# Geography of Communities

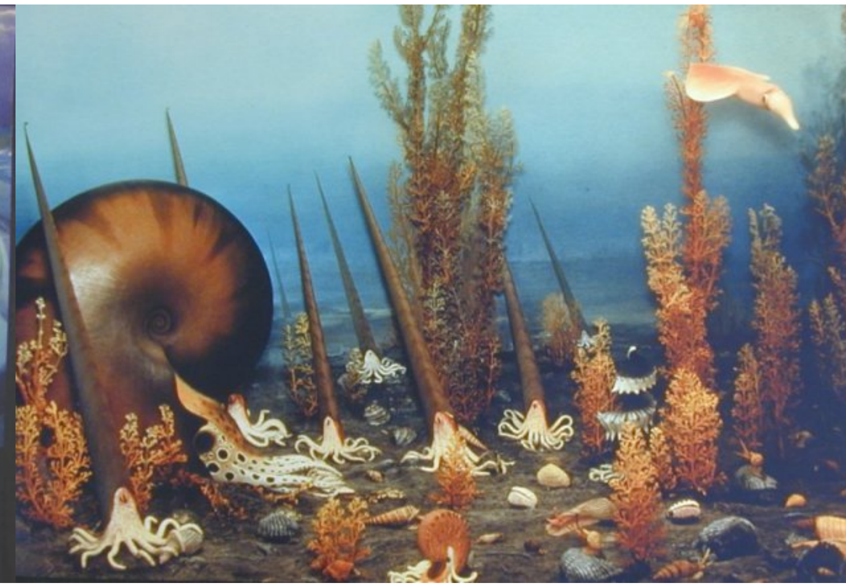



image source: www.dmr.nd.gov/ndfossil

# Geography of Communities

# Goals and learning objectives

1) Describe biogeoclimatic zones (or ecoregions) and biomes, globally and regionally

2) Explore the roles that energetics and productivity have in structuring communities

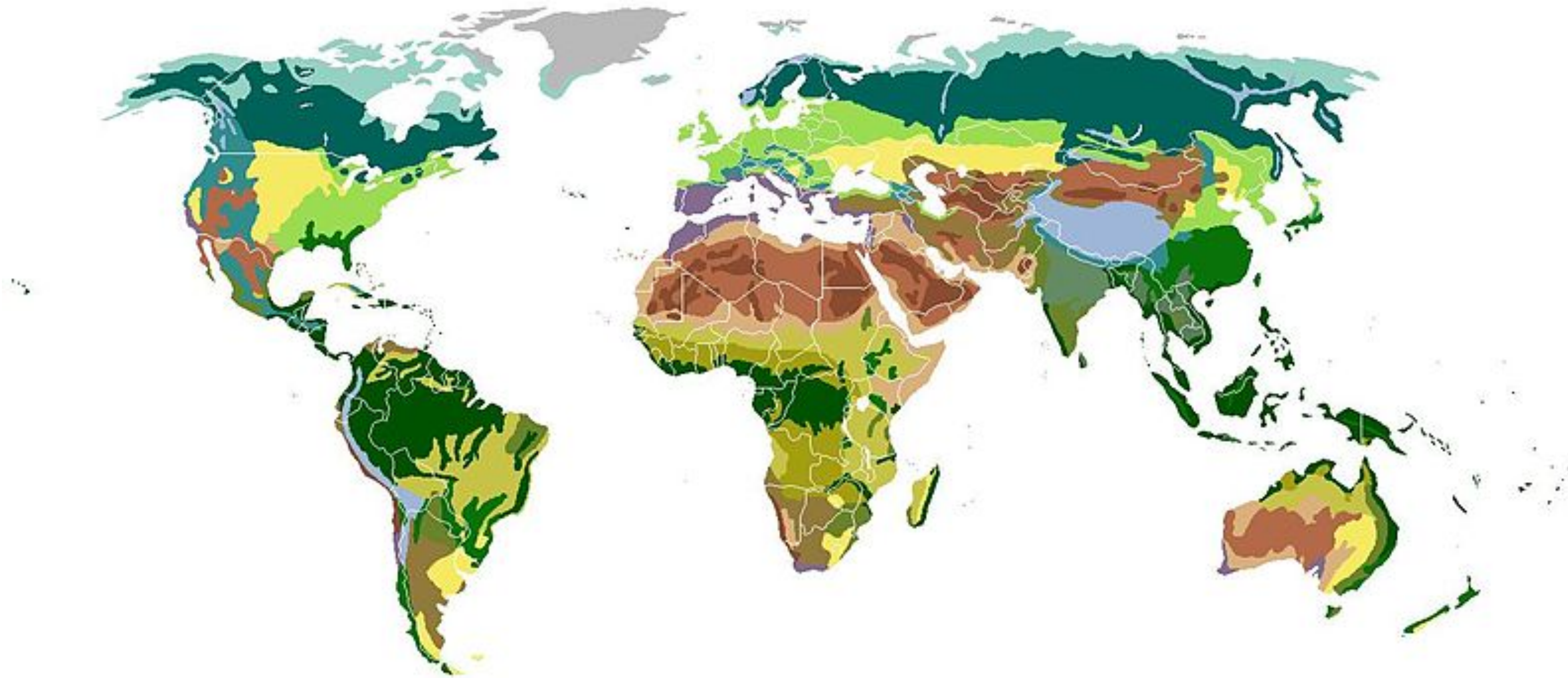
3) Understand perspectives of whether species distributions are independent or dependent on other species within communities

4) Examine how communities change over space and time

5) For Friday? - Discuss whether communities are random collections of species that are co-distributed more by historical accident than by determinism

# Biogeoclimatic Zones

**Species rarely occur alone but instead coexist with others in communities**



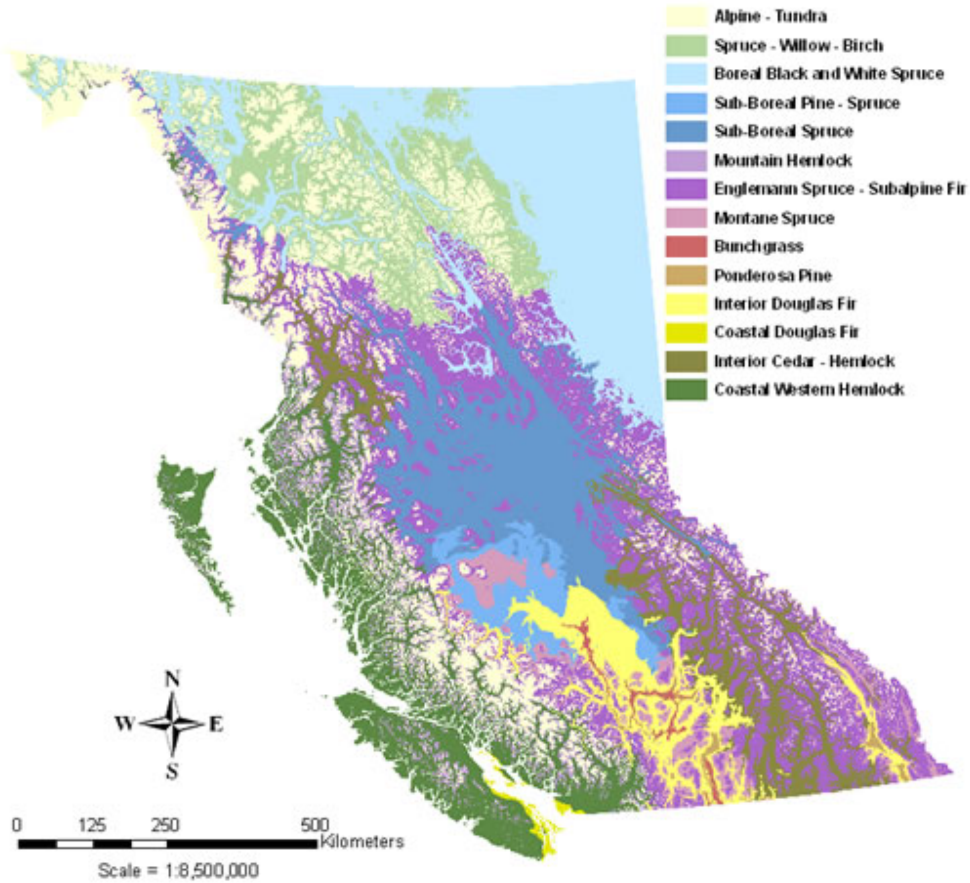
Biogeoclimatic zones of the globe – many species have shared distributions and ranges associated with major geographic habitats

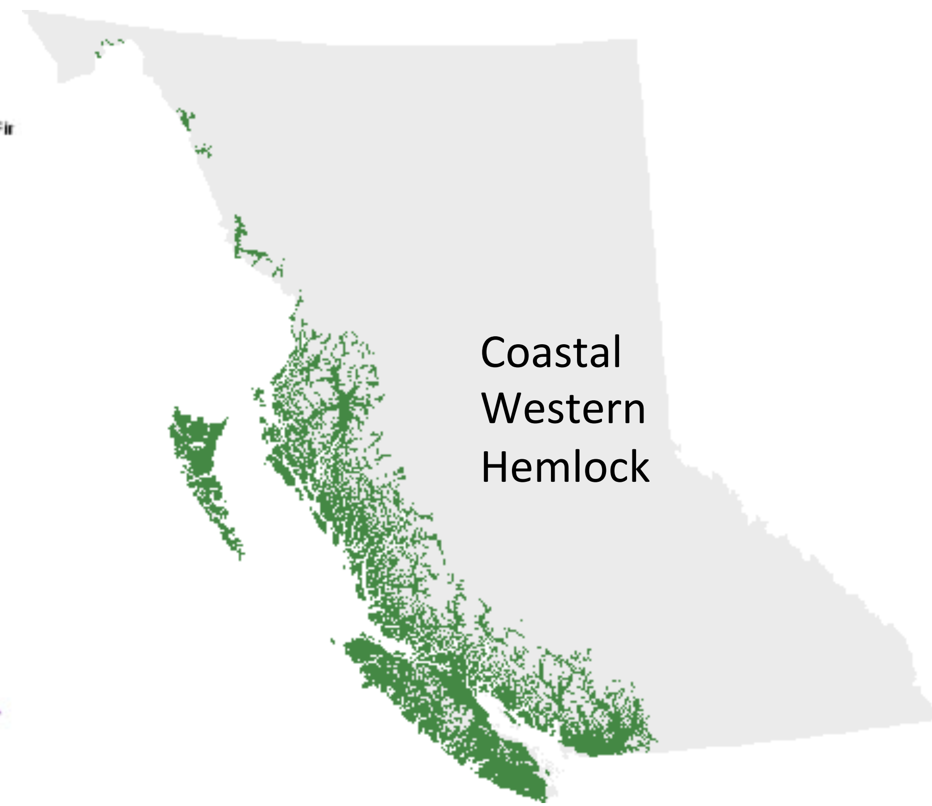
# Biogeoclimatic Zones

**Species exist in communities**

Biogeoclimatic zones of BC (British Columbia Forest Service) after dominant tree species

In some temperate zone systems, which show high dominance by few species, communities may be defined by primary species that structure those habitats



# Biogeoclimatic Zones

**Species exist in communities**

Biogeoclimatic zones, ecoregions, and biomes are defined by:

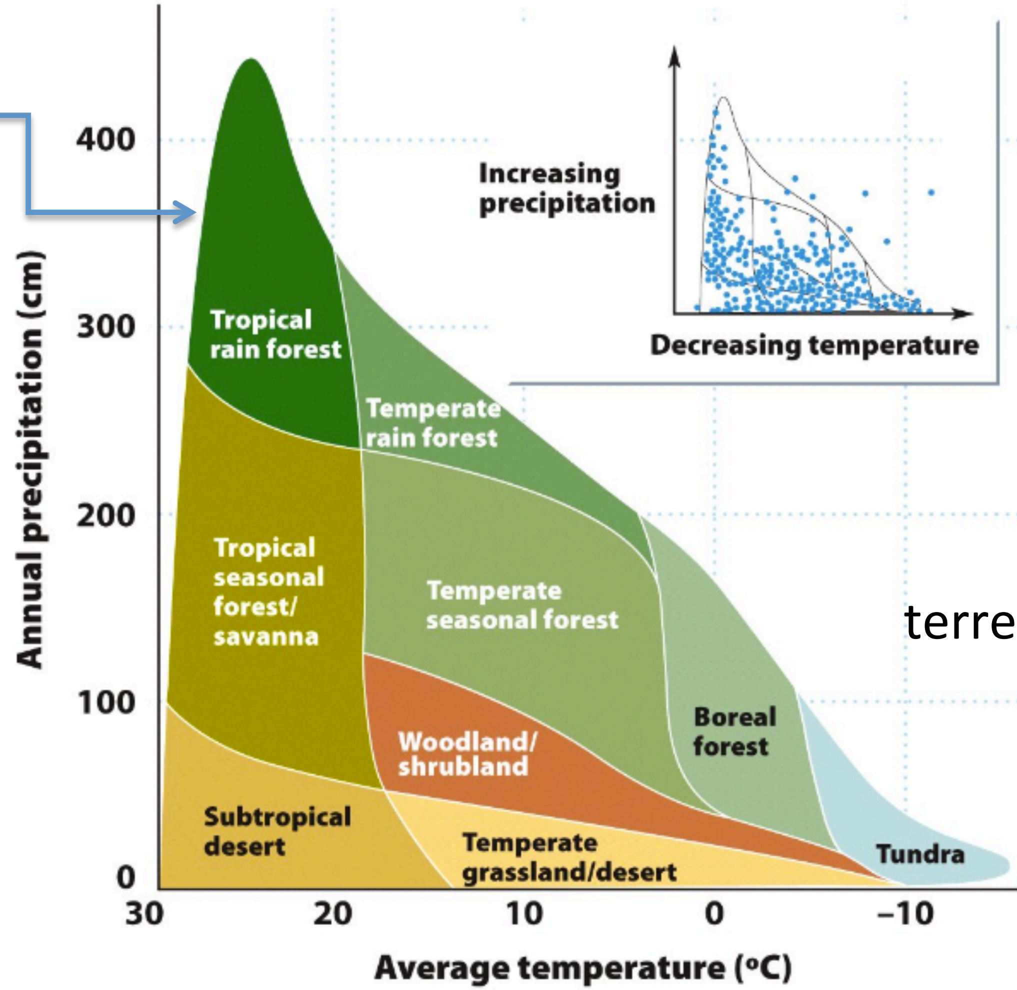
1. precipitation
2. humidity
3. temperature
4. soil characteristics
5. microbial life
6. flora
7. fauna

**Biomes:** regions defined on the basis of distinct abiotic and biotic characteristics involving climatic and soil conditions and assemblage of plant and animal species.

