

Habitats & organisms patchy at all scales

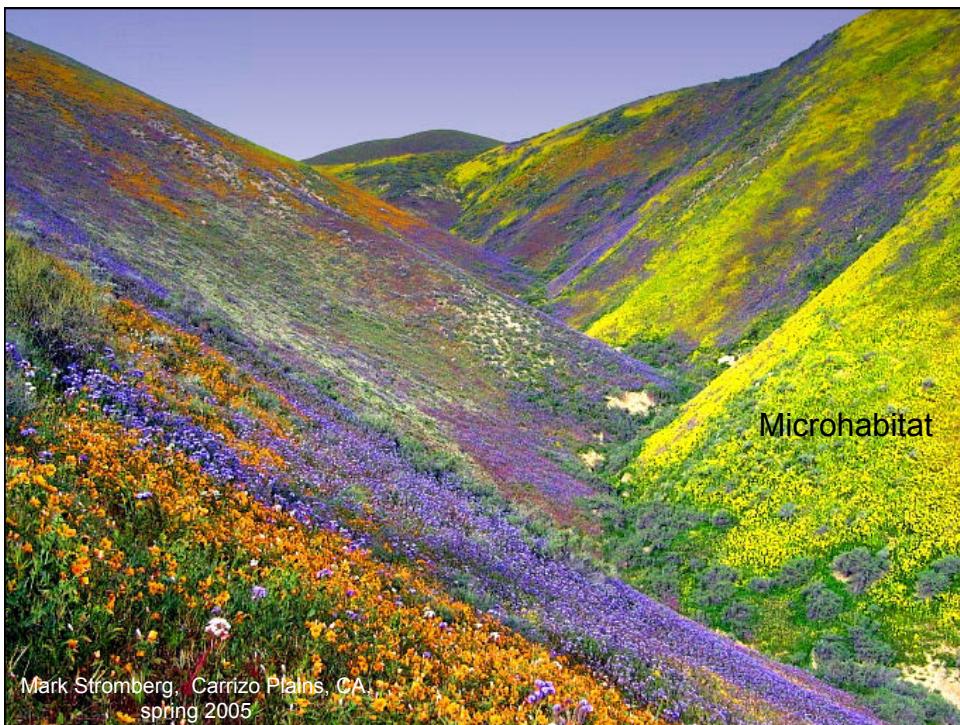
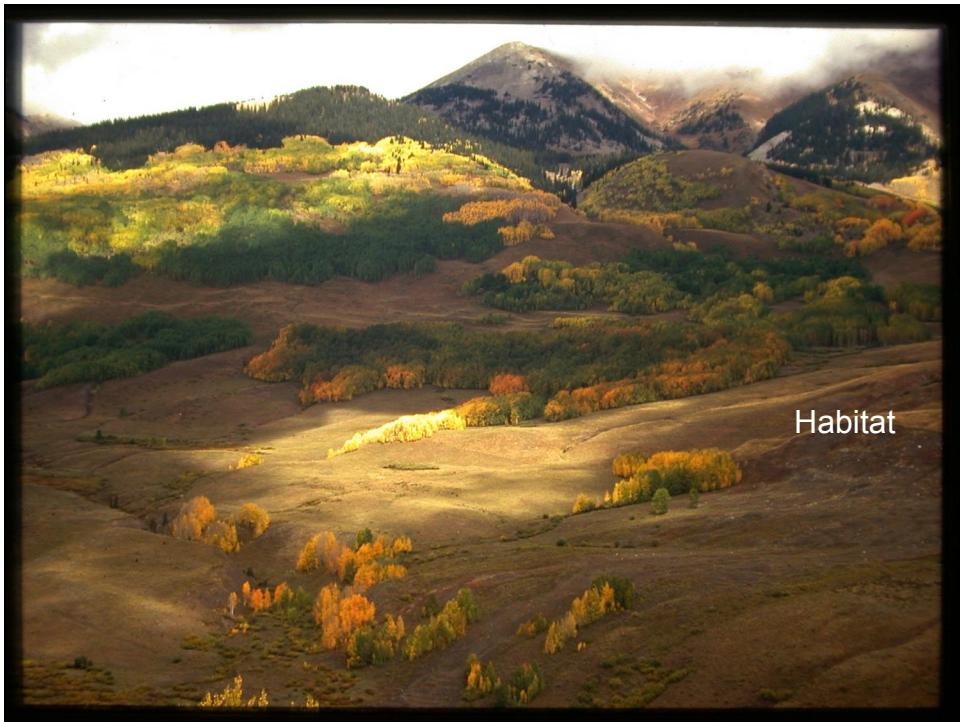


NASA

Forest-grassland interface, eastern Washington state



NASA





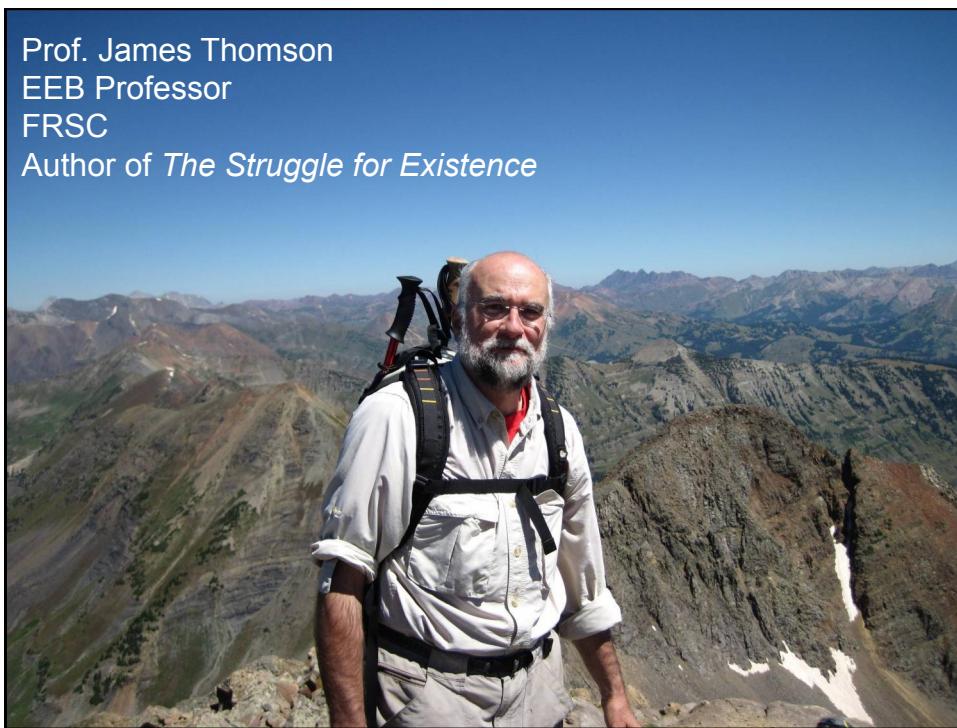
## Lecture 13 and 14: Species ranges and limiting factors; climate

