number of plant species given in many local floras is still far from complete. Epiphytes, for example, are rather poorly recorded and it has been estimated that many hundreds of species remain to be described, as, for example, in the case of orchids in New Guinea (Longman and Jenik, 1974). Considering animal kingdom for a moment, the number of unnamed insects alone is enormous. The larger trees and woody climbers are better documented, and, are, of course, these phanerophytes, which provide the bulk of the forest structure. For instance, in five types of tropical forest in Zaire (Congo Kinshasa), between 90 and 100 per cent of all plants were phanerophytes, the few others being geophytes (4-10 per cent), chamaephytes (2-4 per cent) and hydrophytes (2-3 per cent), while there were no representatives of the hemicryptophytes and theophytes (Evard, 1968).

In South-East Asia, it is used to find more than a hundred different species of trees per hectare, excluding seedlings (Wyatt-Smith, 1953), while some recent estimates suggest that occasionally the total number of woody species may be almost 400 per hectare. The relatively poorest tropical forest region is the African, where less than 100 woody species per hectare is typical. A rare attempt to compare the tree diversity with that of all vascular plants is shown in figure 1 based on the work of Lawson et al. (1970).

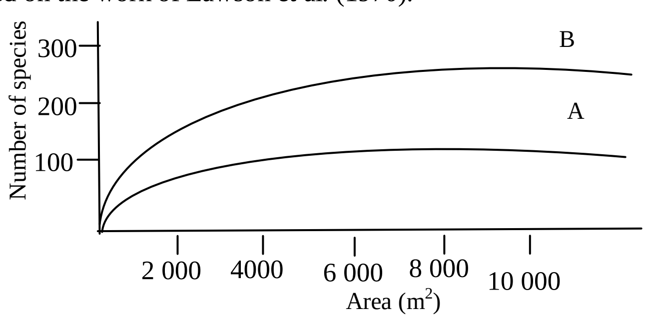

Fig. 1. Comparison between species/area curves for (A) tree species and (B) total vascular plants in an African evergreen seasonal forest.

Lawson et al. (1970)

Some of the important families and genera found in different tropical forests are given in Table 1 while other taxa occur mainly or entirely in one part of the world. America, Africa and Malayan tropical forests are often characterized by the frequency of leguminous trees (Caesalpinaceae, Mimosaceae, Papilionaceae), which commonly appear as emergents in the upper tree layer. The same synusia is often dominated by dipterocarps (Dipterocarpaceae) in the Indo-Malasian region, where the presence of families such as the Fagaceae, which have tree representatives in temperate forests, is worthy of note. At the level of genera and species, only a few taxa are naturally pantropic. For instance, *Ceiba pentandra* is nowadays found widely in America, Africa and South-East Asia, but is only certainly indigenous to the first region (Baker, 1965).

Table 1. Examples of families and genera containing dominant abundant or subendemic species of woody plants in the chief Tropical-forest Regions by Longman and Jenik (1974).

