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Introductory Chapter: Managing World's Forests for Sustainable Development

Mohd Nazip Suratman and Zulkiflee Abd Latif

1. Introduction

Forests are important biological resources as they provide habitat for many of the world's species [1]. Forests also provide timber and non-timber forest products such as bamboo and rattan and food ranging from fruits, mushrooms, honey, and a wide variety of traditional medicines that are critical for human survival [2]. Furthermore, they are key component of many species' habitats, providing nourishment, shelter, and structural features needed for communication, surveillance, and other activities [3]. They also provide significant ecosystem services in terms of nutrients, water cycling, prevention of erosion, sequestration of carbon as well as performing of range of other physical and biological functions. Forests are the main filters in the earth since there are many pollutions from human activities such as industry and motor transportation are disposed, i.e., carbon dioxide (CO₂), water (H₂O), nitrogen (N), nitrogen dioxide (NO₂), and sulfur dioxide (SO₂) (National Research Council U.S., 1972). These pollutants can be filtered by plants for its life cycle, thereby reducing pollution at the atmosphere, although CO₂ and H₂O become main material for their photosynthesis [4]. Results from photosynthesis of plants are the main energy resources for all animal life including human. It is a substantial ecosystem service in terms of providing nutrients, water recycling, prevention of erosion, and carbon storage in the terrestrial ecosystem as well as sequestering CO₂ in the atmosphere [5–8].

2. Forest degradation around the world

The growth in human population has forced mankind to explore existing resources, including forest for multiple purposes [9], for instance, logging of timber for wood-based industries, agricultural activities, urban areas, road, and mining. All these practices are done at different stages of forest growth which give significant impacts on the stand structure, composition, and other components of the forest and will consequently reduce forest productivity and their ecosystem functions [10]. During early civilizations, forest occupied about half of the earth's surface. However, it has, at the moment, reduced into less than one-third of the total earth's surface. The significant reduction of the forest areas requires appropriate planning and management for the conservation [8], especially forest in the tropical and subtropical areas in the developing nations. Today, the degradation of the forest due to anthropogenic activities and natural disturbances is significantly reducing total forest areas in the world. Originally, tropical forest covered about 1.5–1.8 billion ha

of the land surface [6, 11]. Unfortunately, one-third of these original forests have been lost because of deforestation, resulting into large degraded areas. To date, the degraded areas are common in many countries, most of which are converted into other land uses, although some of them will regenerate into secondary forests [12]. Currently, the secondary forest can be found in all areas in the world and it is estimated to reach about 64% of the total world forest [13].

The decrease of world's forest is caused by many activities such as clearing to open land for agriculture, roads, settlement, logging for timber, and cutting for fuel. Indirectly, forest is succumbing to the effect of environmental pollution and further threat by climatic change. Together, these causes have been responsible for decimating many of the world's forest, and they threaten to significantly degrade those that remain. Moreover, the burning of trees, shrubs, and other vegetation during land clearing and after logging further contributes to environmental deterioration [14].

3. The role of natural regeneration

Sapling regeneration is important to restore forest formation after disturbance, balancing the loss of primary forest and as a main sequester of CO₂. Their radial growth characteristics are the main performer of canopy closure, and it can be used to identify the canopy formation in the secondary forest after disturbances. Moreover, the canopy closure can be used to predict the vertical structure in the future; therefore, it will explain the pressure that will be given by dominant species in the later succession.

The continuing loss of primary tropical forest has made the secondary forest to be increasingly important for maintaining the ecology across the large forested landscapes [15]. The regeneration in the tropical secondary forest is strongly influenced by disturbances that resulted from natural tree fall in primary forest [15, 16]. Regeneration is widely recognized as being a key process in determining the structure and dynamism of tropical secondary forest [17]. For instance, the logging of mature trees can reduce seed resource in the forest [9]. Nevertheless, it may increase the light intensity, which reaches the forest floor and will stimulate the seeds' germination and growth of saplings. The ability of regeneration in the degraded areas is determined by the success of the seedlings and saplings to grow [18].