How do abiotic factors affect species distribution?

1. Distribution and abundance: why are organisms found where they are?
2. Abiotic gradients and ranges of tolerance
3. Coarse global patterns of temperature and precipitation: latitudinal patterns (*climate*)
4. Biomes

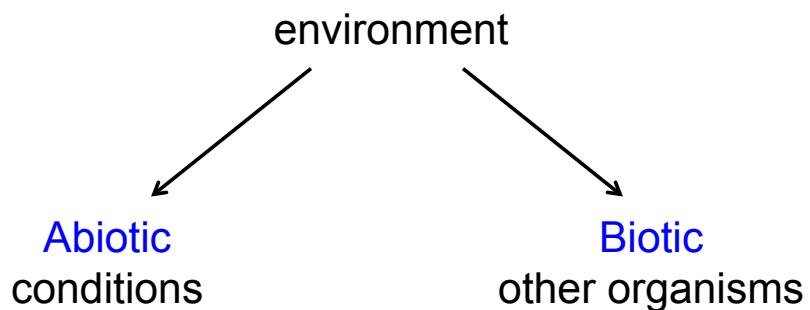
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Prof. James Thomson  
EEB Professor  
FRSC  
Author of *The Struggle for Existence*



## *Ecology*

how the **environment** affects the abundance  
and distribution of an organism

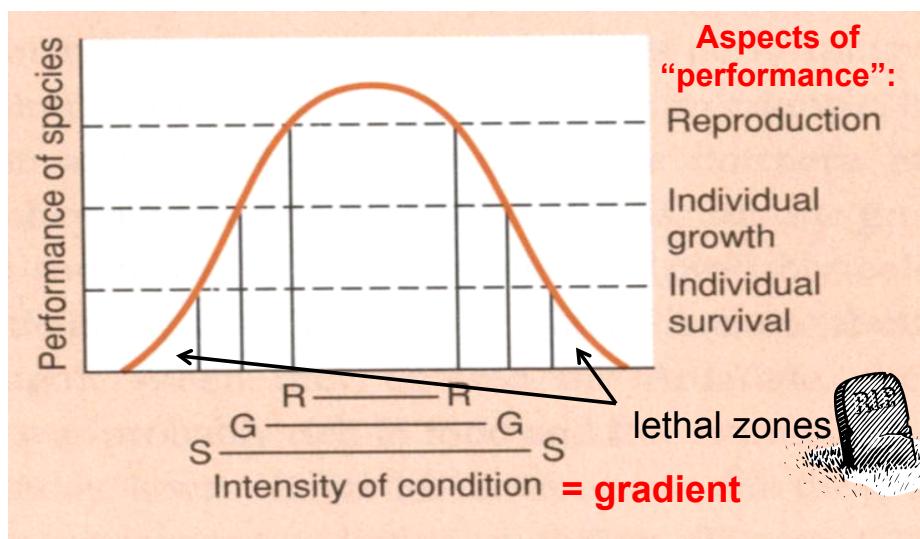


## Abiotic (physical/chemical) factors: resources & conditions

- **Resources** are exhaustible: nutrients, space, etc.
- **Conditions** are not exhaustible: temperature, *pH*, salinity, etc.
- Conditions vary across space and time; we envision **gradients** of conditions
- Organisms perform best at certain levels, *i.e.*, at certain portions of a gradient

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## Species have ranges of tolerance along environmental gradients



## **What factors are most important?**

(Generalizations of breathtaking audacity!)

- For terrestrial plants:

Temperature

Soil moisture

Nutrients (**N** most important, then **P, K**)

Disturbance (esp. fire)

Interactions: herbivory, disease, pollinators,  
seed dispersers, mycorrhizal fungi

- For aquatic plants:

Add salinity, remove moisture & fire, **P** key

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## **What factors are most important?**

(Generalizations of breathtaking audacity)

- For terrestrial animals:

Food and water

Temperature

Habitat quality (cover, nesting sites)

Interactions: predation, disease

- For aquatic animals:

Add salinity/osmotic pressure

- So, **animals will tend to follow plants**

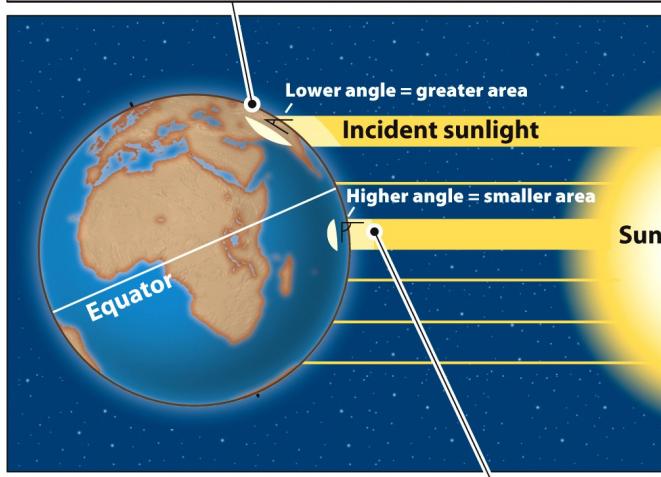
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## Gradients at the global level: temperature, rainfall, seasonality

- Temperature mostly a function of **latitude**
- Higher latitudes colder; seasonality a function of **temperature** (summer-winter)
- Lower latitudes warmer; seasonality a function of **rainfall** (dry season-wet season)
- Rainfall mostly depends on **atmospheric circulation**, offshore ocean currents, rain shadows
- These factors determine **biomes**

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At higher latitudes, light strikes the earth's surface at a lower angle, and is spread over a greater area.

