Tropical Forest Ecology and Silviculture

Dirk Hölscher

Biogeography II

Similarities and differences among tropical forest regions

Forest formations

- Moist forests
  - Moist evergreen forests (rain forest)
  - Moist deciduous forests
- Dry forests
- Forests under special site conditions
  - Montane forests inc. cloud forests
  - Mangroves
  - Fresh water swamps
    - Peat swamps
    - Periodically inundated forest
    - Gallery forests
  - Heath forests
  - Coniferous forests

FAO, 2001

Environment of zonal vegetation in tropical lowlands

Mean temperature >18° C per month

Precipitation variable

Tropical rain forest: wet; 0-3 months dry

Tropical moist deciduous forest: wet/dry; 3-5 months dry

Tropical dry forest: dry/wet; 5-8 months dry

Structural characteristics of forest formations in the tropical lowlands

Moist evergreen forest (rain forest)

- Trees evergreen
- 3 or more strata of trees
- Usually rich in tree species
- Cauliflory common
- Buttresses common

Profile diagram of a rain forest on Borneo

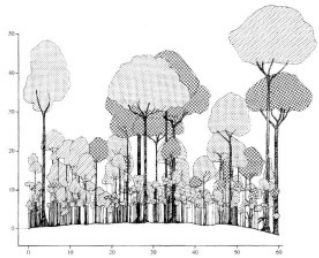
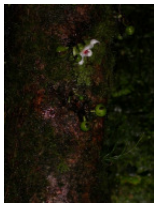


Figure 2.1 Profile diagram of the forest at Ulu Dapoi, Tinjar, Borneo. A plot 60 m × 8 m (200 × 25 feet) is shown. Courtesy of Professor P.S. Ashton.

Cauliflory

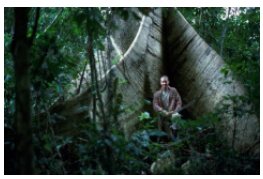
Cauliflory, the development of flowers (and hence fruits) directly from the trunk, rather than at the tips of branches



Theobroma cacao

Buttresses

Buttresses: many species have broad, woody flanges at the base of the trunk

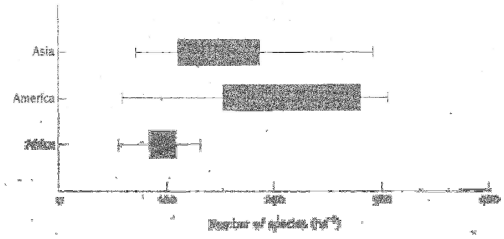


Johannes in Peru

A ladder is required for the measurement of tree diameters where buttresses occur....

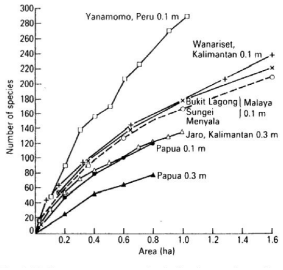
Markus working in a Panamanian montane forest

Tree species richness of rain forest sites
(trees > 10 cm dbh)
(mean values and +- 50% of the values above and below the mean)

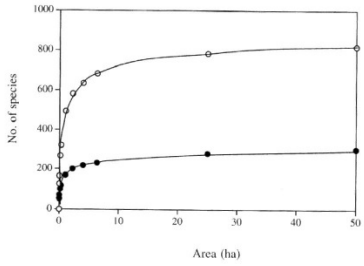


Turner 2001; modified by Priemack & Corlett 2005

Species-area curves for lowland tropical rain forest
(trees > 10 cm dbh, or > 30 cm dbh)



Species-area curve for 50 ha plots
Barro Colorado Island, Panama (closed circles),
and Pasoh Forest Reserve, Malaysia (open circles)
(trees > 1 cm dbh)



Monodominance in tropical rain forest

- Old-growth rain forests dominated by a single canopy species
- Very poor soils or an otherwise extreme environment may promote monodominance by excluding potentially competing species
- A single species may dominate on undisturbed sites where the soils are similar to those of adjacent old-growth, mixed forests.
- Assertion of dominance by a single species in an old-growth forest appears most likely in areas where the species pool contains few late-succession species with similar life history traits.
- Examples of old-growth monodominant tropical forests in stands of >100 km^2 are cited from Malaya (Dipterocarpaceae: *Dryobalanops aromatica*), Borneo (Lauraceae: *Eusideroxylon zwageri*), and Caesalpiniaceae from Trinidad (*Mora excelsa*), east Africa (*Cynometra alexandri*) and central Africa (*Gilbertiodendron dewevrei*).