The success of forest regeneration in terms of its distribution and diversity can be used as parameters to understand the level of forest succession and to figure out the population dynamic condition in the areas that have been controlled [18]. A lot of efforts have been made to study forest regeneration to provide information on ecological condition [18–20]; however, the data which have been collected cannot solve the same problem in different areas in the world. This is because every area in the world has different conditions which make it possible to create the different microclimate after fragmentation, and then influence the recovery process. The change of microclimate because of forest fragmentation will influence the plant species survival. Therefore, only species that can adapt to the environmental change will survive as different species have different capabilities to response to the ecological pressure. Furthermore, there are crucial chemical elements in the soil that have been recognized for growth of all plants [21], and the loss one of these elements will influence the plant growth, especially macronutrient. Besides the chemical elements, forest regeneration is influenced by light intensity which reaches under the canopy. The increasing of light intensity which reaches under the canopy will

stimulate the amount of photosynthesis that directly accelerates regeneration for the light demanding plant [12].

4. Carbon sequestration in forests

Rapid development of industrial technologies in the world has contributed to the increment of greenhouse gases. The increase of greenhouse gases, such as CO₂ in the atmospheres, has led to global warming phenomenon. Nowadays, rise of global temperatures has constituted a challenge to the mankind. The increment of CO₂ today is estimated to be 1.3–1.9 ppm year⁻¹ [22]. According to [23], from the analysis recorded in Malaysia, the average of temperatures has increased by 1.1°C within 50 years, which is consistent with the trend on global warming.

In reality, trees have important function in the carbon sequestration process [24–26]. In this case, the conservation of plant resources in a sustainable manner is the best solution. Forests play important roles in the CO₂ sequestration process. Trees in the forests are important in order to perform the canopy closure in the forest and then influence the other species. Several studies have shown that the light intensity in the understory affects the growth and crown morphology of several tree species [17, 21, 27] and soil properties at allocation of plant biomass [28–31]. Additionally, the effect of soil properties and light intensity has been known to correlate with growth rate, and distribution pattern as well as species composition. In reality, each species has different capability to respond to their environmental factors.

In the tropical rainforests, nutrient cycling is probably one of the most significant ecological processes [32]. Similarly, according to Hamzah et al. [33], tropical rainforests are recognized as the richest ecosystems in the world in terms of structures, species diversity, and ability to maintain the global climate change by reducing the accumulation of greenhouse gases. According to Sands [34], tropical rainforests contain 70% of the world's plants and animals, 70% of the world's vascular plants, 30% of all birds, and more than 90% of all the invertebrates. There can be more than 200 tree species per hectare in tropical rainforest.

5. Tropical rainforests: Malaysia's perspective

The tropical rainforest in Malaysia is one of the most diverse, complex, and productive terrestrial ecosystems in the world. The climate of Malaysia is typically humid tropical and is characterized by year-round high temperatures and seasonal heavy rain. As a result of these climatic conditions, the predominant natural vegetation is tropical rain forest whereby the main forest types being lowland then hill dipterocarp forest, peat swamp forest, freshwater swamp forest, and mangrove forest [35]. Malaysia has a total land area of 32.86 million ha. Of the total land area, 20.46 million ha are forest areas in which Peninsular Malaysia, Sarawak, and Sabah cover 28, 45, and 27% of the total forest areas, respectively [13]. It was estimated that Malaysia forests in Peninsular and Borneo are about 2830 and 9000–15,000 tree species, respectively [36, 37].

5.1 Species composition

Malaysian tropical rainforest is a productive forest which consists of various valuable timbers from the family of dipterocarpaceae and non-dipterocarpaceae. The name “dipterocarp” comes from the Greek for “two-winged seed.” The

dipterocarp species are from the family dipterocarpaceae and are the giants of the South-East Asian forests as well as the dominant family in them. Dipterocarp trees dominate forests in Borneo, Sumatra, Java, Peninsular Malaysia, and the wet parts of Philippines. The largest genera are *Shorea* (196 species), *Hopea* (104 species), *Dipterocarpus* (70 species), and *Vatica* (65 species). Other common genera namely *Dryobalanops*, *Neobalanocarpus*, *Parashorea*, *Cotylelobium*, and *Anisoptera* are also important part of tree communities of tropical rainforests. It is common to find 25 or more species of *Shorea*, and six or more species of the other three genera in the forest of Peninsular Malaysia, Borneo, and Sumatra. Dipterocarp trees have excellent timber qualities, and they are marketed internationally as plywood and as sawn timber [38].

