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EX-SITU CONSERVATION OF PLANT SPECIES IN INDONESIA WITH A FOCUS ON WALLACEA

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Abstract
Biodiversity conservation is a national priority in Indonesia as a part of the implementation of sustainable development. Both *in-situ* and *ex-situ* conservation should be practised so as to make certain that biodiversity can be conserved, studied and sustainably utilized. The Indonesian Institute of Sciences (LIPI) and Ministry of Environment & Forestry (KLHK) are responsible for the conservation of biodiversity as the scientific authority and management authority, respectively. Several pathways of *ex-situ* conservation may be undertaken through restoration of degraded ecosystems, improvement of fallows, development of arboreta, botanical gardens (BG), city parks, and biodiversity parks, planting road-side trees and rehabilitation of degraded lands using indigenous species, particularly rare and protected species. *Ex-situ* conservation of plant species through the above-mentioned pathways will become increasingly important, as *in-situ* conservation is facing many constraints. Several sites in Wallacea have been designated as *ex-situ* conservation areas such as the Toraut Arboretum at Bogani Nani Warta Bone in North Sulawesi [proposed by the Wallacea Development Institute (WDI), and established by local government in 1994], and five new botanical gardens: Massenrempulu, Jompie, Minahasa, Pucak, and Kendari. This paper describes the roles of the floristic conservation pathways and outlines the development of the above-mentioned arboretum and botanical gardens as case examples.

***Key words*:** arboretum, biodiversity parks, botanical gardens, indigenous, city parks, Sulawesi

Introduction

Indonesia is considered to be one of 17 mega-biodiversity countries (CI, 1999). "Biological diversity" means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (Heywood & Baste, 1995), thus there are three levels of biodiversity: ecosystem, species, and genetic variation within species.

A large number of ecosystem types can be found in Indonesia (Whitten *et al*., 1987; Kartawinata, 2013), which can be identified with vegetation characteristics since the physiognomy of vegetation reflects the interactions between plants, animals and microbes and, in turn, between vegetation and the environment (Webb, 1973). Two-thirds of Indonesia's land area was originally forested, and the rest covered by shrubs, ferns and herbs that constitute ecologically complex systems (Choong & Smith, 1994). Forests in Wallacea extend from the wetter north and west to the drier east and southeast along a climatic gradient and from sea level to the subalpine region in the highlands along altitudinal and temperature gradients (Steenis, 1950). Vegetation types along with their floristic constituents reflect this gradient from evergreen and ever wet vegetation types to seasonal and deciduous vegetation types (Steenis, 1950; Whitmore, 1986). In Sulawesi, as in other parts of Wallacea, plant species richness decreases from north to south and from lowland to highland (Steenis, 1950). Much of the natural forest ecosystems of Sulawesi, especially in the lowlands, have suffered destruction and conversion to man-made ecosystems, which has been accompanied by the local and in some cases global extinction of native species, including endemic and rare species (Whitten *et al*., 1987). Thus, natural ecosystems and the constituent species they contain will have to be protected through *in-situ* and *ex-situ* conservation.

Ecosystem diversity

Kartawinata (2013) classified the natural ecosystems in Indonesia into over 60 ecosystem types based on vegetation characteristics. This classification could change as new data from further studies are secured or some types disappear due to conversion into agro ecosystems, human settlements and industrial complexes. The above scheme does not include agro ecosystems, home-garden ecosystems and secondary vegetation, ranging from grasslands; scrubs and secondary forests developed after the natural ecosystems have been disturbed. There is a need, therefore, to conserve natural ecosystems in as many ways as possible and to restore the disturbed ones to a condition similar to the original.

Floristic diversity

Indonesian forests possess extremely high biodiversity and a wealth of rare plant and animal species (Barber, 1998). Indonesia has the second most ecologically diverse rainforests in the world, harbouring 11% of the world's plant species, 10% of its mammal species, and 16% of its bird species (FWI/GFW, 2002).