Region	Family	Genus
American Topical-forest Region	Leguminosae	*Andira, Apuleia. Dalbergia Hymenolobium, Mora*
	Sapotaceae	*Manilkara, Pradosia*
	Meliaceae	*Cedrela, Swietenia*
	Euphorbiaceae	*Hevea*
	Myristicaceae	*Virola*
	Moraceae	*Cecropia*
	Lecythidaceae	*Bertholletia*
AfricanTropical-forest Region	Leguminosae	*Albizzia, Brachystegia, Cynometra, Dialium, Erythrophleum, Gilbertio dendron*
	Sterculiaceae	*Cola, Nesogordonia, Tarrietia, Triplochiton*
	Meliaceae	*Carapa, Entandrophragma, Khaya*
	Euphorbiaceae	*Drypetes, Macaranga, Ricinode,Uapaca*
	Moraceae	*Antiaris, Chlorophora, Ficus*
	Sapotaceae	*Afrosersalisia, Chlorophyllum*
	Ulmaceae	*Celtis*
Indo-Malaysian Tropical-forest Region	Dipterocarpaceae	*Dipterocarpus, Dryobalanops, Hopea, Shorea, Parashorea*
	Mormaceae	*Artocarpus, Ficus*
	Anacardiaceae	*Mangifera*
	Actinidiaceae	*Actinidia*
	Daphniphyllaceae	*Daphniphyllum*
	Dilleniaceae	*Dillenia*
	Gonystylaceae	*Gonystylus*
Australian Tropical-forest Region	Myrtaceae	*Eucalyptus, Agonis, Baeckea, Backhousia, Osbornia*
	Dipterocarpaceae	*Dipterocarpus*
	Casuarinaceae	*Casuarina*
	Himantandraceae	*Galbulimima*
	Corynocarpaceae	*Corynocarpus*
	Dilleniaceae	*Hibbertia*
	Menispermaceae	*Carronia*
	Cunoniaceae	*Ceratopetalum*

In many other cases, further taxonomical and phytogeographical studies will be needed to establish the status of closely related species, as for instance, *Symphonia gabonensis* in Africa and *S. globulifera* in America.

The distinction between regions is also reflected in the floristic composition of the epiphytes, and the main groups can be summarized as follows (Tixier, 1966):

Africa: Orchidaceae, ferns

America: Orchidaceae, ferns, Bromeliaceae, Cactaceae

Indo-Malaysia: Orchidiaceae, ferns, Asclepiadaceae, Rubiaceae

Floristic differences also appear in the composition of secondary forest. Some representative genera and species are:

Africa: *Harungana madagascariensis*, *Macaranga spp.*, *Musanga cecropioides, Trema guineensis*

America: *Cecropia spp.*, *Miconia spp*., *Vismia guianensis*

Indo-Malaysia: *Elaeocarpus spp,,Glochidion spp*., *Macaranga spp.*, *Mallotus spp*.

Dispersal: The Driving Force of Biodiversity in Tropical Forests

It is natural to plant species that, being largely immotile, they have evolved specific and well-developed aids to dispersal which may be extremely efficient. Dispersal is crucial for increasing a seed's chances of escaping predation and shade under the mother tree and reaching microsites favourable for growth, such as tree-fall gaps or better soil (Babweteera and Brown, 2010).

A high percentage of tropical tree species rely on specialized sets of annual vectors for pollination and seed dispersal, especially, birds, bats, and various other mammals, which are both processes that are necessary for successful reproduction by tropical trees (Anitha et al., 2010).). Because of the diversity of seed types and the behavioural ecology of seed dispersing animals, the post-dispersal patterns of seeds vary widely. Therefore, it is likely that frugivore animal diversity in tropical forests strongly influences tree recruitment and spatial distribution.

The importance of seed dispersal for the coexistence of tree species is well established (Seidler and Plotki 2006; Donatti et al., 2011). Thus, the diversity of tropical forest tree species may originate from and is maintained by the mutual relationships of tree species and their pollinators and seed dispersals. These mutual relationships open the door for struggle for survival over limited supply of resources. It can, at this juncture, be inferred that competition and coexistence are central to the origins and maintenance of extremely high degree of species diversity in the tropical forest. According to Satoshi et al. (2015) both coexistence and diversified evolution of tree species can be explained by the introduction of animal seed dispersers.

Possible Reasons for Greater Floristic Richness of Tropical Forest

Tropical forests contain the highest diversities of plants and animals anywhere on the planet (Myers, 1988). There is much argument over the possible reasons for great diversity of species of the tropical forest. There is no single complete theory, but the salient points appear to be, according to Longman and Jenik (1974) as follows:

1. Any explanation of the present differences in species diversity between tropical forests and other vegetation must consider the underlying environments in which they have developed. Naturally, the more variable the conditions the more varied the flora. One cannot ascribe the species diversity to favourable and unchanging warm and moist conditions occurring over large areas, since such uniformity of environment would necessarily tend to yield uniform vegetation. In any case, the climate and soils are in fact rather variable, and most striking, the structure of the tropical forest itself creates a wide range of microhabitats many of which differ profoundly from each other.