# Terrestrial Biomes

**Major Terrestrial Biomes:**

Our most productive terrestrial biomes are in places that are hot and wet

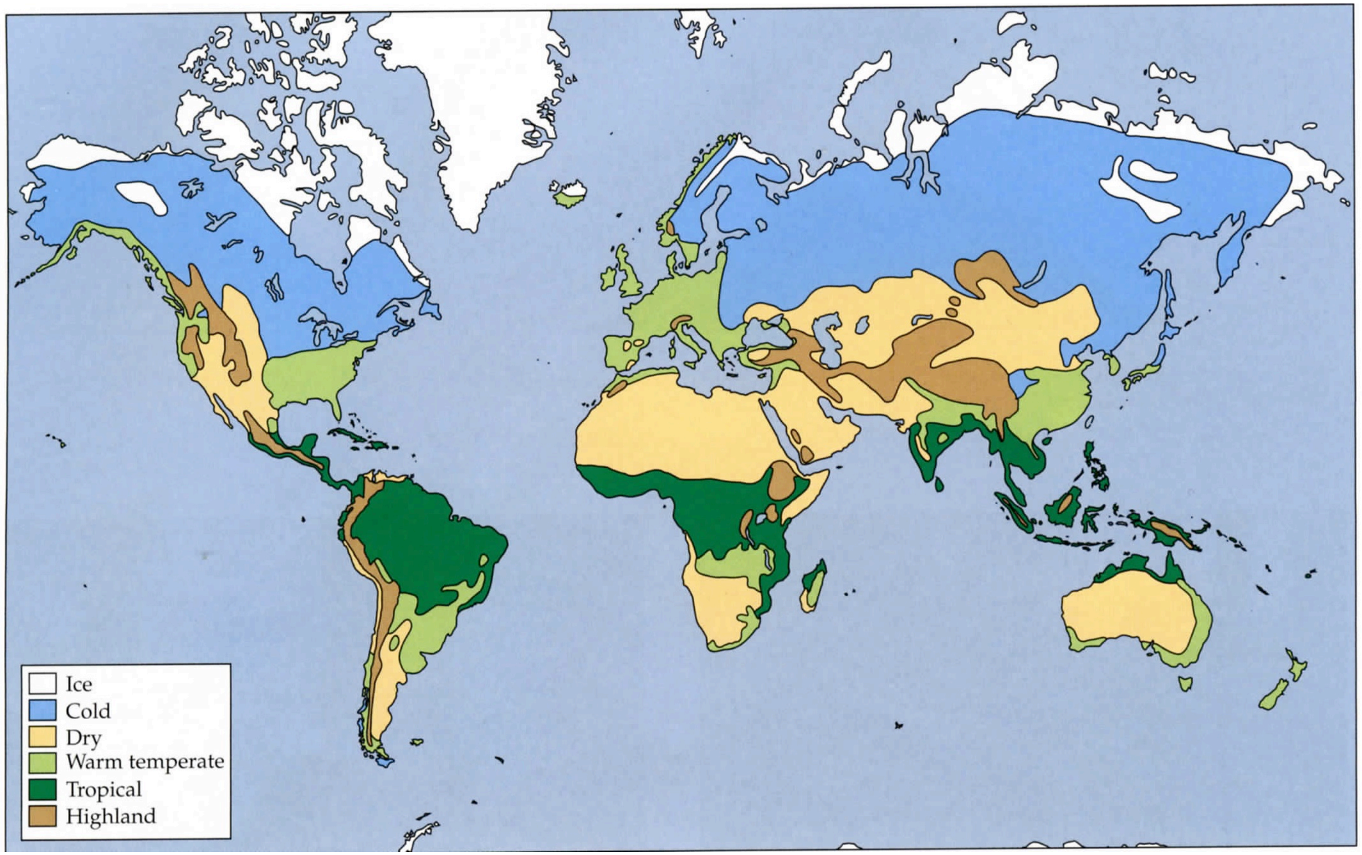



Least productive terrestrial biomes are cold and dry

Figure 5.5
*The Economy of Nature*, Sixth Edition

# Terrestrial Biomes

**Major Terrestrial Climatic Patterns:**

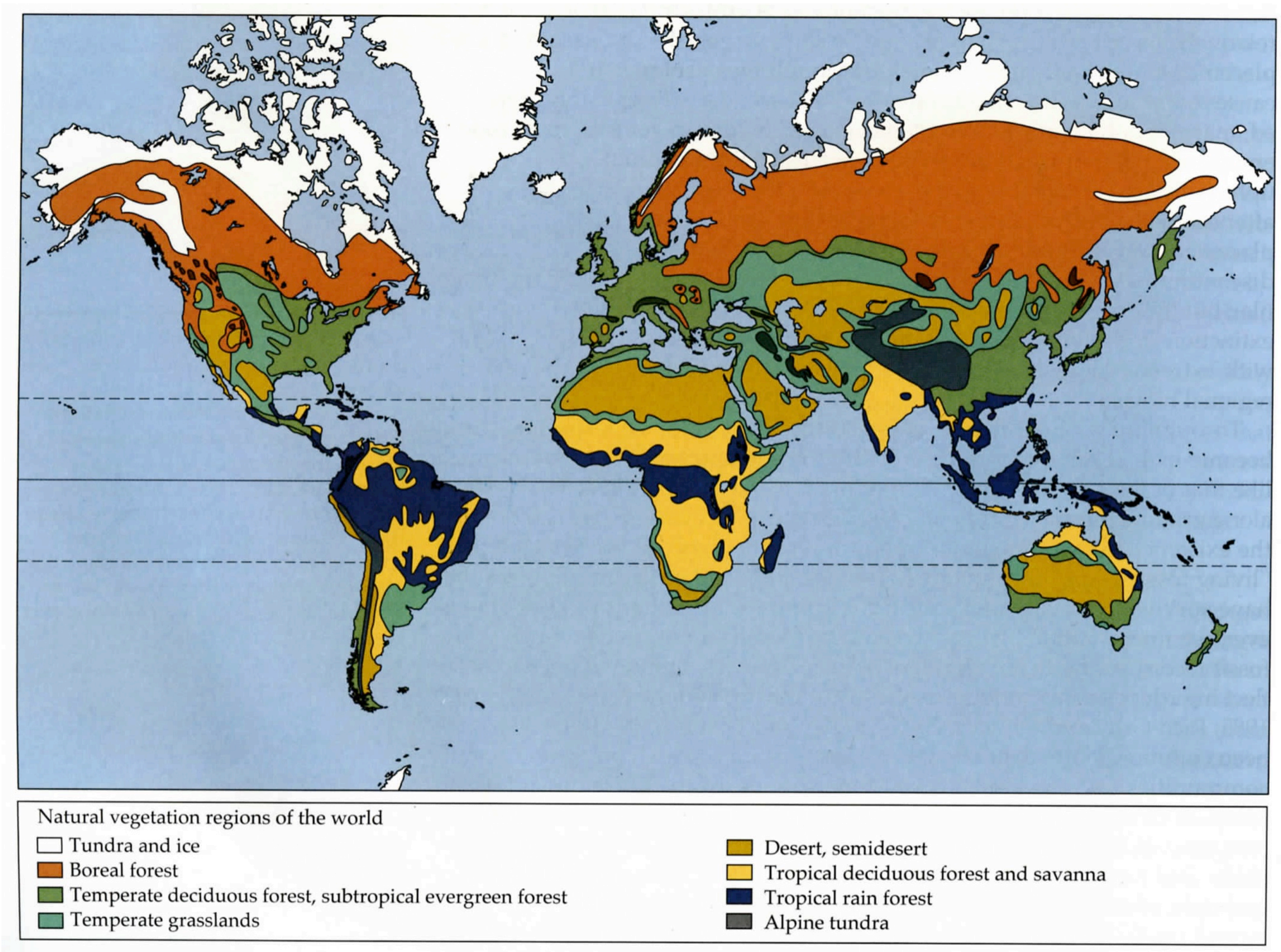



(From Lomolino *et al.* 2010)

Major terrestrial climatic patterns are strongly associated with major terrestrial biomes

# Terrestrial Biomes

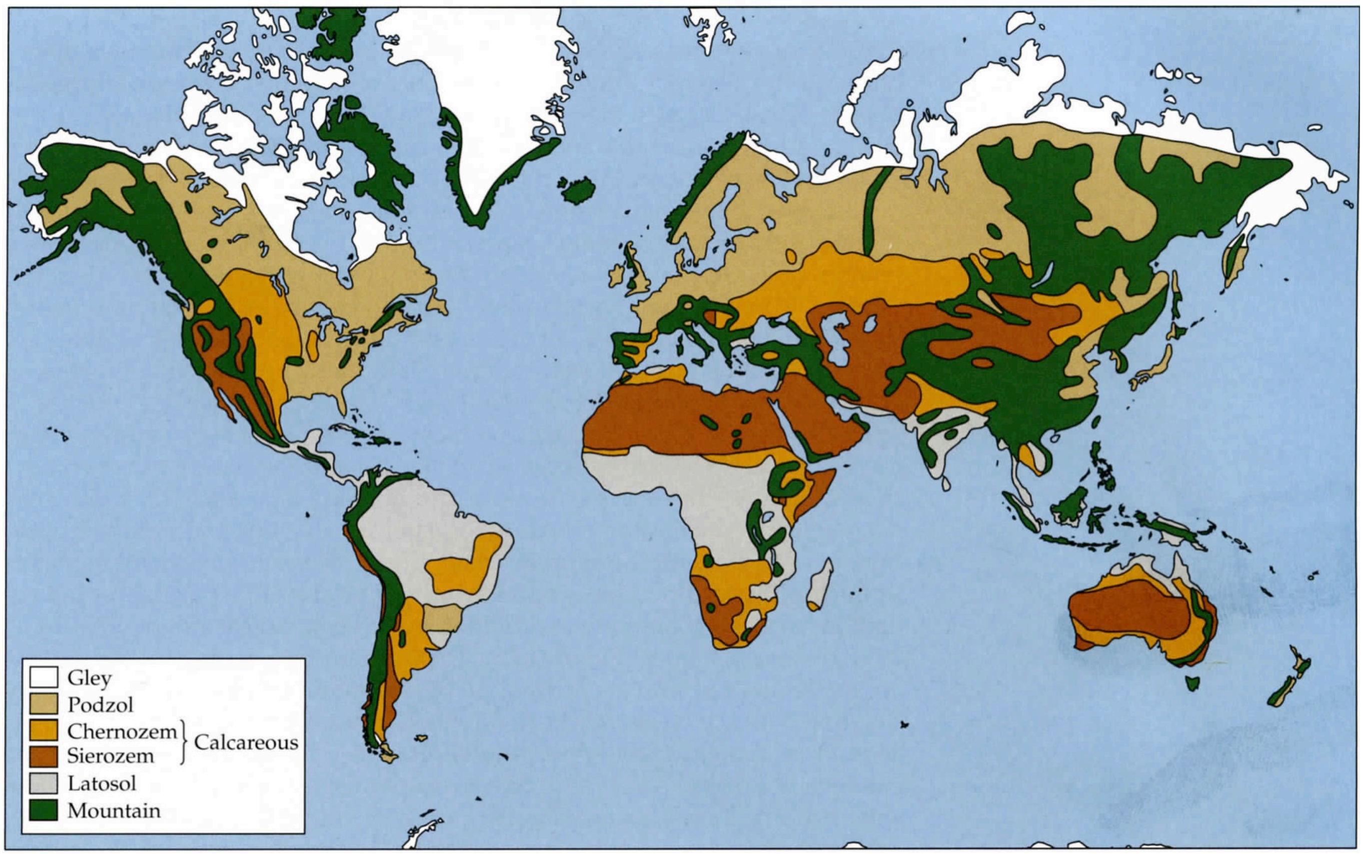
**Major Terrestrial Biomes:**




(From Lomolino *et al.* 2010)

# Terrestrial Biomes

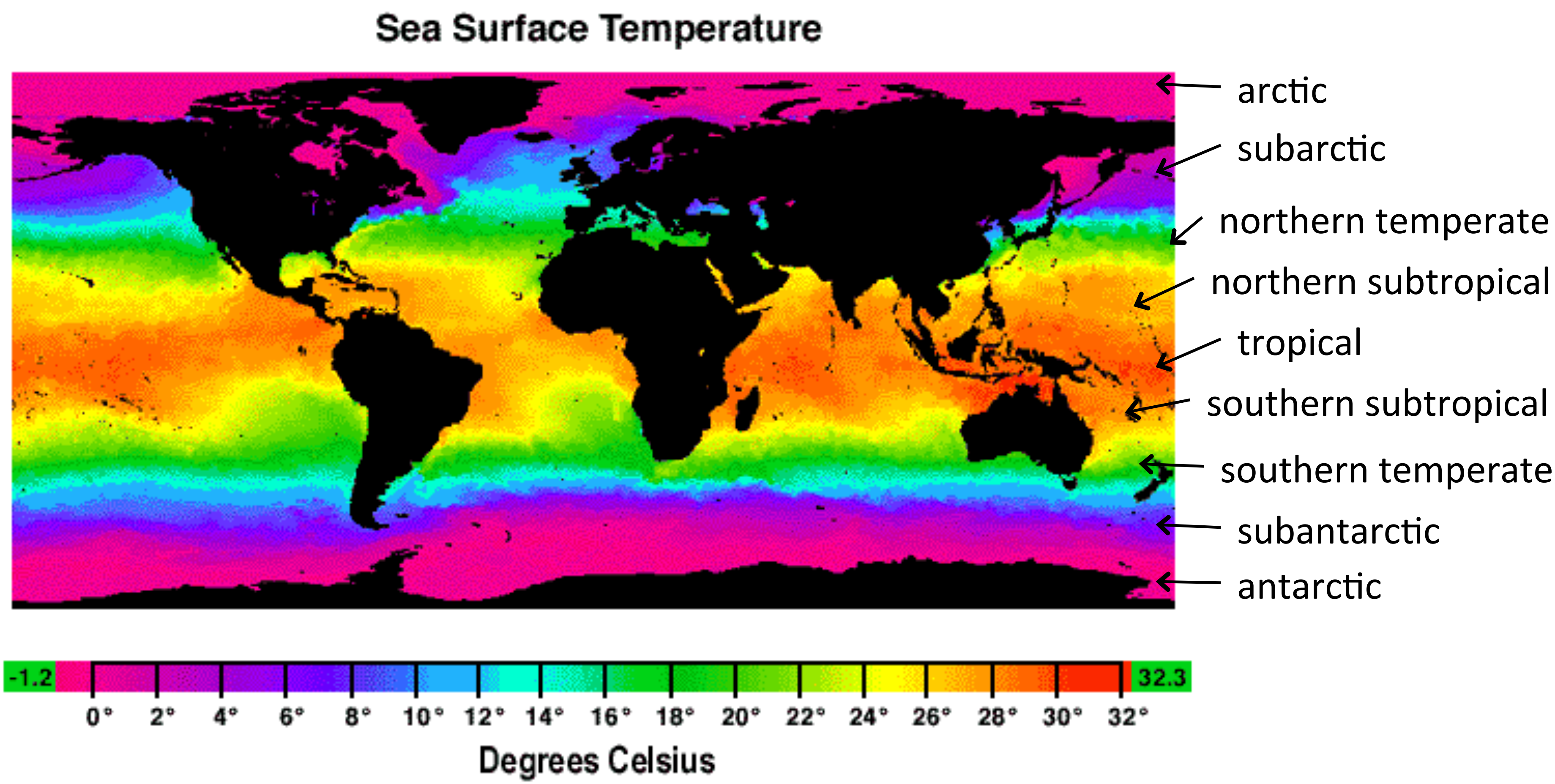
**Matching Terrestrial Patterns in Soil Type:**