According to Steenis (1950), the wet region in Asia has a unique flora that does not merge with the flora in the drier region (Fig. 1: pl. 8). He showed that about 200 genera from the north reach their southernmost distributional range and about 375 genera reach the limit of their distribution in the north at the Kra Isthmus. The two groups of genera with a total of 575 genera are conveniently designated as a "demarcation knot". The same patterns occur in the southeast, separating New Guinea and Australia, with a much stronger demarcation knot of 984 genera and in the north separating the Philippines and China with a demarcation knot of 686 genera. These strong knots coincide with the boundaries of the main forest types. The region bordered by these demarcation knots forms a coherent floristic region known as Malesia, which politically comprises Brunei Darussalam, Indonesia, Malaysia, Papua New Guinea, Philippines, Singapore, and Timor Leste (Steenis, 1950). It is clear that Malesia is a distinct phytogeographic entity, with 40% of its genera endemic to this region (Steenis, 1950). Malesia is very rich in species. It is estimated that it contains about 40,000 species of flowering plants, which mostly occur in Indonesia (Kartawinata, 2010). It has about 10% of the world's flora. The floristic richness of Malesia, including Indonesia, is the results of complex forest structure. Tall trees constitute the framework that create favourable environments for a large number of smaller species ranging from mosses to shrubs and small trees to develop (Whitmore, 1986). Within the Malesian region there are also smaller demarcation knots; an important knot lies between Sumatra and Java with 200 genera occuring mainly in Sumatra (Steenis, 1950). Another knot is between Kalimantan and Sulawesi with the Strait of Makassar as the barrier, with 297 genera present in Kalimantan but absent in Sulawesi (Steenis, 1950). This dividing line, which coincides with the Wallace Line, signifies the eastern boundary of the Asian elements in the Malesian flora. Towards the west of this line: Sumatra, Kalimantan, Malaysia, Brunei, and the Philippines, form West Malaesia, containing 150 endemic genera and to the east is East Malesia comprising Sulawesi, Maluku and New Guinea harbouring 132 endemic genera (Steenis, 1950; Fig. 2: pl. 8). Sulawesi has a low number of endemic genera (7) and New Guinea has the highest (124). At the species level however the number of rare endemics in Sulawesi is relatively high (Table 1). The family Ericaceae, for example, has a relatively high number of rare species, especially in the genus *Rhododendron*, which occur in the highlands (Sleumer, 1966).

South Malesia consists of Java, Bali and Nusa Tenggara and contains only 14 endemic genera. New Guinea is the centre of East Malesia. Although it is close to Australia, the flora contains only 11% of Australian and the Pacific elements and 16% of Asiatic elements, while 4% are native Malesian and 30% have widespread distributions (Steenis, 1950).

Table 1: Rare and endemic species in Sulawesi, Source: unpublished data of K. Kartawinata.

Family and Species
Arecaceae
Calamus didymocarpus Warb. Ex Becc.
C. inops Becc. ex. K. Heyne
C. karuensis Ridl.
C. koordersianus Becc.
Pinanga celebica Scheff.
P. ternatensis Scheff.
Burmanniaceae
Gymnosiphon minahassae Schltr.
Celastraceae
Euonymus impressus Blakelock
Glyptopetalum loheri Merr.
Salacia blepharophora Ding Hou

Family and Species
Fagaceae
Trigonobalanus verticillata Forman
Gnetaceae
Gnetum gnemon var. *gracile* Mgf.
Haloragaceae
Halorragis halconensis Merr.
Icacinaceae
Gomphandra velutina Sleumer
Merriliodendron megacarpus (Hemsl.) Sleumer
Leeaceae
Leea smithii Koord.
Lobeliaceae
Lobelia nicotianaefolia Roth. ex R. & S.

Combretaceae
Terminalia calamansanay Rolfe
T. celebica Exell
T. kjellbergii Exell
T. samoensis Rechinger
T. supitiana Koord.
Convolvulaceae
Ipomoea stibaropoda Ooststr.
Dipterocarpaceae
Hopea celebica Burck
Vatica flavovirens Slooten
Dioscoreaceae
Dioscorea kjellbergii R. Knuth
Ericaceae
Diplycosia retusa Sleumer
D. sagittanthera J.J. Sm.
D. stenophylla Sleumer
D. undata J.J. Sm.
Gaultheria celebica var. *celebica* J.J. Sm.
Rhododendron impositum J.J. Sm.
R. arenicolum Sleumer
R. celebicum DC
R. eymae Sleumer
R. lindaueanum var. *bantaengense* J.J. Sm
R. nanophyton var. *nanophyton* Sleumer
R. poremense J.J. Sm.
R. pseudobuxifolium Sleumer
R. psilanthum Sleumer
R. pubitubum Sleumer
R. pudorinum Sleumer
R. radians var. *radians* J.J. Sm.
Vaccinium aucupis Sleumer
V. centrocelebicum var. *centrocelebicum* Sleumer
V. centrocelebicum var. *maius* Sleumer
V. contractum Sleumer
V. gracilipes Sleumer
V. henrici Sleumer

Loganiaceae
Fagraea truncata Blume
Myristicaceae
Gymnacranthera maliliensis R.T.A. Schouten
Horsfieldia lancifolia W.J. de Wilde
Knema celebica W.J. de Wilde
K. matanensis W.J. de Wilde
K. stellata Merr.
Myristica devogelii W.J. de Wilde
M. kjellbergii W.J. de WIlde
M. ultrabasica W.J. de Wilde
Najadaceae
Najas tenuifolia R. Br.
Nepenthaceae
Nepenthes eymae Sh. Kurata
N. glabrata J.R. Turnbull & A.T. Middleton
N. hamata J.R. Turnbull & A.T. Middleton
N. tomoriana Danser
Proteaceae
Helicia celebica Sleumer
H. kjellbergii var. *kjellbergii* Sleumer
H. kjellbergii var. *calva* Sleumer
H. teysmanniana Sleumer
Macadamia hildebrandii Steenis
Rosaceae
Prunus clementis (Merr.) Kalkman
Sapindaceae
Cupaniopsis strigosa Adema
Elattostachys erythrocarpum Adema
Symplocaceae
Symplocos maliliensis Noot.
Thymelaeaceae
Gyrinops decipiens Ding Hou
Violaceae
Viola kjellbergii Melch.