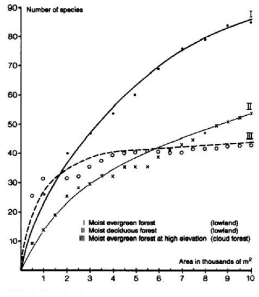
Hart, 1990

Structural characteristics of forest formations in the tropical lowlands

Moist deciduous forest

- +- many periodically deciduous species
- 2-3 strata
- rich in tree species

Species-area curve for different forest types in Latin America (trees > 10 cm dbh)



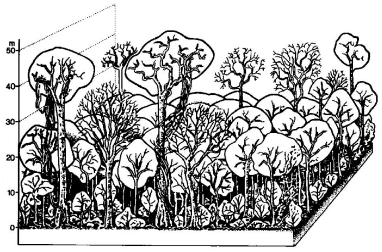
In this forest type e.g. *Tectona grandis* (teak) occurs (SE Asia)

Structural characteristics of forest formations in the tropical lowlands (continued)

Dry deciduous forest

- Periodically bare for longer periods
- 1-2 strata
- +- poor in tree species
- Many thorned species
- Xeromorphous structure

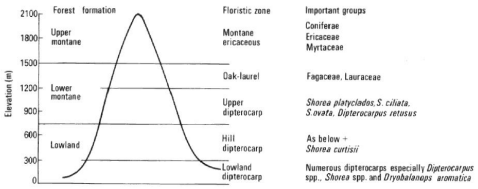
Profile diagram of a semi-deciduous lowland forest in the dry season



Tropical Montane Forest

Polylepis forest enshrouded in mist.

Zonation along an elevational gradient: Forests of the mountains of Malaya



Characters of structure and physiognomy used to define the principal montane forest formations

Formation	Tropical lowland evergreen rain forest†	Tropical lower montane rain forest	Tropical upper montane rain forest
Canopy height	25–45 m	15–33 m	1.5–18 m
Emergent trees	Characteristic, to 60(80) m tall	Often absent, to 37 m tall	Usually absent, to 26 m tall
Pinnate leaves	Frequent	Rare	Very rare
Principal leaf size class of woody plants‡	Mesophyll	Mesophyll	Microphyll
Buttresses	Usually frequent and large	Uncommon, small	Usually absent
Cauliflory	Frequent	Rare	Absent
Big woody climbers	Abundant	Usually none	None
Bole climbers	Often abundant	Frequent to abundant	Very few
Vascular epiphytes	Frequent	Abundant	Frequent
Non-vascular epiphytes	Occasional	Occasional to abundant	Often abundant

Some definitions

Big woody climbers: Free-hanging climbers with woody stems. Also called lianas.

The bole climbers: attach tightly to the tree trunk and ascend. They hug the tree they cling to.

Vascular plants: Group of plants having lignified conducting tissue (xylem vessels or tracheids).

Non-vascular plants: Plants lacking lignified vascular tissue (xylem), vascularized leaves, and having a free-living, photosynthetic gametophyte stage that dominates the life cycle. Common examples are the mosses and liverworts

Pinnate leaves

- leaf shape; featherlike; having leaflets on each side of a common axis (the petiole or rachis)

Fraxinus excelsior

Litchi chinensis

Acacia spec.