2. The diversity of a certain location depends, in addition, on the possibility of immigration, with exchange of forms and species. The existence of neighbouring regions of different character such as mountains and semi-arid regions, will affect the chance of interchange. This will also depend on such factors as the direction of winds and sea currents, the orientation of main river valleys and mountain ranges, and migration routes of birds and herds of

mammals. For example, one may expect the floras of the Amazon Basin to be influenced by their accessibility from the neighbouring Andes (i.e., a mountain range which extends along the western coast of the South America).

3. The effectiveness of immigration also depends on whether the exchanging forms and species can permanently establish themselves in their new environments. The question here is whether the tropical forests possess special advantages as far as preservation of species is concerned. Since it has been shown in point 1 above that there are many different niches within the tropical forest structure, it seems clear that this kind of vegetation can indeed serve as a refuge for species. It may be objected that there is severe competition inside the tropical forest, and indeed there is at any one site. But, throughout the mosaic of the forest at large, new gaps are always appearing, providing opportunities for colonization by both old and invading forms.

4. Diversification also comes about through speciation *in-situ*. Is the tropical forest particularly for the development of new forms? In order to answer this, one has to consider the relevant population patterns. Unlike the conditions in temperate forests and many other widely-studied ecosystems, individual specimens or small groups of a species are often isolated from their kind. Population patterns therefore are quite different from those in communities containing large numbers of each species, and cross-pollination, so important in evolution, may be restricted in extent except where specialized adaptations are in play, as, for example, gregarious flowering. The general isolation, however, will tend to produce new forms through genetic drift. Thus, internal isolation occurs within the same vegetation structure that is potentially accessible to invading species. In addition, speciation may be enhanced through violent but local disturbances, such as hurricanes, volcanic eruptions and mountain building.

5. All in all the reasons for species diversity in tropical forests are very complex, showing many interactions of the environmental and evolutionary features, which have been discussed above. Moreover, one should be ready to consider that there may be special biochemical or biophysical characteristics which favour both a luxuriance and speciation in the warm and humid tropics. An obvious example would be if mutations occurred more frequently in tropical forests, for it is well established that higher temperatures promote mutation rates of organisms under experimental conditions. A number of high-yielding tropical plants, such as maize and sugar cane, have been shown recently to differ from many other crops in lacking photo-respiration, and thus in conserving carbohydrates. It remains to be seen how widespread this phenomenon is among other tropical plants, but it could possibly be a factor in the high primary production and the general luxuriance of the tropical forest. These might also be influenced by biophysical considerations, for instance, by changes which occur in the properties of water molecules at relatively higher temperatures, or by other biochemical aspects, such as generally increased enzyme activity occurring under the prevailing mild temperatures in the region of 25^0 C.

The Estimated Rate of Loss of Regional Tropical Forests

There has been a serious and growing concern regarding the status and use of natural forests. The rate of forest destruction has accelerated significantly since the turn of the century. This is most critical in the tropics where over 2.5 billion people depend on the natural forest resources for a variety of services (Park, 1992).
Cunningham and Cunningham (2004) report that an estimated 12.5 million km^2 of tropical lands were covered with closed canopy forests a century ago and 9.2 million ha or about 0.6 per cent of the remaining tropical forest is cleared each year. According to Waggoner (2000), the Asian-Pacific sub-region has experienced continuing deforestation and degradation. From 1990-1995, the sub-region recorded a decline of almost 16.3 million ha of natural forest or approximately 3.25 million ha annually. The largest losses were in Indonesia (5.4 million ha), Myanmer (1.9 million ha), Malaysia (2.0 million ha) and Thailand (1.6 million ha) (Otu et al. (2011). However, the Philippines had the largest rate of deforestation at (3.5%) annually, followed by Pakistan (2.9%), Thailand (2.6%) and Malaysia (2.4%) (Otu et al., 2011).