Note in Fig. 3 (pl. 9) that the species richness (the number of species in one hectare plot) in the forests of the Lore Lindu National Park and Wanoni Island in Sulawesi are much lower than those in Kalimantan and Sumatra.

The Wallace Line, passing through the Makassar Strait and Lombok Straits, clearly distinguishes the fauna to the west from that to the east. It is not so clear cut for the flora; the distinction is vague, although the distribution of some species, such as species of *Artocarpus* section *Duricarpus* (Whitmore, 1986) and Dipterocarpaceae (Ashton, 1982), do center to the west of the line. Most species of Dipterocarpaceae are in the western part of Malesia with only 10 species occuring in Sulawesi (Fig. 3: pl. 9). Some species, which are confined to the eastern part of Malesia and do not cross the Wallace Line include *Araucaria* sp. (*A. beccarii* Warb., *A. cunninghamii* Sweet, *A. hunsteinii* K. Schum.) and *Elmerillia* sp. (Whitmore, 1986).

The largest family in Malesia is Orchidaceae which is estimated to have 3,000–4,000 species (Sastrapradja *et al*., 1989). Among woody plants Dipterocarpaceae is one of the large families containing 386 species (Ashton, 1982), though only 10 occur in Sulawesi (Fig. 4: pl. 9). Other large families include Myrtaceae where the number of species of *Eugenia* alone is more than 500 (Whitmore, 1986) and Ericaceae (Sleumer, 1966). Large genera include *Rhododendron* (287 species), *Vaccinium* (239 species) and *Ficus* (735 species) of the family Moraceae (Berg & Corner, 2005). While species of Dipterocarpaceae are dominant forest trees in West Malesia, in East Malesia other species take over the dominance, such as *Pometia pinnata* J.R. Forst & G. Forst, *Agathis* sp. (*A. dammara* Lamb. & Rich., *A. labillardierei* Warb., *A. robusta* F. Muell.) and *Araucaria* sp. (*A. beccarii*, *A. cunninghamii*, *A. hunsteinii*) (Johns *et al*., 2007; Whitmore, 1986).

Global issues on biodiversity decline have for long focused on production forests, which have suffered intensive logging, followed by legally planned or spontaneous conversion to other uses, resulting in extensive deforestation. Large-scale commercial timber extraction is the main cause of forest degradation in Indonesia. The commercial logging operations have taken place primarily in biodiversity-rich lowland forests that have been set aside as production forests.

These rich biological regions, including Sulawesi, are now critically degrading and leading to the depletion of species diversity. This can be attributed to the pressure of human activities and unsustainable land use and resource management practices. A large number of forest plant species are now considered to be threatened with extinction and are on the IUCN Global Red List (IUCN, 2010). These forest plants are threatened by direct extraction and fires. The populations of at least 14 forest plant species, for instance, have drastically been reduced and threatened by forest clearance during the past decade (IUCN, 2010), ranging from ornamental species, such as *Rafflesia arnoldii* R. Br., to important commercial timber species, such as Bornean ironwood (*Eusideroxylon zwageri* Teijsm. & Binn.). Little is known about the conservation status of most Indonesian tree species and many of them will be lost before their ecological and economic values are fully understood. With thousands of Indonesian tree species exposed to the threat of extinction resulted from deforestation, the Indonesian government should give a high priority to the sustainable management and conservation of forests.

Promoting utilization of forest plants for human needs

Forest resources are widely used throughout the world for a host of purposes and forest plants are the fundamental components of many ecosystems as well as human economies. Some plants are of great economic and local importance as a source of timber, medicinal products, food and ornamental plants. Forest ecosystems provide important services to people, such as climate control, water supply and the provision of medicine, food, timber and other products.

The followings are currently harvested and potential products from non-timber forest species that can be used in *ex-situ* conservation and restoration programmes

(Kartawinata, 1990, 1994; Kartawinata & Abdulhadi, 2014). They may also be developed into crop plants, to be used for improving the productivity of fallows and other abandoned and degraded lands.

Fruits and carbohydrate**:** Native Southeast Asian fruit species are primarily forest species, including *Baccaurea* sp., *Durio* sp., *Mangifera* sp., *Lansium* sp. and *Nephelium* sp. The genus Durio has 27 species that grow in forests, particularly in the forests of Borneo, and nine of them bear edible fruits: *Durio dulcis* Becc. , *D*. g*randiflorus* (Mast.) Kosterm. & Soegeng, *D*. *graveolens* Becc., *D*. *kutejensis* Becc., *D*. *lanceolatus* Maast., *D*. *lowianus* Scort. Ex King, *D*. *oxleyanus* Griff., *D*. *testudinarum* Becc, *and D*. z*ibethinus* L. (Soegeng-Reksodihardjo, 1962). It is unfortunate that to date only one of them (*D*. *zibethinus*) has been widely cultivated in Southeast Asia, and one (*D*. *kutejensis*) is under semi-cultivation in East Kalimantan. Other species that commonly occur in Southeast Asian forests, and are used as sources of food, include those of the genera *Alocasia*, *Amorphophallus*, *Antidesma*, *Arenga*, *Canarium*, *Castanopsis*, *Colocasia*, *Cubilia*, *Cyrtosperma*, *Dioscorea*, *Flacourtia*, *Gnetum*, *Licuala*, *Musa*, *Pithecellobium*, *Stelechocarpus*, *Sterculia*, *Symplocos*, and *Vaccinium*.

