What and where are the tropics?

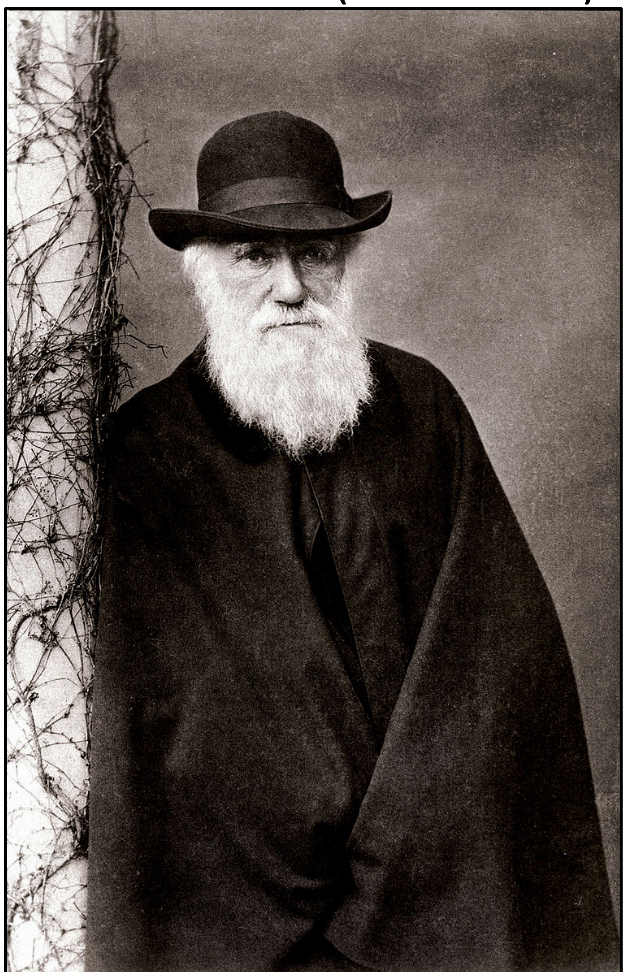
Important historical players and research sites

Diversity and unique attributes of the tropics

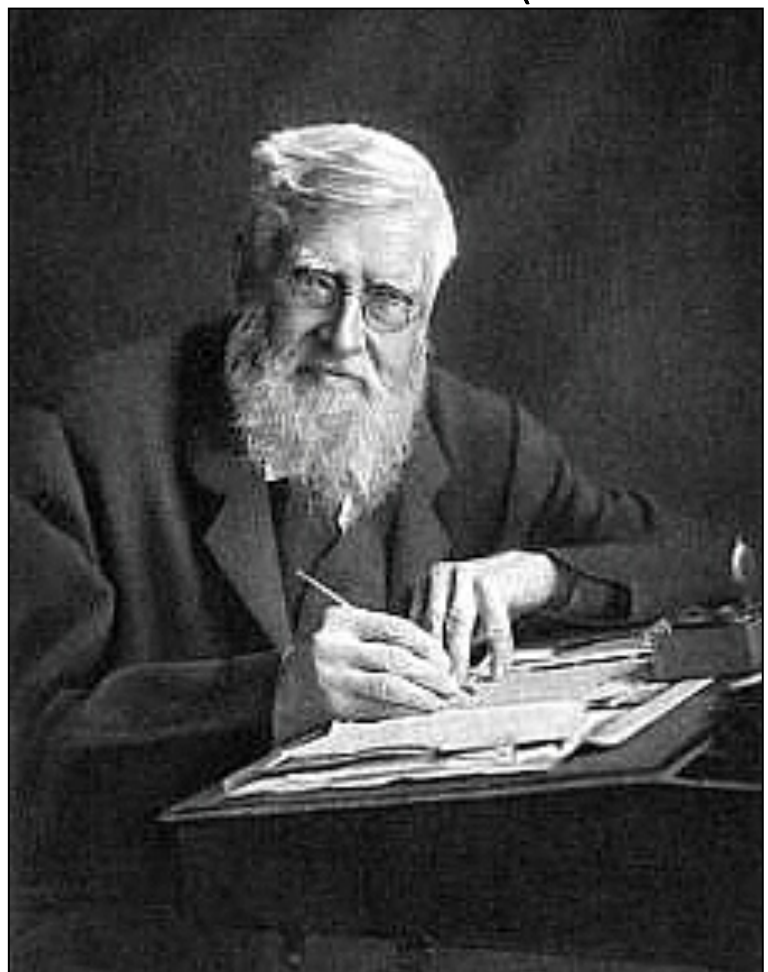
Climate and life zone concepts

Major historical players in exploration

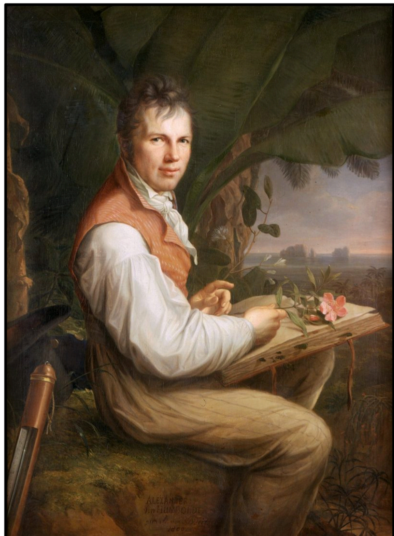
Charles Darwin (1809-1882)



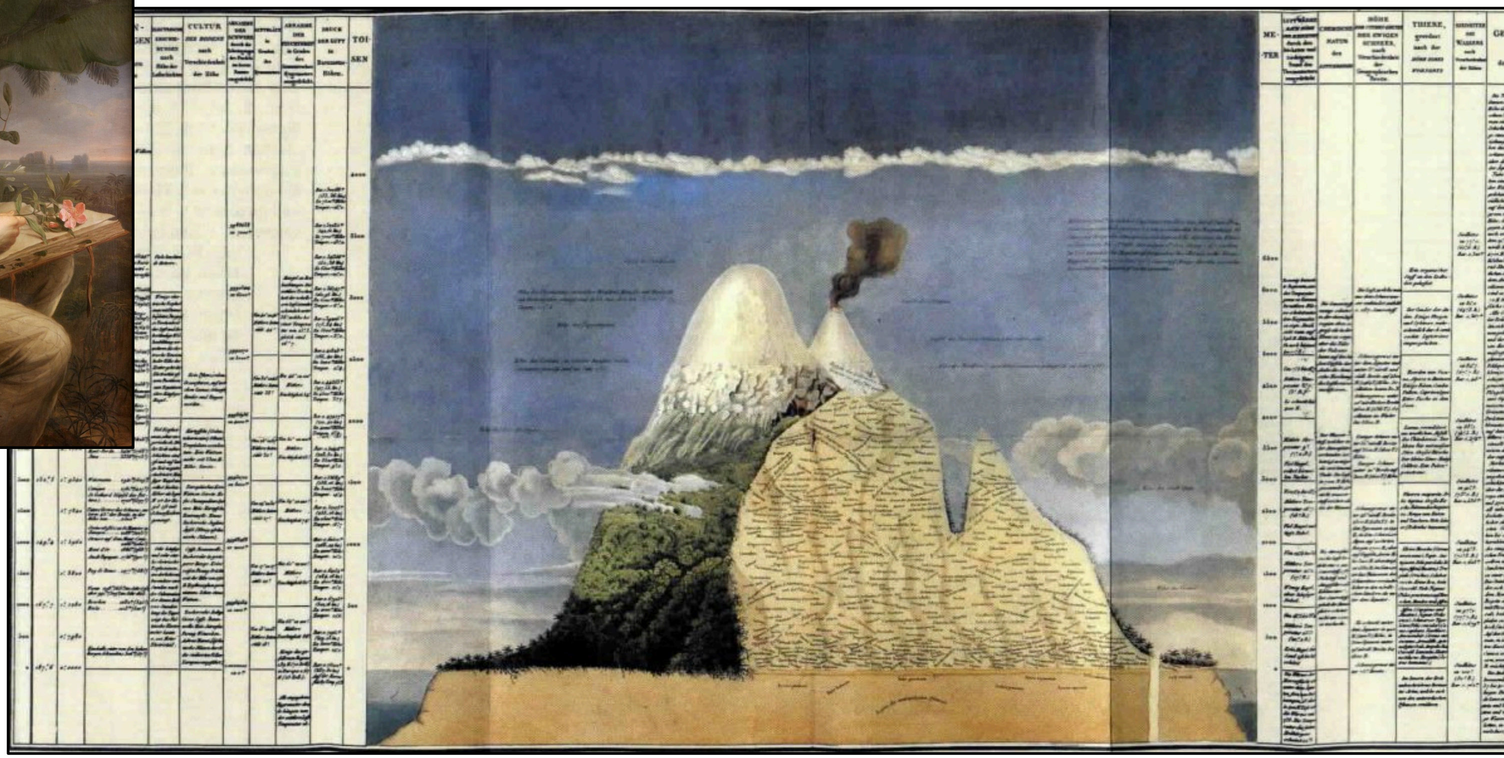
Alfred Russel Wallace (1823-1913)



Major historical players in exploration

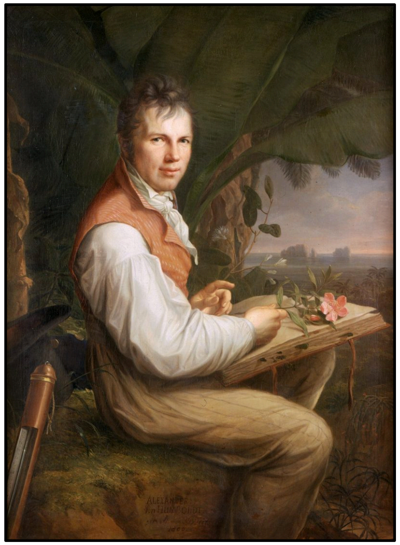


Alexander von Humboldt (1769-1859)

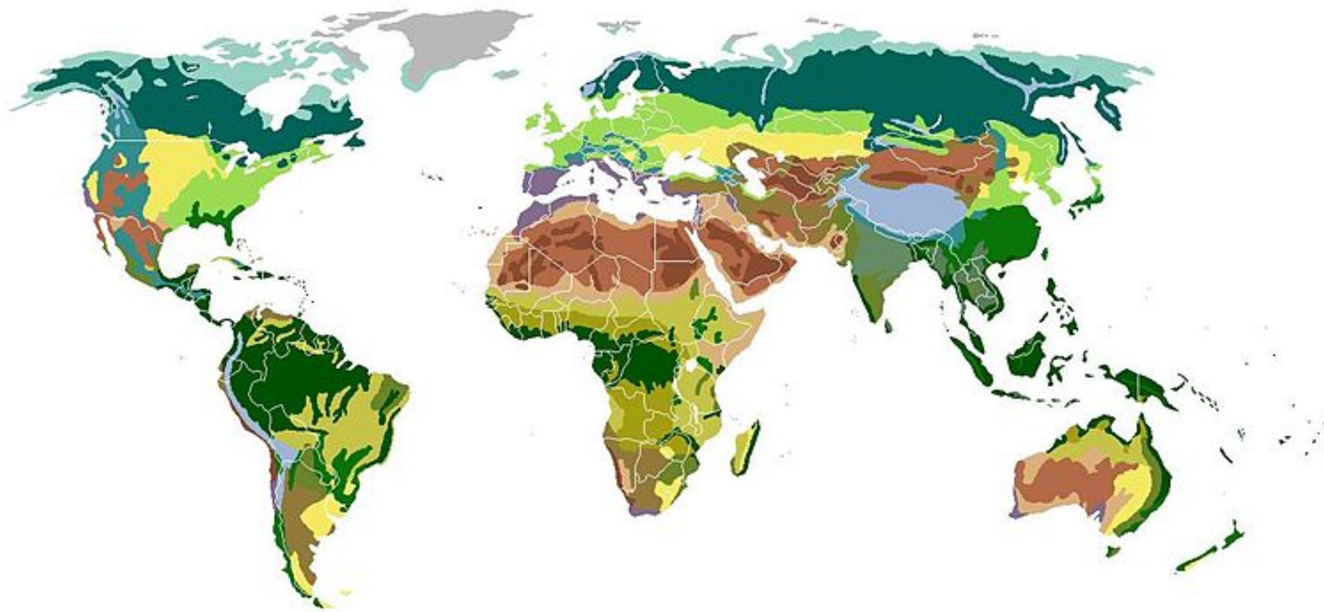


One of the greatest contributors to early knowledge of the tropics – sometimes called the founder of Biogeography – he led bold expeditions through South America, from the Orinoco River to the high Andes. The first to note the complementarity of South American & west African coastlines, suggesting the continents may have been joined!