(From Lomolino *et al.* 2010)

# Aquatic Biomes

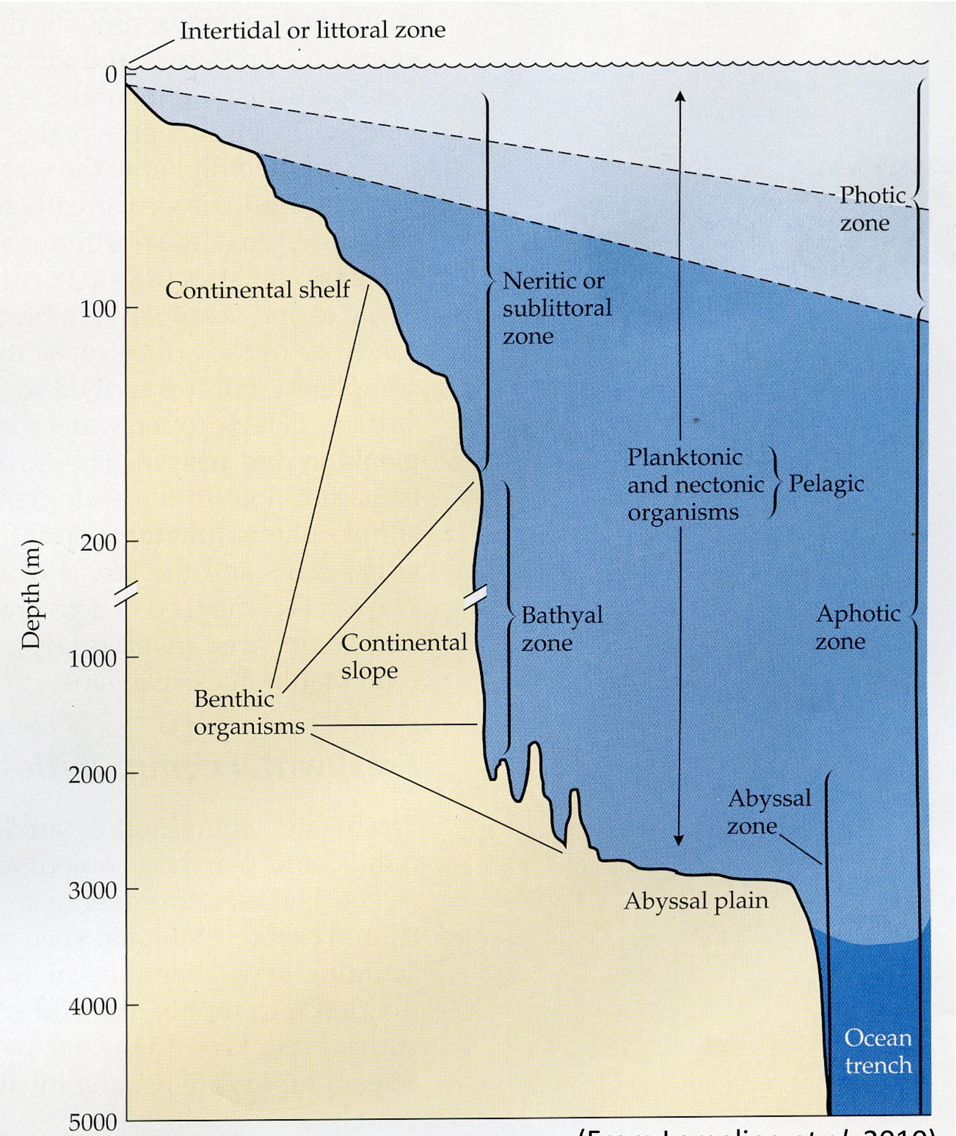
**Marine**




In marine systems, biomes are best delineated by sea surface temperature regimes, as well as light/depth and nutrient gradients

# Aquatic Biomes

**Marine**



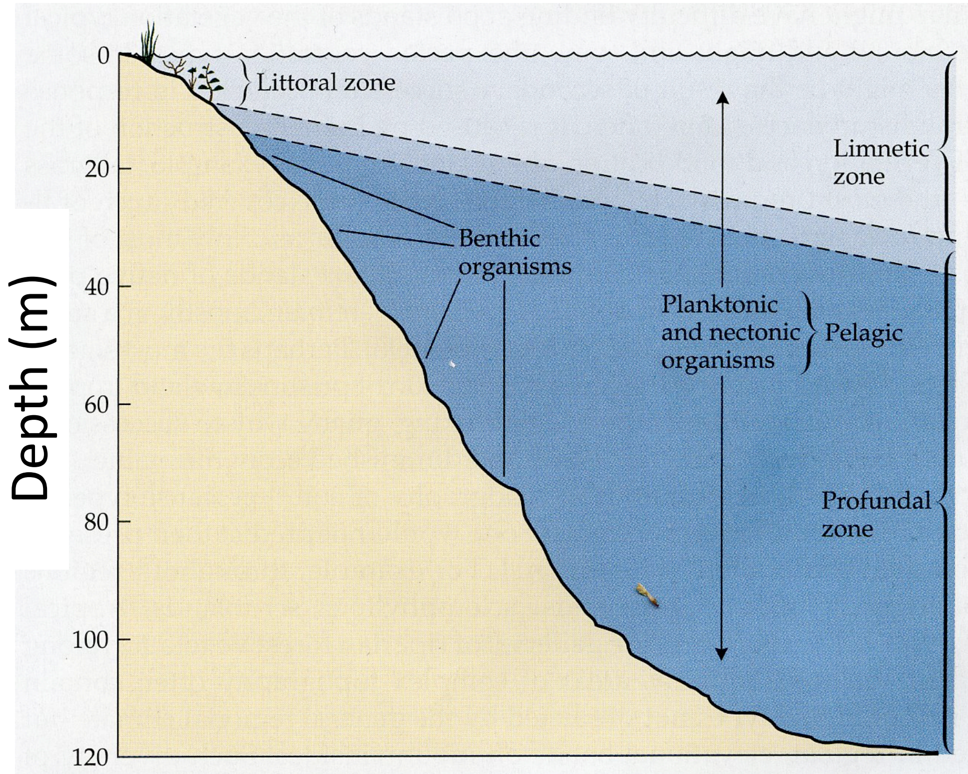

(From Lomolino *et al.* 2010)

← photic

← aphotic

# Aquatic Biomes

**Freshwater**



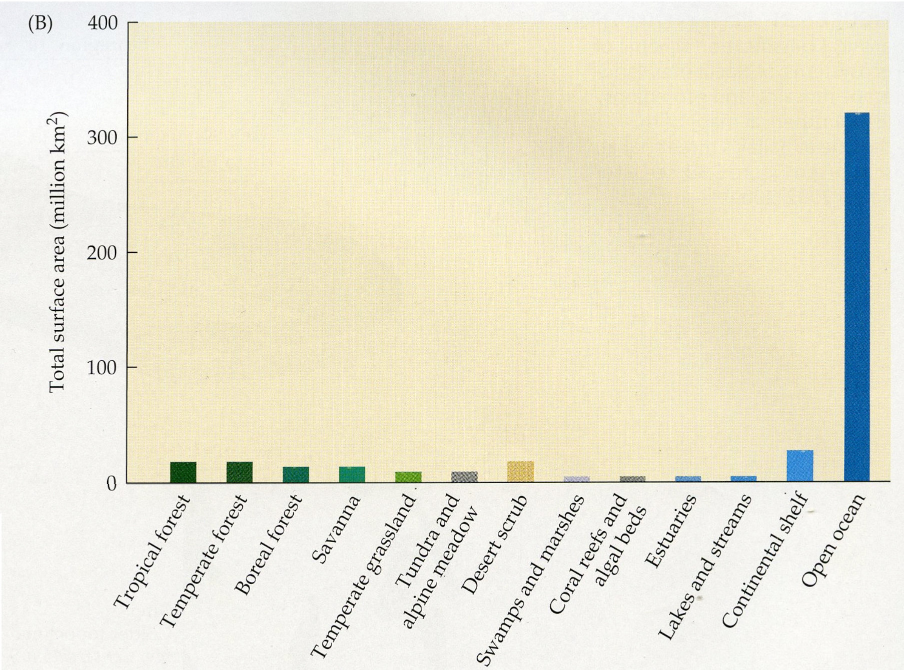

(From Lomolino *et al.* 2010)

Basic division between flowing *lotic* environments (streams, rivers) and standing water *lentic* environments (lakes, ponds, swamps)

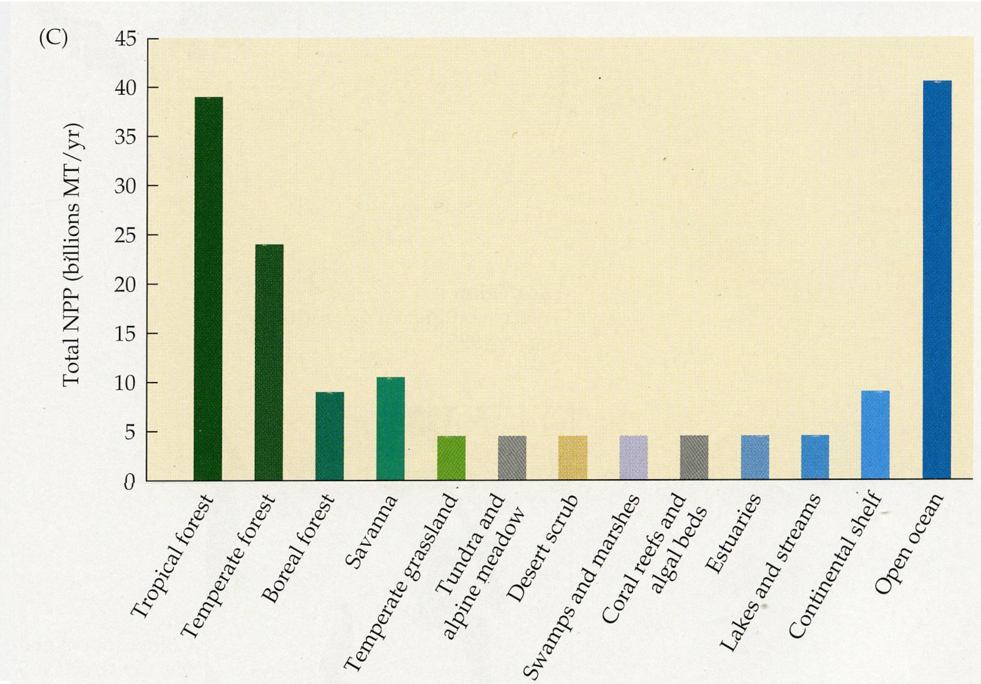
Freshwater environment is profoundly influenced by surrounding terrestrial environment (e.g., availability of nutrients from watersheds)

# Biome Comparisons

Total Surface Area




Total NPP (Net Primary Productivity)




(From Lomolino *et al.* 2010)

Only the open ocean has both high surface area and high NPP

Only tropical and temperate forest have low surface area and high NPP

# Energetics and Communities

**Community assemblage depends, in part, on energetics and productivity**

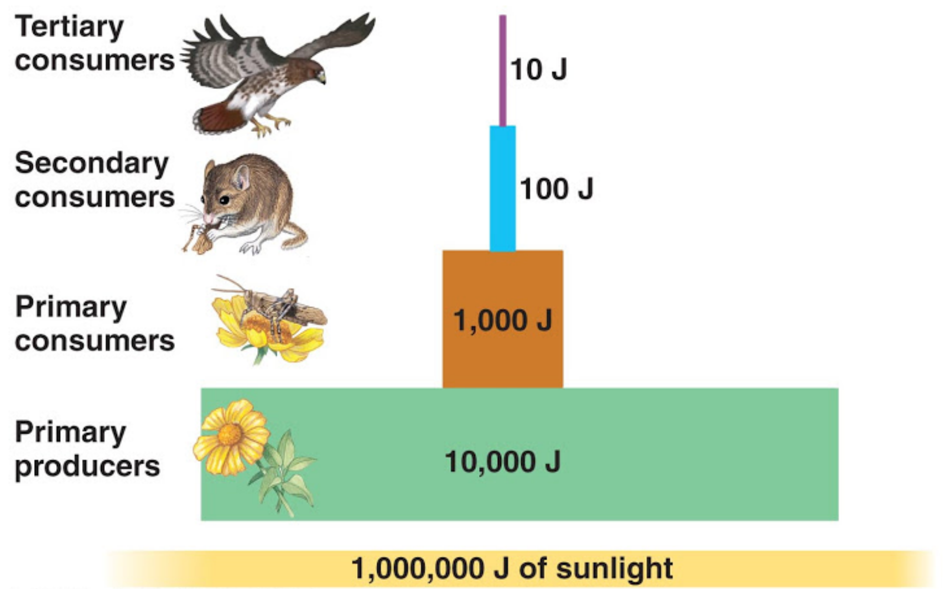
Two basic characteristics affect energy use: **body mass** and **trophic level**