South America stands the region with the highest rate of loss in floristic diversity on the planet. Unfortunately, currently the Amazon suffers the highest rate of deforestation associated with land-use change, especially for agriculture expansion (pasture and soya bean), commercial logging and settlements (EOLSS).

Estimate of forest losses in Africa and Nigeria (Okonkwo et al., 2002) were observed to be higher. According to the (FAO, 2003), Africa lost the highest percentage of tropical forests of any continent during the 1980s, 1990s, and early 2000s. FAO (2007) also reported a net loss of about 4 million hectares for the period 2000-2005.

Nigeria has lost 81% of its old-growth forests in just 15 years (1990-2005). Massive deforestation threatens food security in some Africa countries (Rhett, 2014). One contributing to the continent's high rates of deforestation is the dependence of 90% of its population on wood as fuel for heating and cooking (Yvonne, 2001).

Diverse Uses of Forest Resources in Tropical Regions

Forest resources increasingly constitute a significant element in the national economies on many tropical countries. Tropical rainforests are sources not only of widely exploited timber and plantation products, but also food species, medicine, resin, oils, gums, pest control agents, fuels, fibre and forage for forest dwellers and small scale farmers (Bisong, 2001). Our tropical forests offer a unique contribution to biological knowledge in respect of phenomena that remain unknown in temperate regions. In fact, there is no gainsaying that when an equivalent amount of research has been conducted in the tropics it will be necessary to re-visit many literatures. Beyond supplying industrial raw materials, forest also have the added value of conservation for scenic purposes, sterilization of climate, maintenance of water supply and prevention of erosion (Longman and Jenik, 1974). The distillation of wood yields a variety of valuable industrial chemicals such as methanol, acetic acids, turpentine and other products. In this age of energy shortages and oil politics, the possible use and establishment of energy plantation or tree plantation to harvest solar energy through bioconversion have been increasingly explored. The dense forest canopies form good protectors of soil against radiation and excessive temperature fluctuation. Vegetation generally serves as a good conserve of soil water by encouraging percolations and discouraging run-offs. Its humus content also augments the water storage capacity of the soil for future use by both plants and animals. Trees also offer important function of breaking the sources of wind, thus preventing wind erosion. Such wind breaks help to increase in the productivity of land by reducing the desiccating and aggressive effects of wind. Forest provides food and habitat for wildlife; wildlife management is almost impossible without some form of forest management.

In fact, forests are naturally endowed with numerous resources that are valuable to mankind, but unfortunately, the increased demand for forest resources and the technology adopted by man for extraction from the forest without corresponding advancement in ensuring sustainable management has caused severe deforestation and degradation of forest resources (Jimoh, 2001).

The Effects of Agricultural Practices on Floristic Diversity

The consequences to world ecosystem structure of man's cultural progression from a predator to a domesticator and farmer, and the associated diffusion of agricultural concepts throughout the world, have really, been profound. While a hunter and even a collector and gatherer, he usually lived conservatively, according to the confines of his environment, and with low inclination towards ecological dominance, except where he used fire relatively frequently.

Within a few thousand years of the adoption of cereal agriculture, the old hunting-gathering style of social organization began to decline (Wadley and Martin, 1993). Agriculture and civilization meant the end of foraging; a subsistence method with short- goals and rewards, and the beginning (for most) of regular arduous work, oriented to future pay offs and the demands of superiors (Wadley and Martin, 1993). To achieve this aim, there were schedules, quotas, overseers, and punishments for slacking off (Pfeiffer, 1977). As a result of forest clearance, the extent to which forest ecosystem interrelationships are further altered depends mainly on the type of agricultural system adopted and on the human population density.