Major historical players in exploration



Alexander von Humboldt (1769-1859)

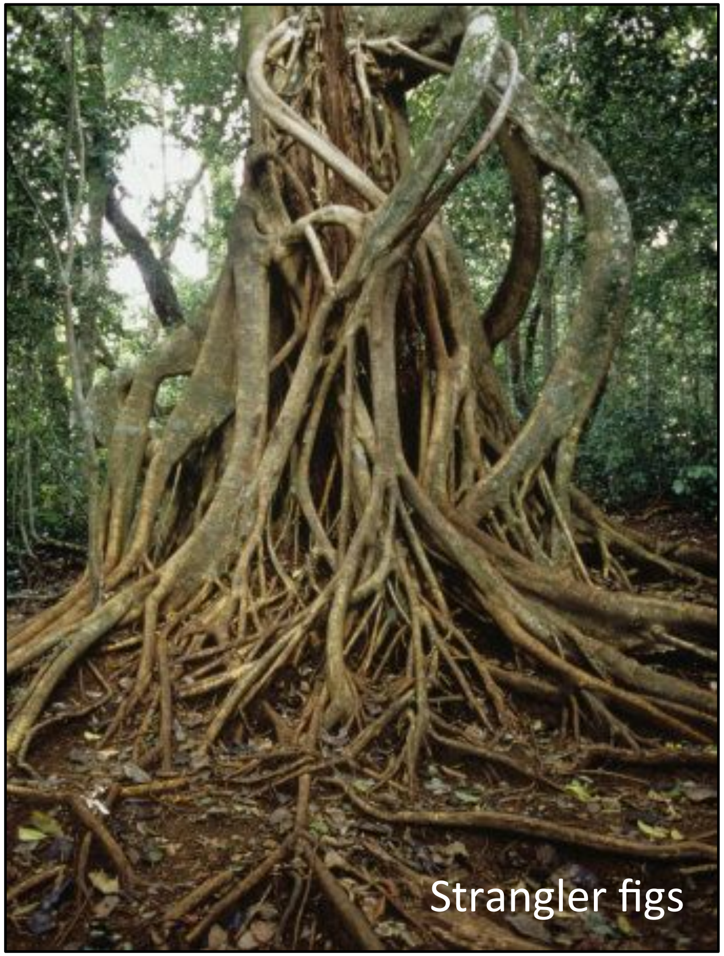


Humboldt coined the term 'floristic belts' and promoted the idea that plant distribution is determined by climate – the *life zone* concept

During his travels through Venezuela, discovered the nocturnal oilbird (*Steatornis caripensis*), which resides in tropical caves.

What makes the tropics unique?

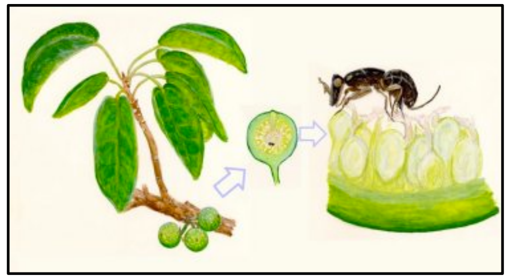
Structural features of forests



What makes the tropics unique?

Figs have important roles

"Who eats figs? Everybody." – Daniel Janzen 1979



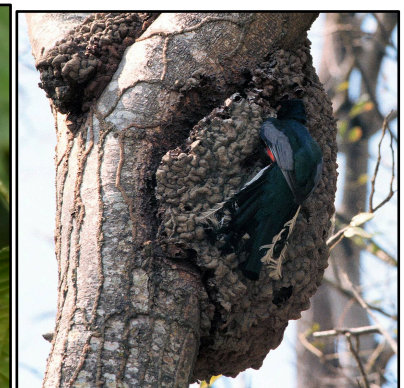
At least 1270 bird and mammal species consume fig fruits

What makes the tropics unique?

Specialized multi-species interactions

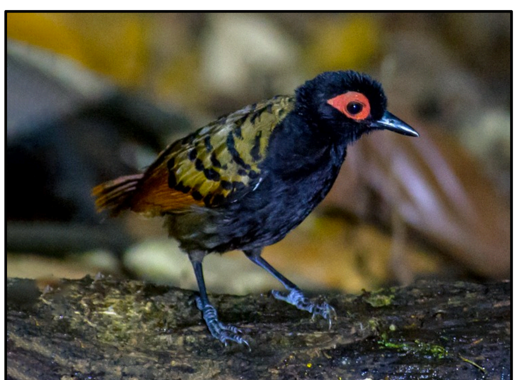
Leafcutter ants:
farmers that grow fungi

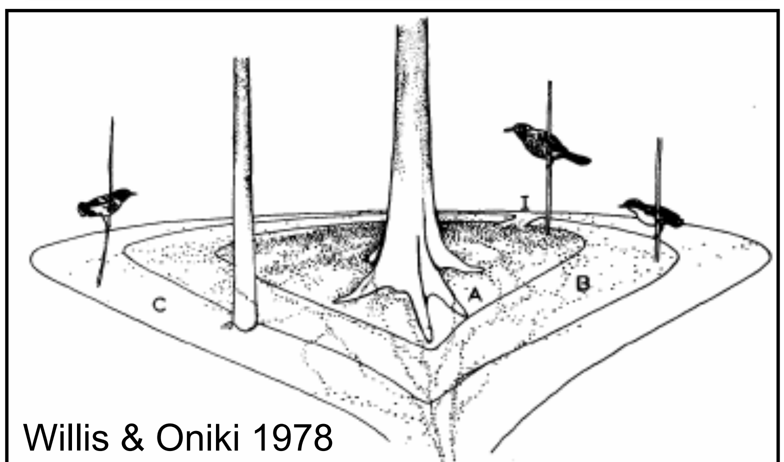
Termites build large globular nests:
creates nesting habitat for Trogons



What makes the tropics unique?

Specialized multi-species interactions



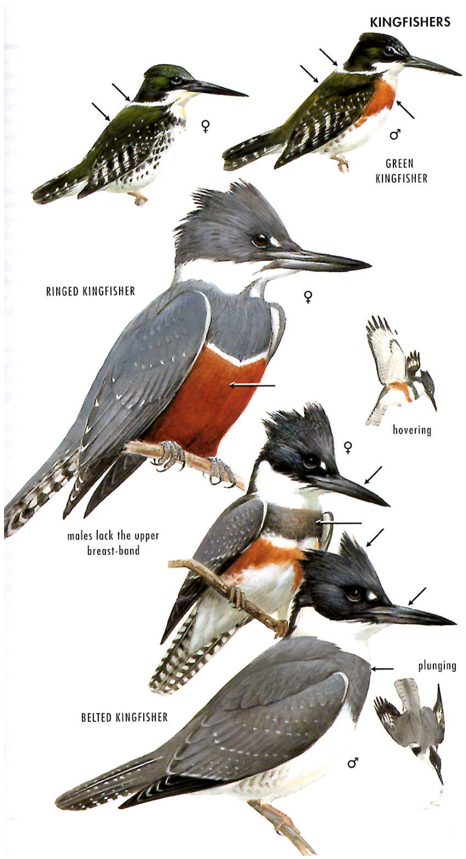


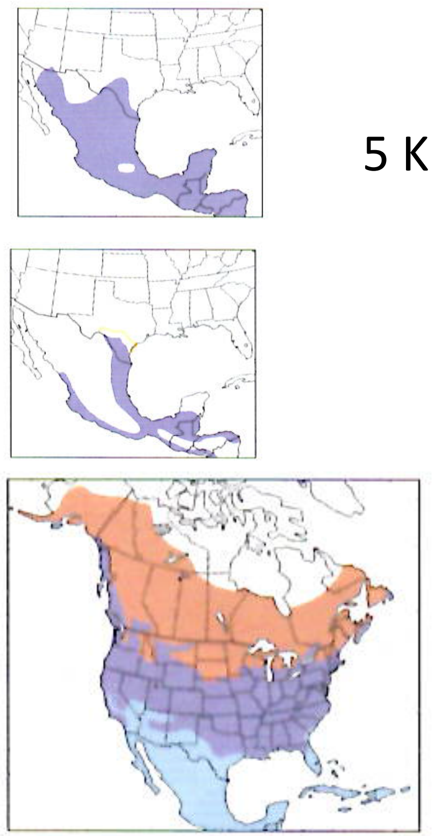
Willis & Oniki 1978

What makes the tropics unique?

Species are many variations of a theme

3 Kingfisher species of North America
(two of these barely reach South Texas)



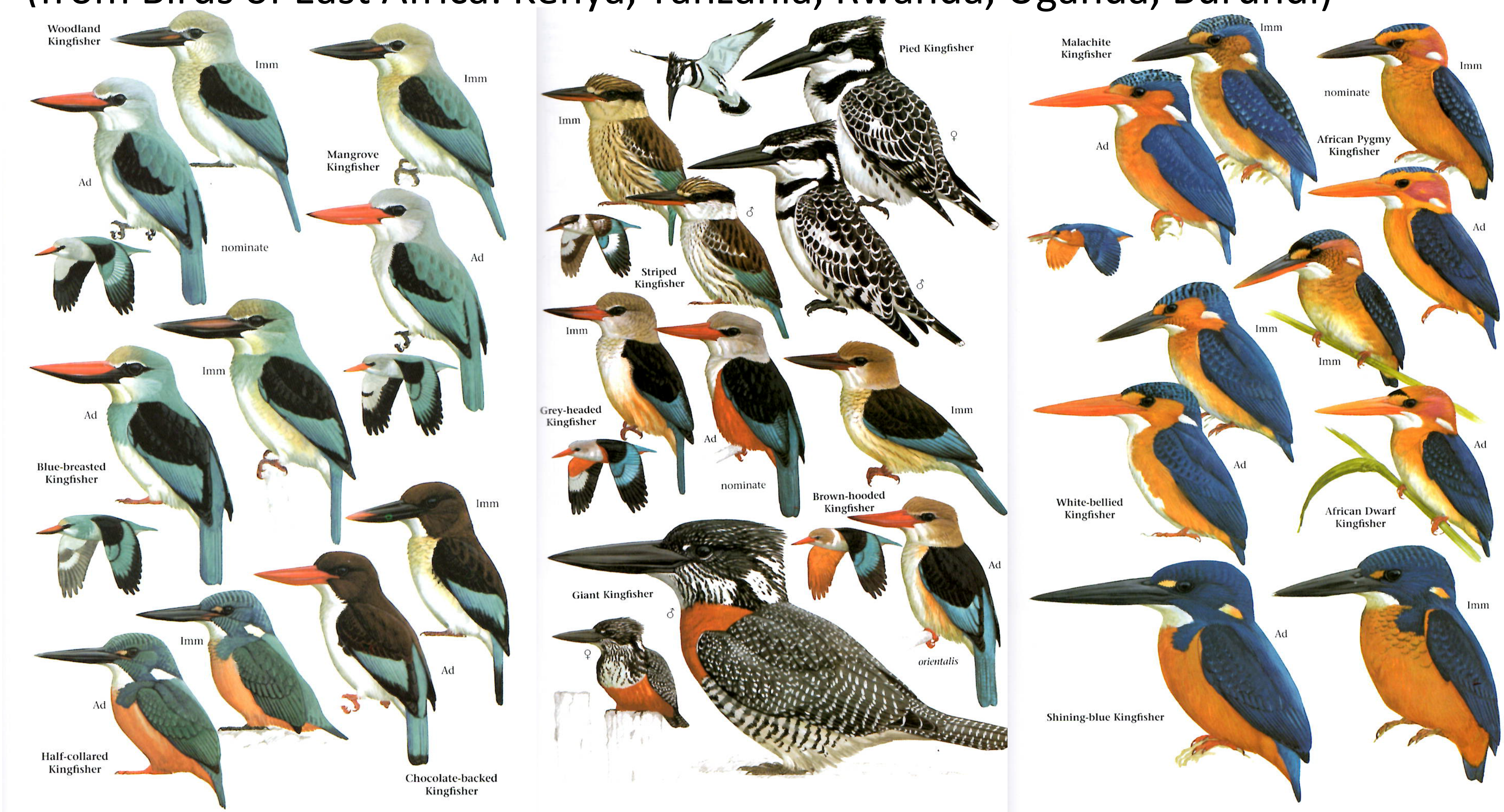


5 Kingfisher species occur in Peru

What makes the tropics unique?

Species are many variations of a theme

The Afrotropics boast 15 species of Kingfisher
(from Birds of East Africa: Kenya, Tanzania, Rwanda, Uganda, Burundi)



How do we study tropical systems?

Field stations support much tropical research

La Selva Biological Station, Costa Rica

Cocha Cashu Biological Station, Peru

Yasuni National Park, Ecuador

Monteverde Cloud Forest, Costa Rica

How do we study the tropics?