Chemical products**:** Various chemical compounds may be extracted from forest plants so forests have potential as a source of raw materials for biochemical and pharmacological products. Many chemical products from tropical plants are known to have commercial values and many compounds have potential uses, as insecticides, colouring media, essential oils, drugs, medicines and others. Rotenoids (a source of insecticides) are produced by species of *Derris*, *Milletia*, *Tephrosia* and other leguminous species; reserpine is produced by *Rauvolfia* sp. Diosgenin (a plant steroid used in antifertility pills) is produced by *Dioscorea* sp.; and diterpene alcohol (used as a substitute for ambergris by the perfume industry) is produced by *Dacrydium* sp. (Lowry, 1971). Edible protein can be extracted from leaves. Lignin is used in the manufacture of plastics, ion-exchange resins, soil stabilizers, rubber reinforcers, fertilizers, vanillin, tanning agents, stabilizers or asphalt emulsions, dispersants for oil-well drilling and for ceramics processing and cellulose can be used for rayon and plastics and as a raw material for hydrolysis to sugar (Bray & Gorham, 1964; Whitmore, 1975). Tannin and dye are also produced by many forest plants, such as *Albizia* sp., *Adenanthera microsperma* Teijsm. & Binn., *Aporusa frutescens* Bl., *Artocarpus heterophyllus* Lam., *Baccaurea* sp., *Castanopsis* sp., *Casuarina equisetifolia* L., *Daemonorops* sp., *Eugenia* sp., *Garcinia* sp., *Peltophorum* sp., *Pithecellobium* sp., *Pterospermum* sp., *Terminalia catappa* L., and *Uncaria* sp.. (Burkill, 1966; Heyne, 1950, 1987; Sastrapradja *et al*., 1989).

Essential oils**:** Rain forest species, such as *Aquilaria* sp., *Cananga odorata* (Lam.) Hook. F. & Thomson, *Cinnamomum* sp., *Cinnamomum porrectum* (Roxb.) Kosterm., *Dryobalanops aromatica* C.F. Gaertn., *Eucalyptus* sp., *Ganua mottleyana* Pierre ex Dubbard, *Gaultheria* sp., *Illicium* sp., *Litsea odorifera* Valeton, *Litsea* sp., *Melaleuca leucadendra* (L.) L., *Michelia champaca* L., *Payena* sp., *Pogostemon* sp., and *Sideroxylon glabrescens* Miq. (Lowry, 1977; Sastrapradja *et al*., 1977) produce essential oils used in perfume and medicinal industries.

Fatty oils**:** Of about 163 species of *Shorea* (Dipterocarpaceae) occurring in Malesia (Ashton, 1982), 17 species are known to produce nuts containing oil, known commercially as illipe or ‘tengkawang’ nuts (Anderson, 1975). The oil is used as an alternative to cocoa-butter in the confectionery, cosmetics and soap industries and is also used to a small extent for medicinal purposes. The primary species include: *Shorea macrophylla* (de Vriese) P.S. Ashton, *S. beccariana* Burck, *S. amplexicaulis* P.S. Ashton, *S. pinanga* Scheff., *S. splendida* (de Vriese) P.S. AShton, *S. stenoptera* Burck, *S. macrantha* Brandis, *S. palembanica* Miq., *S. mecistopteryx* Ridl., *S. fallax* Meijer, and *S. seminis* Slooten. The secondary species are *S. almon* Foxw., *S. parvistipulata* F. Heim, *S. hemsleyana* King ex Foxw., *S. pilosa* P.S. Ashton, and *S. smithiana* Symington. Other species include *S. atrinervosa* Symington and *S. ferruginea*. Other forest-tree species producing fatty oils include those of the following families: Arecaceae (e.g. *Areca catechu* L.) and Mysristicaceae (*Horsfieldia* sp.).

Conservation strategies
Plant conservation can be implemented in two ways, namely by *in-situ conservation* and *ex-situ conservation*. In principle, they complement each other. *In-situ* conservation is the best way as it aims to protect plants and their ecosystems where they naturally occur. In Indonesia, *in-situ* conservation has been carried out through the establishment of 527 nature reserves, wildlife sanctuaries, national parks, nature parks, forest parks, ecotourism parks, hunting parks and biosphere reserves, comprising 27.2 million hectares (PHKA, 2013). To date, seven *in-situ* conservation areas have been established in Sulawesi, i.e., Bunaken NP (National Park), Bogani Nani Wartabone NP, Lore Lindu NP/Biosphere Reserve, Rawa Opa Watumohai NP, Taka Bonerate NP, Wakatobi NP/Biosphere Reserve, and Tangkoko Batu Angus Nature Reserve. All conservation areas are managed by the Directorate General of Forest Protection and Nature Conservation (PHKA) of the Ministry of Environment & Forestry (KLHK). The existence of customary forests should also be noted. These are managed by indigenous communities and to a certain extent provide a conservation function.