Organisms use stored energy to move, grow and reproduce

When energy stores are used, most energy (> 90%) is dissipated as heat

Most organisms can only incorporate 1-10% of energy into tissue

Producers harness 1% of sunlight resources





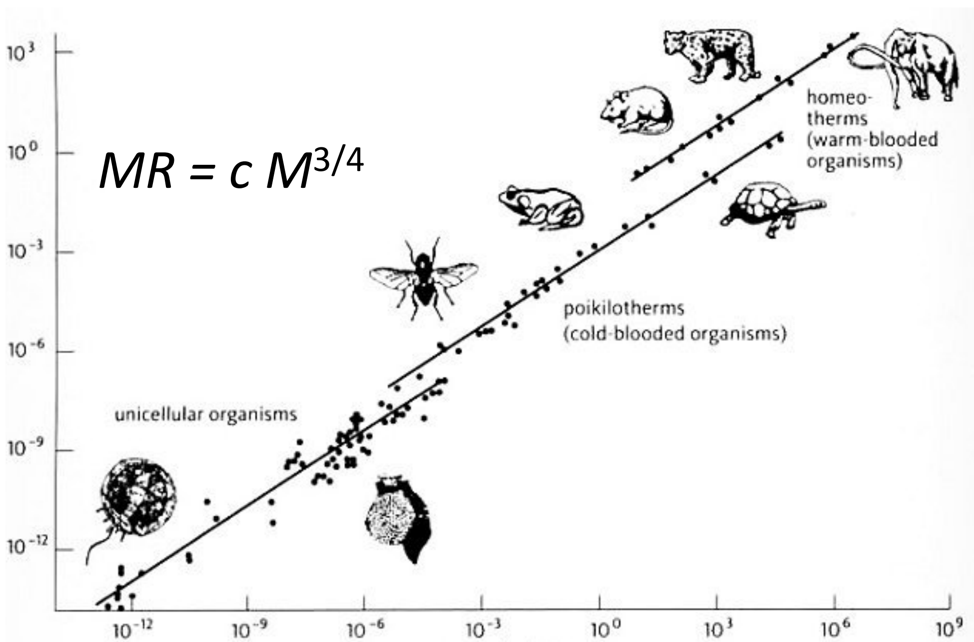

http://picasaweb.google.com/lh/photo/PifWR9JmBZcrm-7nihofCA

# Energetics and Communities

**Community assemblage depends, in part, on energetics and productivity**

Two basic characteristics affect energy use: **body mass** and **trophic level**

Metabolic rate (kcal/h, log scale)




$MR = c\, M^{3/4}$

Mass (g, log scale)

Body mass scales with metabolic rate as a power function (note the log scale) between 2/3 and 3/4

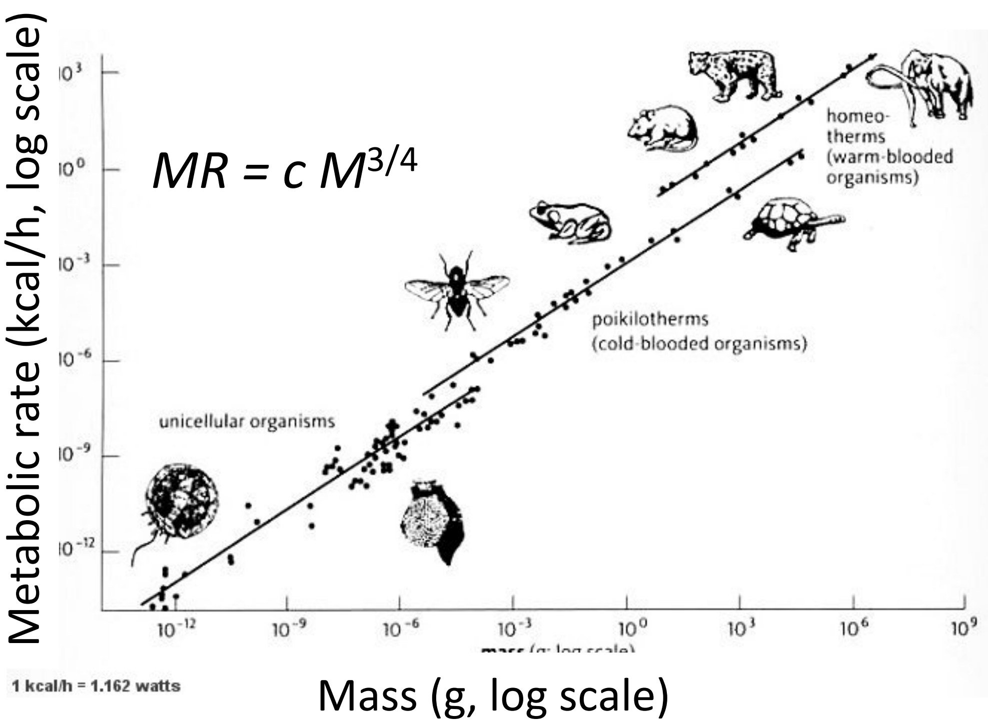
Bigger animals have higher (whole organism) metabolic rates and require more energy to meet their energetic demands

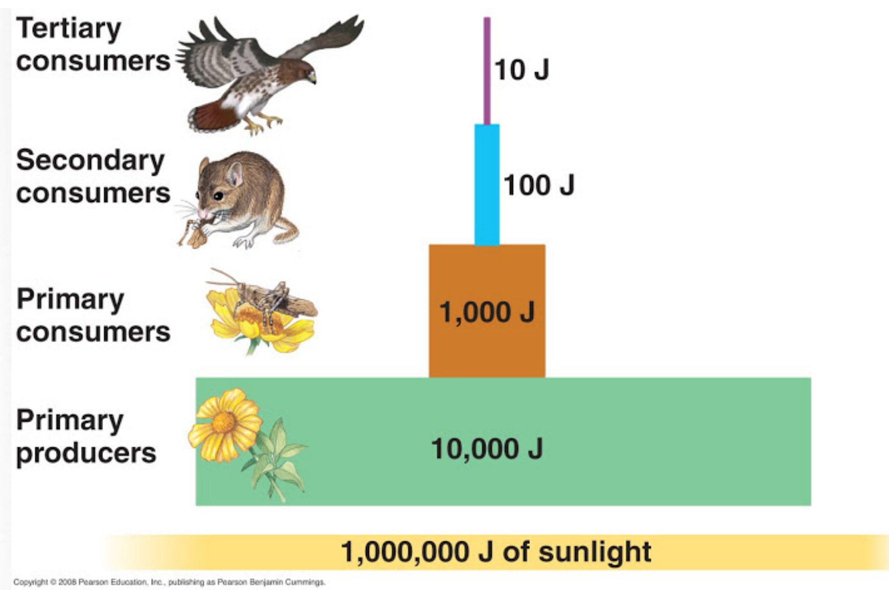
http://universe-review.ca/R10-35-metabolic.htm

# Energetics and Communities

**Community assemblage depends, in part, on energetics and productivity**

Tertiary consumers tend to be large bodied and numerically rare in communities: **they have the largest energetic demands and receive the lowest amount of energy compared to lower trophic levels**



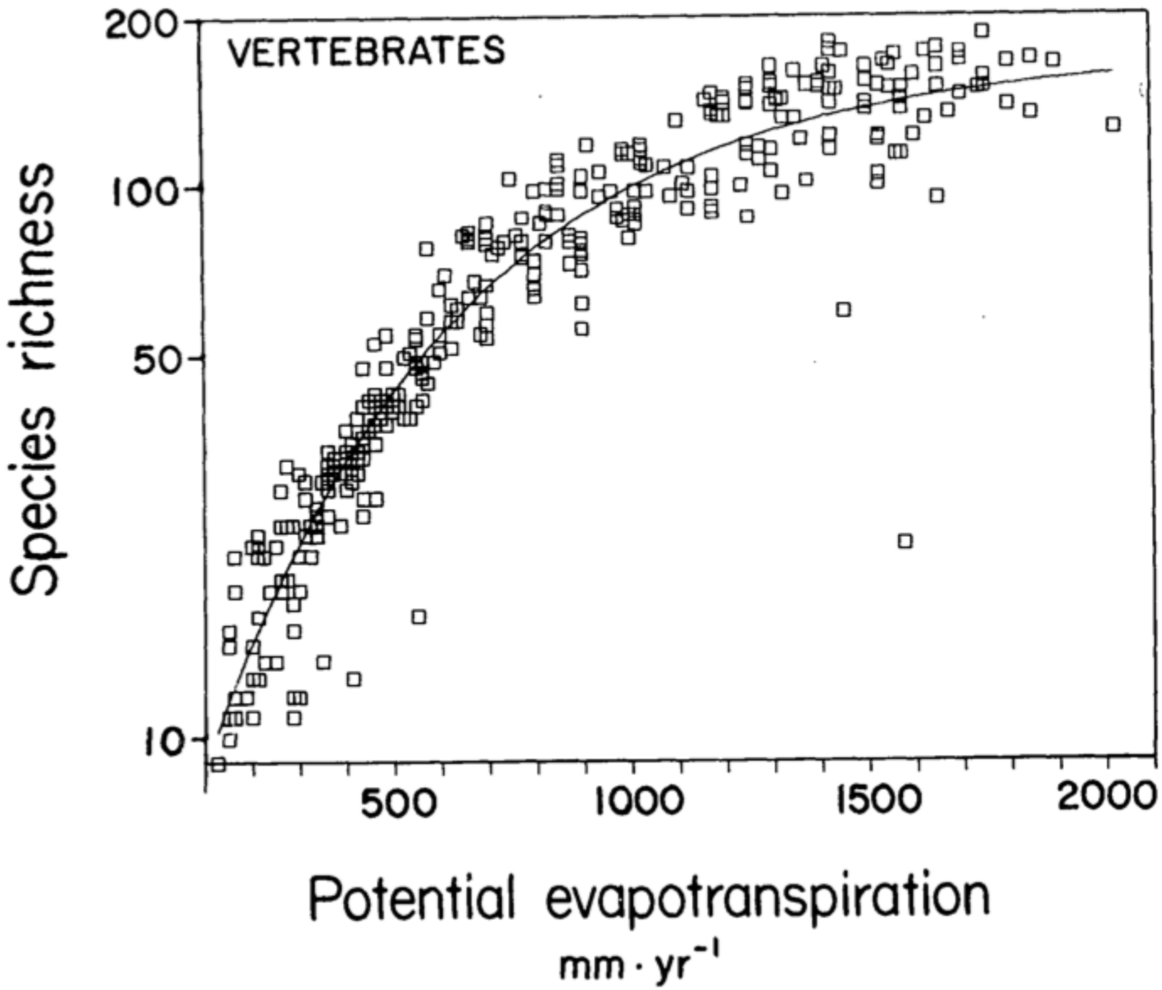



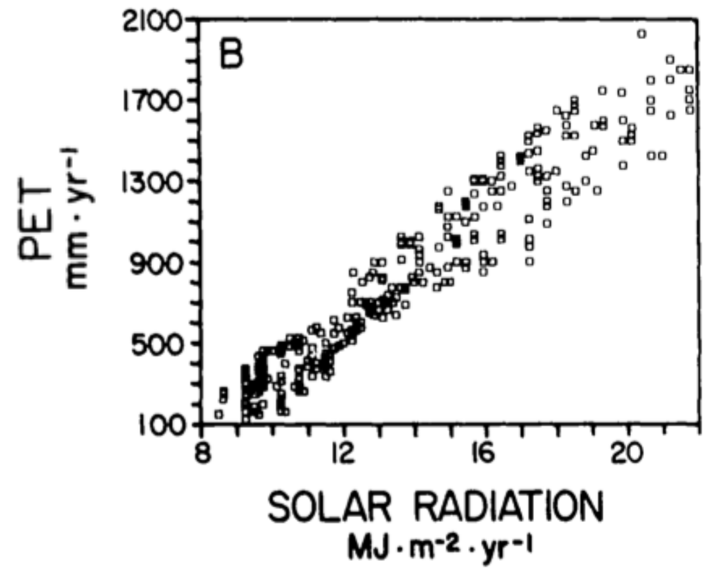

http://universe-review.ca/R10-35-metabolic.htm

http://picasaweb.google.com/lh/photo/PifWR9JmBZcrm-7nihofCA

# Energetics and Communities

**Community assemblage depends, in part, on energetics and productivity**



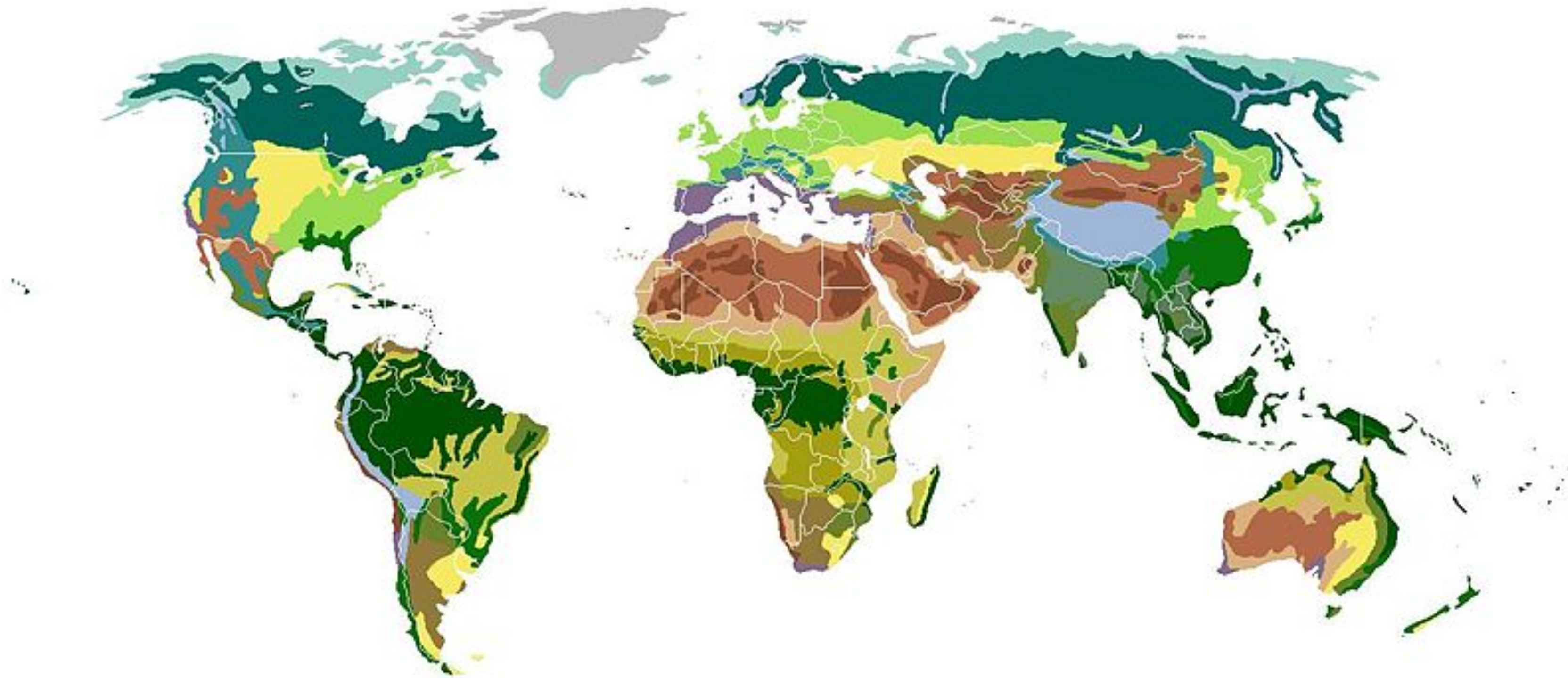




Recall where the productive terrestrial biomes are: we should have more species represented at all trophic levels in these biomes