Established field stations

Barro Colorado Island (BCI)
Lago Gatun, Panama

https://stri.si.edu/

Smithsonian Tropical Research Institute

A 15 km^2 island formed by the creation of Lake Gatun in 1913 during the construction of the Panama Canal.

The oldest tropical research station in the world; visiting scientists study ecology, evolution and behavior of this system.

Goals and learning objectives

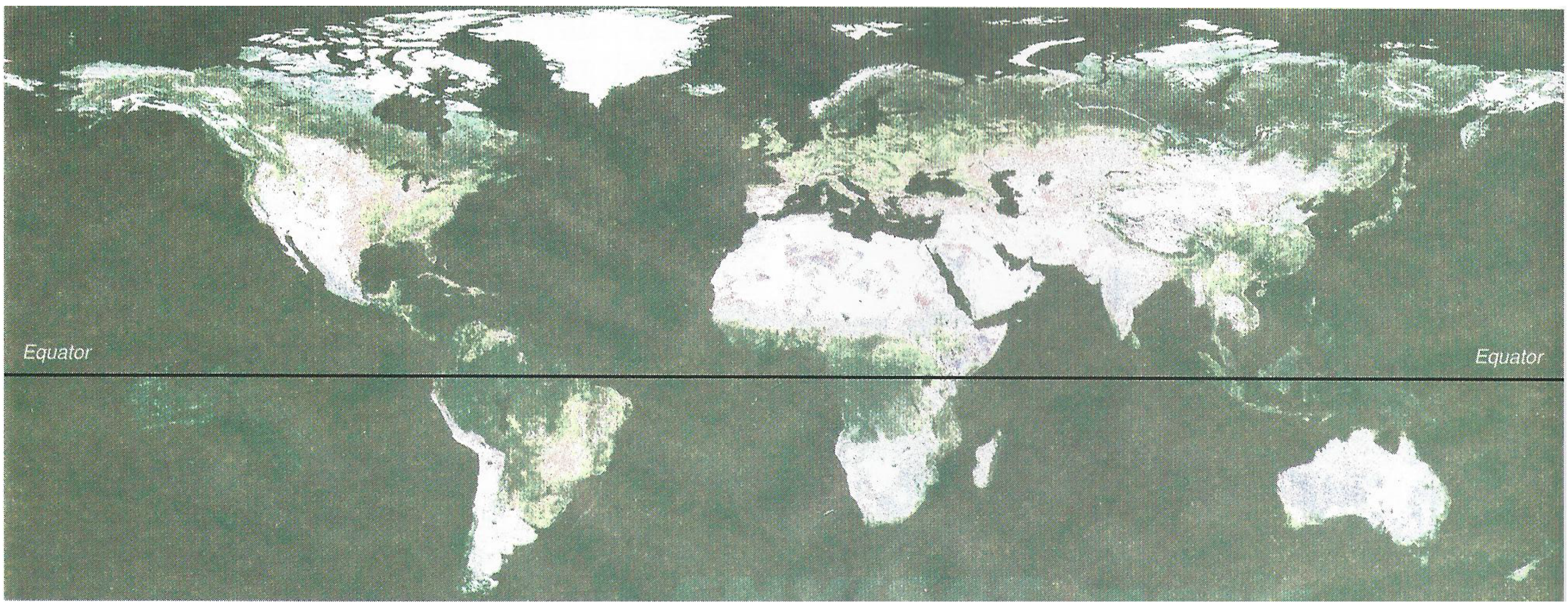
Climate, diversity of communities and classification:

- Understand how climates vary across the globe and the factors that determine these patterns – use this to explain why tropical forests are found where they are.

- Describe the diversity of ecosystems within the tropics and identify features of different tropical environments across the globe (what are the differences between tropical dry and wet forests, or within tropical montane regions).

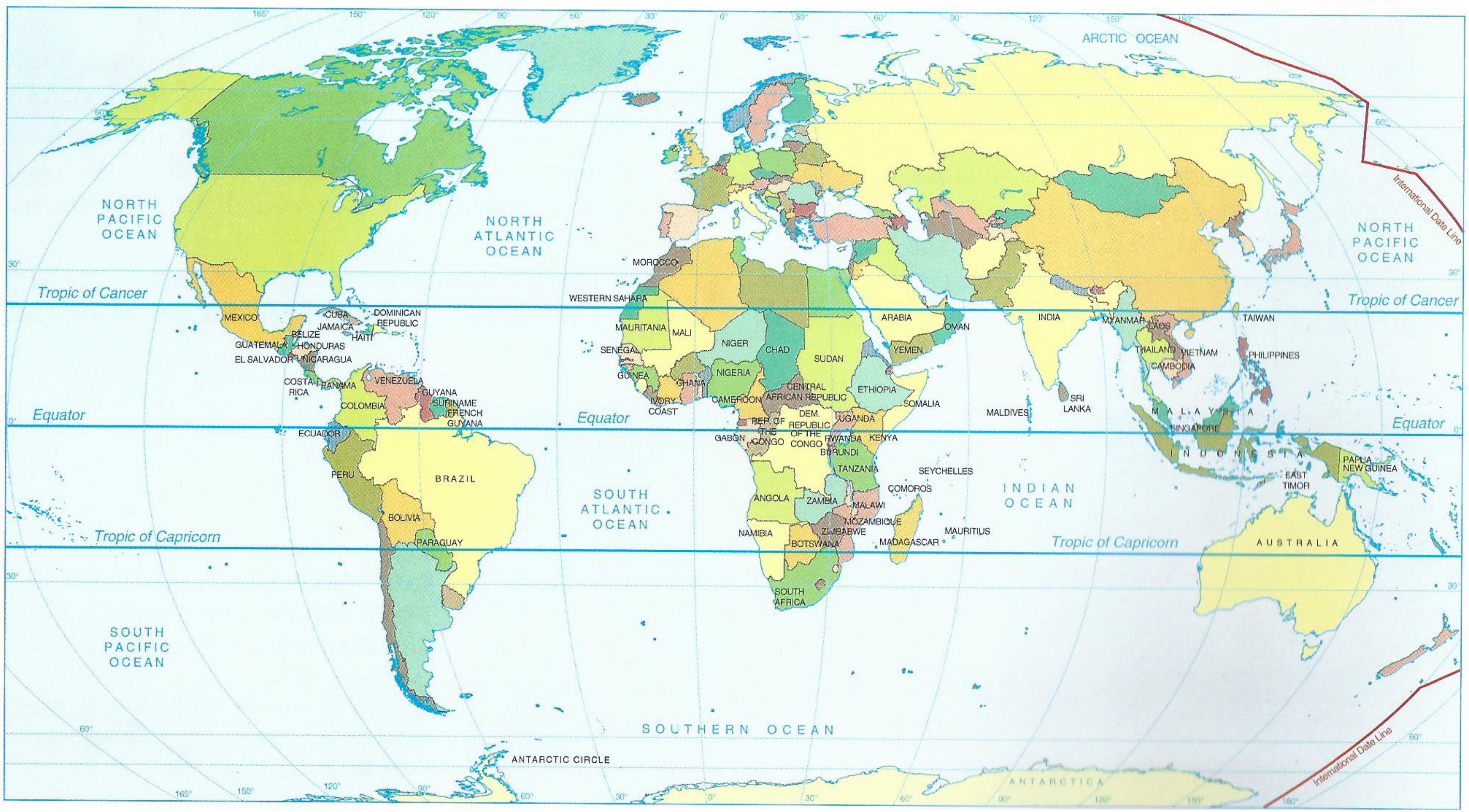
Geographic distribution of the tropics

Today the tropics are found between 23° 27'N and 23° 27'S latitude



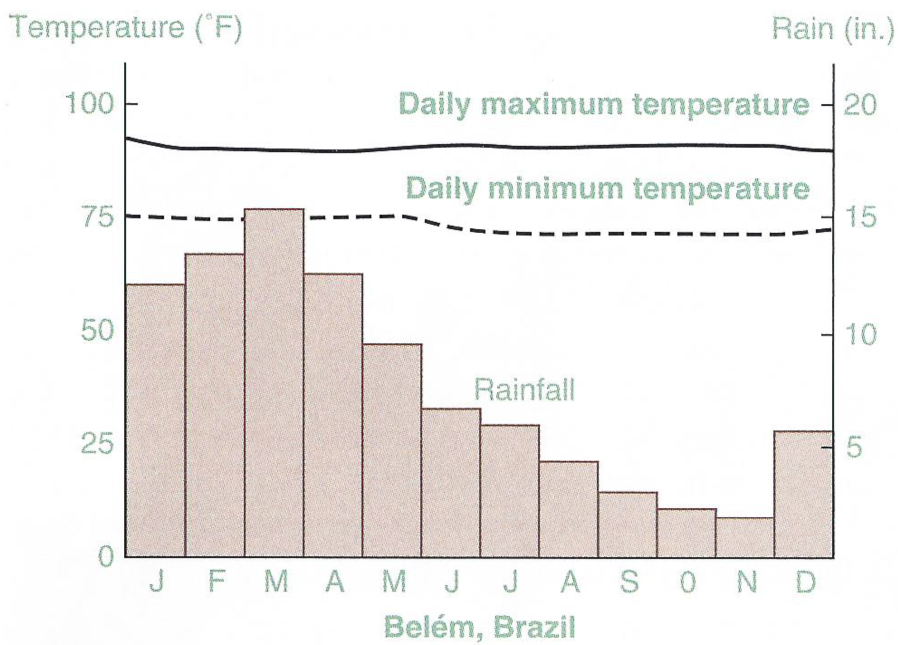
Geographic distribution of the tropics

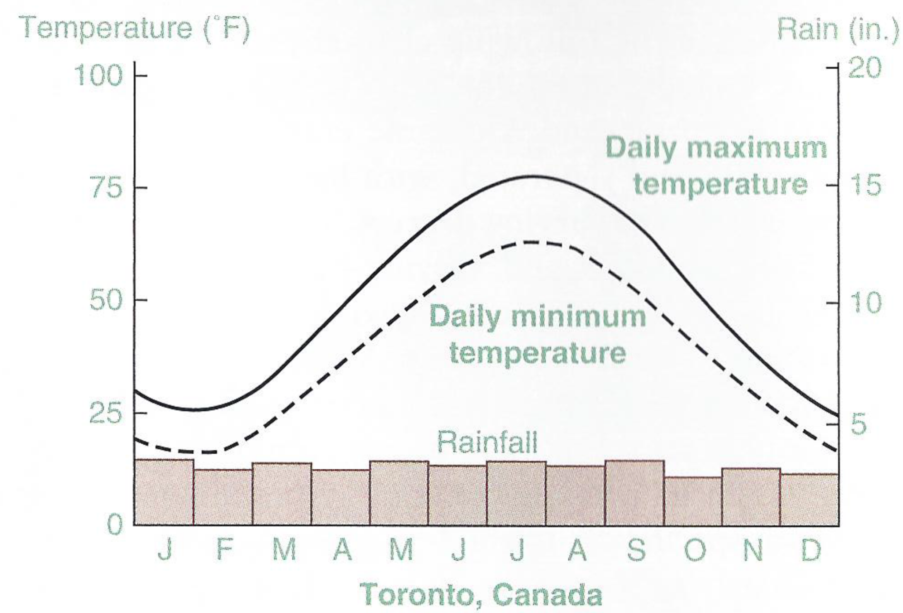
Political boundaries found within the tropical zone



Temperature and precipitation profiles of tropics and temperate zone

Tropical regions have largely stable temperature regimes, but can have strong seasonality in precipitation