Ex-situ conservation is undertaken in a variety of sites outside the places where the target species grow naturally. Selected species can be planted in such diverse sites as botanical gardens (BG), home gardens, research arboreta, provincial gardens, city parks, community parks, universities, school and office campuses, road sides, experimental gardens, plantations, degraded lands and any other sites deemed suitable and available for the purpose. It should be borne in mind that any effort to undertake any *ex-situ* conservation should take into consideration the aesthetic aspects and involvement of local communities, be they urban, rural or forest-dweller communities. *Ex-situ* conservation is useful not only for species conservation *per se* but also for education, research, ecotourism and non-timber products such as food and medicines.

***Role of Botanical Gardenss in ex-situ conservation in Indonesia*:** The botanical gardens of Indonesia have implemented *ex-situ* conservation initiatives since first established in 1817. A botanical garden has three main functions (Hyams & MacQuitty, 1969):

1. Botanical research complemented with a collection of herbarium specimens.

2. Applied research on such subjects as acclimatization and introduction of plant species having economic values, such as rubber, coffee, tea, chocolate and others.

3. Horticultural research activities including the selection, hybridization, and development of valued products.

Over time, changes in the environment and mind-set of those managing botanical gardens have dynamically altered the functions of the gardens. Now, they also serve as a place for education and tourism as well as providing ecosystem services.

Compared with other countries in the Americas, Western Europe, East Asia, South Asia, West Asia and Southeast Asia, the number of botanical gardens in Indonesia is still low (Table 2), especially when taking into account that Indonesia is a mega diverse country.

Table 2: Numbers of botanical gardens in various countries (BGCI, 2013)

Country	Number of BGs
USA	459
Russia	155
India	131
Australia	128
England	116
Italy	105
Japan	64
Argentina	48
Brazil	40
Colombia, Belgium & Spain	28
South Korea	14
Malaysia & Philippines	12
Thailand	7
Indonesia & Saudi Arabia	4

In Indonesia there are actually 23 botanical gardens but only the four managed by the LIPI, Bogor BG, Cibodas BG, Purwodadi BG, and Bali (Eka Karya) BG are considered large and secure enough to adequately represent the species planted in them. Between them, they conserve 8,304 plant species (about 20% of Indonesian native plant species), with a total of 69,050 specimens planted in the gardens (Table 3). Due to physical constraints, such as the availability of land and capacity of the soil, these four are able to accommodate and conserve a maximum of only 30–40% of the plant species present in Indonesia. Therefore, they are insufficient to satisfy the need to have all species represented. Ideally, every Indonesian plant species should be conserved in botanical gardens that are located in areas that have appropriate environmental conditions for the species they are designed to represent. The 19 regional gardens contribute towards this goal but it would be better achieved through the establishment of new local gardens in areas that represent ecoregions of Indonesia not currently covered by existing botanical gardens.

Table 3: Plant collections in the botanical gardens managed by LIPI (KRI, 2011)

	Family	Genus	Species
Bogor	238	1389	4273
Cibodas	240	902	1929
Purwodadi	175	980	2207
Bali	206	1021	2314

Table 4 shows that the 19 regional gardens, managed by local government, have a collection of 23,128 plant specimens, which have been planted in the gardens and 84,556 specimens are still maintained in the nurseries for acclimatization.

***The role of FRDA in ex-situ conservation*:** FRDA of KLHK has established arboreta of both indigenous and exotic species (Soekotjo, 2005). The first arboretum was established in Bogor in 1922, containing 50 families, 136 genera, 167 indigenous species and 67 exotic species. In 1958 two other arboreta were established at Kaliurang, Yogyakarta and at Watusipat, Central Java. FRDA has also established indigenous and exotic species trials in many sites in Java with the main purposes as follows:

1. To assess growth characteristics of each species tested in the trials.

2. To identify, and develop sylviculture techniques to achieve management objectives in future commercial plantation establishment.

3. To develop and transfer techniques and methods to enhance understanding of sylvicultural characteristics of tree species tested.

4. To be used as *ex-situ* conservation areas.

Table 4: Regional botanical gardens managed by local governments, sources: KRI (2012); N, north; S, south; W, west; E, east; SE, southeast; C, central; "—" = data not available.