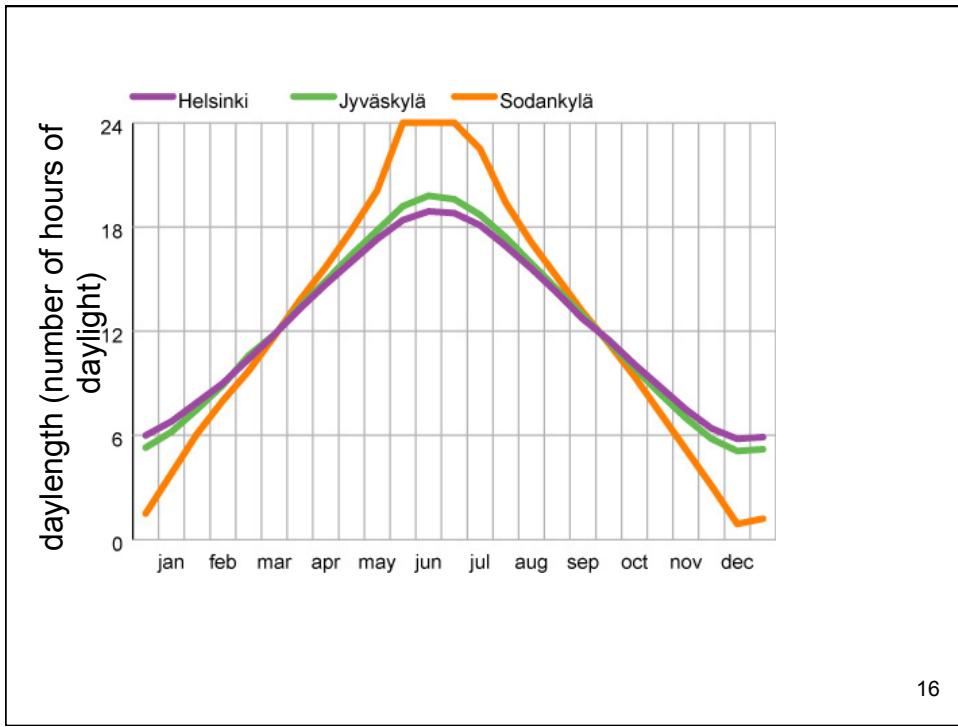
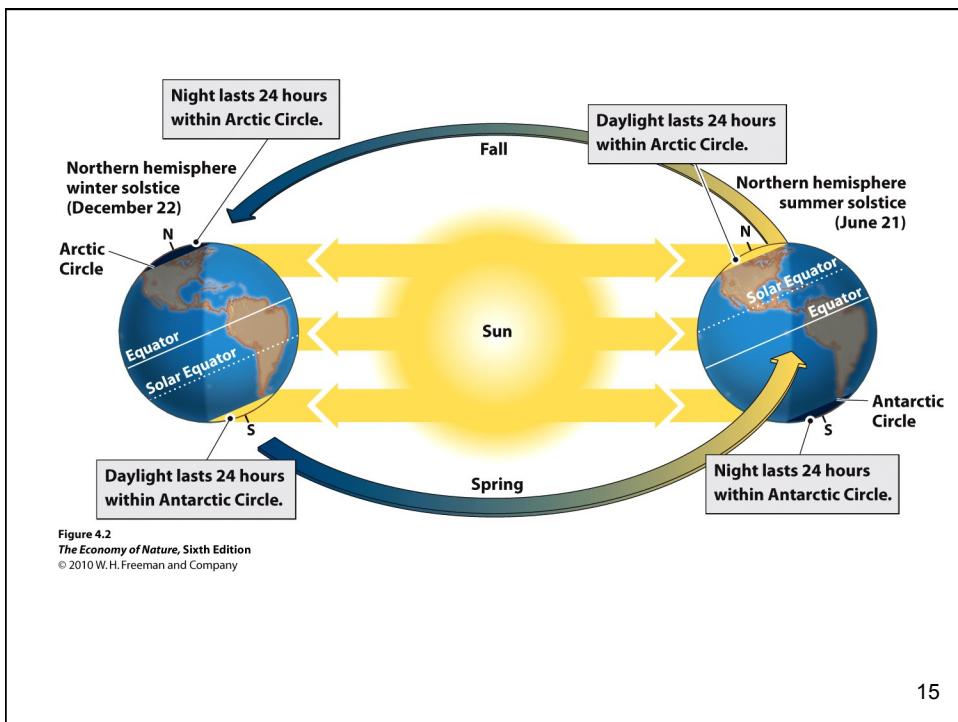


Differential heating drives the Earth's atmospheric heat engine.

At the equator, the sun is closer to the perpendicular and shines directly down on the earth's surface.