Latitudinal gradient in thermal radiation

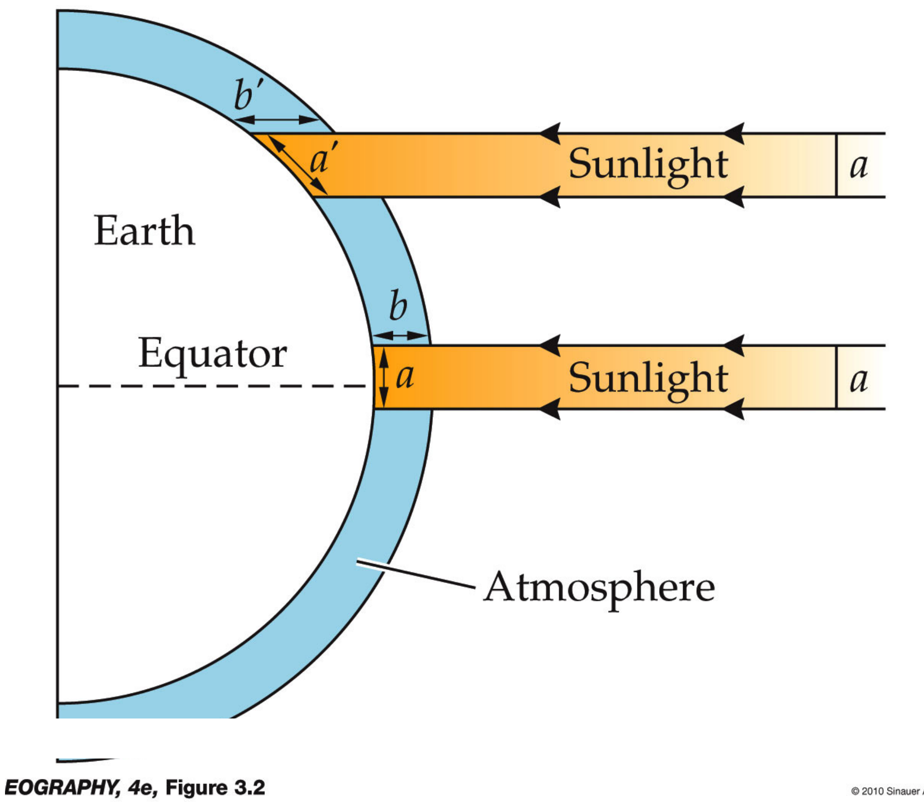


Figure 3.2 Lomolino *et al.* 2010

Most intense heating occurs where incoming sunlight is perpendicular to Earth's surface:

In the tropics, more energy is delivered to a smaller surface area (a < a')

And solar radiation is filtered through less atmosphere (b < b')

Latitudinal gradient in thermal radiation

Tropical regions are warm and wet because sunlight falls most directly and constantly on Equatorial regions

Air at the equator expands as it is heated, becomes less dense than surrounding air and rises

Rising heated moist air undergoes adiabatic cooling, condensing the water, which falls as precipitation

This accounts for the rainy aspect of tropical climates

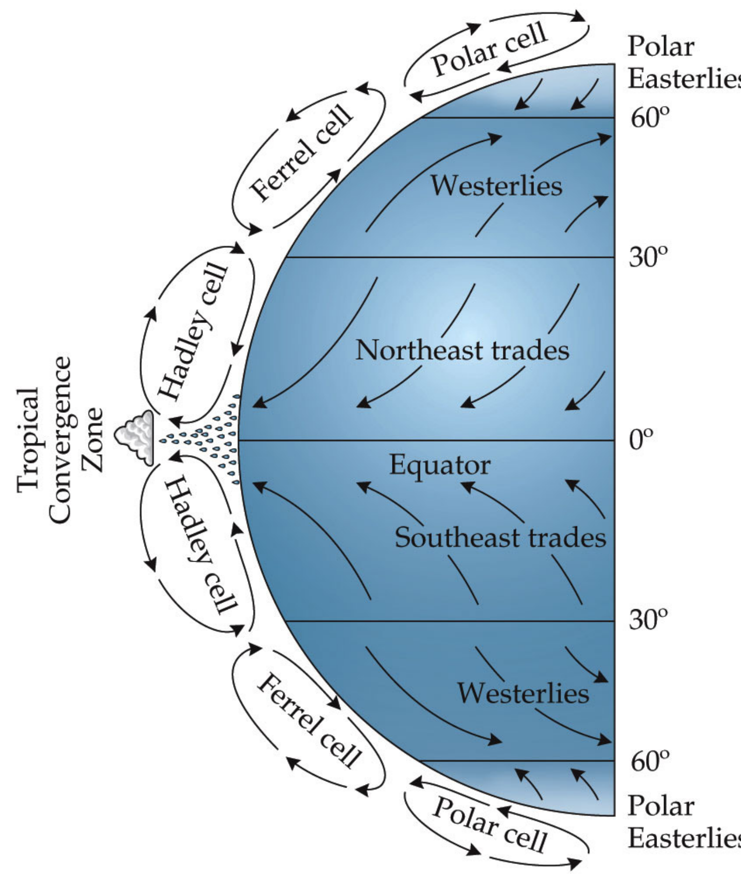


Figure 3.4 Lomolino *et al.* 2010

Latitudinal gradient in thermal radiation

Tropical regions are warm and wet because sunlight falls most directly and constantly on Equatorial regions

The Intertropical Convergence Zone (ITCZ) is formed by two major air masses (from the north and south), along with major ocean currents, driven by Hadley cells

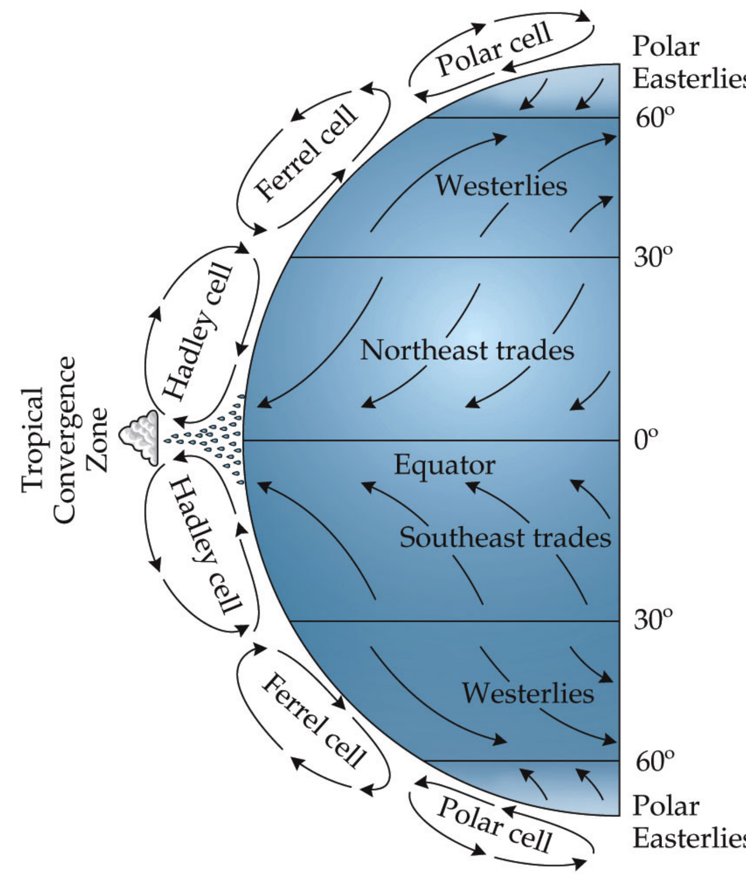


Figure 3.4 Lomolino *et al.* 2010

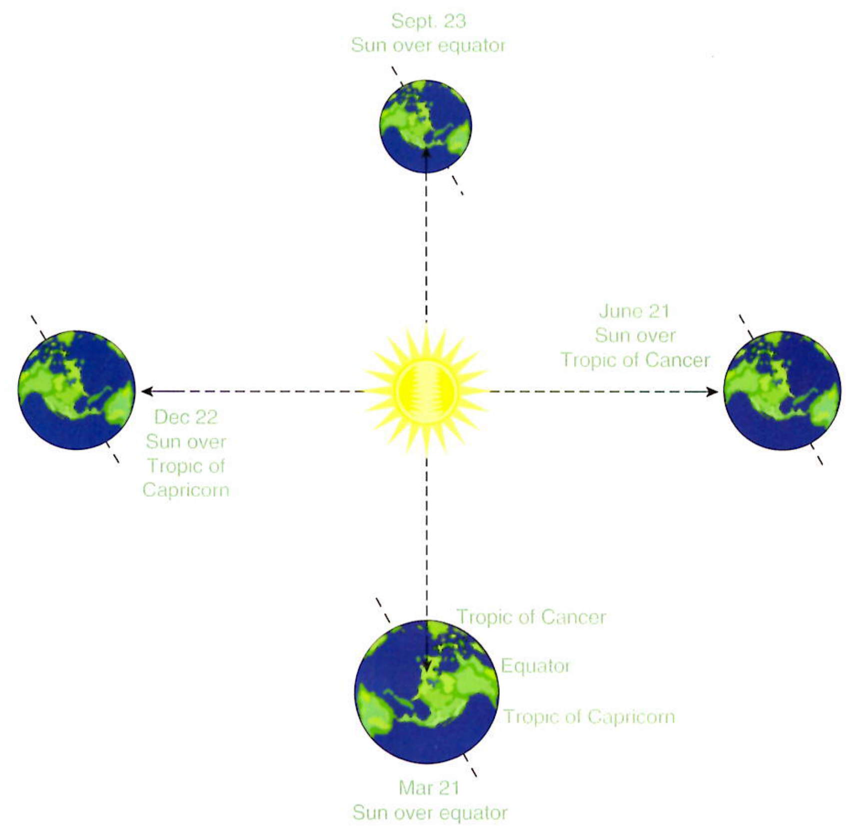
Latitudinal gradient in thermal radiation

Tropical regions are warm and wet because sunlight falls most directly and constantly on Equatorial regions

The Intertropical Convergence Zone (ITCZ) is formed by two major air masses (from the north and south), along with major ocean currents, driven by Hadley cells

As Earth, tilted on its axis, orbits the sun, the direct angle of sunlight varies with latitude

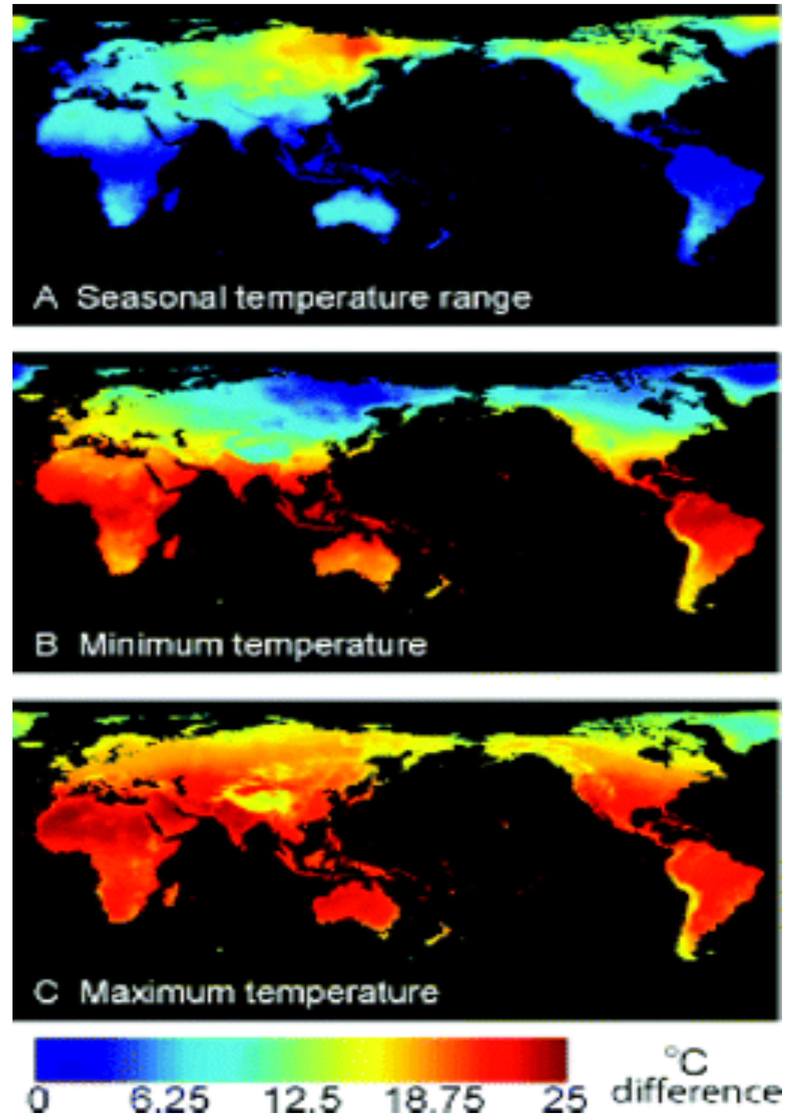
Changing heat patterns of air masses around the ITCZ results in seasonal rainfall patterns.