Name of local BG, District, Province	Area (ha)	Established year	Plant collection	
			Species	Specimens
Sulawesi				
Minahasa BG, Minahasa, N Sulawesi	186	2009	—	—
Kendari BG, Kendari City, SE Sulawesi	113	2009	—	—
Jompie BG, Parepare City, S Sulawesi	14	2009	—	—
Massenrempulu BG, Enrekang, S Sulawesi	300	2006	281	6714
Pucak BG, Maros, S Sulawesi	120	2006	57	279
Sumatra				
Samosir BG, Samosir, N Sumatra	100	2008	57	540
Solok BG, Solok, W Sumatra	112	2009	—	—
Batam BG, Batam City, Riau Islands				
Bukit Sari BG, Bungo Tebo & Batanghari, Jambi	425	2005	168	1952
Liwa BG, West Lampung, Lampung	116	2007	162	894
Kuningan BG, Kuningan, W Java	172	2007	199	7941
South Sumatra BG, Ogan Ilir, S Sumatra	100	2011	—	—
Kalimantan				
Balikpapan BG, Balikpapan City, E Kalimantan	309	2007	577	1732
Banua BG, Banjarbaru City, S Kalimantan	122	2011	—	—
Sambas BG, Sambas, W Kalimantan	300	2008	—	—
Danau Lait BG, Sanggau, W Kalimantan	328	2008	—	—
Katingan BG, Katingan, C Kalimantan	127	2006	60	779
Java				
Kuningan BG, Kuningan, W Java	172	2007	199	7941
Baturraden BG, Banyumas, C Java	142	2004	509	2135
Nusa Tehnggara Barat (NTB)				
Lombok BG, East Lombok, NTB	130	2008	31	162

Table 5: Plantation trials established by FRDA in Java; W, west; E, east.

Locality	Established year	Area (ha)	No. of tree species tested
Pasirhantap (W Java)	1937	35	78
Cikampek (W Java)	1937	45	61
Sumberwringin (E Java)	1937	24	64
Pasirawi (W Java)	1938	15	47
Cirendeng (W Java)	1939	8	9
Haurbentes (W Java)	1940	100	70
Padekanmalang (E Java)	1952	21	25
Yanlapa (W Java)	1953	46	44
Arcamanik (W Java)	1954	16	15
Cikole (W Java)	1954	20	45
Carita (W Java)	1955	50	54

FRDA has established three research stations with areas set aside for planting trees located in a wet tropical forest ecosystem at Malili in East Luwu District (738 ha), in a highland ecosystem at Mengkendek in Tana Toraja District (100 ha) and in a lowland dry ecosystem at Borisallo in Gowa District (180 ha), through the KLHK Decree Number 275/Kpts-II/1994, which were later converted into arboreta through KLHK Decree Number 367 /Menhut-II/2004. The conversion into arboreta was aimed at enabling the sites to: (1) enhance forest research and development, (2) promote education and training, and (3) explicitly take into consideration the social and cultural activities in forest development.

The Role of the Wallacea Development Institute (WDI) 20 years Ago**:** *Ex-situ* conservation in the Wallacea region has been implemented in the Toraut Arboretum, which is located in the Bogani Nani Wartabone NP in North Sulawesi. It is one of the WDI project activities dealing with conservation from the perspectives of forest utilization (Samsoedin, 1994). The establishment of the arboretum in Toraut was based upon the recommendations of the Tropical Environmental Management Workshop held at the Toraut Research Centre, Bogani Nani Wartabone NP, in February 1993 and the outcome of discussions of the team of the WDI in Jakarta in coordination with the KLHK, represented by the PHKA and the Nature Conservation and Forest Research and Development Centre. The main goal of the program is the conservation and wise utilization of tropical rainforest (Samsoedin, 1994).

Tree Conservation in Urban Areas**:** Tree planting can be used effectively to improve urban environments and urban life (Samsoedin, 1994). By developing the arboretum in Toraut it is hoped that the need for native tree species for planting in various cities, especially such big cities as Jakarta and Surabaya can be satisfied (Samsoedin, 1994). It is planned to utilize plant species native to Indonesia, which to date have not been promoted in city plantings. It is further envisaged that urban areas, especially future real estate developments and industrial parks, will have 40% of their area set aside by regulation as open space green areas. Such green areas can be used as sites for *ex-situ* conservation by planting them with selected plant species, particularly those satisfying the requirements of possessing unique architectural forms, ability to help control the water table, help absorb pollution and provide habitat for wild life, particularly bird and insect species.

Conclusion

The above account shows that the Indonesia parts of the three regions of the botanical realm known as Malesia, west Malesia, east Malesia and south Malesia, each have their own unique features. Population structure, reproductive ecological features, distributional patterns, regeneration stategies, floristic composition and structure and dominant species are different. The utilization of plant resources, restoration and rehabilitation of damaged ecosystems, conservation of ecosystems, *in-situ* and *ex-situ* conservation practices and development in general in the three regions, cannot be implemented with the same strategies. The uniqueness of and the variability within each region should be taken into consideration in developing strategies.

The issue of conservation is becoming more and more important due to the increasing pressure on natural habitats, vegetation and ecosystems. *In-situ* plant conservation should be complemented by *ex-situ* plant conservation, in regards to both scientific and management perspectives. In Indonesia, scientific responsibility lies with LIPI and management responsibility with the KLHK. Botanical gardens are one important example of institutions and sites for *ex-situ* plant conservation, where plant species and genetic diversity are maintained. Education plays a vital role in understanding the meaning and purpose of conservation. Promoting awareness of conservation to all levels of society, from students to politicians and decision-makers is important and should be carried out continuously. It is for these reasons that conservation is considered a long-term investment.