New land is then cleared through felling of trees or burning to be cultivated rotationally in its turn. This slash-burn type of agriculture is extremely conservative in its approach, in that, consciously or unconsciously it seeks to preserve the structure of the forest ecosystem, and rarely overstraining chemical and energy resource of the environment, albeit some reduction in productivity may be noticed if population density becomes very great and the rotational patterns have to be compressed so as to meet the increased human food requirements.

In contrast, exploitative and seriously destructive agricultural systems have been recently extended in scale in the tropical regions by the widespread adoption of ever more intensive methods of food-crop production, especially monoculture (Miguel, 2000). The adoption and retention of these approaches frequently give rise to a major depreciation in the physical and chemical resources of the soil, a general loss of fertility, and eventually soil loss and soil erosion.

The ever-expanding global population is already placing intense strain on natural resources, and one of the major facets of this is land-use change. For example, one of the most lost of all tropical forest regions, South-East Asia, is experiencing one of the most rapid rates of loss, and could lose 75% of its original forest extent and 30-40% of its biodiversity by 2100 (Laurance, 1999). The main sources of deforestation in the Amazon are human settlement and development of the land (Bierregaard et al., 1992). Prior to the early 1960s, access to the forests interior was highly restricted, and the forest remained basically intact (Kirby et al., 2006). Farms established during the 1960s were based on crop cultivation and the slash and burn method. However, the colonists were unable to manage their fields and the crops because of the loss of soil fertility and weed invasion. The soils in the Amazon are productive for just a short period of time so farmers are constantly moving to new areas and clearing more land. Between 1991 and 2000, the total area of forest lost in the Amazon rose from 415,000 to 587,000 sq km, with most of the lost forest becoming pasture for cattle (Bierregaard et al., 1992).

Increasing Scale of Logging Activity in the Tropics: Ecological Consequences for Biodiversity

It is no surprise that the world's natural tropical forests are being exploited, especially for economic purposes, at two to three times higher intensity than what they have shown themselves able to recover. The most valuable species are selectively harvested first and when they are depleted, the next-most-valuable set is taken, until the forests are mined completely of their timber and the land becomes worth more for agriculture or ranching than for forestry (Hall, 2008; Asner et al., 2006; Schulze et al. 2008b). However, there have long been questions as to whether industrial logging of tropical forests can truly sustain natural ecosystems while permitting repeated harvests of high-value timber (Nasi and Frost, 2009).

Logging activity, apart from disrupting the floristic structure and composition of forest ecosystem, poses a huge threat to forest understorey species. During and immediately after timber harvest, understorey plants are exposed to major changes in their physical environment. These changes can include increased nutrient levels, greater diurnal temperature fluctuations, and fluctuations in soil moisture content and relative humidity (Denslow, 1985; Philips and Shure, 1990). The most dramatic change is in the form of increased levels of direct Photosynthetically Active Radiation (PAR) on the previously shaded groundstorey strata (Canham et al., 1990). These changes are not uniform across a forest gap, and can vary significantly depending on the position of a microsite in relation to the edge or centre of the zone of disturbance and the spatial orientation of noncircular gaps (Runkle et al., 1982; Canham et al., 1990). The temporal component of changes in understorey light environments is also emphasized, and depends on the direction in which light levels are changing. Typically, increases in light levels to the groundstorey are instantaneous through natural tree fall or canopy tree removal as a result of timber harvest.

Most tropical trees of undisturbed primary forest, including virtually all currently high-value timber species, are exceptionally long-lived and slow growing, occur at low adult density, undergo high rates of seed and seedling mortality, sustain very sparse regeneration at the stand level, and rely on animal diversity for reproduction, all of which point to the conclusion that tropical trees possibly need very large continuous areas of ecologically intact forest if they are to maintain viable population sizes (Piman et al., 1999).