Figure 4.1  
*The Economy of Nature*, Sixth Edition  
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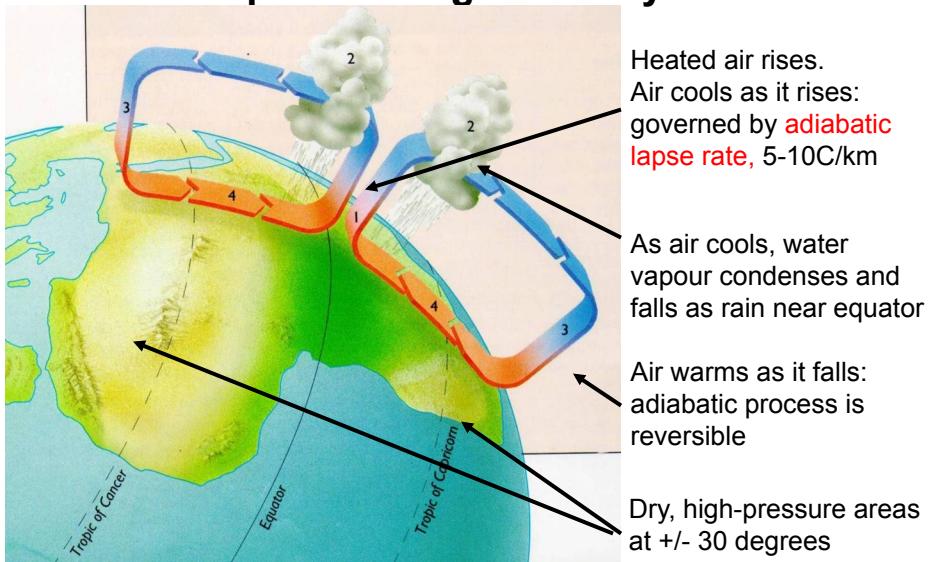


	Air temperature	
	Hot	Cold
Density	Less	More
Moisture	More	Less
Movement	Rises	Sinks

as air rises in the atmosphere it gets less dense and it gets colder, releasing water (precipitation)

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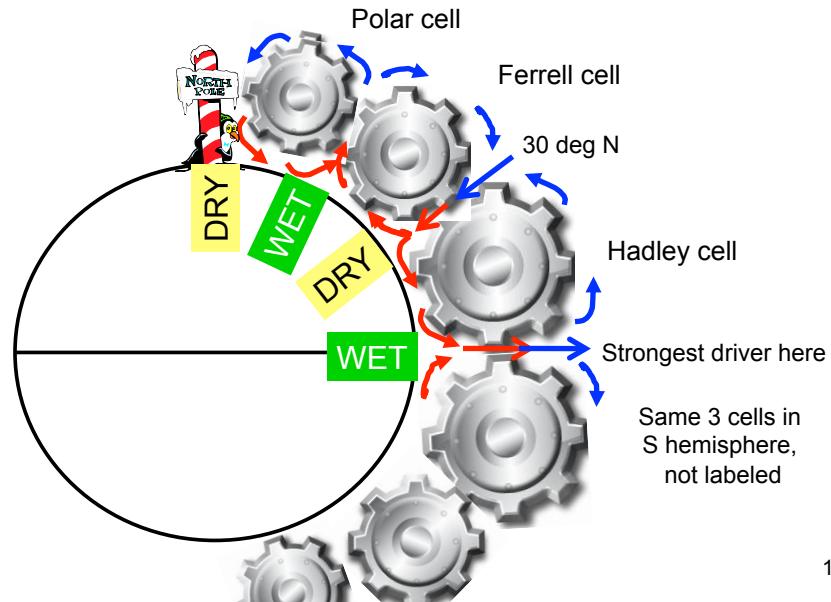
### Atmospheric circulation: Hadley cells make equatorial regions rainy



Compare figure in textbook

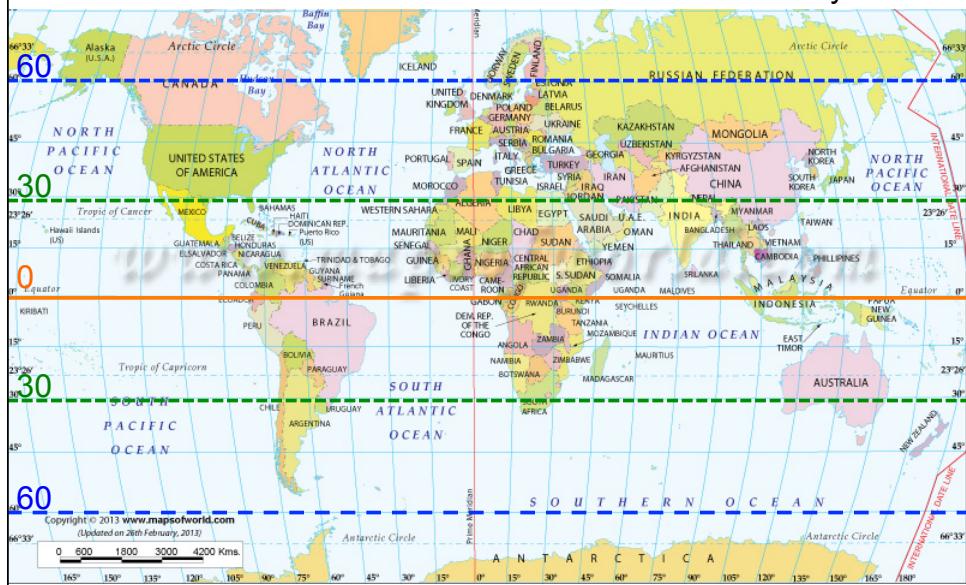
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## Other atmospheric cells interlock like a gear train