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Volume and increment of logs in different forest types of Venezuela

(trees > 10 cm dbh)

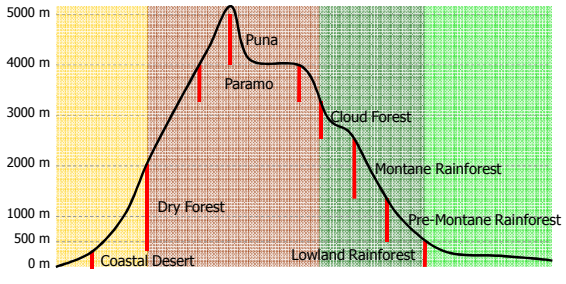
Moist forest type	Altitudinal zone (m)	Mean standing volume $m^3 \cdot ha^{-1}$	Increment $m^3 \cdot ha^{-1}$ p.a.			DBH increment mm p.a.
			Min.	Max.	Mean	
Deciduous	0– 500	150	2	6	4	3.5
Evergreen	0– 500	300	4	12	8	4.5
Evergreen	1,000–1,500	400	4	10	7	2.5
Evergreen	1,500–2,500	300	2	6	4	2.0
Evergreen	2,500–3,500	300	2	5	3.5	1.5

Tree line

- The tree line or timber line is the edge of the habitat at which trees are capable of growing.
- Beyond the tree-line, they are unable to grow due to inappropriate environmental conditions.
- Alpine tree line: The highest elevation which sustains trees: higher up, it is too cold, or snow cover persists for too much of the year, to sustain trees

Tropical South America

Profile of the Andean Cordillera and its Ecological Regions



Alpine Treeline; nomenclature

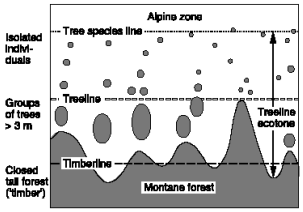
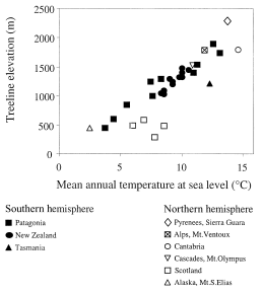


Figure 1 A schematic representation of the high altitude treeline ecotone and the nomenclature used in this study. Note that such definitions are conventions for communication and do not deserve a major scientific debate.

Körner und Paulsen 2004

Forest line elevation as a function of mean annual temperature at sea level

sites with a seasonal thermal amplitude < 15 K



All sites in Patagonia, three sites in Scotland, and the site in Cantabria are occupied by broadleaf **deciduous trees.**

Sites in New Zealand and Tasmania are dominated by **broadleaf evergreen forests**.

All North American sites, the sites in the Pyrenees and the Alps, and one site in Scotland, are dominated by **evergreen conifers**.

Jobbágy et al. 2000

Latitudnal position of treeline and snowline

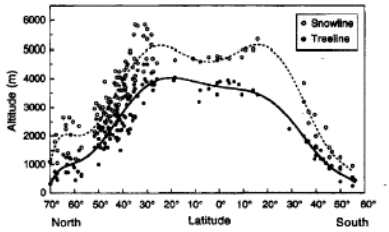
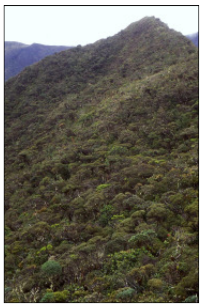


Fig. 1 The latitudinal position of treeline and snowline taken from a worldwide survey by Hermes (1955), supplemented by data from various other sources

Bolivia

ca. 4000 m asl., *Polylepis pepei* Photo: D. Hertel

Ecuador




ca. 3100 m asl., *Weinmannia*, *Clusia*, *Hedyosmum*, *Ilex* Photos: D. Hertel

Patagonia, Argentina

ca. 1700m asl., *Nothofagus pumilio* Photo: D. Hertel

S-Patagonia, Argentina

ca. 1100 m asl., *Nothofagus pumilio* Photo: D. Hertel

Tierra del Fuego, Beagle Bay, Argentina

ca. 550 m asl., *Nothofagus pumilio* Photo: D. Hertel

Puna

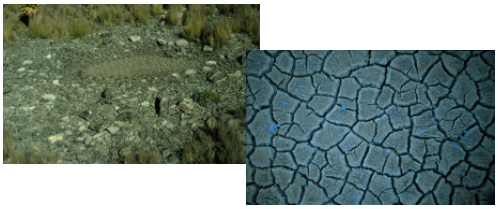
Dry to wet, high elevation montane grassland and herbaceous community of the high Andes

Giant rosette plants in the Andean Páramo vegetation

Espeletia spec.

