

Tropical Rainforest: Structure & Diversity





WHAT'S A RAINFOREST?

- Low elevation
- Evergreen
- Mean daily temperature 18° - 24° C
- >2000 mm of rain/yr
- Precip >100 mm at least 9 mos of year
- Annual Pc: **PET** >1



CHARACTERISTICS

- **canopy** ~45 m tall
- structurally complex
- >50% of all species
- high **net primary productivity**
 - NPP \approx 2,500 kg C/ha/yr

Bromeliads adorn the thick branches of *Ceiba pentandra*, emerging from the canopy in Yasuní National Park in Ecuador. (photo by C. Woodward)

WHERE ARE RAINFORESTS FOUND?



3 MAIN BIOGEOGRAPHIC REGIONS:

Americas, Africa, Australasia

7% of land area, 50% of species

RAINFOREST DIVERSITY

<7% land area, >50% of species

American tropics > Asian tropics > African tropics

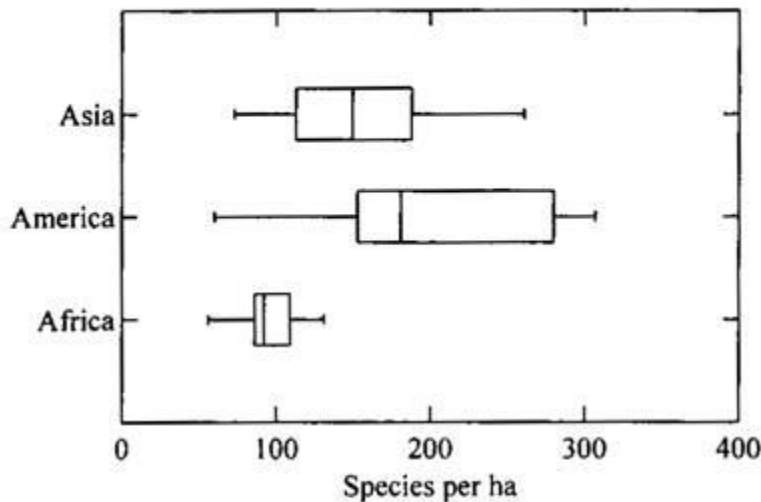
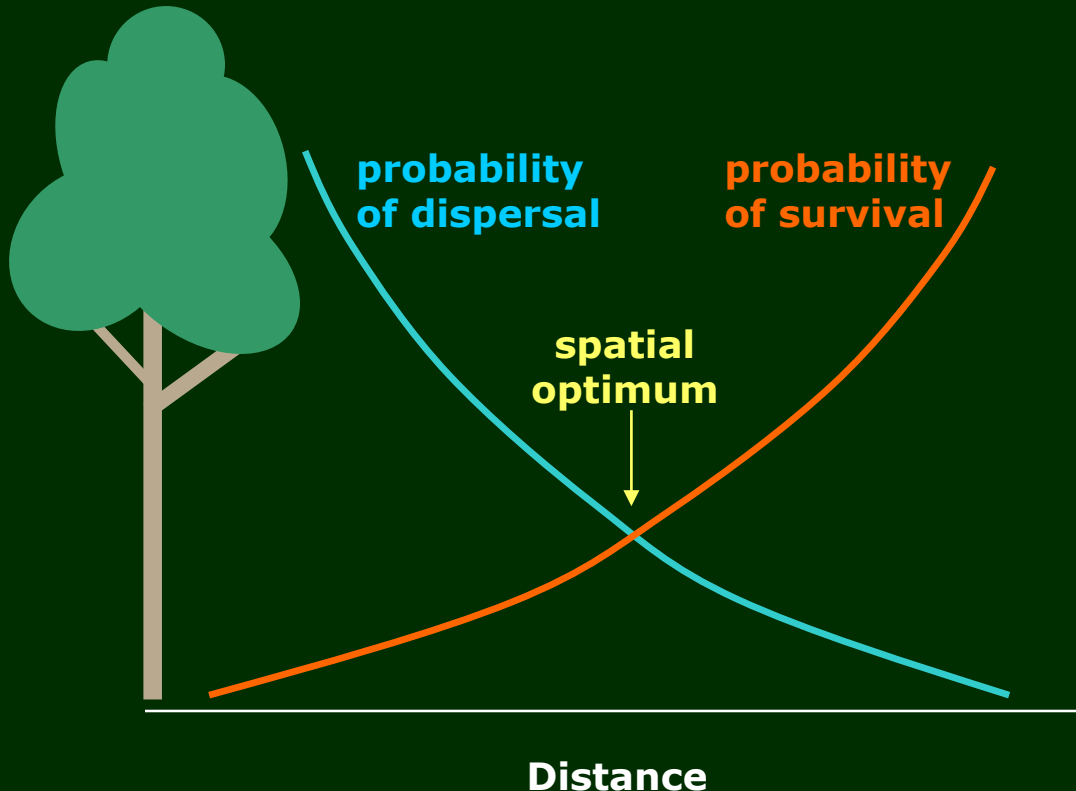