Table 2. Net Primary production and biomass estimated for different types of vegetation

	Net primary production			Biomass	
	Area (10^8 ha)	per unit area (dry tonnes/ha/yr)	On a world basis (10^9 dry tonnes/yr)	per unit area (dry tonnes/ha)	On a world basis (10^9 dry tonnes)
Tropical forest	20	20(10-50)	40.0	450(60-800)	900
Savanna	15	7(2-20)	10.5	40(2-150)	60
Temperate forest	18	13(6-30)	23.4	300(60-2 000)	540
Boreal coniferous forest	12	8(4-20)	9.6	200(60-400)	140
Tundra and alpine grassland	8	1.4(0.1- 4)	1.1	6(1-30)	5
Steppe and other temperate grassland	9	5(1.5- 15)	4.5	15(2 -50)	14
Agricultural land	14	6.5(1- 40)	9.1	10(4 -120)	13

Data from Whitaker's Almanack (1970)

Silviculture: Hope for the Future of Tropical Forest?

Silviculture comes into forest resource management in the biological sector. Literally, it is understood to involve the formation of new or regeneration of old forest and caring for them until they are mature for their intended use (principles of silviculture). It is therefore a science of how a forest crop can be produced naturally or artificially and cultured under the prevailing economic conditions to maturity for the projected use so as to realize the highest profits in terms of the land owner's objectives in managing the forest. The historic objective of silviculture in natural tropical forest has been to enhance the growth increment and abundances of timber species (Guitet et al., 2009). Silviculture in the tropics was intended to maximize access to light and nutrients for high value timber trees, seedlings, and saplings and, therefore, relied on removing competing trees and vines.

Contributing to the ways to improve the silvicultural practices for efficient forest management, silvicultural system should start with logical examination of the various natural and economic factors which enter into their conservation and evolutionary development (Smith, 1962). A rational silvicultural system should satisfy the socio-economic objectives of management of the forest, provide for sustained yield through adequate reproduction and growth of the desired species and protection of site productivity. However, silviculture models developed for tropical forests have yet to result anywhere in a sustainable timber yield at operational scale. Where attempts have been made to apply post-logging silvicultural treatment broadly, such as in Indonesia and Malaysia, they have failed to achieve the objective of sustainable timber production or forest conservation (Kuusipalo et al., 1997; Nawir and Rumboko 2007).

In addition to its failure to achieve its objective of sustainable timber production, silvicultural practices seem to have neglected the post-effects of tree removal on the ecology and phytogeography of the forest understorey. The herbaceous forest component has been identified as an important indicator of land-use history (Foster, 1992), microclimate and microsite conditions (Beatty, 1984), soil moisture conditions (Davdson and Forman, 1982), nutrient cycling pathways (Siccama et al., 1970), ecosystem resilience and post disturbance (Roberts and Gilliam, 1995), a determinant of spatial distribution and relative densities of seedlings (Maguire and Forman, 1983), as a potential tool for indicating site index for timber production (Strong et al., 1991) and as well as an important factor in the early stages of stand development (Smith et al., 1997). Thus, the herbaceous understorey plants are to be understood physiologically and demographically if forest managers are to successfully maintain or increase biological diversity within vegetative communities (Ellum, 2009).

Conclusions

From the rich biodiversity and unprecedented net production of tropical forest, the forest remains an outstanding global natural resource (Table 2). The fact remains that the tropical forest is hitherto progressively diminishing. Although, silviculture has contributed substantially to forestation with the chief aim of producing commodity forest species, it is imperative that forest managers refine current silvicultural methods to give greater attention to the ecology of non-commodity forest species, especially the understorey and herbaceous floras.

Consolidated efforts on the information on parameters such as the levels of threats, the spatial patterns of population/species richness, distribution, their interactions, genetic diversity, e.t.c., are utmost needed for planning and effective conservation and sustainable utilization. Endangered, highly threatened and economically important species need to be selected and given the utmost attention. Also, national as well as local programmes aimed at sustainable forest conservation should be conducted to integrate the local community, forest managers, policy-makers and the scientific community for attainment of a common goal.

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