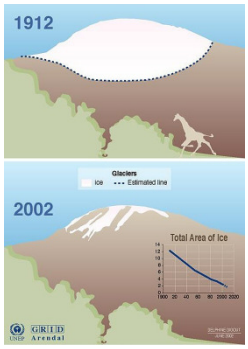
Vegetation in the alpine zone of Mount Kenya: Giant Rosette Plants

Soil on Mount Kenya



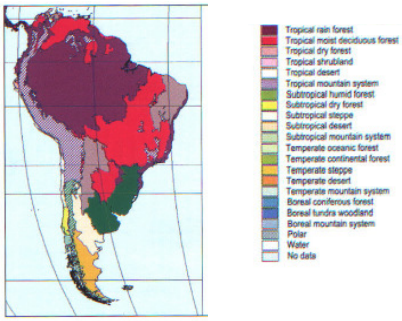
As influenced by diurnal cycles of freezing end thawing

The melting snows, Mt. Kilimanjaro



- peak: 5895 m asl
- 82 % of the icecap that crowned in 1912 is now gone
- the ice is thinning as well

Ecological zones: South America



The Central American land bridge

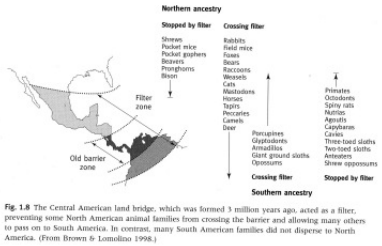


Fig. 1.8 The Central American land bridge, which was formed 3 million years ago, acted as a filter, preventing some North American animal families from crossing the barrier and allowing many others to pass on to South America. In contrast, many South American families did not disperse to North America. (From Brown & Lomolino 1998.)

From Primack & Corlett 2005

Tropical rain forest (South America)

Rainfall: > 1500 mm yr^{-1}
short dry season (0 to 2 months)

Distribution: Amazon basin*, Pacific coast of Colombia and Ecuador, Atlantic coast of Brazil, Iguaçu and Parana river valleys;
*world's largest area of tropical rain forest

Tree families: Annonaceae, Bombacaceae, Euphorbiaceae, Leguminosae, …

Tropical moist deciduous forest (South America)

Rainfall: 800-1500 mm yr^{-1}
pronounced dry season (3 to 5 months)

Distribution: Brazilian and Guiana shields, a wide area with rather high rainfall extends around the wet Amazonian basin

Vegetation: Cerrado; tree families: Leguminosae, Myrtaceae

Tropical dry forest (South America)

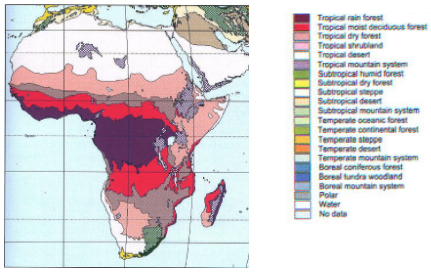
Rainfall: <500 - 1000 mm yr^{-1}
dry season (5 to 8 months)

Temperature: coldest month > 20° C

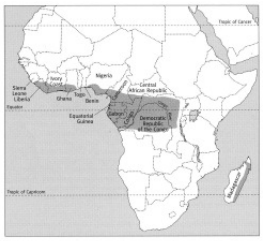
Distribution: Areas sheltered from the humid trade winds (e.g. North-East Brazil, Carribian coast Venezuela) or inland (e.g. Argentine chaco)