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PLATE 8

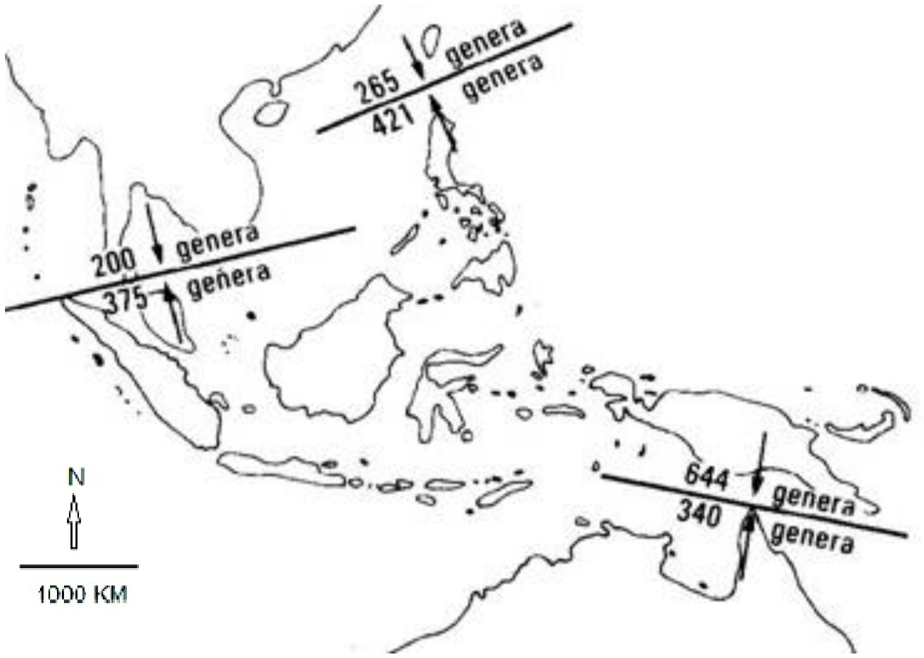

Figure 1: The three principal "demarcation knots" of the Malesian flora; after Steenis (1950).

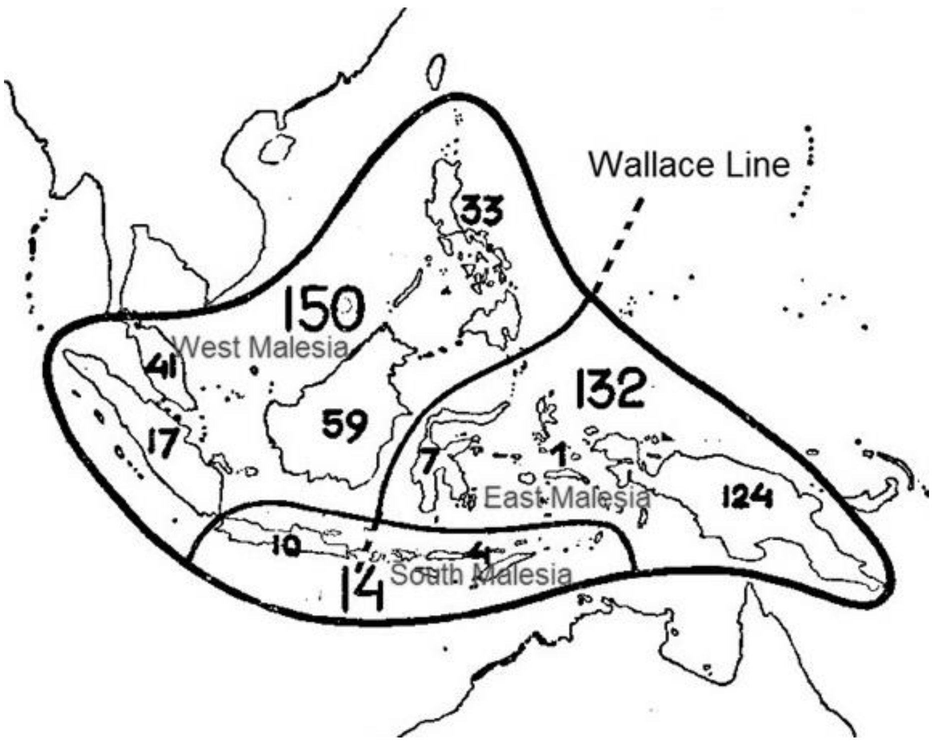

Figure 2: Number of endemic genera in Malesia with Sulawesi having only 7 endemic genera. The line separating West and East Malesia coincides with the Wallace Line; After Steenis (1950) with modifications.