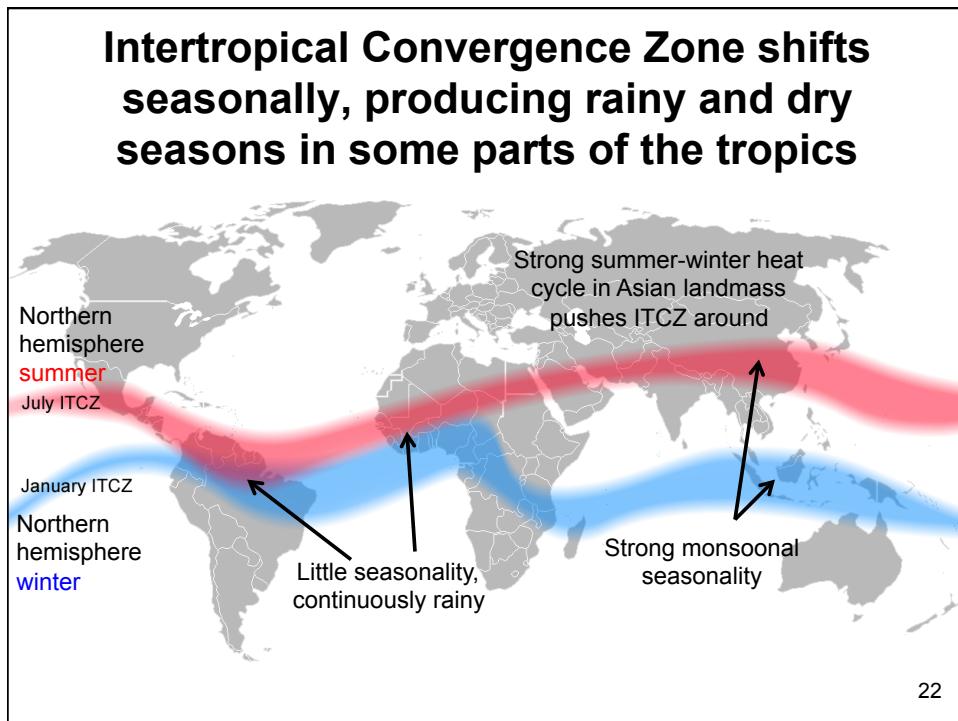
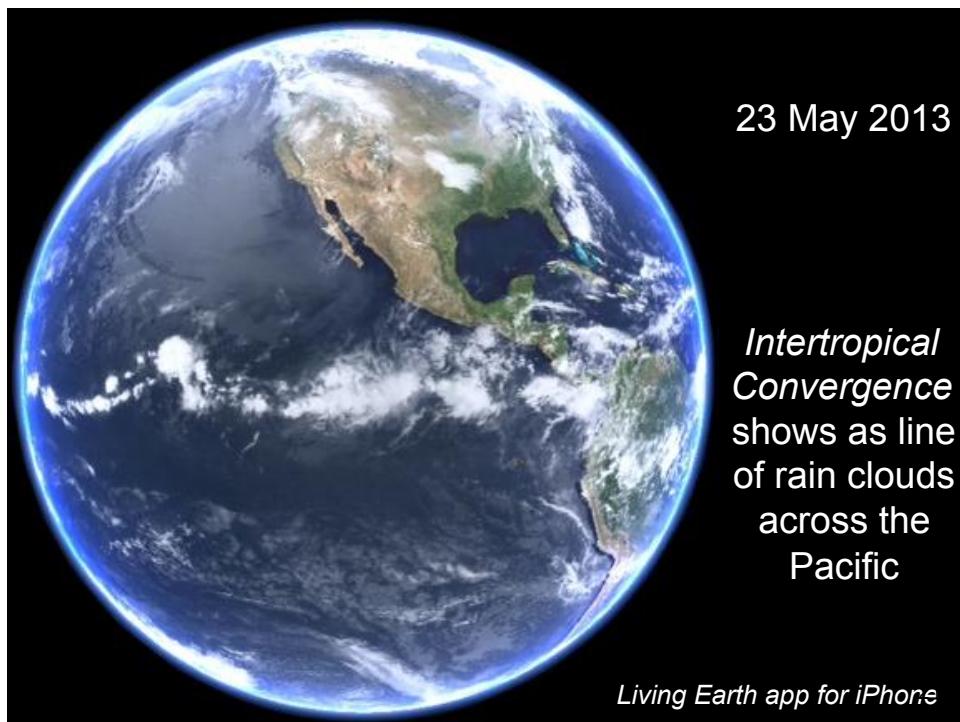
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## What areas of will be wet and what areas will be dry?

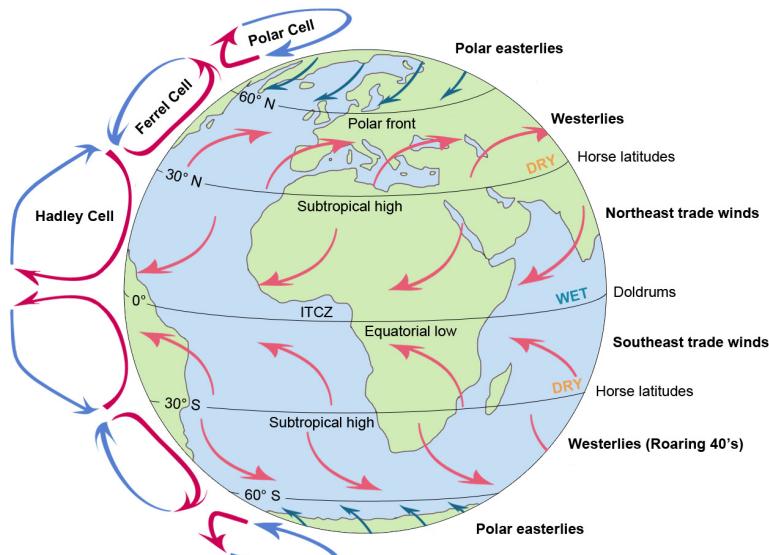


mapoftheworld.com

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## Coupled cells + Coriolis effect = prevailing wind patterns



©Hannah Fung

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## Additional climate patchiness overlaid on basic latitudinal belts

- Temperature: land changes temperature more readily than water; **maritime** climates are moderate, **continental** climates are extreme; oceans provide thermal inertia
- Precipitation: where does atmosphere get laden with moisture; where does it condense?
  - Evaporation high from warm bodies of water, low from cold
  - Prevailing winds
  - Orogenic precipitation:** air forced up mountainsides undergoes cooling, precipitates on upper windward slopes
  - Rain shadows** created on leeward slopes of mountain ranges
  - Seasonality of moisture also important (e.g., ICTZ)

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Latitudinal patterns complicated by distribution of landmasses