(From Currie 1991)

# Energetics and Communities

**Community assemblage depends, in part, on energetics and productivity**



Recall where the productive terrestrial biomes are: we should expect to see more species represented across trophic levels in these biomes

# Interdependence of species in communities

One of the longest standing themes in community ecology is the definition of an ecological community

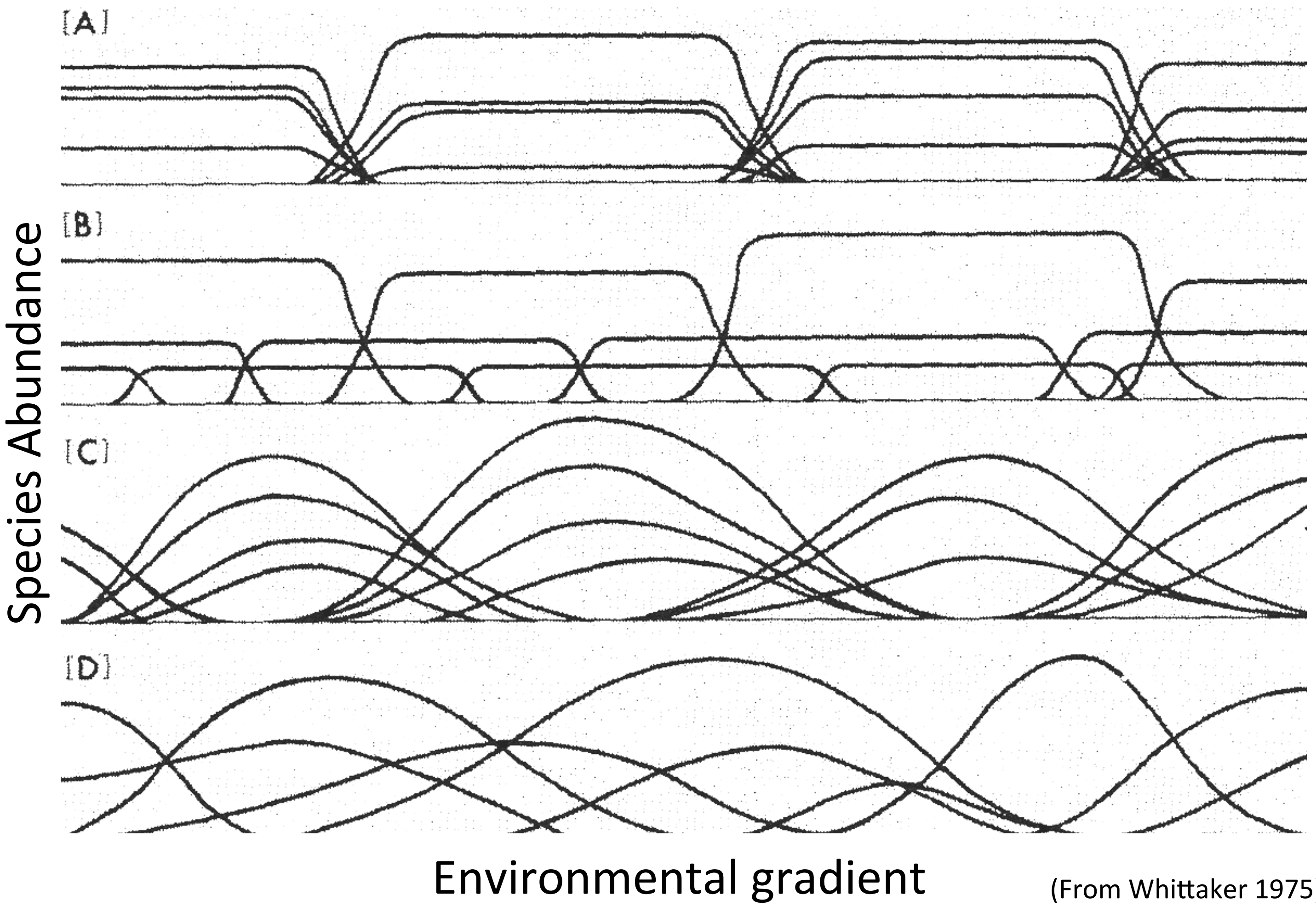
How do we define communities of coexisting species?
What "boundaries" separate one community from another?
To what extent are coexisting species interdependent?

The classic views: cohesive-unit and individualistic communities

The expanding view: communities should not be defined (Ricklefs)

# Interdependence of species in communities

Whittaker describes a classic and comprehensive view of the delineation of communities and distribution of species within those communities




(From Whittaker 1975)

# Interdependence of species in communities

Whittaker describes a classic and comprehensive view of the delineation of communities and distribution of species within those communities

Species Abundance

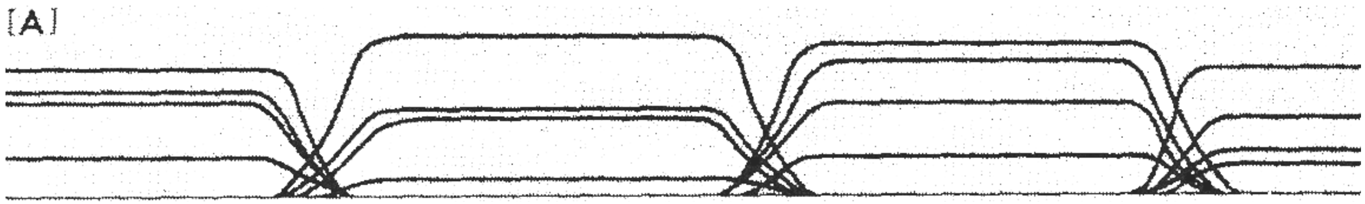
The "individualistic" hypothesis, proposed by Gleason, states that species do not occur in definable communities


Environmental gradient

(From Whittaker 1975)

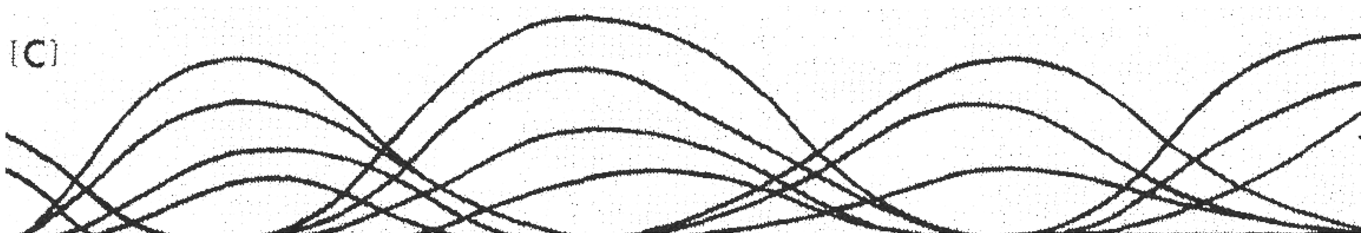
# Interdependence of species in communities

Whittaker describes a classic and comprehensive view of the delineation of communities and distribution of species within those communities




Species Abundance

Clements proposed that species co-occur as definable units; species within communities are interdependent and coevolved

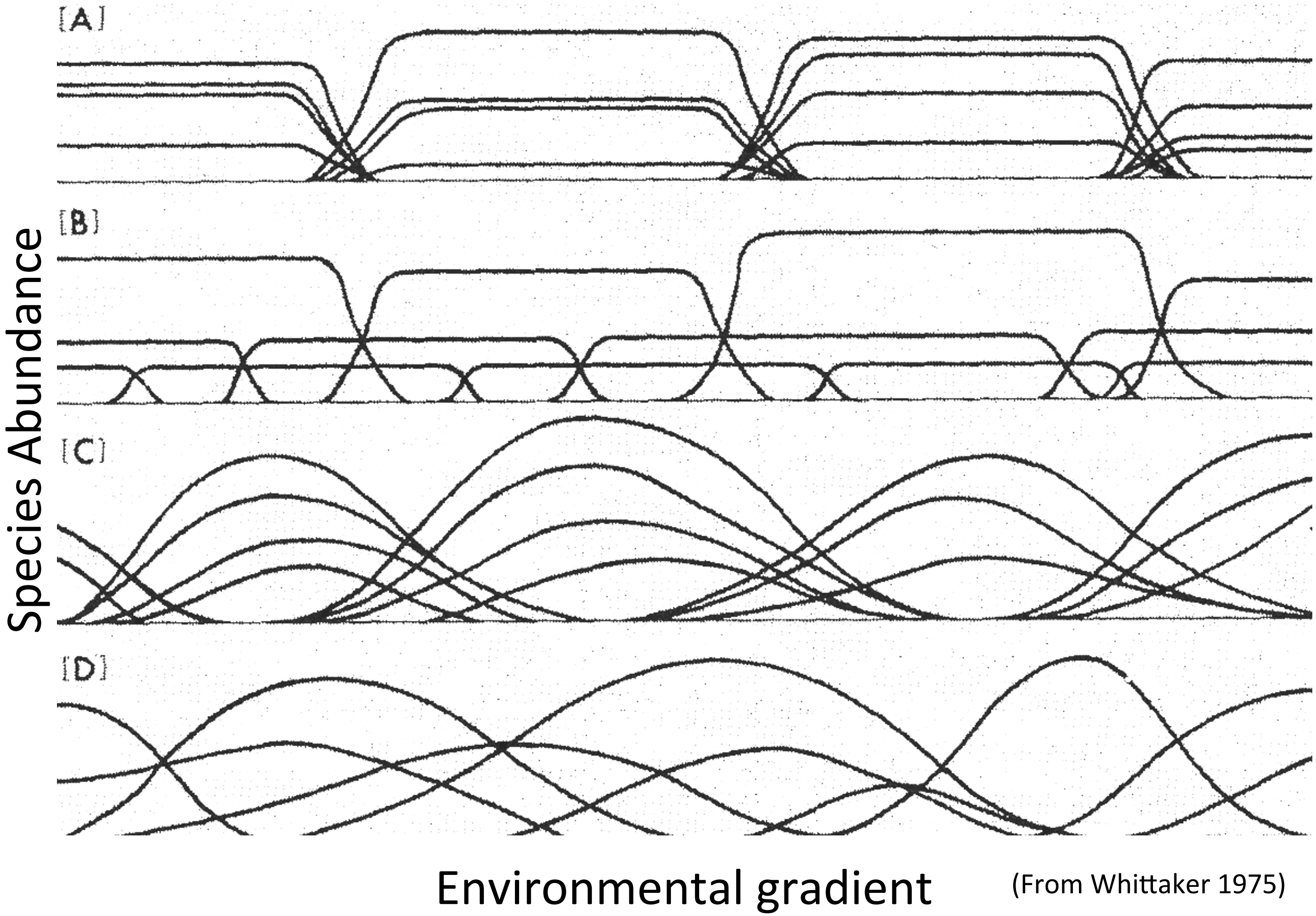



Environmental gradient

(From Whittaker 1975)