Figure 1.2 Box-and-whisker plot of species richness for trees greater than 10 cm dbh of rain-forest sites for the major tropical regions (Asia-Pacific, America and Africa). The line inside the box represents the mean value of the average number of species per hectare. The box extends for the range of 50% of the values above and below the mean. The whisker covers the complete range of the recorded values. Data from compilations by Phillips *et al.* (1994) and Turner (2001).

Location	# tree spp. in 1 ha plot
Tiputini Biodiversity Station, Ecuador	655
Pasoh Forest Reserve, Malaysia	328
La Selva Biological Station, Costa Rica	118
Davis Creek, Queensland Australia	121
Korup Forest Reserve, Cameroon	75
Igapó swamp forest, Brazil	60

RAINFOREST STRUCTURE

“RARE IS COMMON & COMMON IS RARE”



- most rainforest trees are rare
- dispersal and density-dependent mortality determines spacing of trees

DENSITY-DEPENDENT MORTALITY AND DIVERSITY
(Janzen-Connell Hypothesis)

RAINFOREST STRUCTURE

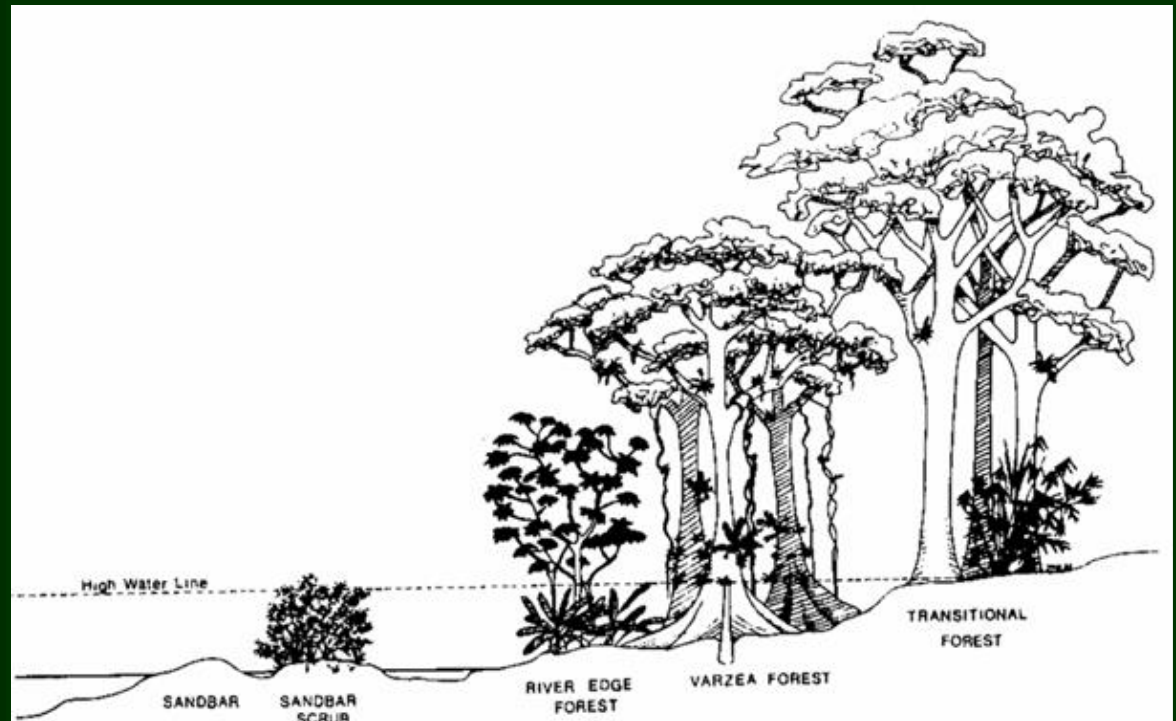
HORIZONTAL COMPLEXITY due to:

Flooding

- *Terra Firme* = never flooded
- *Várzea* = seasonally floods with whitewater
- *Igapó* = seasonally floods with blackwater

Differ in:

- species composition
- canopy height
- O.M. accumulation
- moisture content
- soil & water pH
- 2° compounds



RAINFOREST STRUCTURE

HETEROGENEITY WITHIN *TERRA FIRME*

- topographic complexity
 - hill tops vs. valley bottoms
- phasic complexity
 - gaps, early + late successional growth



RAINFOREST STRUCTURE



VERTICAL COMPLEXITY

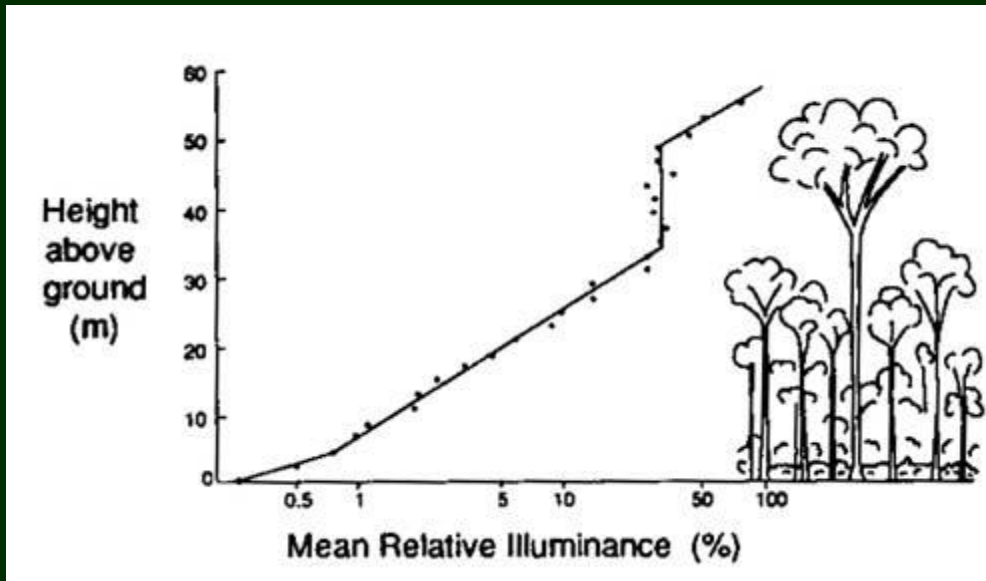
Vegetation “layers”

- emergent
- canopy layer
- subcanopy layer
- understory layer



RAINFOREST STRUCTURE

VERTICAL STRATIFICATION



L.A.I. = Leaf Area Index ($4-8 \text{ cm}^2/\text{cm}^2$)