Tree families: Leguminosae (Caealpinia, Mimosa, Amburana) Caatinga

Ecological zones: Africa

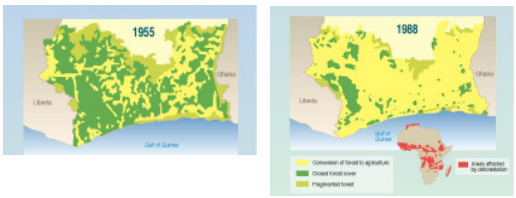


Estimated historical extent of tropical rain forest in Africa and Madagascar



From Primack & Corlett 2005

Deforestation in West Africa. Cote-d'Ivoire



UNEP, 2000

Tropical rain forest (Africa)

Rainfall: > 1500 mm yr^{-1}
short dry season (0 to 3 months)
Temperature: coldest month > 20° C

Distribution: both sides of equator, south-eastern coast; Today little undisturbed forest remains

Floristic kingdoms: West Africa; Guineo-Congolian*; Madagascar**

* Not as rich in species as the rain forests in Asia and South America
** rich in tree species

Tropical moist deciduous forest (Africa)

Rainfall: 800-1500 mm yr^{-1}
pronounced dry season (up to 6 months)
Temperature: coldest month > 20° C

Distribution: Great African Plateau South of the Guineo-Congolasian Basin (~ 1000 m asl); a strech in the North

Vegetation: dry (semi) evergreen forest on Kalahari sands; wetter Zambezian miombo woodland (south) and Sudanian woodland to the north

Tropical dry forest (Africa)

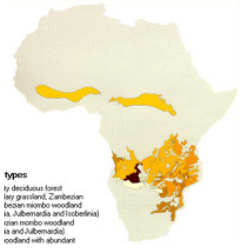
Rainfall: <500 - 1000 mm yr^{-1}
dry season (6 to 8 months)
Temperature: coldest month > 20° C

Distribution: Farther from the equator

Vegetation: Zambezian drier Miombo; in the Sudan region woodlands typically include Acacia species

Miombo and other dry forest

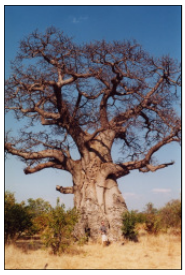
- Miombo woodland covers an estimated area of 2.7 million km2
- >700 mm of precipitation on nutrient-poor soils
- Miombo is dominated by tree species of the family Fabaceae - particularly the genera *Brachystegia, Julbernardia* and *Isoberlinia*



Baobab

(Adansonia digitata)

A characteristic species of tropical dry forest/wooded grassland in Africa (region e.g. Angola)

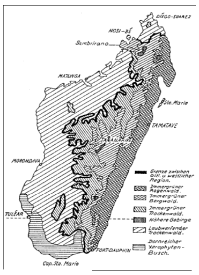


Madagascar

Vegetation Zones

Zonal Forest Formations

I. Evergreen Moist Forest
II. Montane Rain Forest
III. Evergreen Dry Forest
IV. Dry Deciduous Forest
V. Savannah with xerophilous vegetation



HUMBERT 1927 changed in GÖHLER 2003

Tectonics

Madagascar

- was landlocked in the middle of the supercontinent Gondwana, sandwiched between land that would eventually become South America and Africa and land that would eventually become India, Australia, and Antarctica.
- Through movements of the Earth's crust, Madagascar, along with India, first split from Africa and South America and then from Australia and Antarctica, and started heading north.
- India eventually smashed into Asia — forming the Himalayas in the process — but Madagascar broke away from India and was marooned in the Indian Ocean.
- Madagascar has been on its own for the past 88 million years.

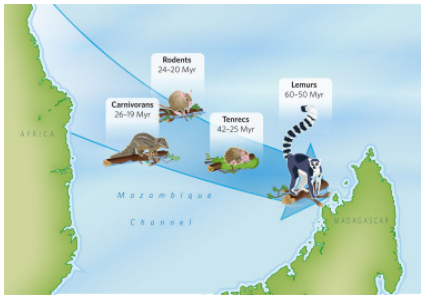
Tectonics

Madagascar

An example of species evolution in isolation

Despite close proximity to Africa, the islands do not share any of the typical animal groups of nearby Africa

Instead, an exquisitely unique assemblage of species, with high levels of endemism has evolved



Lemurs are small primates
-native only to the island of Madagascar and the neighboring Comoro Islands
- lemurs resemble the oldest ancestors of primates which existed tens of millions of years ago.