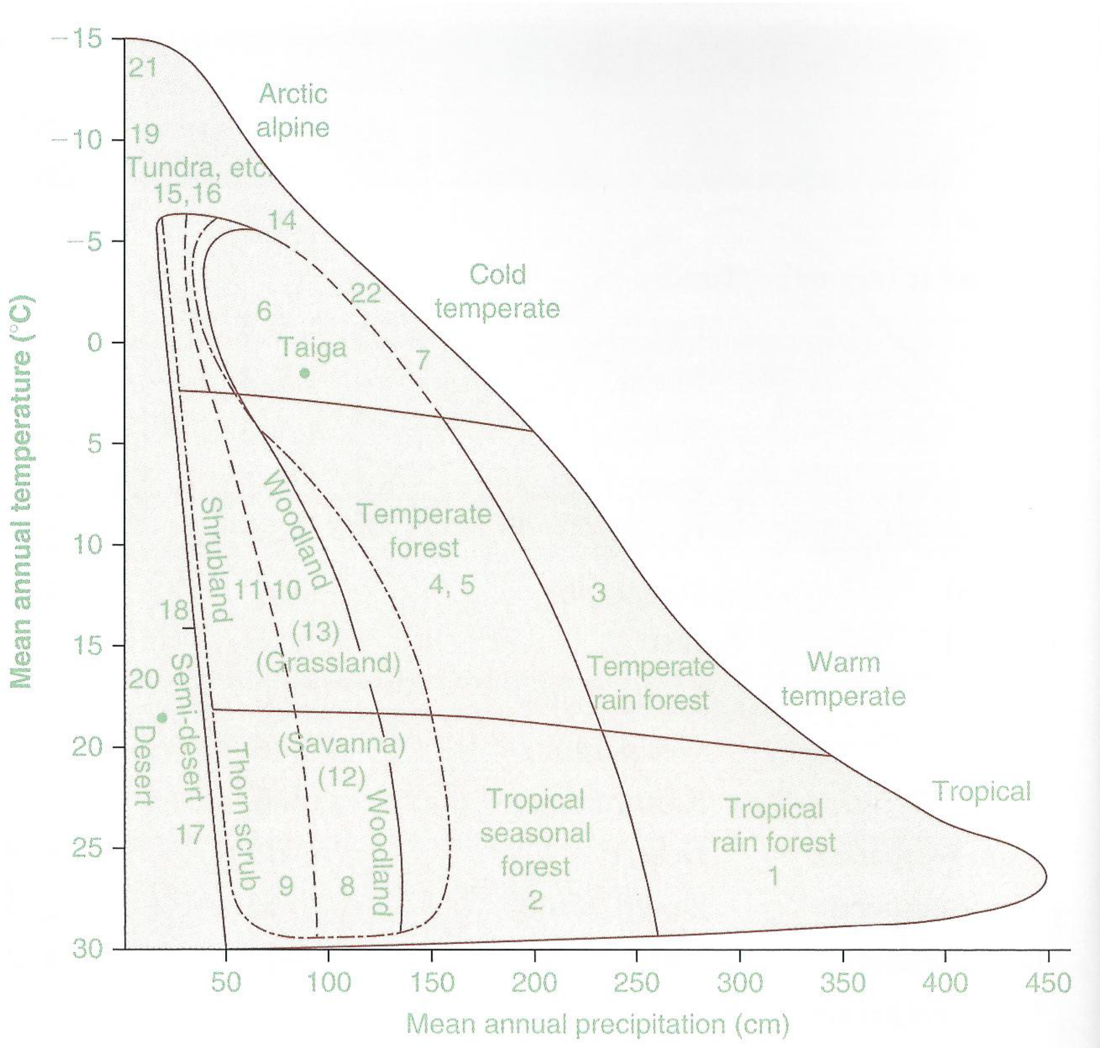
Latitudinal gradient in seasonality

Global patterns of temperature show that the latitudinal gradient of seasonality is caused mainly by a strong gradient in minimum temperature and less by the gradient in maximum temperature.

A) Colors are normalized to the site with the least seasonal variation (deep blue)
B) Colors are normalized from the coldest site (deep blue)
C) Colors are normalized to the warmest site (deep red)



Relationships between ecosystem types, precipitation and temperature



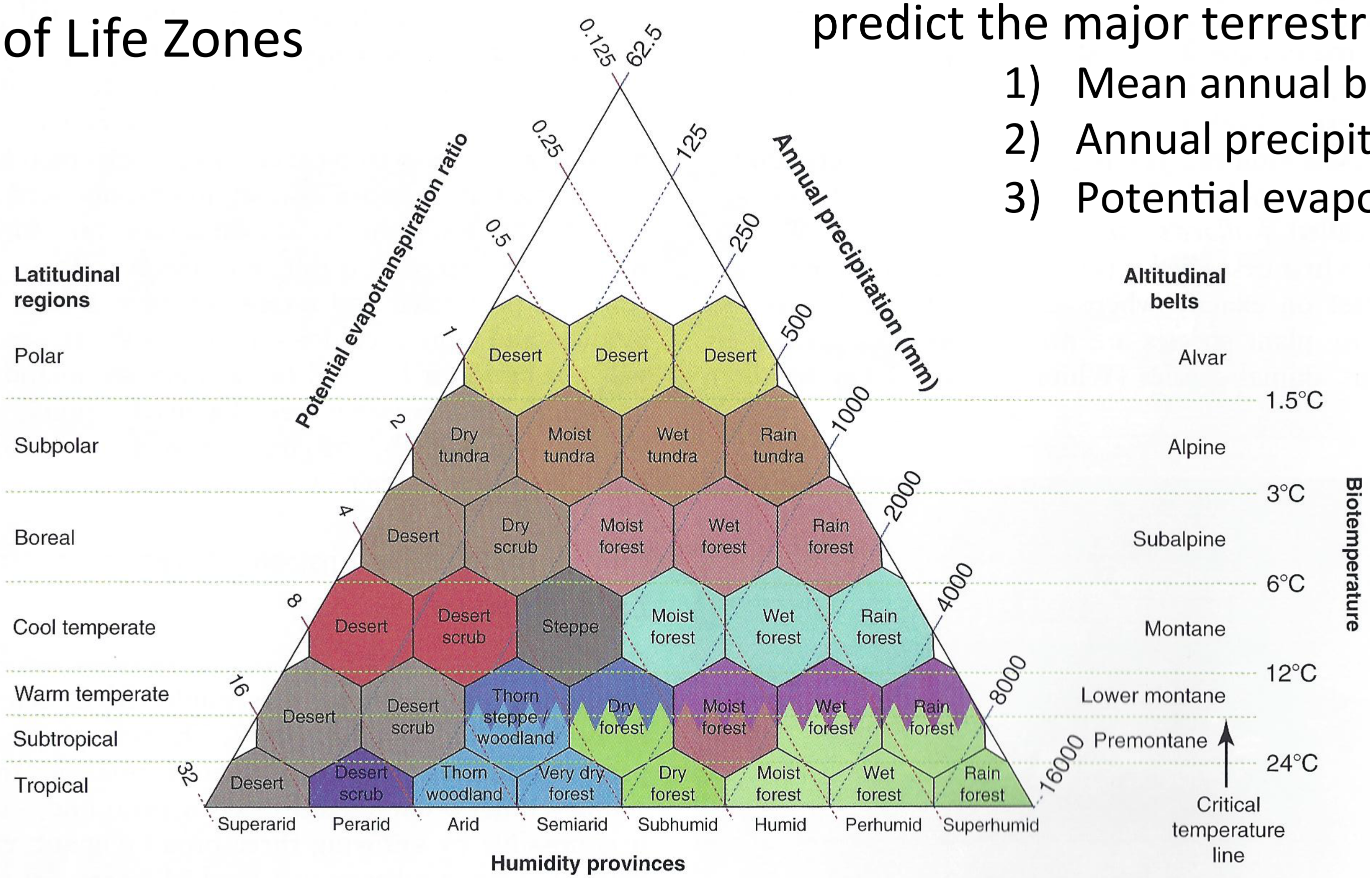
Tropical rain forest occurs where both climatic variables are highest

Relationships between ecosystem types (latitude, elevation, precipitation, temperature)

Holdridge diagram of Life Zones

Using three broad climatic variables, we can predict the major terrestrial ecosystem type:

1) Mean annual bio-temperature
2) Annual precipitation
3) Potential evapotranspiration ratio



The tropics show many different forms

Tropical life zones include:

Tropical desert

Tropical desert scrub

Tropical thorn woodland (savanna)

Tropical dry forest

Tropical moist forest

Tropical wet forest

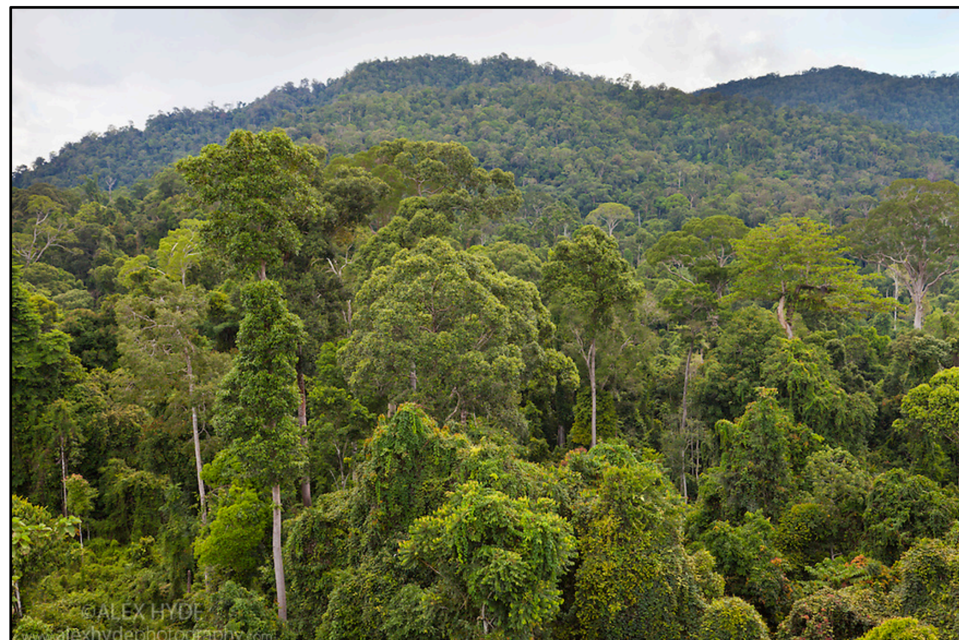
Tropical rain forest

Tropical lowland rain forest

Amazon forest and Dipterocarp forest (Borneo)

Tropical rain forests are characterized by little change in temperature, and low potential evapotranspiration (PET) ratio with superhumid conditions, usually with >800 cm of rain annually

(1 species of Dipterocarp tree)



(445 species of Dipterocarp tree)

Tropical lowland dry forest

Typically dry forests are characterized by little change in temperature, but with a pronounced dry season during part of the year

We see adaptations in plants (and animals) in these forests, often with high proportions of endemic species (restricted to dry forest habitat)

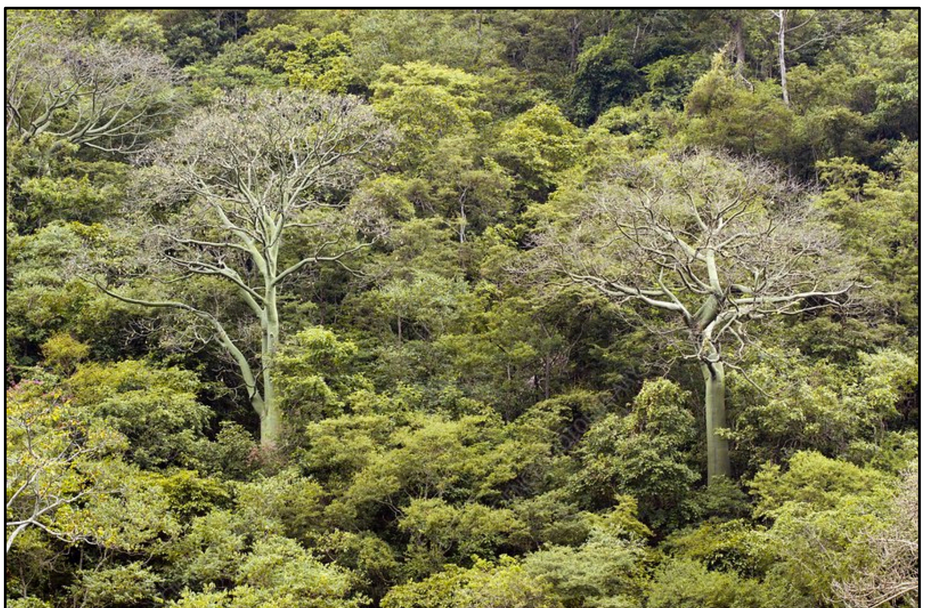




Tropical lowland dry forest

In contrast to tropical rain forest, tropical dry forest have deciduous species of trees that lose their leaves at the onset of the dry season

Some trees, like species in the genus *Ceiba* have photosynthetic bark, allowing growth after leaves drop