Non-dipterocarps consist of 427 species from 201 genera and 50 families of non-dipterocarps. Examples of important non-dipterocarp families are Leguminosae, Myristicaceae, Euphorbiaceae, Burseraceae, Sapotaceae, and Apocynaceae. Unlike dipterocarp species, generally non-dipterocarp timbers are less durable than the dipterocarp. However, according to Schulte [39], the non-dipterocarp species also play an important role within the tropical rainforest. They either form the major components of the understory layer (i.e., Annonaceae, Euphorbiaceae, Lauraceae, Meliaceae, Myristicaceae, and Rubiaceae) or they have the commercial use, frequently only locally as fruit trees (i.e., Moraceae, Anacardiaceae, Bombacaceae, Euphorbiaceae, Guttiferae, Lauraceae, Mimosaceae, Polygalaceae, and Sapindaceae).

5.2 Tropical rainforest formation

The main forest types in Malaysia are formed from three types of formation, that is, climatic, edaphic, and biotic climax. **Figure 1** shows five forest zones are developed from climatic climax formations are lowland dipterocarp forest (0–300 m above sea level [a.s.l.]), hill dipterocarp forest (300–800 m a.s.l.), upper hill dipterocarp forest (800–1100 m a.s.l.), oak-laurel forest (1100–1600 m a.s.l.), and montane ericaceous forest (above 1600 m a.s.l.) (Symington, 2004). These forests are characterized by species composition. The first three forest types are mostly dominated by trees from the dipterocarpaceae family; hence, they are termed as

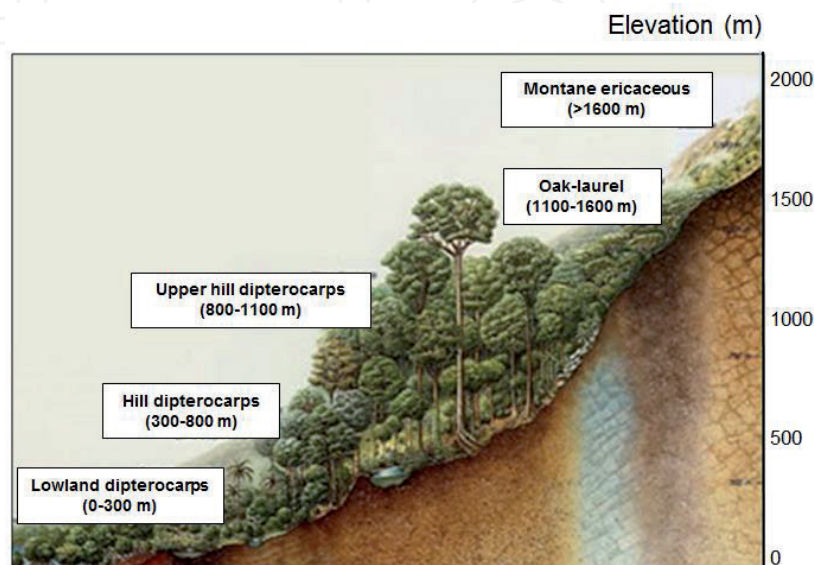


Figure 1. Altitudinal profile of forest zones developed from climatic climax formation in Malaysia (modified from Symington [40]).

dipterocarp forests. Montane ericaceous and oak-laurel are characterized by an abundance of trees from Fagaceae–Lauraceae and Ericaceae families, respectively [41]. They can be distinguished by a number of structural characters which include the size of canopy height, canopy layer, leaves, and the presence of vascular and non-vascular epiphytes and climbers. The montane forest also differs from lowland in having fewer and smaller emergent trees, flattish canopy surfaces, gnarled limbs, and denser sub-crowns [42]. The montane ericaceous and oak-laurel forests are moist and are characterized by a thick layer of mosses and bryophytes.

There are seven forest types that were developed based on edaphic climax formations [40]. The edaphic refers to ecological climax resulting from soil factors which are commonly persisting through cycles of climatic and physiographic change. These forests include mangrove swamp, peat swamp, freshwater swamp, beach, riparian, heath, and limestone. Mangroves occur on estuarine mud below the tide mark mainly concentrated in the west of Peninsular Malaysia [24]. Main genera of mangroves include *Rhizophora*, *Sonneratia*, *Avicennia*, *Bruguiera*, *Ceriops*, and *Lumnitzera*.

Beach forests form narrow strips of woodland, sandy, or gravel beaches along the seacoast, above the level of all but the highest tides. *Calophyllum inophyllum* (Bintangor laut), *Syzygium grande* (Kelat jambu laut), and *Casuarina equisetifolia* (Ru pantai) are the main common trees dominated the beach forests. Dipterocarpaceae species such as *Shorea siamensis* (Temak batu) has been recorded to occur in the beach forests of Pulau Rebana located at off the coast of Perlis [40].