Biodiversity and endemism

Taxonomic Group	Species	Endemic Species	Percent Endemism
Plants	13,000	11,600	89.2
Mammals	155	144	92.9
Birds	310	181	58.4
Amphibians	230	229	99.6

Ecological zones: Asia

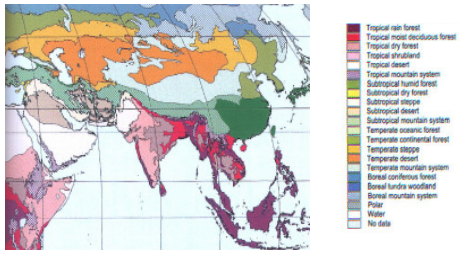


Photo: J. Epstein 2005.
Copyright Wildlife Trust

Malayan Flying Fox (*Pteropus vampyrus*)
is native to Malaysia and the Indonesian archipelago and is heavily hunted for food, sport, traditional medicine and as an agricultural pest in Peninsular Malaysia.

Tropical rain forest (Asia)

Rainfall: > 1500 mm yr^{-1}
short dry season (0 to 3 months)
Temperature: coldest month > 20° C

Distribution: south-western coast of India and Sri Lanka, Myanmar and Himalayan foothills, the coastal lowlands of Southeast Asia, the Philippines and most of the Malay Archipelago

Tropical rain forest (Asia)

Vegetation:
- Dipterocarpaceae (west of the Wallace line)
  - Sumatra, Malaysia, Borneo, Philippines
  - Genera: *Dipterocarpus*, *Shorea*, *Dryobalanops*, *Hopea*
  - especially the genera *Dipterocarpus* (~ 75 species) and *Shorea* (~150 species) have valuable timber species
  - e.g. Sal (*Shorea robusta*) in the Brahmaputra valley (India)

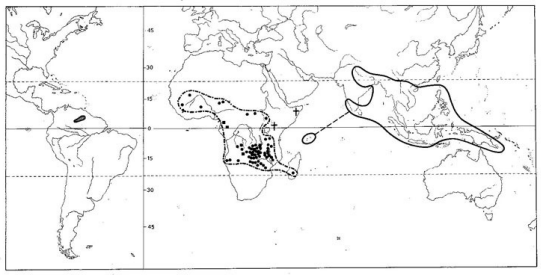
In the dipterocarp forest the volumes of commercial species are usually high

- Malay archipelago:
  - very rich flora, over half (220) of the world's flowering plant families are present
  - 40 % of the species are endemic;
  - of about 30.000 plant species about 1/3 are trees (> 10 cm dbh)

Fruits of some Dipterocarp trees from the Philippines

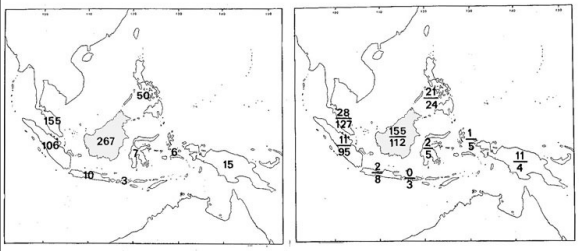
two-winged fruits

Range of the Dipterocarpaceae



Dipterocarpoideae (solid line and two fossil sites in East Africa)
Monotoideae (interrupted line)
Pakaraimoideae (monotypic genus in northern South America)

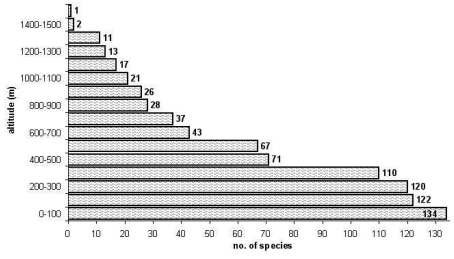
Dipterocarp species in the Flora Malesia