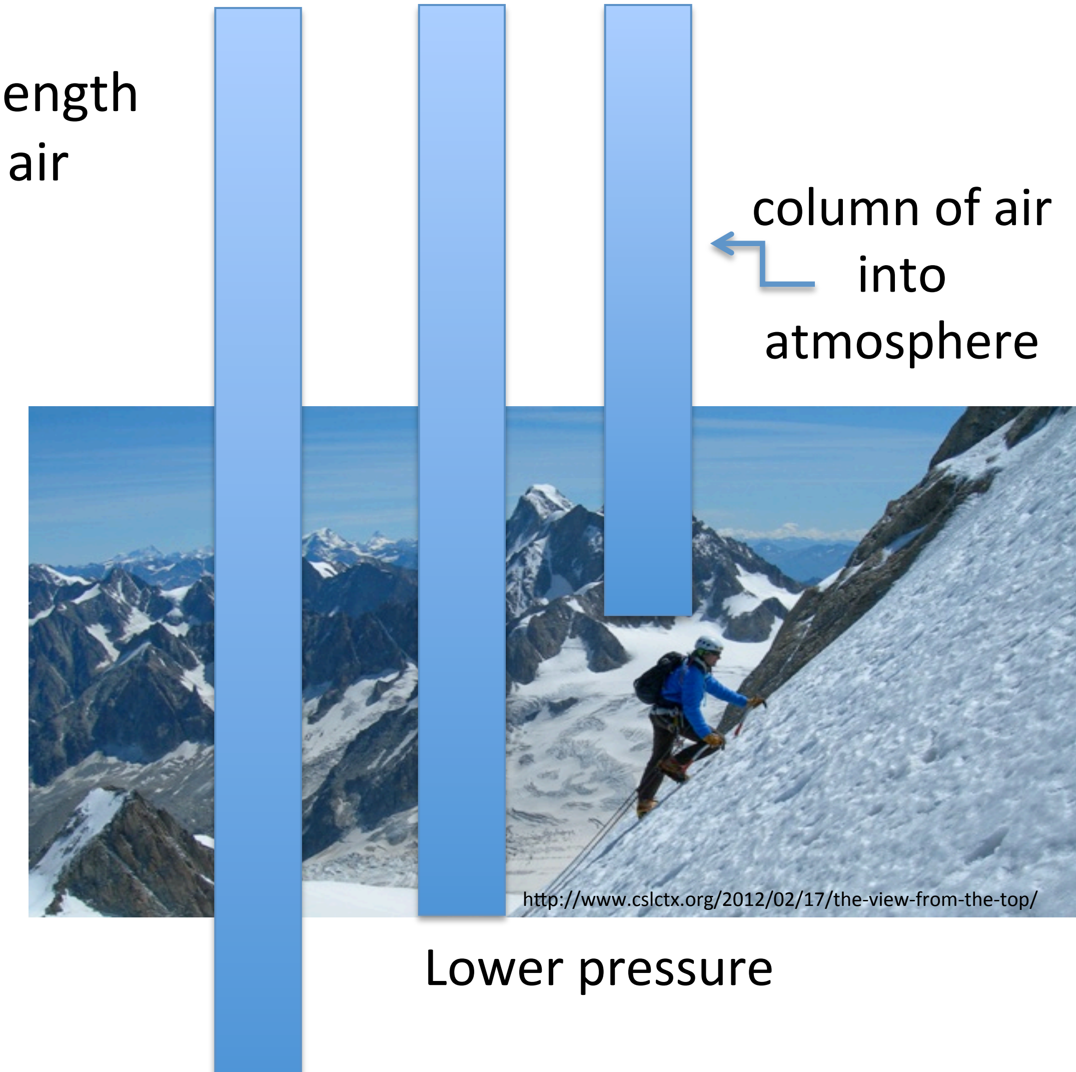
Tropical lowland dry forest

Tropical dry forests are also easily converted to cattle pastures, and the dry season makes these areas more hospitable for human settlement

Elevational gradients in temperature

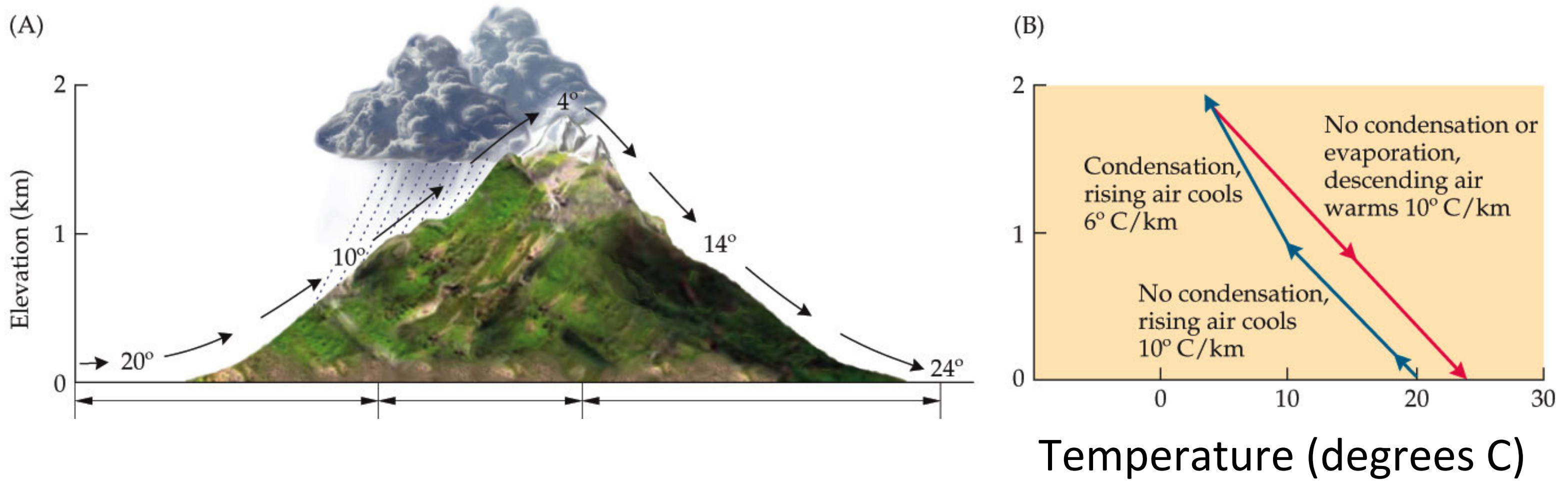
Ascending a mountainside, the length (and pressure) of the column of air above decreases

With reduced pressure, air undergoes **adiabatic cooling,** a process where gasses lose heat energy as molecules move farther apart (and have fewer collisions)



Mountains affect regional precipitation

Air cools and loses moisture as it moves up slope. When it descends on the other side, it warms (at a higher rate). This results in "windward" sides of a mountain that are wet, and "leeward" sides that are dry



Rain shadow effect in Puerto Rico showing habitats on windward and leeward slopes

Figure 3.7 Lomolino *et al.* 2010

Elevational gradients in the tropics

Lower montane and cloud forest

Elevational gradients in the tropics

Elfin and Polylepis Forest

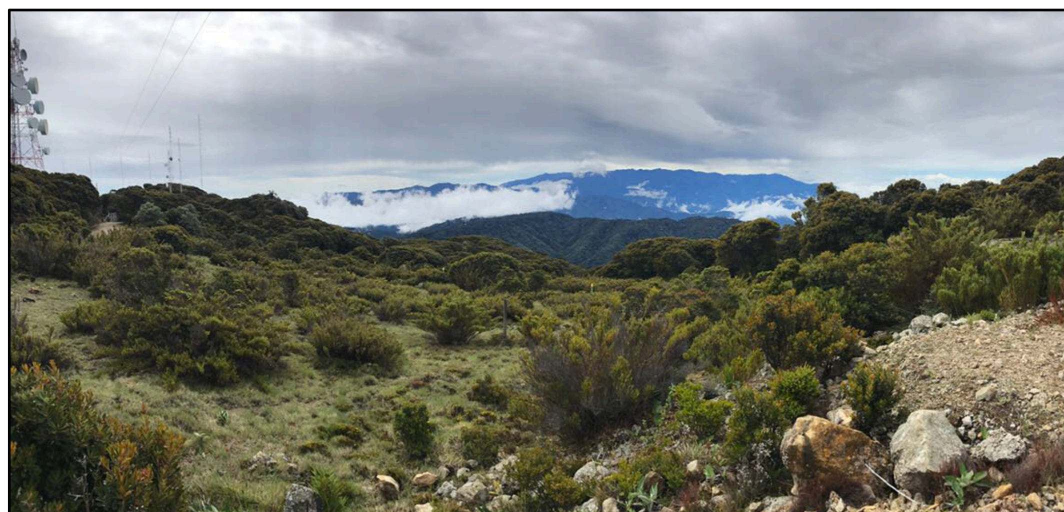
(characterized by stunted
trees just below tree line)