P.A.R. = Photosynthetically Active Radiation

- blue and red wavelengths most active

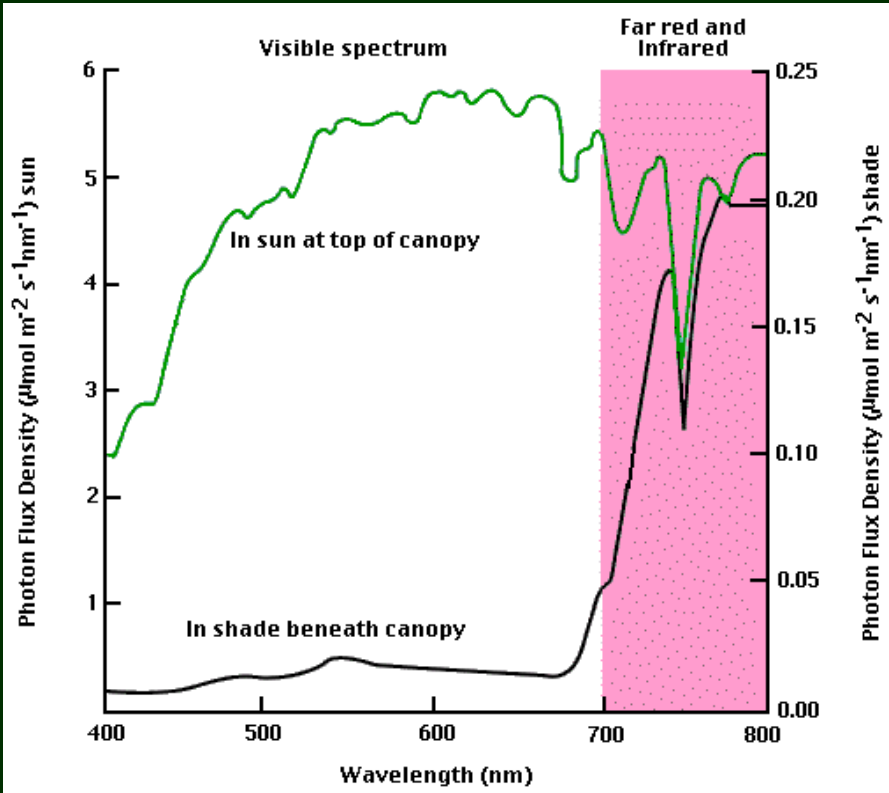
Canopy



Forest Floor

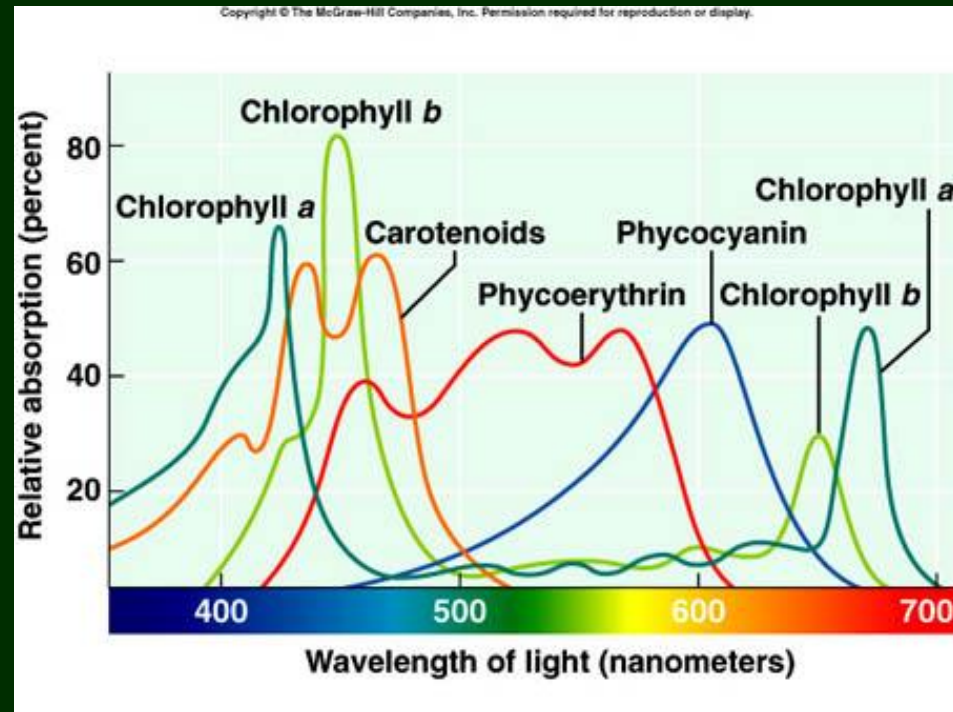
decreasing P.A.R.
decreasing red : far red light
increasing humidity
decreasing wind
less temperature fluctuation

The Light Environment



Forest floor: low light, enriched with far red light

Absorption spectra of plant pigments



Photosynthetic capacity ($\mu\text{mole CO}_2/\text{m}^2/\text{s}$)
sun plants > shade plants