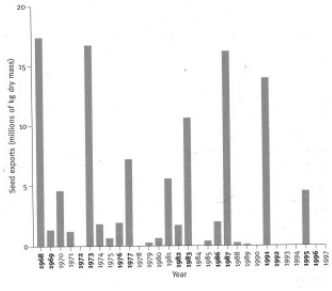
Total number of species per island

Endemics (above the hyphen) and non-endemics (below the hyphen)

Diperocarp species at different altitudes, Borneo



Dipterocarp – mass flowering



Dipterocarp trees mass flower once ever 2 to 7 years, with little or no flowering in the intervening years.

This is illustrated by the export of illipe nuts, from a common dipterocarp species in West Kalimantan, Indonesia. (Corran & Leighton 2000)

Some dipterocarp trees can be used for resin production

From Laos

The Wallace Line in SE Asia

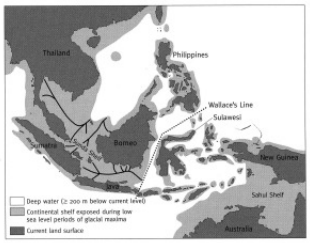


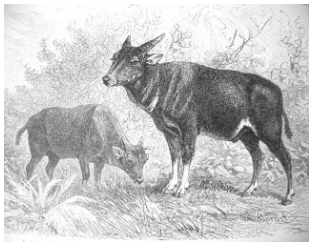
Fig. 1.9 The Sunda Shelf (shaded) was exposed during the peaks of glaciation, allowing the movement of animals and plants along the river valleys connecting Borneo, Sumatra, Java, the Malay Peninsula, and smaller islands. These river valleys (shown as solid black lines) are submerged today beneath the South China Sea. Note that the Philippines is still separated from the Sunda Shelf. The Sahul Shelf, which surrounds Australia and New Guinea, is also shown. The area between the Sunda Shelf and the Sahul Shelf is known as Wallacea; the western boundary of Wallacea was described by Wallace as the eastern limit of distribution for many species of Asian animals, and is known today as Wallace's line. (From Brown & Lomolino 1998.)

From Primack & Corlett 2005

Wallace Line, Wallacea

- The Wallace Line is a boundary that separates the biogeographical regions of Asia and the Wallacea
- During the ice ages, sea levels were lower, exposing the continental shelf that links these islands to one another and to Asia, and allowed Asian land animals to inhabit these islands
- West of the line are found organisms related to Asiatic species (e.g. tigers, rhinoceros and apes)
- East, many organisms related to Australian species; and many endemics! (e.g marsupial mammals)
- The line is named after Alfred Russel Wallace, who noticed the apparent dividing line during his travels in the 19th century

Lowland anoa, endemic to the forest of Sulawesi



- A dwarf buffalo
- Highly endangared

Spottet cuscus

A marsupial mammal living in the forest of the Wallaceae

Tropical moist deciduous forest (Asia)

Rainfall: 1000 - 2000 mm yr^{-1} (less influenced by southwest monsoon)
pronounced dry season (3 to 6 months)

Temperature: coldest month > 20° C

Distribution: Sri Lanka, northern west coast and the east of India, most of Myanmar, northern Vietnam, Laos, Cambodia,

Vegetation: Teak forest (*Tectona grandis*) in northern and western Thailand; Laos, Myanmar, East India
Sal forest (*Shorea robusta*) in eastern India

Tropical dry forest (Asia)

Rainfall: 500 - 1500 mm yr^{-1} (dry wind of northeast monsoon)
dry season (5 to 8 months)

Temperature: coldest month > 15° C

Distribution: northeastern India, Cambodia (central plain of Mekong river)

Vegetation: sometimes stunted forests (southeastern India, Northern Sri Lanka), dry deciduous dipterocarps; *Pinus merkusii* (on Sumatra crossing the equator)

Thanks for attention!