Peat swamp forest developed on un-decomposed and partly decomposed organic matter. Over time, these create thick layers of acidic peaty soils. Most of the species are different from dry land. Dipterocarps are important components in peat swamp forests such as *S. albida* (Meranti merah), *S. uliginosa* (Meranti bakau), *S. teysmanniana* (Meranti bunga), *S. platycarpa* (Meranti paya), and *A. marginata* (Mersawa paya). Non-dipterocarpaceae species include *Tetramerista glabra* (Punah), *Gonystylus bancanus* (Ramin melawis), and *Koompassia malaccensis* (Kempas).

Riparian forests are narrow strips of vegetation in adjacent to a body of water such as a river, stream, and lake [43]. The zones of riparian forest are determined by the incidence of tidal influence, width of stream, rate of flow, and altitude. The most abundant Dipterocarpaceae is *D. oblongifolius* (Keruing neram). The best known non-dipterocarpaceae include *Saraca thaipingensis* (Gapis), *Pometia pinnata* (Kasai daun besar), *Tristanopsis whiteana* (Pelawan), and *Dysoxylum angustifolium* (Maris).

Freshwater swamp forests occur in flat land, which is inundated with freshwater, either permanently or seasonally. The forests contain many of the endangered species such as *D. semivestitus* (Keruing padi), *S. hemsleyana* (Cengal pasir daun besar), *V. flavida* (Resak padi), *H. apiculata* (Giam melukut), and *S. macrantha* (Meranti kepong hantu) as discovered at Hutan Simpan Parit, Perak [44]. Commonly found non-dipterocarps include *Alstonia spatulata* (Pulai basung), *Fagraea crenulata* (Malabera), and *Lagerstroemia* spp. (Bungor).

Heath forests are moist forest in areas with acidic and sandy soils that are extremely nutrient poor. The forests developed on pale, light-textured, and acidic sandy soils. The forests are known in Borneo as Kerangas—an Iban language means land too poor for rice growing once cleared. *S. glauca* (Damar laut daun kecil) occurs gregariously, other dipterocarps are *H. semicuneata* (Sama rupa cengal) and *Vatica odorata* (Resak kesat).

The association of man has resulted in destruction or interference of forests that produce a type of vegetation that is in equilibrium with the prevailing biotic factors. For example, lowland dipterocarp forests were converted into very different type of

forests due to cutting, firing, grazing, or intermittent cultivation. The forests mainly contain a mixture of *Schima wallichiana* (Medatang gatal) and *Oxytenanthera nigrociliata* (bamboo), which also includes forest remnants in the form of secondary forests in all stages of development from open grassland to scrub. Some common dipterocarps found in this type of forests are *S. roxburghii* (Meranti temak nipis), *Anisoptera* spp. (Mersawa), and *V. cinerea* (Resak laut).

Ecologically, Gelam swamp forests are related to the peat swamp forests but their floristic composition is almost entirely different. Many of secondary species exist, namely, *Macaranga maingayi* (Mahang) and *Stenochlaena palustris* (Akar paku). Fire has prevented the development of peat swamp complex and promoted predominance of the fire-resistant gelam—*Melaleuca cajuputi*. No dipterocarps occur in gelam freshwater swamp forest.

6. The need for sustainably managed forests

Sustainable forest management is high on both political and scientific agendas of many countries and at a global level, with much recent attention being focused on the tropical rainforest. Forest is the most biologically deserved terrestrial ecosystems within which trees are central to the habitat and environmental of other plant and animal species. Knowledge of the biology of tree flora is therefore critical in providing a sound scientific basis to the management and conservation of the world's forest resource. By its very nature, biodiversity and its conservation are complex and multi-faceted. With respect to forest, biodiversity may be viewed at the level of the forest community and constituent population of species.

The emphasis on conservation often has one dimension, traditionally focused on the establishment of national park for the protection of fauna or particular ecosystems with little regard for hierarchy of organization and the spatial and temporal dynamic of biological processes [40]. Deforestation continues to keep forest stand, and sustainable management of forest ecosystems for the future has become a global environmental imperative. Within this, effective management of forest genetic resources is a key element in the future forest conservation.