**Temperatures vary more in the Northern Hemisphere where the moderating influence of water is less.**

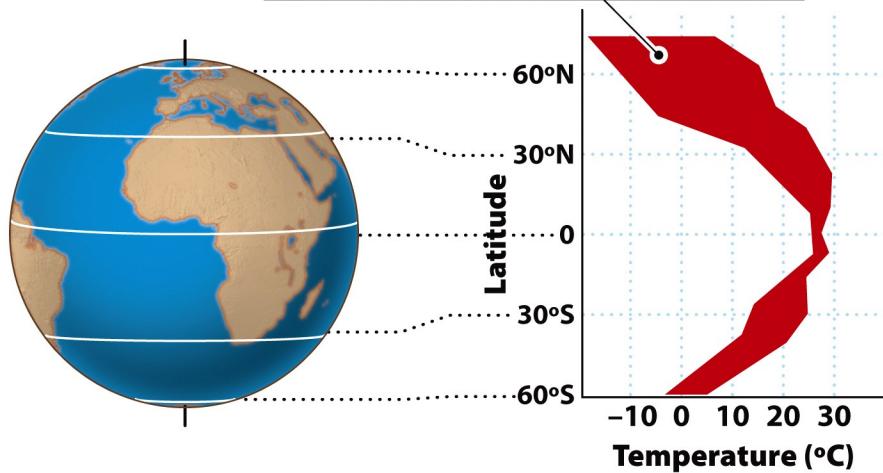
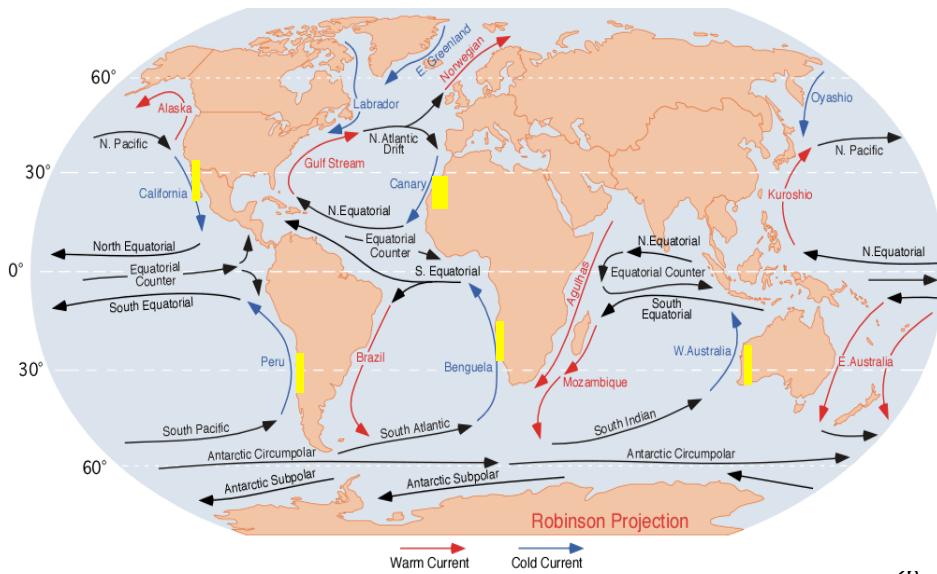


Figure 4.3  
*The Economy of Nature*, Sixth Edition  
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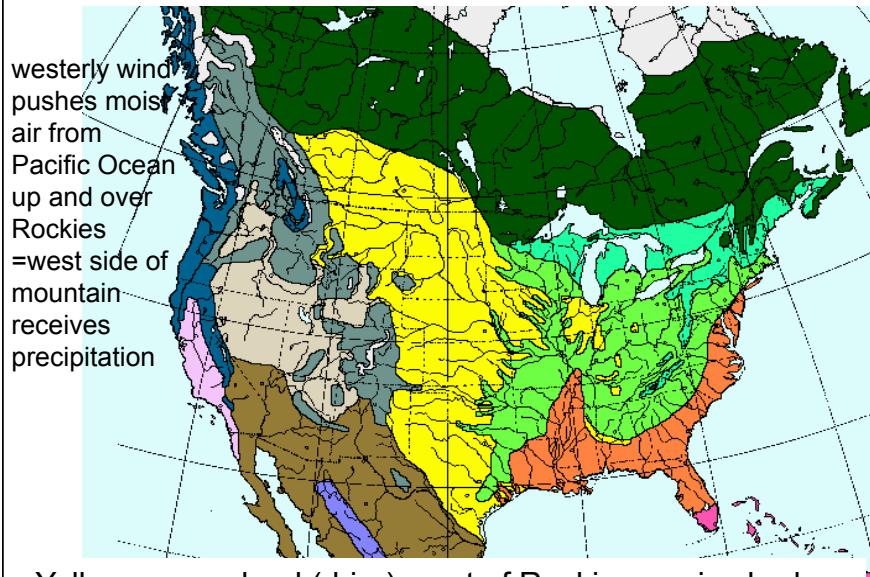
Width of red ribbon shows annual variation in temp.

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**The driest deserts occur inland of cold-water upwellings: cold water => dry air**



### Orogenic (mountain-generated) precipitation



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### Gradients on the global level

- What determines temperature?
- What determines daylength and seasonality?
- What determines precipitation?