UNDERSTORY / FOREST FLOOR



- large-leaved herbs
- shade-tolerant
- red pigments
- many seedlings

palms & aroids

terrestrial mammals

ground birds

herps

SUBCANOPY



- small trees & palms
- saplings of large trees
- climbers and epiphytes

insectivore flocks

woodpeckers

forest falcons

lizards & snakes

small arboreal mammals

CANOPY



high light

more wind

epiphytes

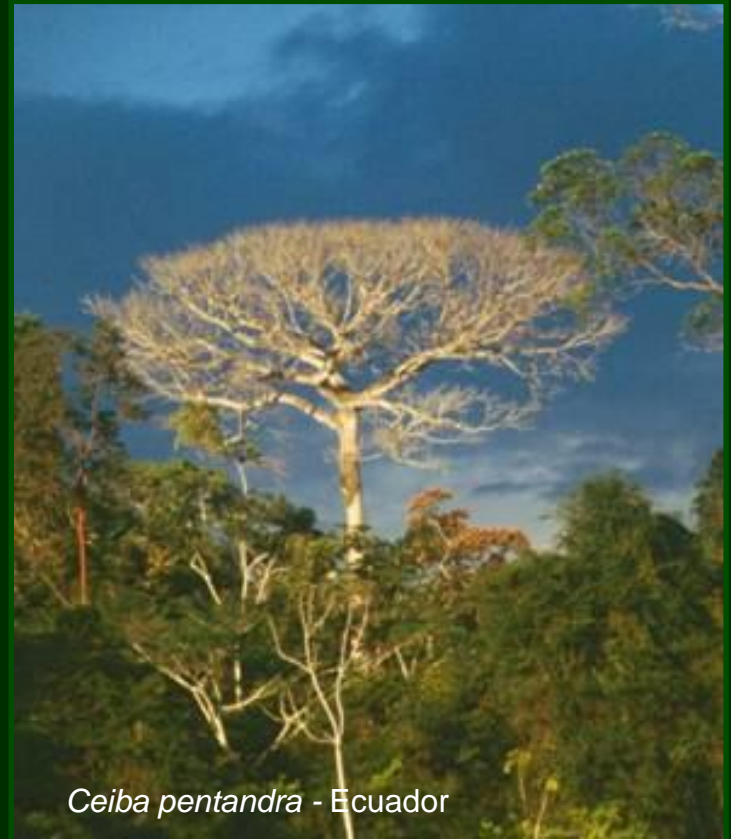
toucans, parrots

mixed-species flocks

large primates

EMERGENTS

- >60 m tall
- < 1 per hectare
- e.g., *Ceiba*, *Parkia*



Ceiba pentandra - Ecuador

Lecythis ampla - Costa Rica (photo C. Woodward)

Ceiba tree



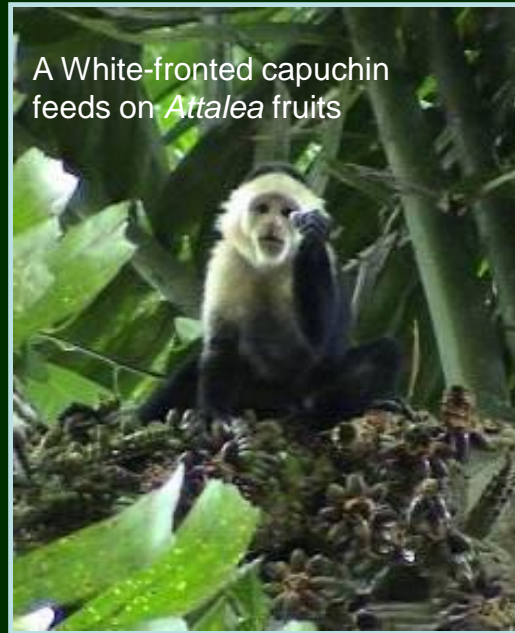
LEGUMES

- bean & pea family
(**Fabaceae**)
- most numerous canopy trees
in the rain forest
- **N-fixing**



PALMS

Family Palmae



A White-fronted capuchin feeds on *Attalea* fruits

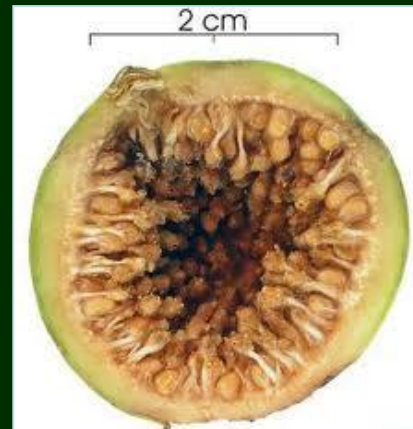


Geonoma a common understory palm



Iriartea deltoidea – one of the most abundant neotropical rainforest palms

FIGS (*Ficus sp.*)