7. Biodiversity of forest

Biodiversity is referred to as the variety of plants, animals, and microorganisms that exist, the genes they contain, and the ecosystems they live in. The diversity of life that a tree can support is incredible. A single tree in the tropical rainforest can house up to 2000 different species of insects, birds, amphibians, reptiles, mammals, fungi, mosses, and epiphytic plants. Trees are an important component of biodiversity. The tropical rain forests are blessed with abundant biodiversity and are known to have more species per unit area than temperate areas and biodiversity decreases with increasing altitudes [41]. Tropical rain forests contain the mixture of species as compared with temperate forests which tend to be dominated by one species.

The status of biodiversity tropical rainforest as elsewhere has always been dynamic. Over millions of years, under natural conditions, some species have increased in variety or numbers and others have been reduced or lost. Some people wonder why we should be worried about conserving biodiversity now, in particular, when the world has gone on more or less as it is for so long. But natural habitats everywhere are being destroyed as never before and as habitats are lost, we are also losing various types of plants and animals. No one would have thought, even a few years ago, that some members from the family dipterocarpaceae in Malaysia could

be endangered, but now it is. With the rapid land use and cover changes, there are concerns that anthropogenic changes to environment are leading to too many of forest species being lost and biodiversity becoming seriously depleted.

Biodiversity is important because it helps to keep the environment in a natural balance. An ecosystem which is species rich is more resilient and adaptable to external stress than the one in which the range of species is limited. In a system where species are limited, the loss or temporary reduction of any one could disrupt a complex food chain with serious effects on other species in that same system.

Biodiversity is the key issue to natural conservation, and plant diversity is one of the important components of the biological diversity [45–47]. The diversity of tree species is fundamental to total forest biodiversity. The central biodiversity in the world are tropical and subtropical forest [42]. Central and western Amazonia Tropical rain forests have been considered as the two central mega-diversity areas in the world [48, 49], and the other tropical rain forests could be found in central Africa, west Africa, Madagascar, and Indo-Malaysian area [50, 51].

8. Conclusions and recommendation

Any initiatives involved in sustainable forest management and conservation are essential to human well-being. Therefore, to ensure a successful conservation effort, an understanding on the significance roles of forests among general public is extremely important. Promoting and raising awareness to the public toward forest resource management are crucial for the general public to be aware on their importance, roles, and threats. Understanding their intrinsic values and variability within and among living organisms and the systems they inhabit is critical to the survival of the planet, species, and mankind. In order to spread the message, the use of social media can be an effective way to disseminate the information far and wide. Another way to communicate various aspects of forest (i.e., species of flora and fauna, genetic, ecosystem, and environmental diversity), a street mural can be constructed in a public space as an approach of communicating to raise awareness to a public audience. Recognizing the importance of forest management and conservation is necessary toward achieving sustainable development in terms of contribution to species conservation, provision of water supply, food security, and poverty alleviation. These can be incorporated into education curriculum beginning from the primary level. Providing capacity building to the teachers on sustainable forest management will enhance the effectiveness of teaching and learning.

Strengthening governments' efforts at all levels for the full implementation of the National Forestry Policy, especially through increased allocations of human and technical resources and financial could contribute toward the success of sustainable forest management strategy. Coordination efforts among all agencies responsible in the development of policy, planning, and natural resources management are important to ensure the ecosystem approaches and objectives of forest conservation can be incorporated in sectors such as forest management, agriculture, transportation, and water management. These coordinate efforts can reduce the significant loss of forest resources in both terrestrial and aquatic ecosystems.

Establishment of protected areas is extremely important in particular for endangered species and sensitive habitats. The current terrestrial protected areas in Peninsular Malaysia of 1.8 million ha are not sufficient for the implementation of full range conservation biodiversity efforts. More protected areas should be established to increase more habitats for rare and threatened species and sensitive habitats. In addition, Malaysia should establish uniform national protected areas system operating in the country. Currently, the protected areas are managed by

different networks and governed by different laws with varying degrees of protection status. Protected areas need to be better located and effectively managed to deal with problems of such as illegal logging, human settlements, unsustainable tourism, encroachment, and challenges in climate change.

The setting up of natural history museum (government- or privately-run) can contribute to demonstrate and educate about the importance of forest management and conservation. In addition, besides raising a greater awareness, the collection of specimens can be used for research and education by the students, communities, and relevant stakeholders. The museum can be used not only as a significant repository for specimens of the threatened animal and plant populations but also serves as a primary source of information about historical aspects of biodiversity at the national, regional, and global levels.

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