# Interdependence of species in communities

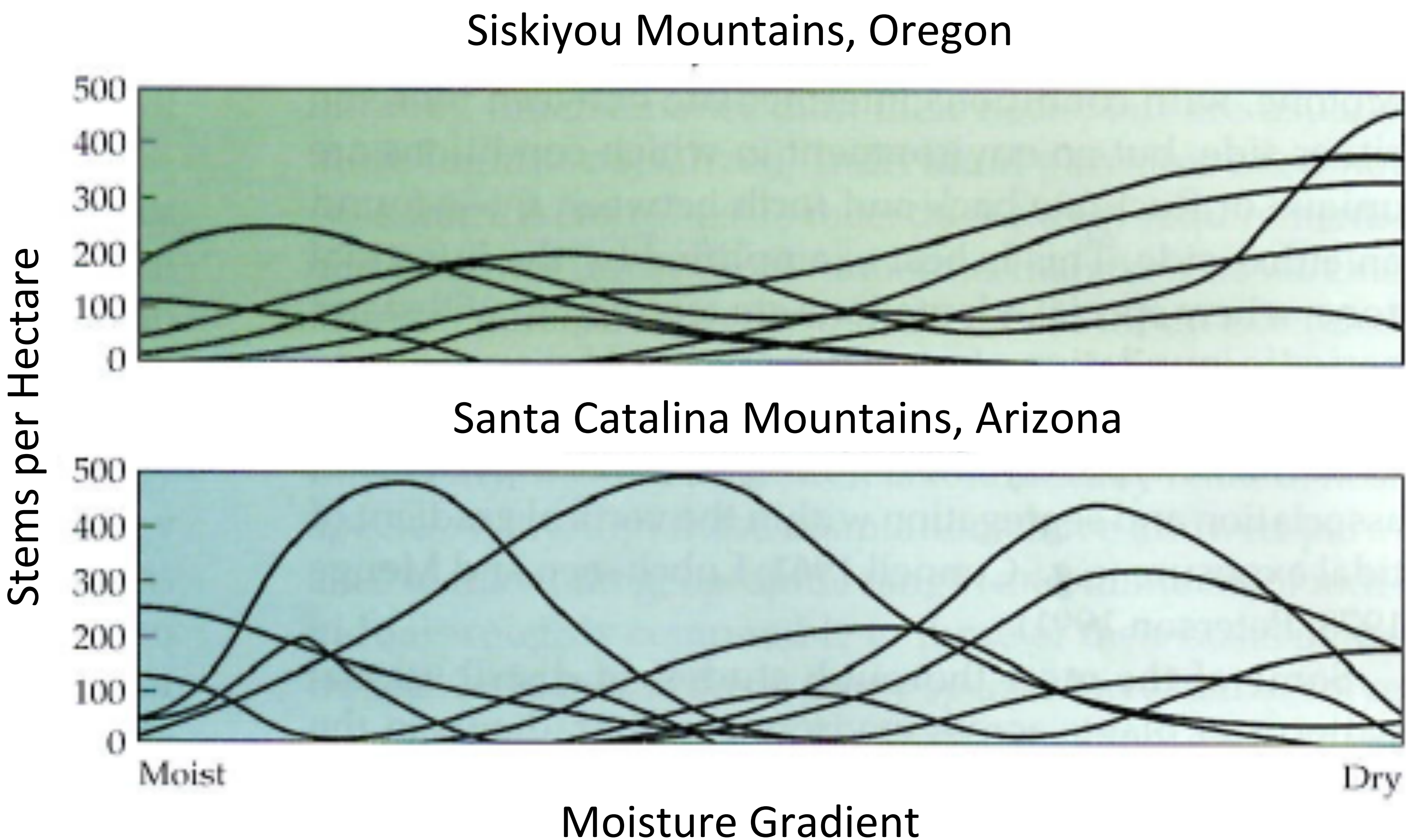
Whittaker combines both individualistic and community-unit scenarios including biotic processes (also competitive interactions and species replacements)




(From Whittaker 1975)

# Interdependence of species in communities

Whittaker tested these hypothesized distribution patterns with trees species in two different temperate mountain ranges




After Whittaker 1967, Lomolino et al. 2017

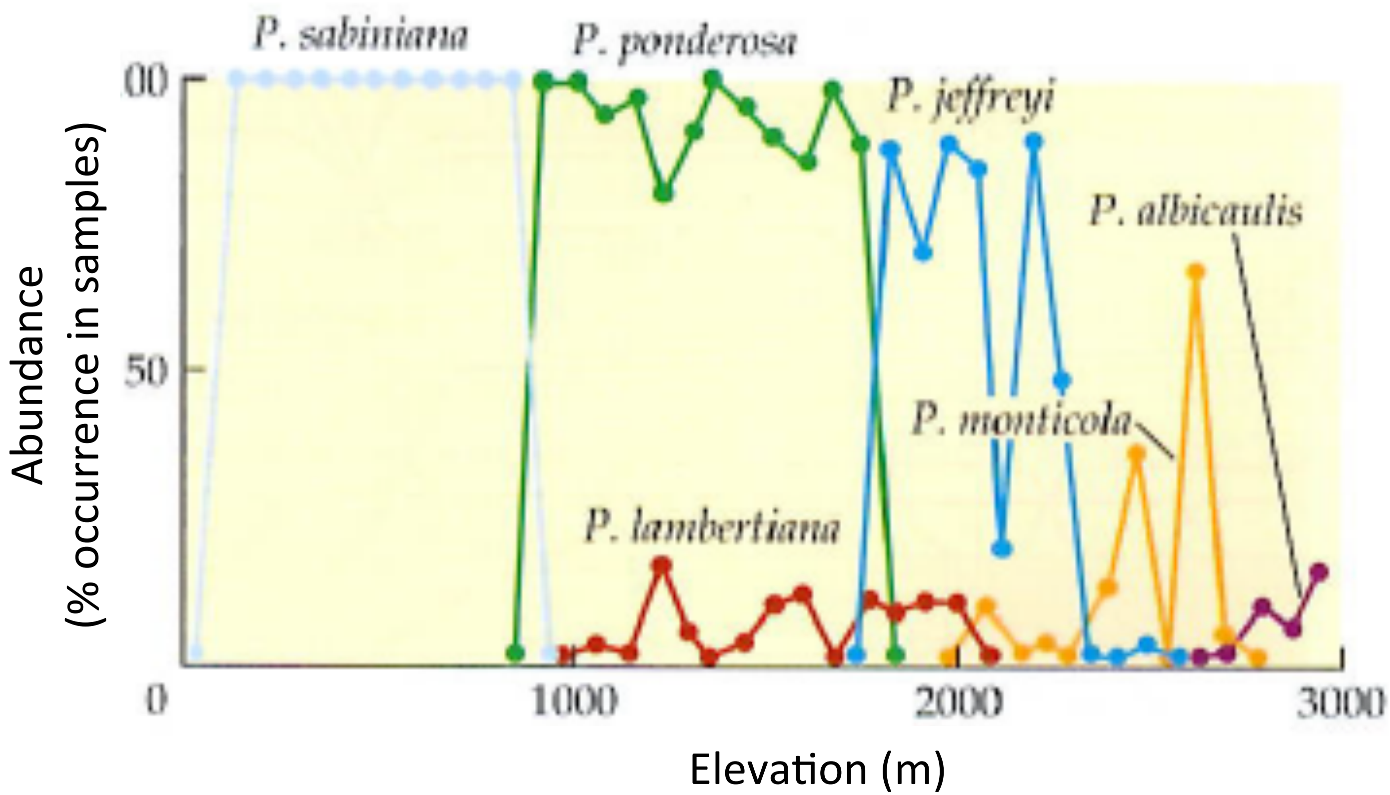
# Interdependence of species in communities

By surveying large areas and averaging over multiple mountain slopes, Whittaker may have missed abrupt, local-scale replacements of species…

Yeaton analyzed *Pinus* species along western slopes of Sierra Nevada, California. -

Species with the same number of needles are ecologically similar

- show little overlap on sites with similar slopes, exposure and soil types

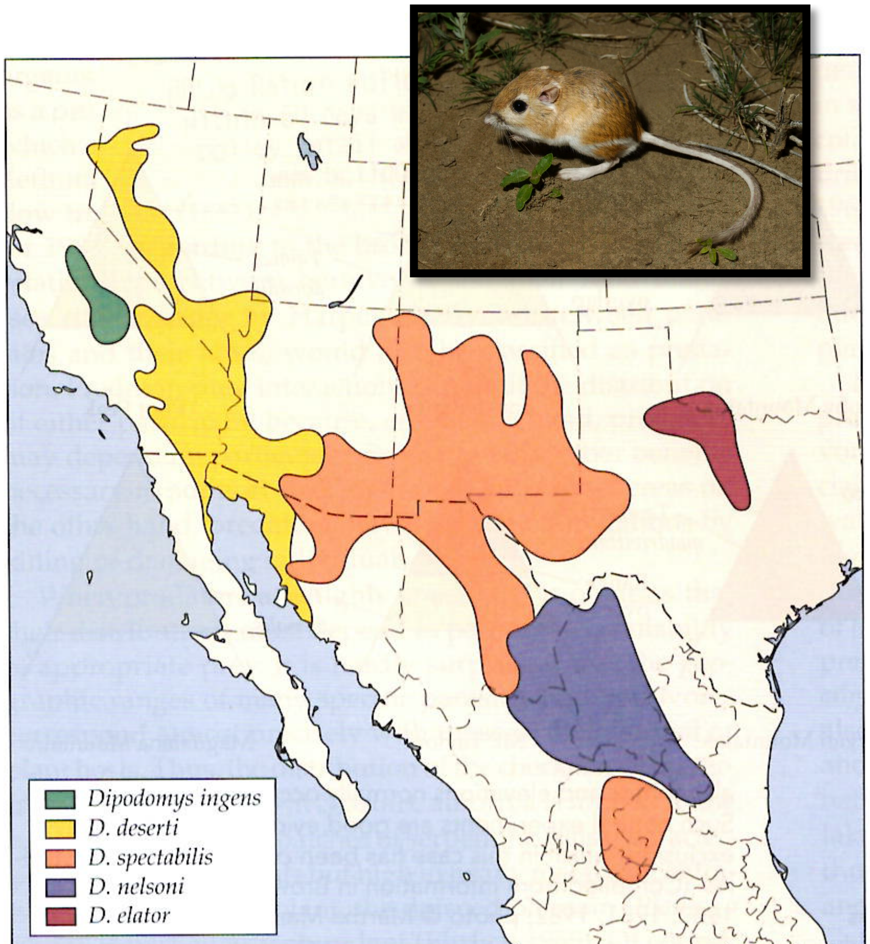



After Yeaton 1981, Lomolino et al. 2017

# Interdependence of species in communities

Other taxa show patterns of segregated ranges across spatial scales

*Dipodomys ingrens* – Giant kangaroo rat




Non-overlapping geographic ranges of five species of large kangaroo rats

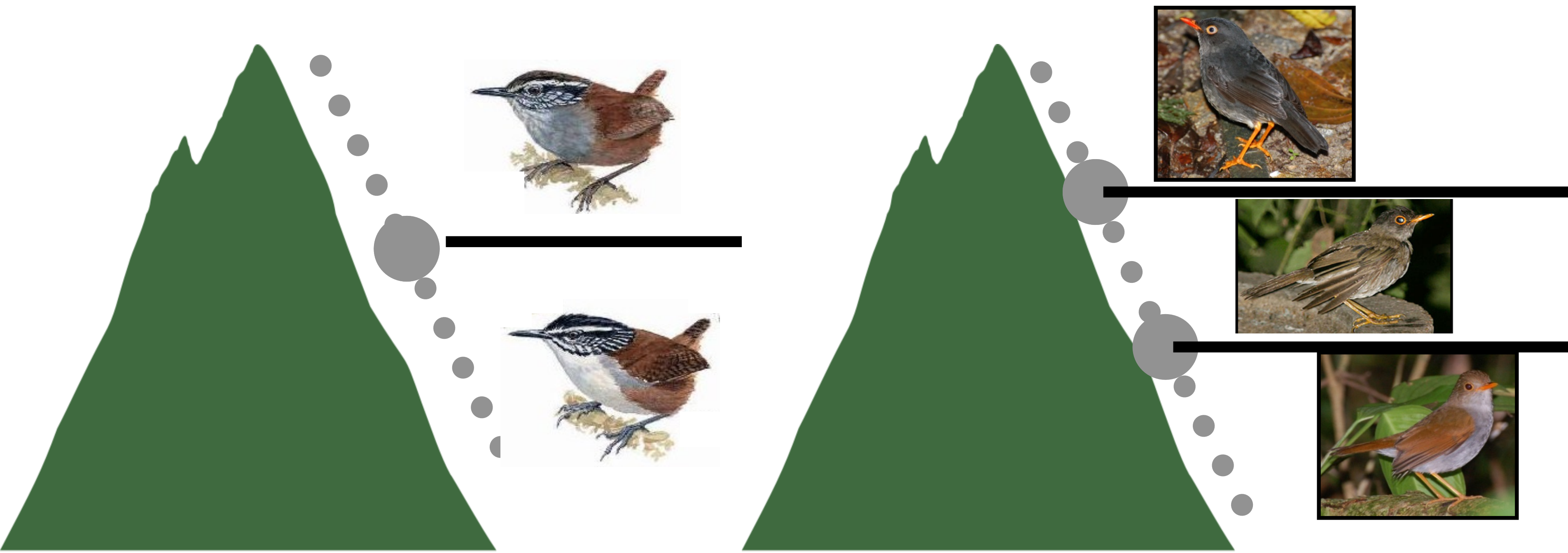
Limited overlap in ranges and abutting range edges suggests a role for interspecific competitive interactions in determining range limits

From Bowers & Brown 1982, Lomolino et al 2017

# Interdependence of species in communities

Recall from lecture on determinants of distributions

Species often show elevational replacements between closely related species, likely due to strong direct competitive interactions

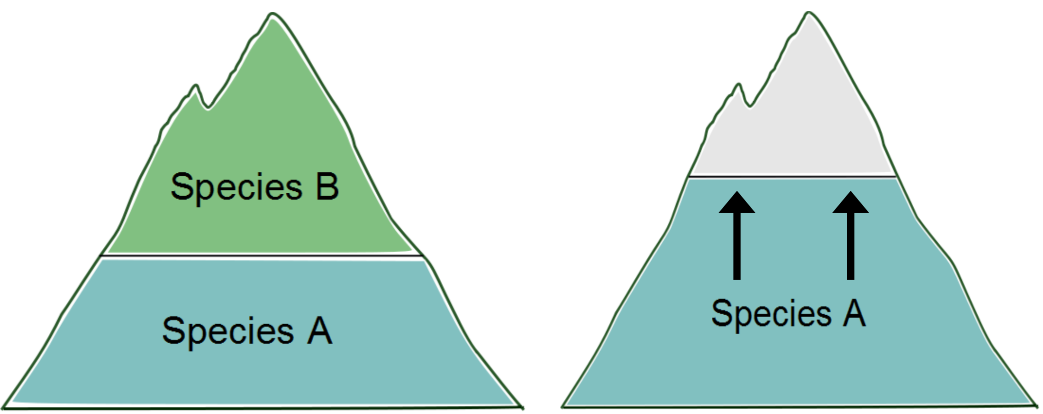


Jankowski et al. 2010, *Ecology*

# Interdependence of species in communities

Recall from lecture on determinants of distributions

Species often show elevational replacements between closely related species, likely due to strong direct competitive interactions




Cordillera Vilcabamba
Main Andes

Cerros del Sira
100 km from Andes

In a range isolated from the Andes:

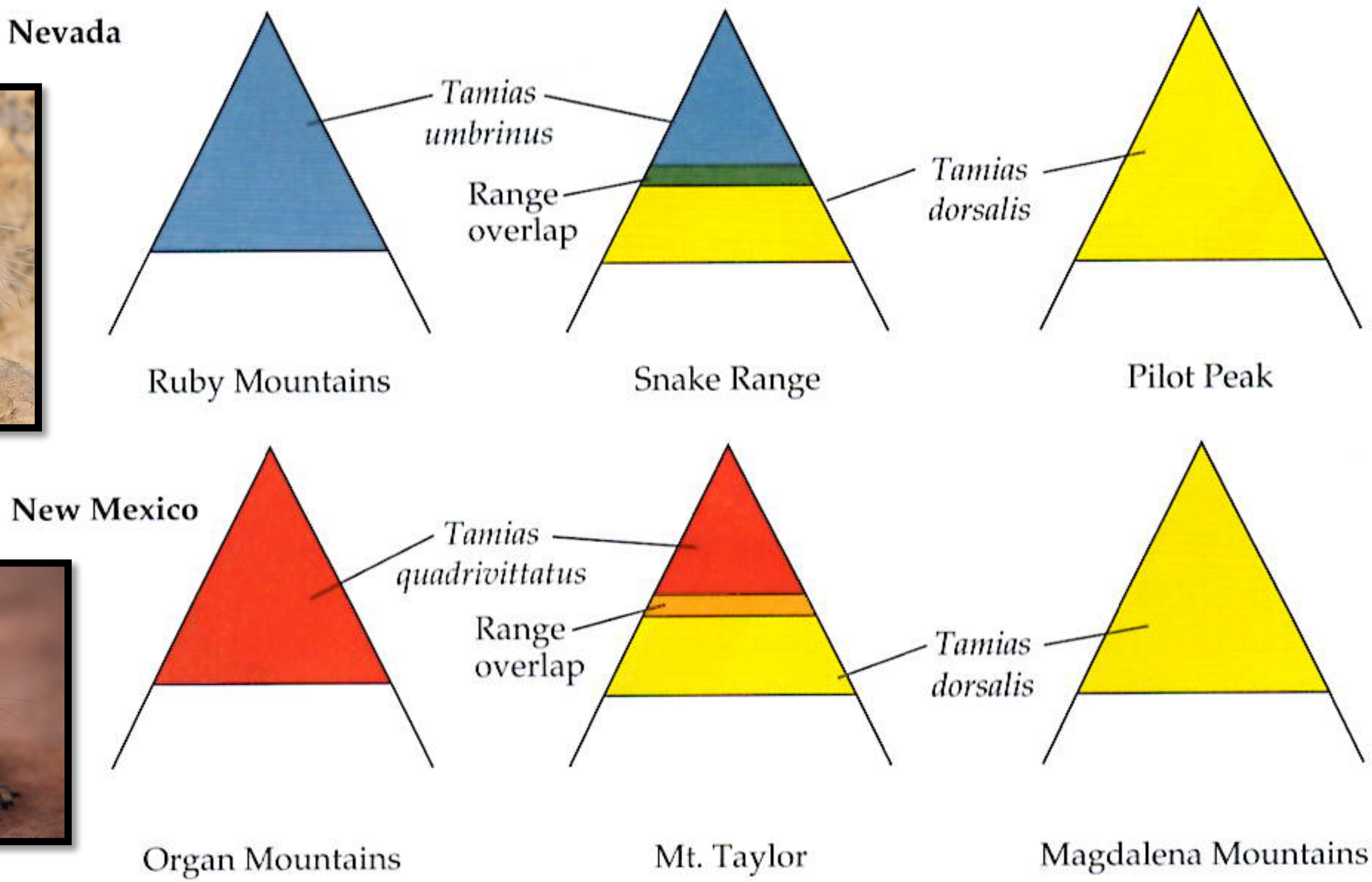
- high elevation species absent
- low elevation species expands range upward

**Ecological release:** expansion of the realized niche of a species where few competitors exist but an undiminished range of resources and habitats is present

Terborgh & Weske 1975, *Ecology*

# Interdependence of species in communities

On most mountain ranges, two species of chipmunks are present and their ranges overlap very little. In ranges where a single species occurs, the species range has expanded to include elevations normally occupied by both species.




From Brown 1971, Lomolino et al 2017

# Interdependence of species in communities

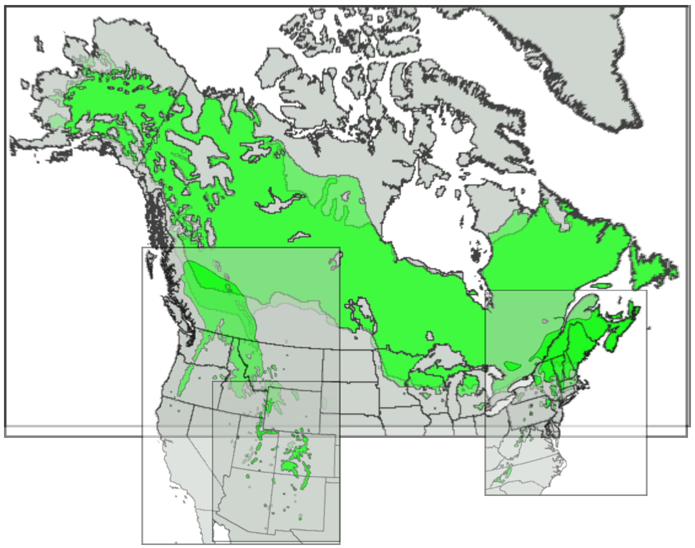
- Although Whittaker's results reflect the distributions of many plant species along environmental gradients, abrupt replacement by competing species can occur in many cases in which ecologically similar or close relatives come into contact

- Do we also see patterns of replacement for entire communities?

# Interdependence of species in communities

**Northern forest (spruce-moose) community:**

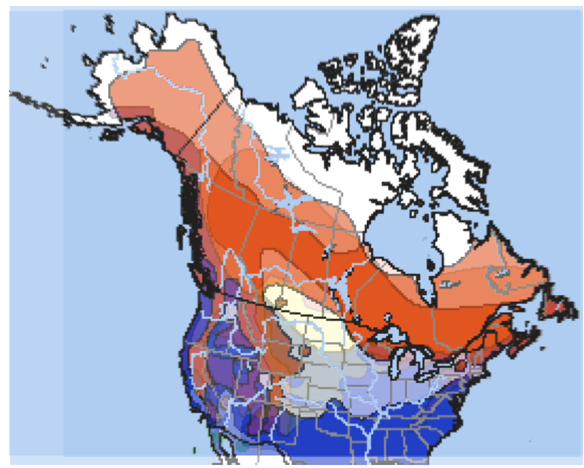
Coincident distribution of 12 species from distantly-related taxa.



Five tree species:

- black spruce
- white spruce
- blue spuce
- red spruce
- Engelmann spruce

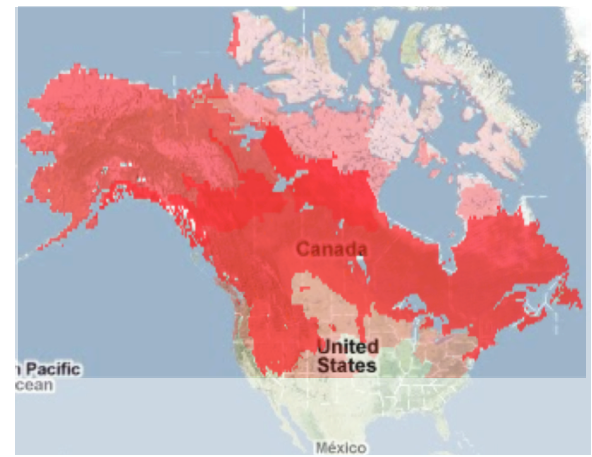
(from www.conifers.org)



Three bird species:

−white-throated sparrow
−ruby-crowned kinglet
−golden-crowned kinglet

(from avibase.bsc-eoc.org)

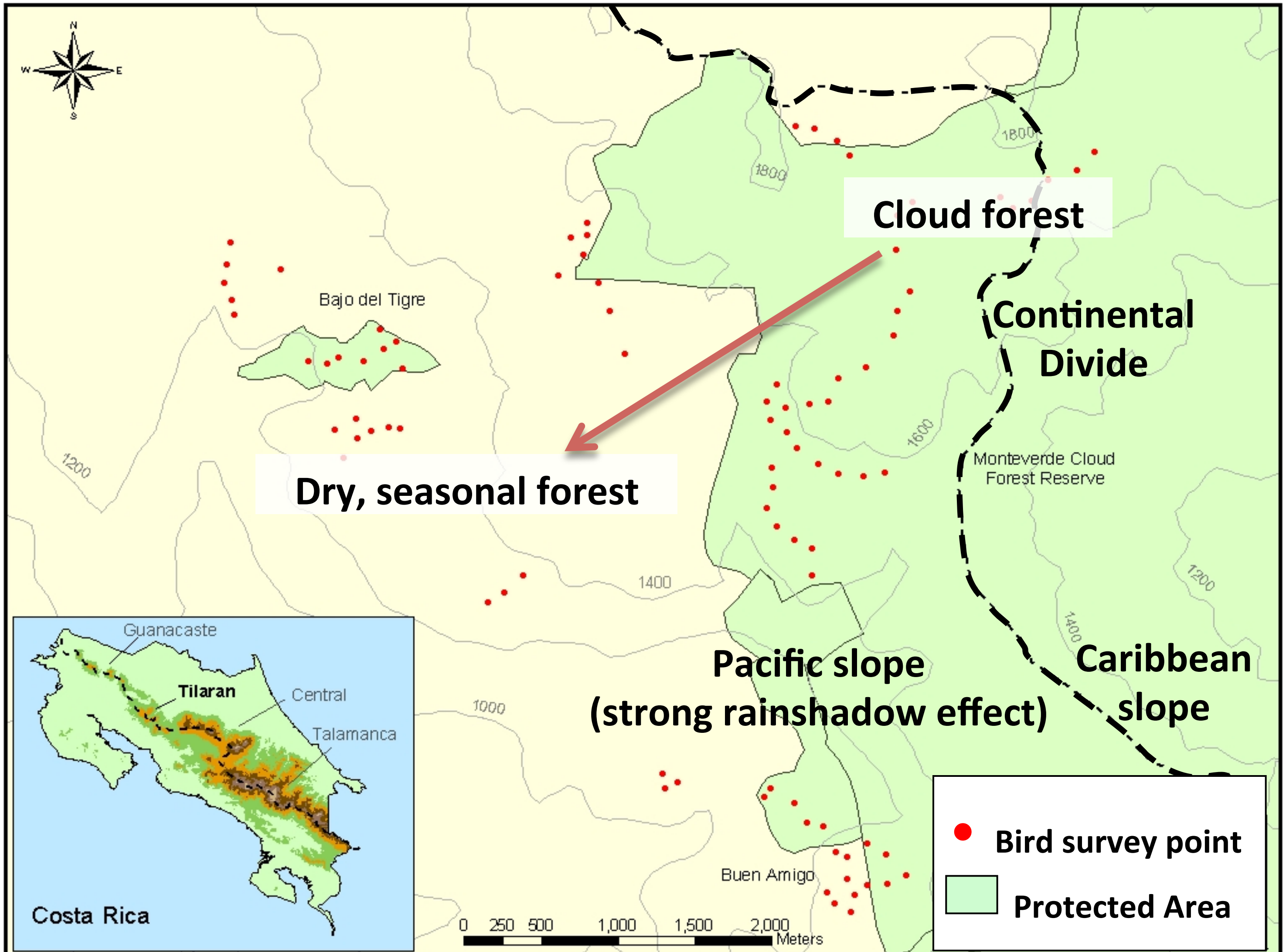



Four mammal species:

- moose
- northern red-backed vole
- southern red-backed vole
- western red-backed vole

(from gis.wwfus.org/wildfinder)

# Interdependence of species in communities

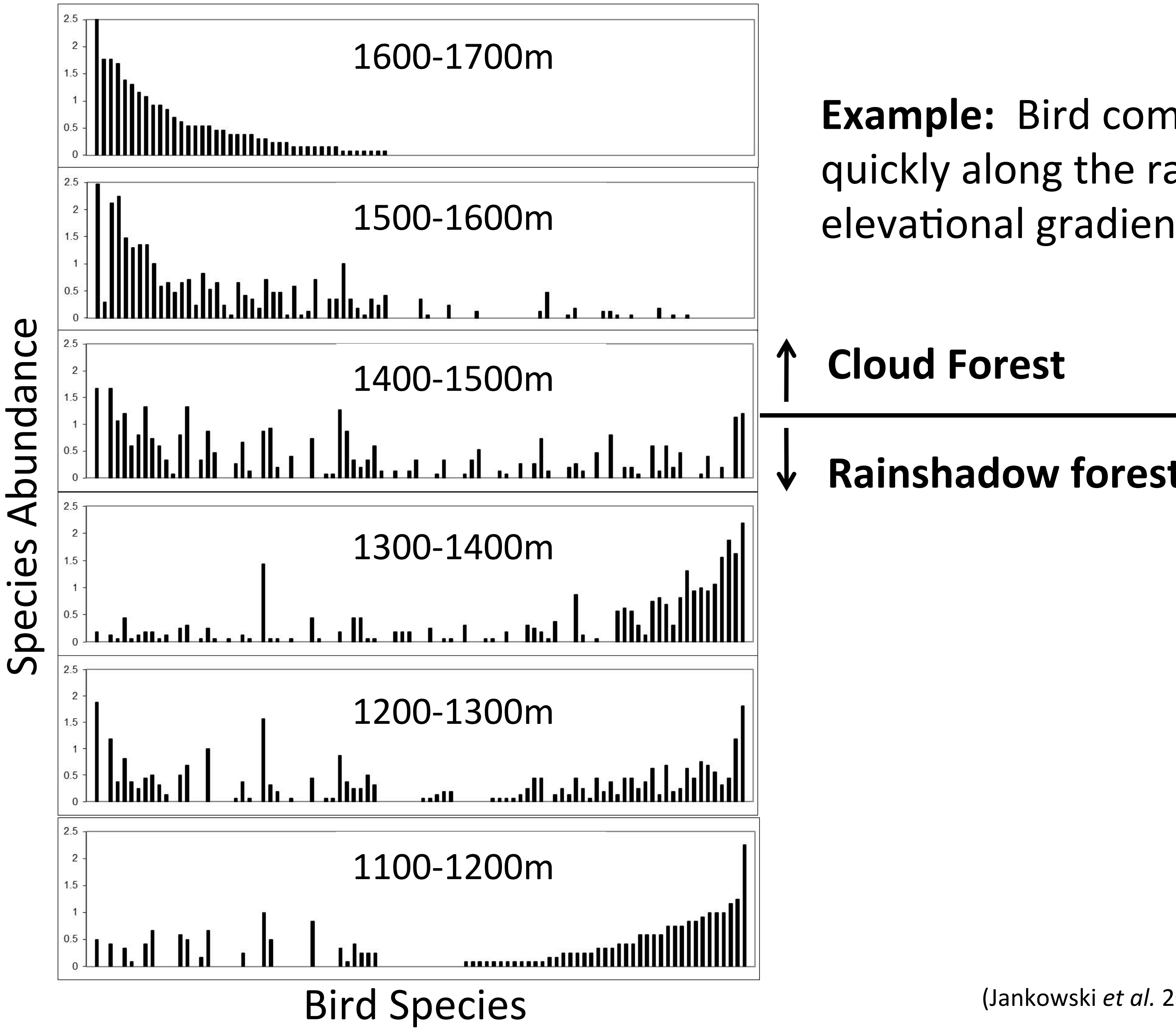



Tilarán Mountains, Costa Rica: 1100-1800m

Change in bird community composition with elevation in Costa Rica.