**keystone
species!**



WOOD & BARK

- hard wood
- no growth rings (terra firme)
- thin smooth bark
- prized for timber



Mahogany



TRUNKS

- Columnar
- **Intense light competition**
- No lower branches
- **Climbers & structural parasites**



ROOTS

- Surface root mat
- **Buttresses**
- Prop roots
- Tap roots uncommon



LEAVES

- tend to be large, simple, entire, *lanceolate*
- smooth and shiny (waxy cuticle)
- drip tips
- red pigments (anthocyanins)
- many secondary compounds



LIANAS & VINES

- **Lianas** = large woody vines
- rapid growth
- climbing adaptations
- **negative phototaxy**
- **anomalous 2° growth**
 - efficient water transport
 - elasticity



A "twiner"

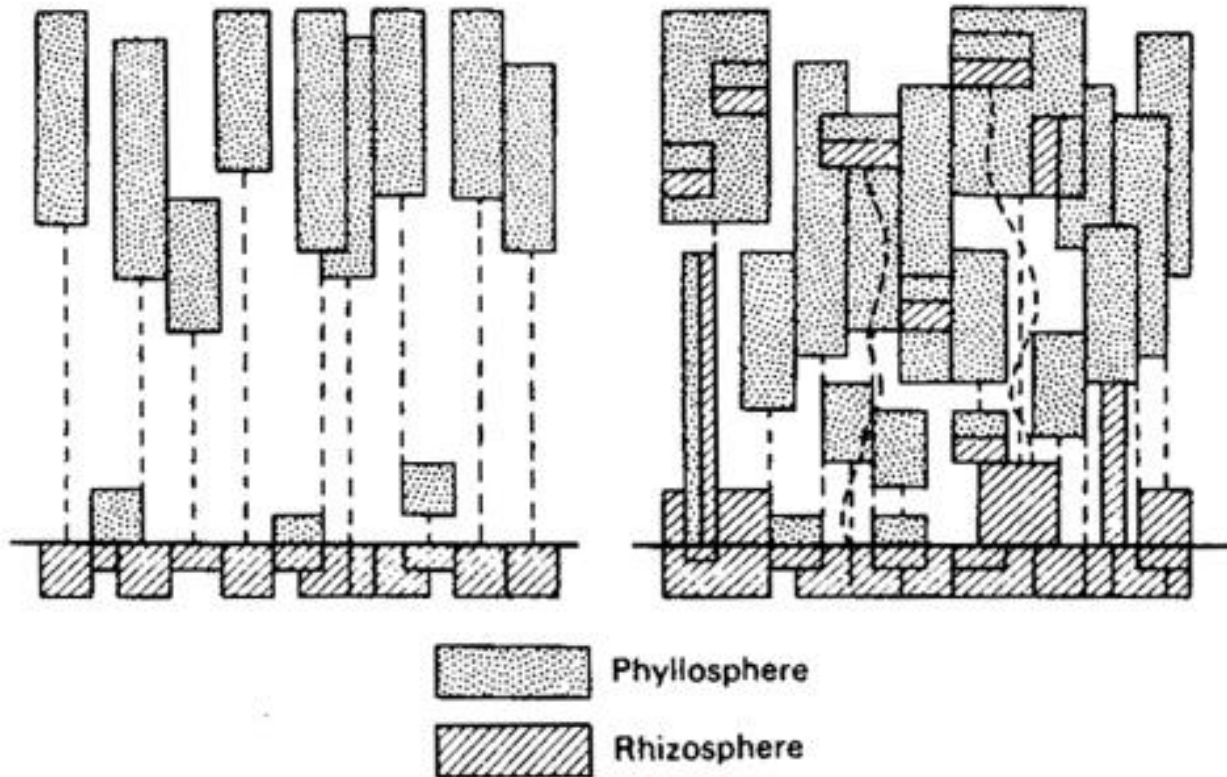


tendrils

STRUCTURAL COMPLEXITY

Leaf and root biomass in temperate vs. tropical forests

temperate



tropical

Fig. 3.1 The spatial distribution of rhizosphere and phyllosphere in *left* – a temperate beech forest; and *right* a tropical rain forest.