Elevational gradients in the tropics

Paramo and puna

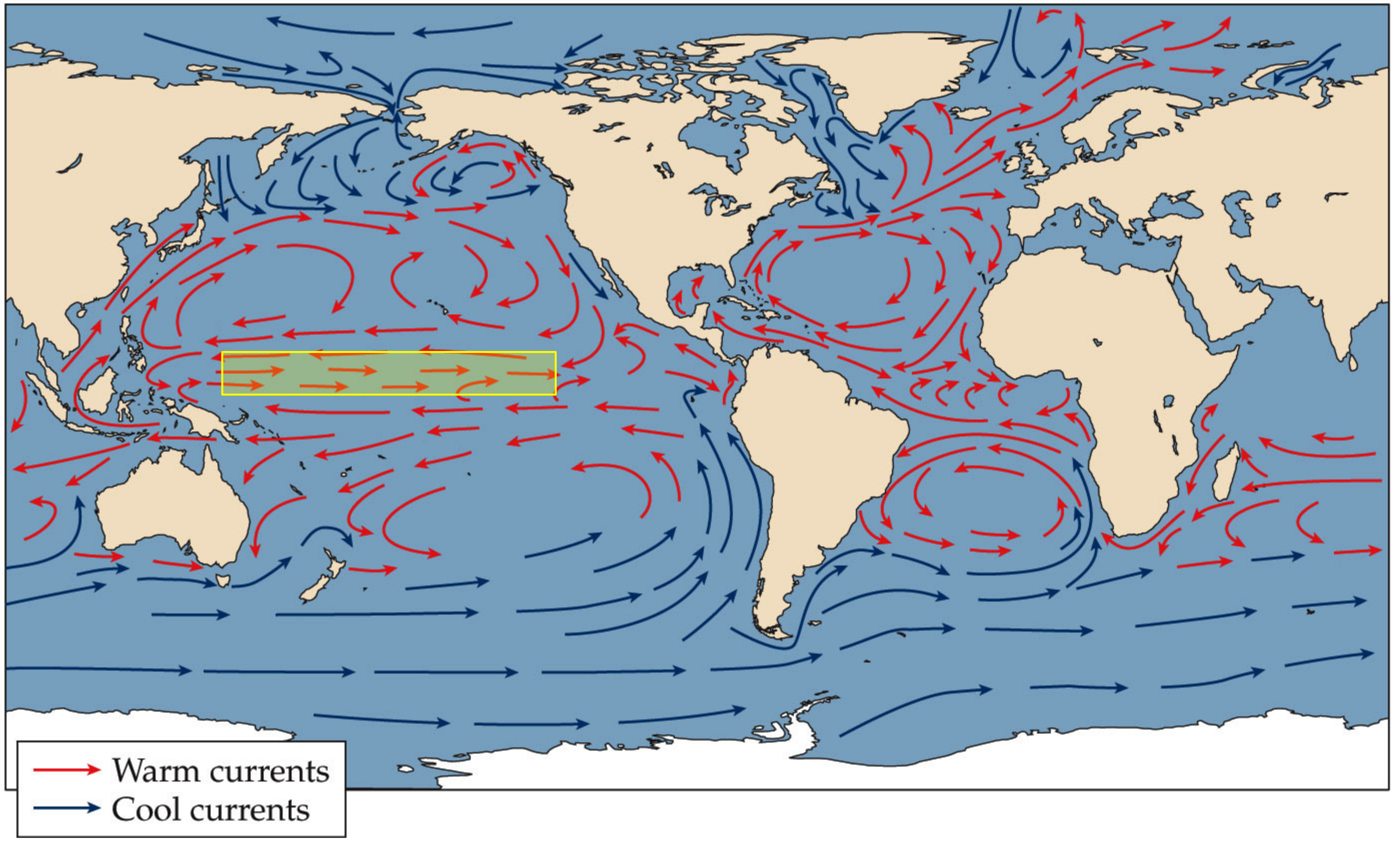

Puna of southern Peru


Frailejones ('big monks') of Colombian paramo



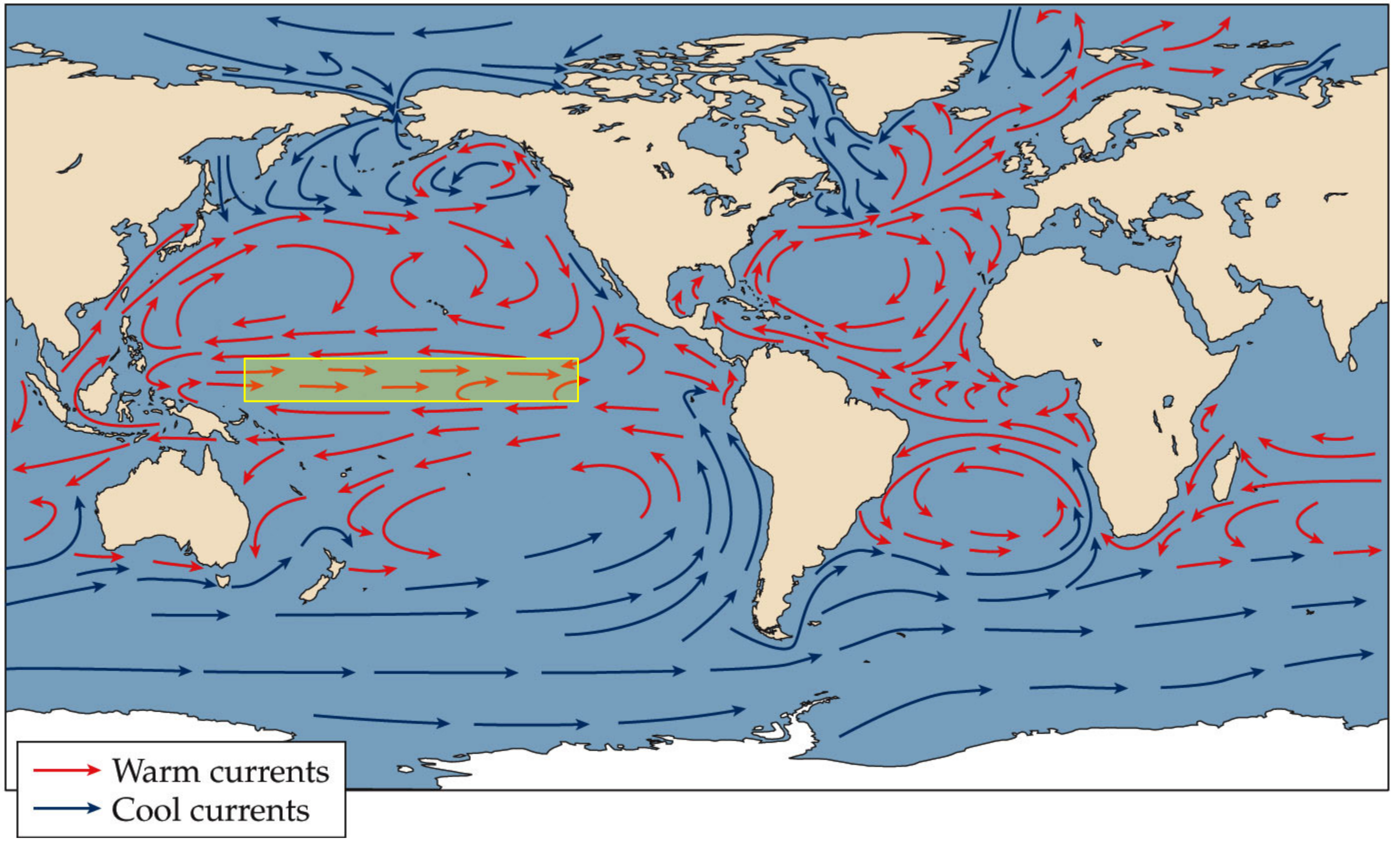
Short term climate changes: ENSO

El Nino Southern Oscillation (ENSO): period of weather change that occurs every 2-7 years due to strengthening of the equatorial countercurrent (the exact cause of ENSO is still unknown)



Short term climate changes: ENSO

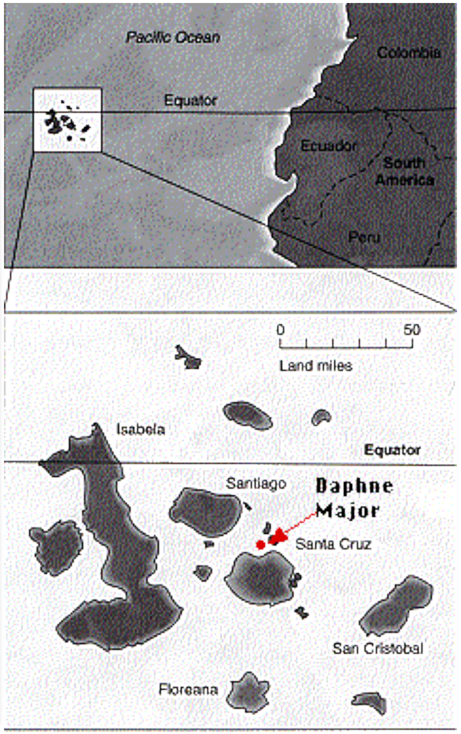
Warm water from western Pacific flows east, blocking the cold, nutrient rich waters and prevents upwelling of nutrients from the deep ocean



Short term climate changes: ENSO

This disrupts oceanic food chains, changes weather systems across broad scales (downpours and flooding, or droughts where there should be rain)

Galapagos Islands

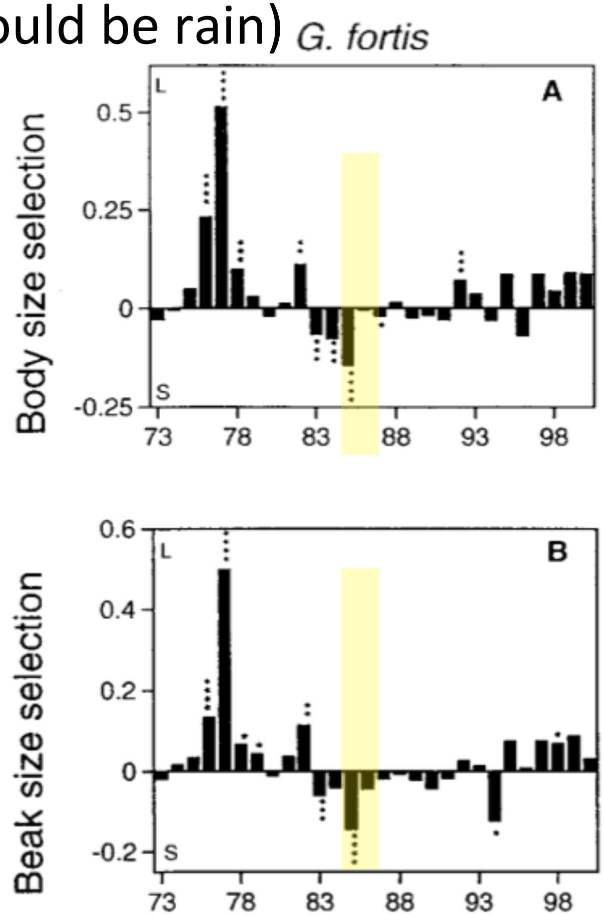


Brings more rain (good for land dwellers)

Warm current reduces upwelling and food (bad for marine life)

Short term climate changes: ENSO

This disrupts oceanic food chains, changes weather systems across broad scales (downpours and flooding, or droughts where there should be rain)



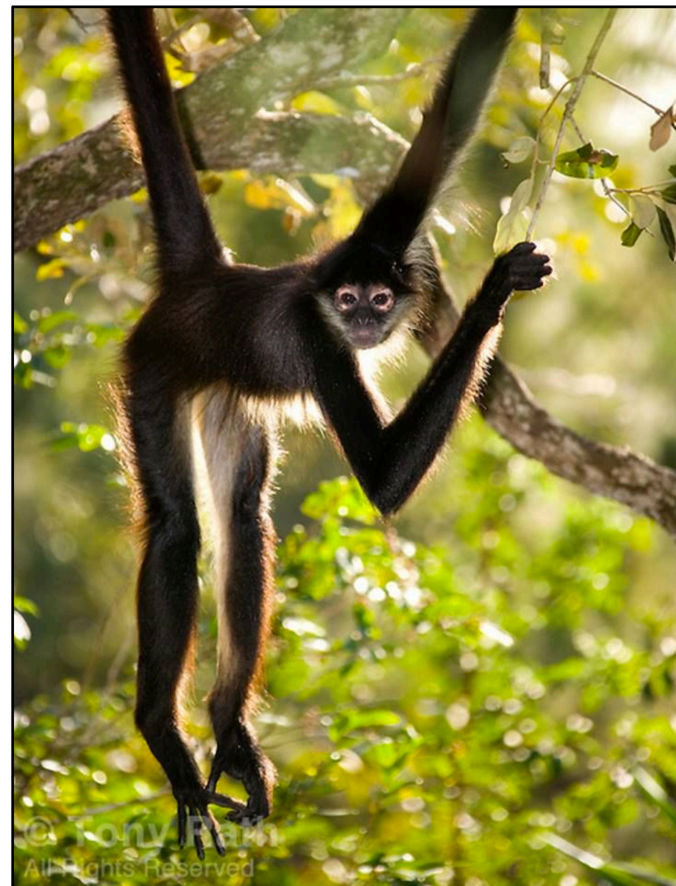
The especially strong El Nino in 1983 increased food availability on the islands, which alleviated selection on beak and body size in two finch species

(From Grant and Grant 2002)

Short term climate changes: ENSO

This disrupts oceanic food chains, changes weather systems across broad scales (downpours and flooding, or droughts where there should be rain)

The 1983 El Nino affected Barro Colorado Island fauna in Panama with the failure of fruit crops – resulting in starvation of many mammals



The tropics show many different forms

Ecological analysis of tropical systems should consider biogeographic history, climate and frequency of disturbance

Savanna and rain forest found at the same latitude in Africa

Rainforest in Papua New Guinea and Brazil are structurally similar, but with distinct species composition because they have been separated for 100 million years.

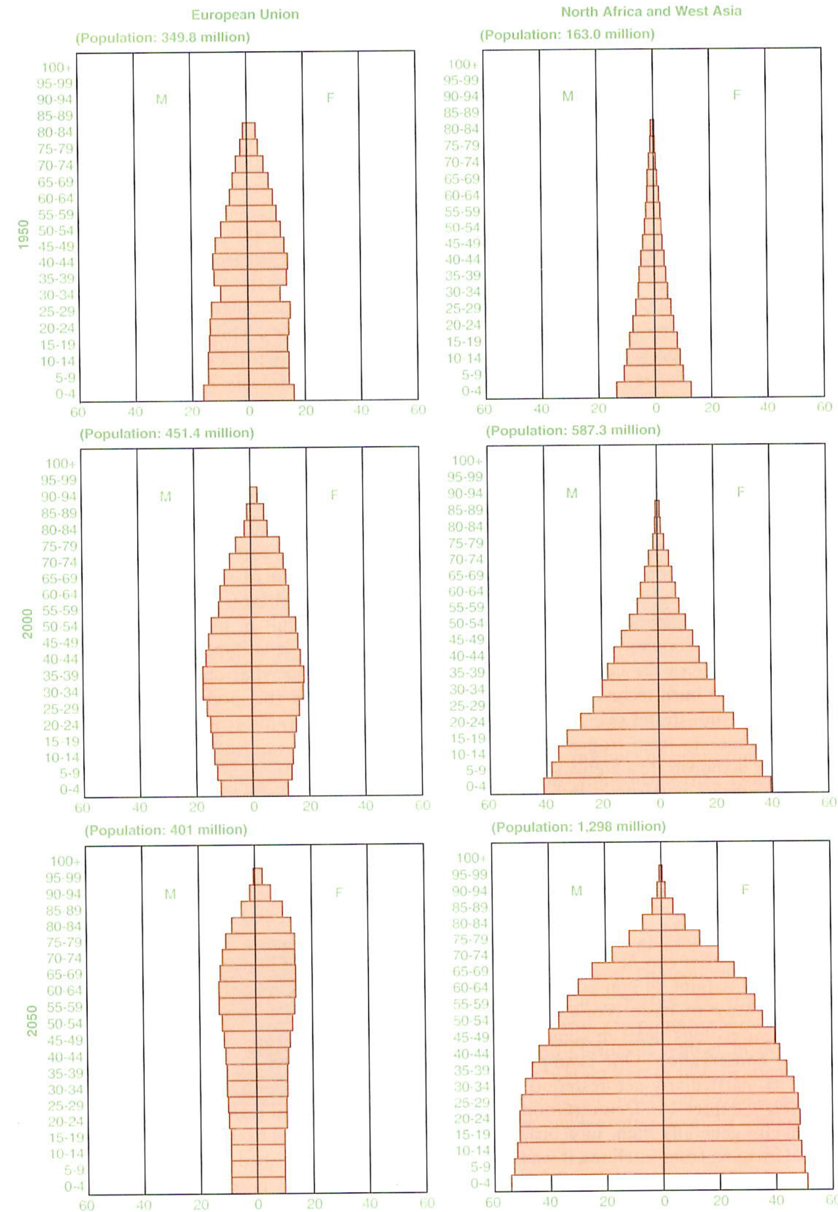
Key research directions in tropical ecology