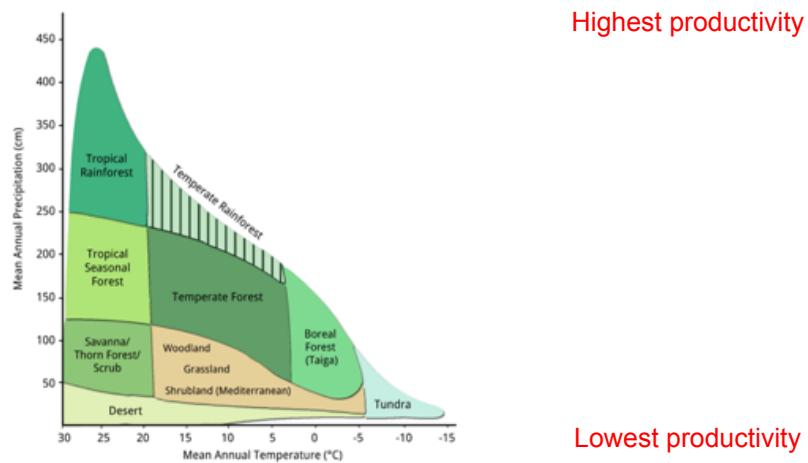
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## General trends of terrestrial vegetation with climatic variables

- Vegetation growth (primary productivity) increases with **moisture** and **temperature**
- Vegetation stature also increases...
- ...so regions with certain combinations of moisture and temperature develop predictable, characteristic types of vegetation = **biomes**
- **Seasonality** is secondarily important

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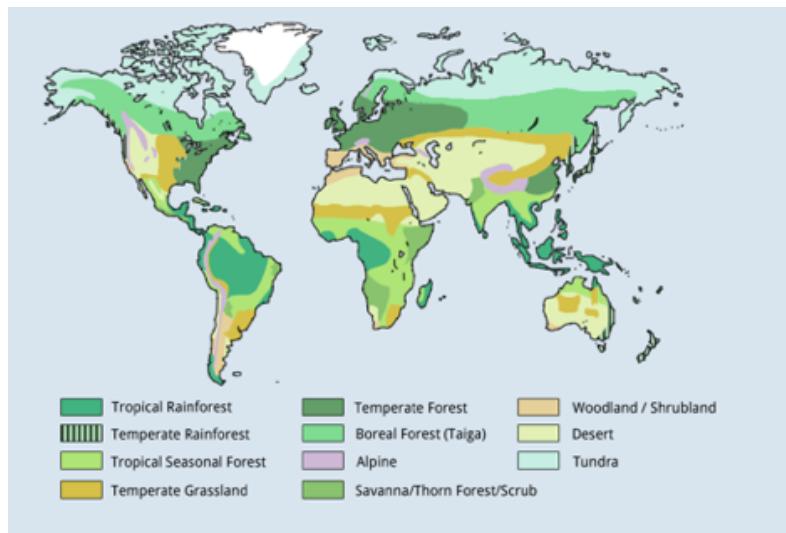
Biome types depend on combination of temperature and precipitation



From Krebs after R.H. Whittaker

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Latitude **mostly** determines major terrestrial biomes; learn classification in SFE

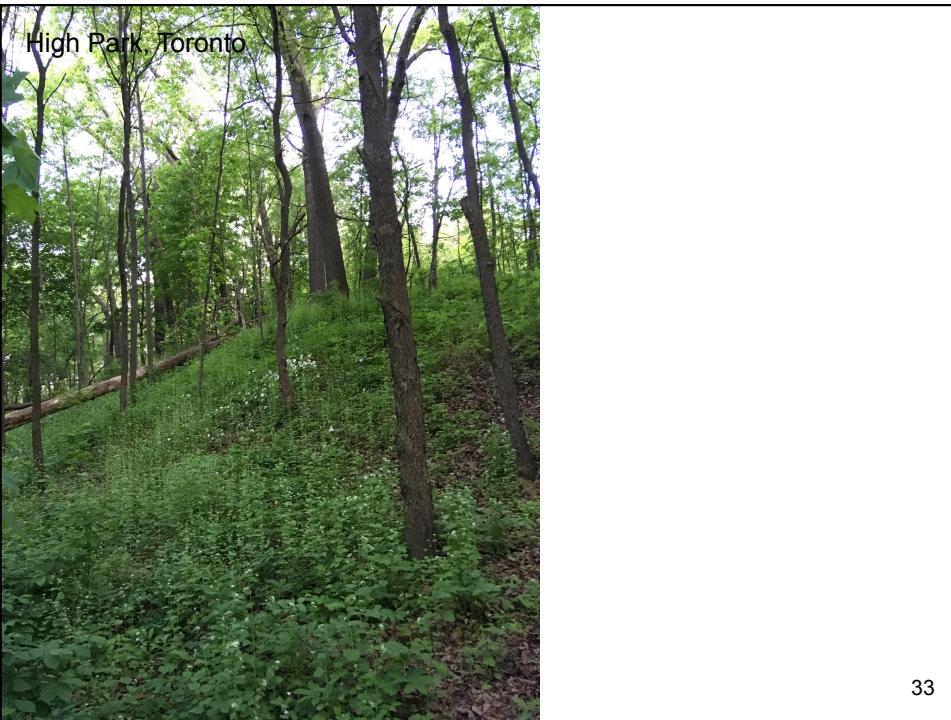


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### Temperate (deciduous) forest

- warm summers and cold winters; long growing season
- ample precipitation all year-round
- dominated by many species of deciduous trees, with understory of shrubs and spring ephemerals
- high animal diversity: many herbivorous insects, small vertebrate carnivores, large mammals