PLATE 9

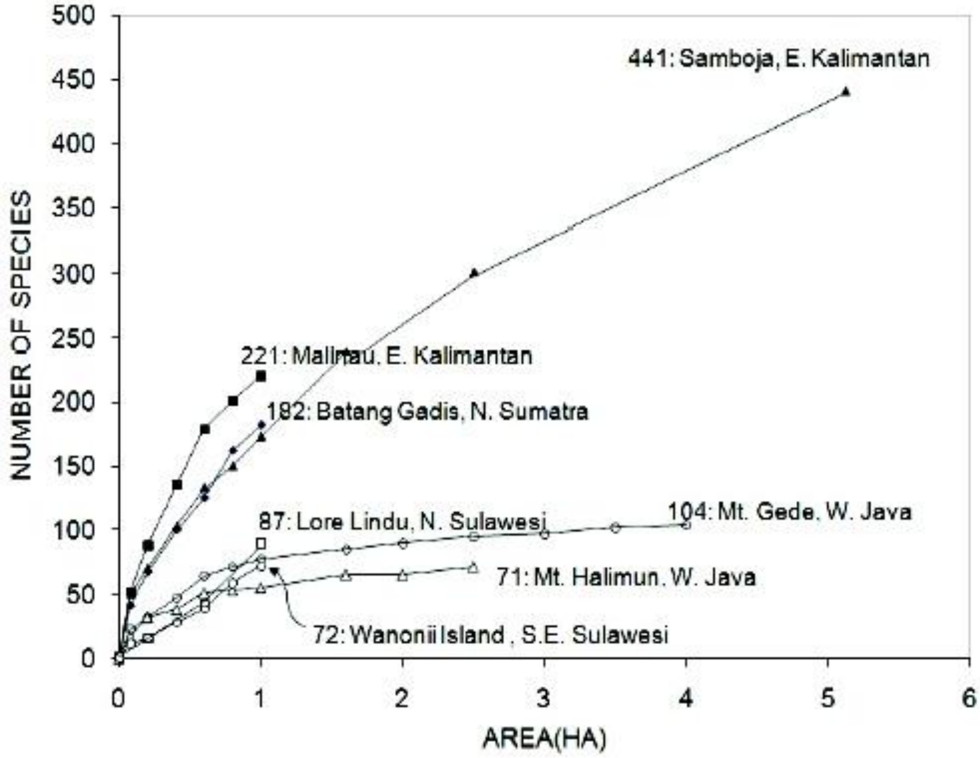

Figure 3: Species richness in one hectare plots as shown by the species-area curves in various lowland forests of Summatra, Kalimantan and Sulawesi and montane forests in Java after Kartawinata (2005).

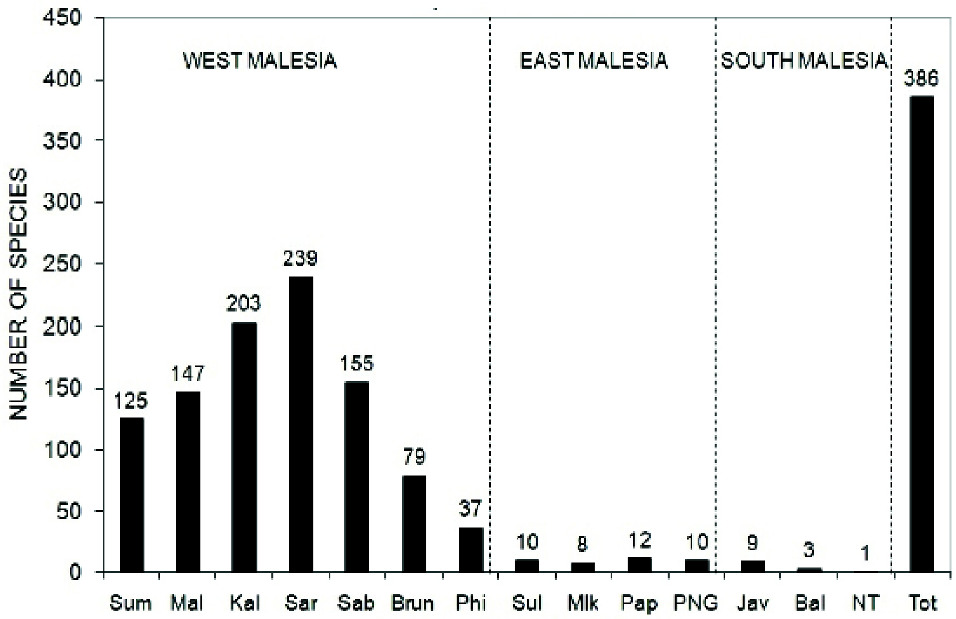

Figure 4: Number of species and distribution of Dipterocarpaceae in Malesia (Brunei, Indonesia, Malaysia, Philippines, Papua New Guinea and Timor Leste) showing that the majority of species occur in West Malesia. Bal – Bali; Brun – Brunei; Jav –Java; Kal – Kalimantan; Mal – Malaysia Semenanjung;Mlk – Maluku; NT – East and West Nusa Tenggara; Pap – Paua; Phi – Philippines; PNG – Papua New Guinea; Sab – Sabah; Sar – Sarawak; Sul – Sulawesi; Sum – Sumatra; Tot – Total; after Kartawinata (2005), data from Ashton (1982).