- Interactions among interdependent species
- Carbon sequestration in forests
- Effects of climate change
- Mechanisms of speciation (what generates high biodiversity)
- Food web dynamics
- Species coexistence
- Causes and function of high biodiversity

Conservation Issues in the Tropics

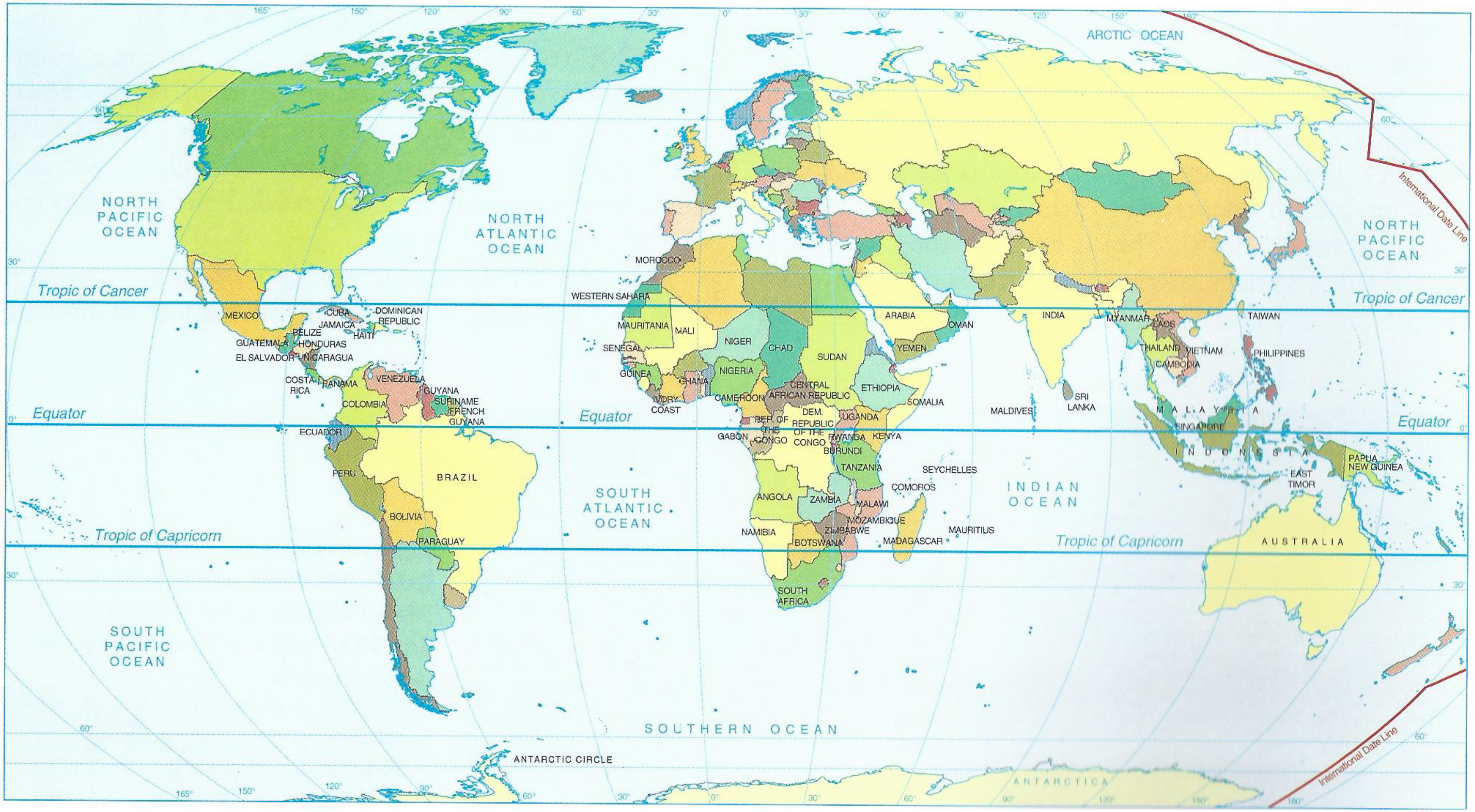
Growth rate of humans is high in most tropical regions

Global projected trends in population size will reach ~9 billion by 2050, and much of that increase will be in less developed equatorial countries

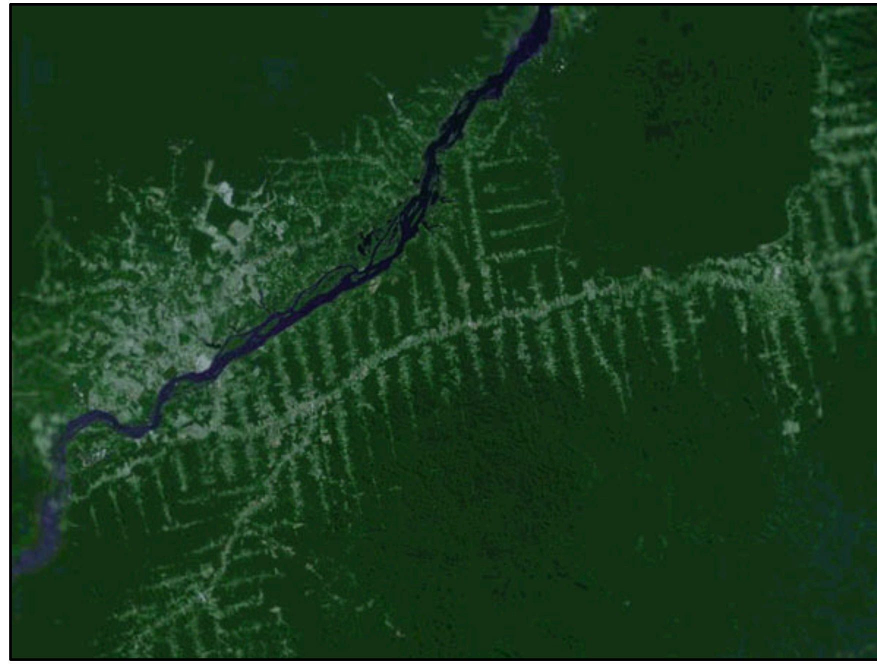


Conservation Issues in the Tropics

Consider countries that harbor tropical ecosystems

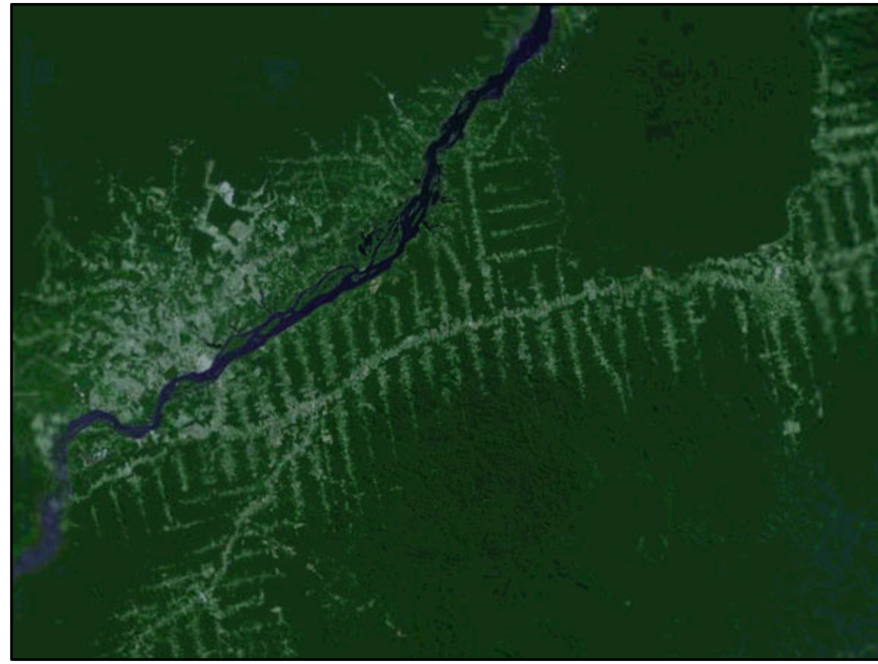


Conservation Issues in the Tropics



Logging, fragmentation, removal of forest areas and creation of edge environments has multiple effects on diversity, species composition and population connectivity

Conservation Issues in the Tropics

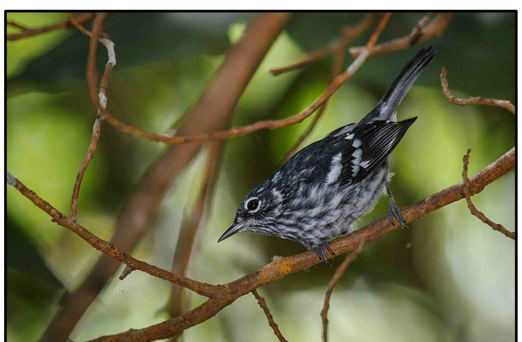


Opening up forests to resource extraction raises other local pressures, such as bush meat extraction

Climate change will affect regions and species differently:

April 2019: NASA Reports "Neotropical Cloud Forests to Lose What Most Defines Them: Clouds"

"In as few as 25 years, climate change could shrink and dry 60-80% of Western Hemisphere cloud forests, finds a study published today."



Elfin Wood Warbler
endemic to cloud forest of Puerto Rico

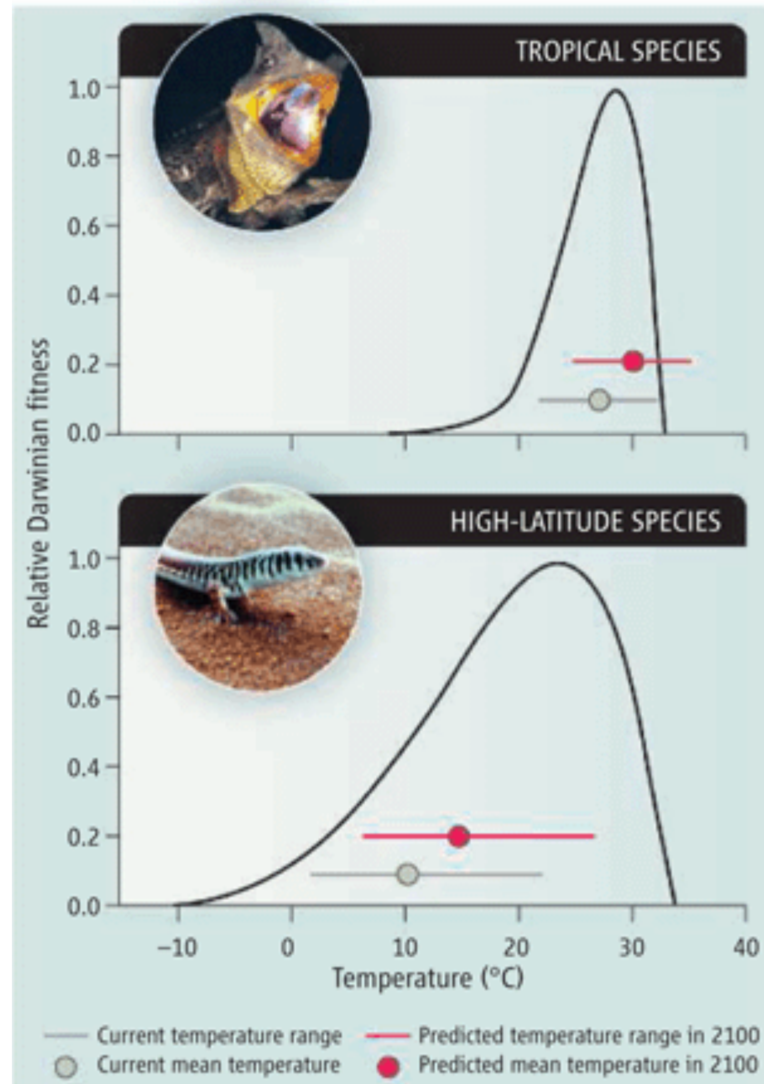
Helmer et al. 2019, *PLOS ONE*

Climate change will affect regions and species differently:

Are tropical species more sensitive to thermal changes?

Evidence for different ectothermic species say 'YES'

We'll explore this later in the term and gather evidence for other taxa



Tewksbury et al. 2008, *Science*