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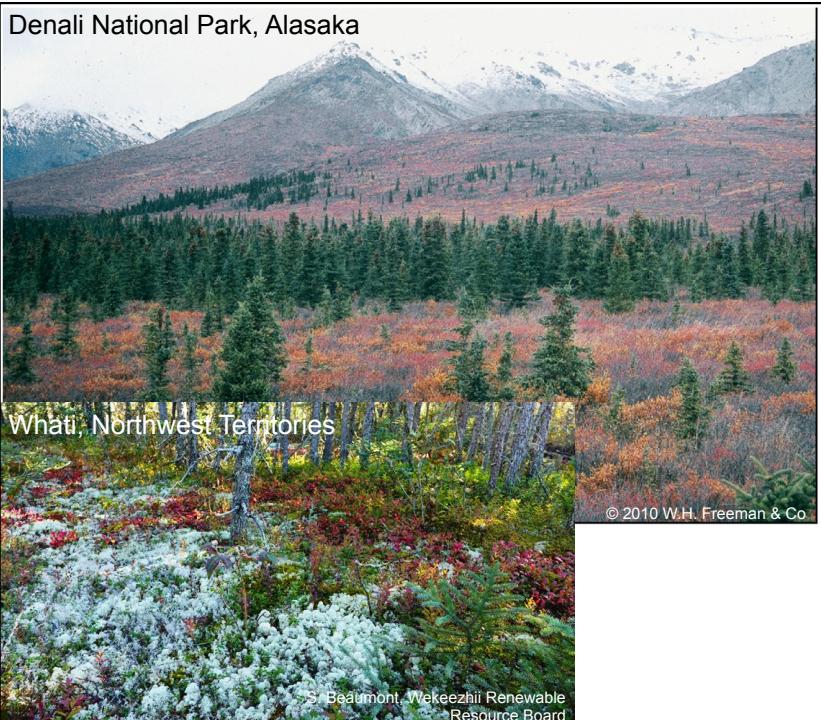


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### Boreal forest (taiga)

- very cold winters and short summers; shorter growing season
- lower precipitation
- dominated by few species of coniferous evergreen trees, with some aspen, shrubs, and “Canada carpet”
- lower animal diversity: herbivorous insects, birds, mammals

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## Tundra

- Very cold – permafrost
- Short summer with very long daylength; shortest growing season
- Very little precipitation
- Short trees, low-growing plants
- Grazing vertebrates, pika, insects, geese

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Churchill, Manitoba



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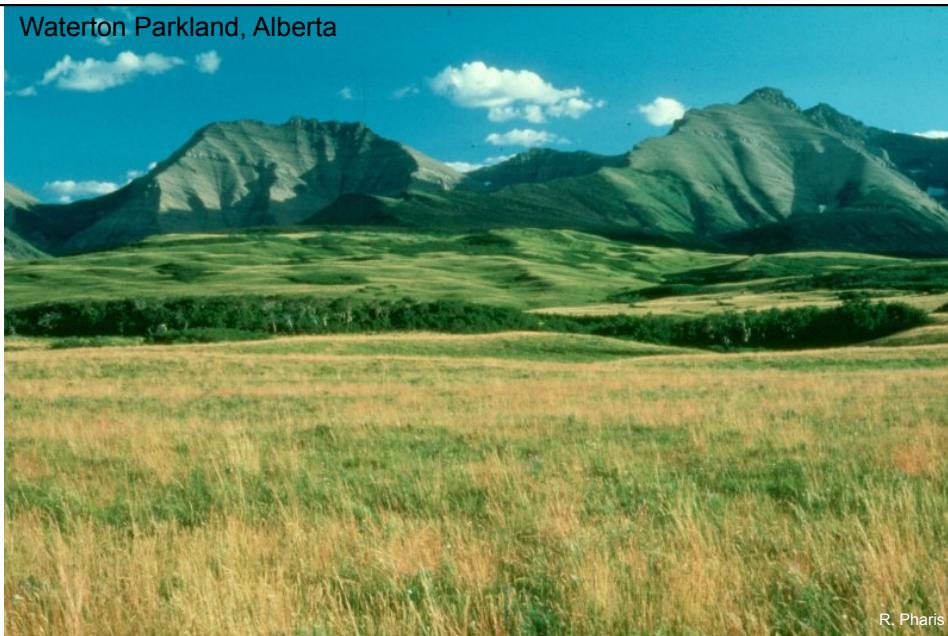
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## Grasslands

- cold winters and hot summers
- low, infrequent rainfall
- grasses, forbs,
- grazing mammals

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Waterton Parkland, Alberta



R. Pharis

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Sonoran Desert, near Maricopa, Arizona



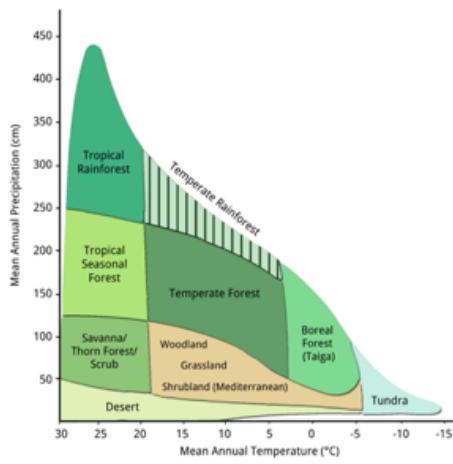
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Wikimedia Commons



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What causes this difference in precipitation between Tropical Rainforests and Deserts?



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## Biomes

- What is the temperature?
- How much precipitation does it receive?
- Is there seasonality?
- What vegetation grows in this biome?
- What animals are found in this biome?

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## Two types of range: ranges of tolerance and geographical ranges

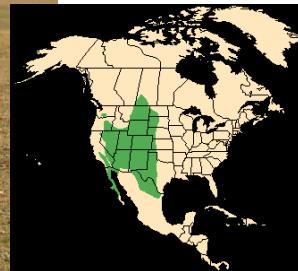
- Animals' geographical ranges often correspond to biomes, *i.e.*, limited by climate and/or vegetation...
- ...but sometimes not. Possibilities include:
  - Limited to special habitats (behavioural **habitat selection**)
  - Limited by other organisms (enemies, friends)
  - Transcend biomes (**ecological versatility**, super generalists)

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Limited by habitat: Pronghorn (*Antilocapra americana*):  
**broad climate tolerance, narrow habitat range** (short-grass prairie biome, American High Plains)



South Park, Colorado April 2012



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### Behavioural choices in habitat selection



WClarke/Wikimedia Commons



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Elf Owl (*Micrathene whitneyi*) nest  
in abandoned woodpecker holes in  
saguaro cacti

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Transcending  
biomes: **broad**  
**temperature**  
**tolerance,**  
**broad habitat**  
**range**

Tropical  
rainforest,  
Sumatra



Tiger,  
*Panthera tigris*

Boreal forest, Siberia



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