What processes structure these communities?

# Interdependence of species in communities

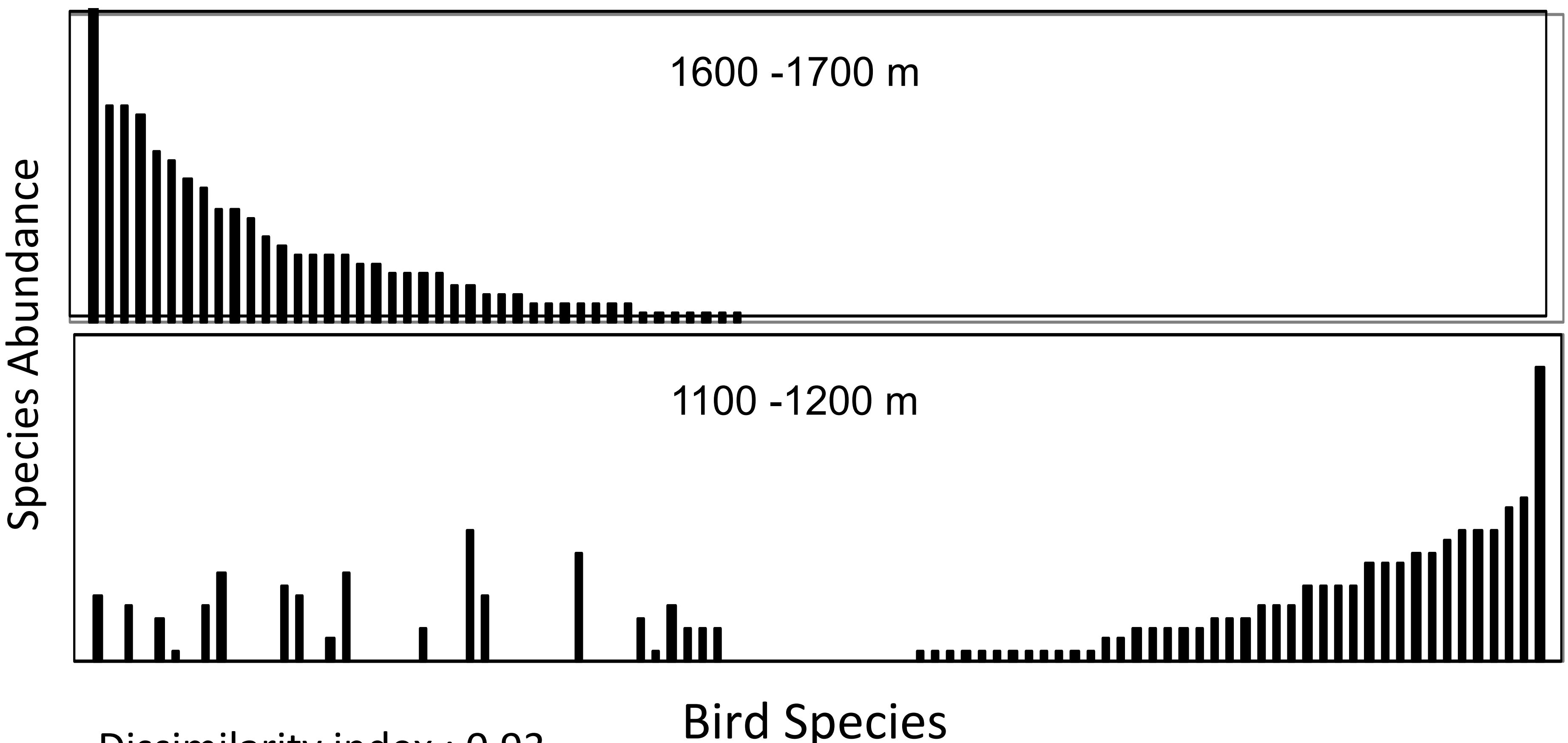



**Example:** Bird communities change quickly along the rainshadow elevational gradient in Costa Rica

(Jankowski *et al.* 2009)

# Interdependence of species in communities

In 500m elevation, nearly 100% turnover in species...

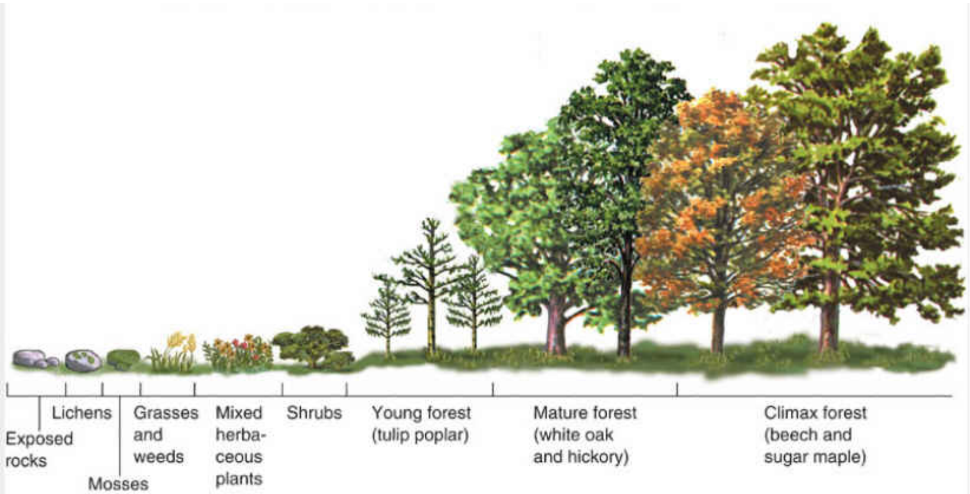



Dissimilarity index : 0.93

Jankowski et al. 2009, *J. Anim. Ecol.*

# Communities Over Space and Time

**Assemblages of species in a location change over long periods of time**



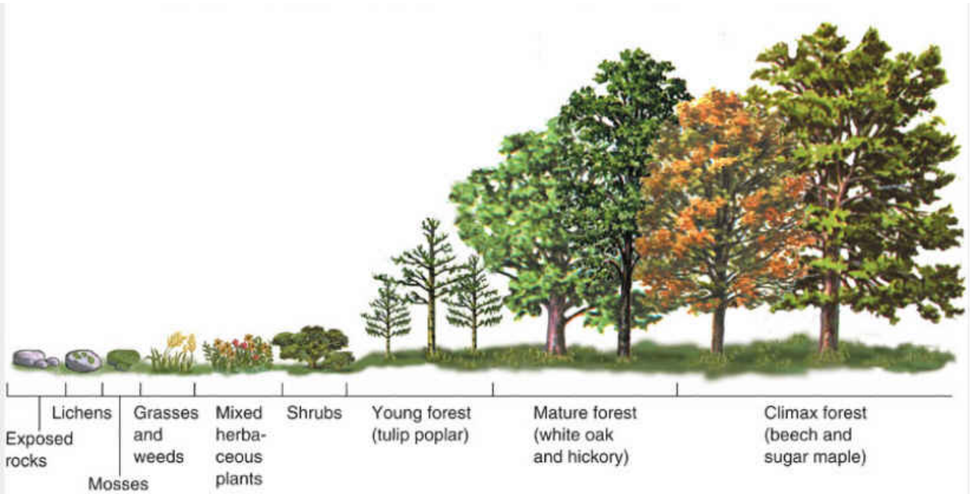

**Succession:** progressive change in community structure, composition, and function with time

**Primary succession:** succession "from scratch” or from a place devoid of life and the soil on which it depends (e.g., a volcano or glacier that destroys all life, leaving bare rock or till).

**Secondary succession:** succession when the soil is left after a disturbance (e.g., flood or fire). Also includes later stages of succession as communities return to natural vegetation.

# Communities Over Space and Time

**Assemblages of species in a location change over long periods of time**




Generally follows an orderly pattern of species replacement, beginning with species that are good colonizers that then facilitate establishment of other species towards a climax community.

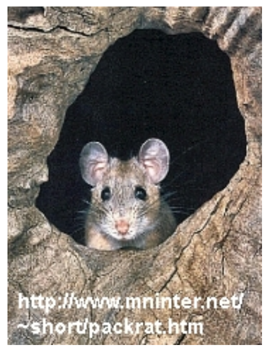
**Primary succession:** succession "from scratch" or from a place devoid of life and the soil on which it depends (e.g., a volcano or glacier that destroys all life, leaving bare rock or till).

**Secondary succession:** succession when the soil is left after a disturbance (e.g., flood or fire). Also includes later stages of succession as communities return to natural vegetation.

# Communities Over Space and Time

**Assemblages of species in a location change over long periods of time**

Biomes of western North America at 0, 6000 and 18,000 $^{14}C$ yr BP reconstructed from pollen and packrat midden data.

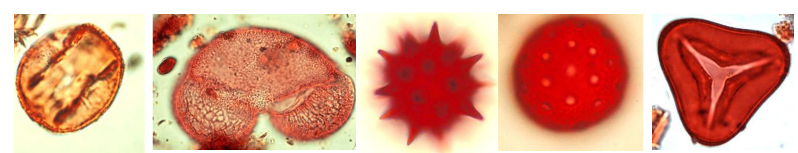




Packrat "middens" are organic deposits of plant debris and feces cemented by dried urine (amberat).

Pollen grains are preserved in sediments below lakes and bogs, extracted in cores that show timeline of settlement.



Sediment coring at Crystal Lake in Knoxville, TN and Amazon lakes, Peru

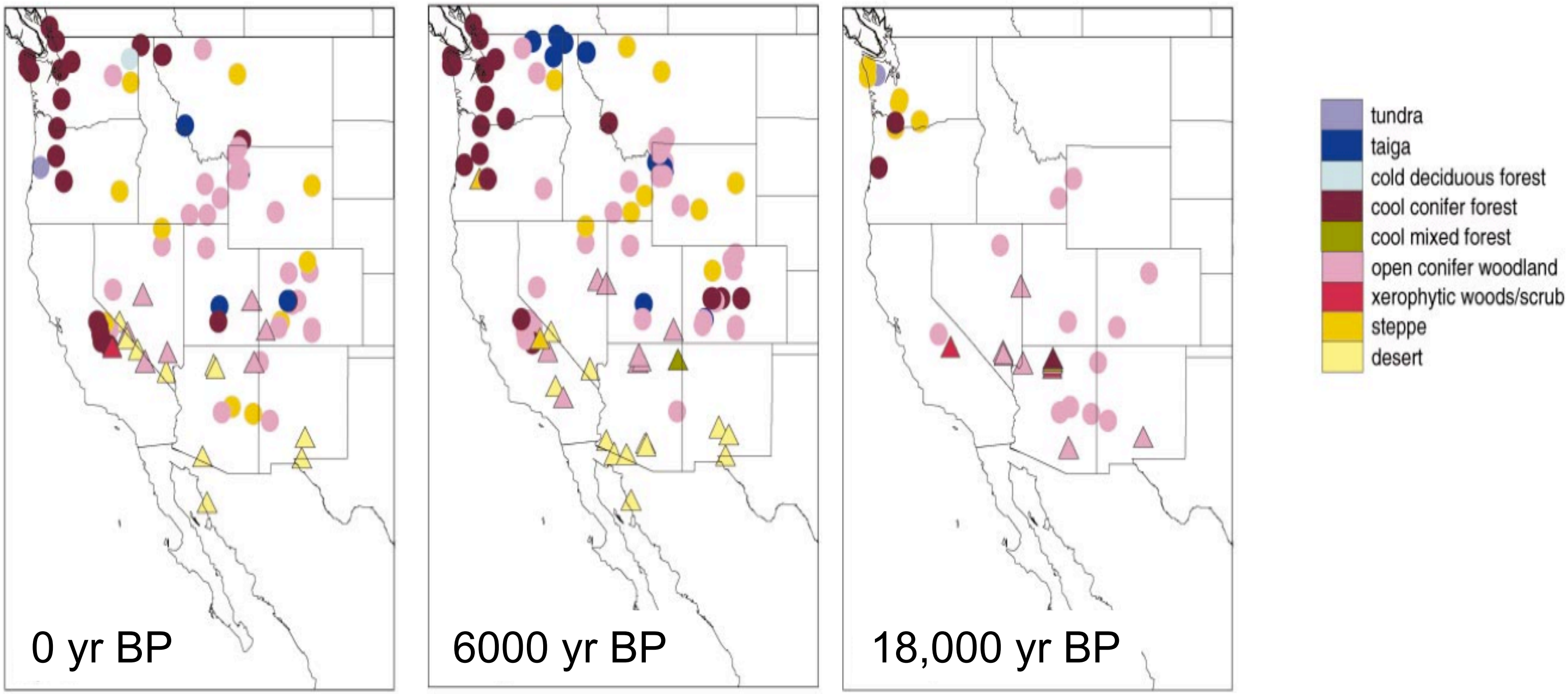


Pollen grains of Quercus, Pinus, Asteraceae, and Amaranthaceae, and a trilete fern spore.

Thompson & Anderson 2000

# Communities Over Space and Time

**Assemblages of species in a location change over long periods of time**

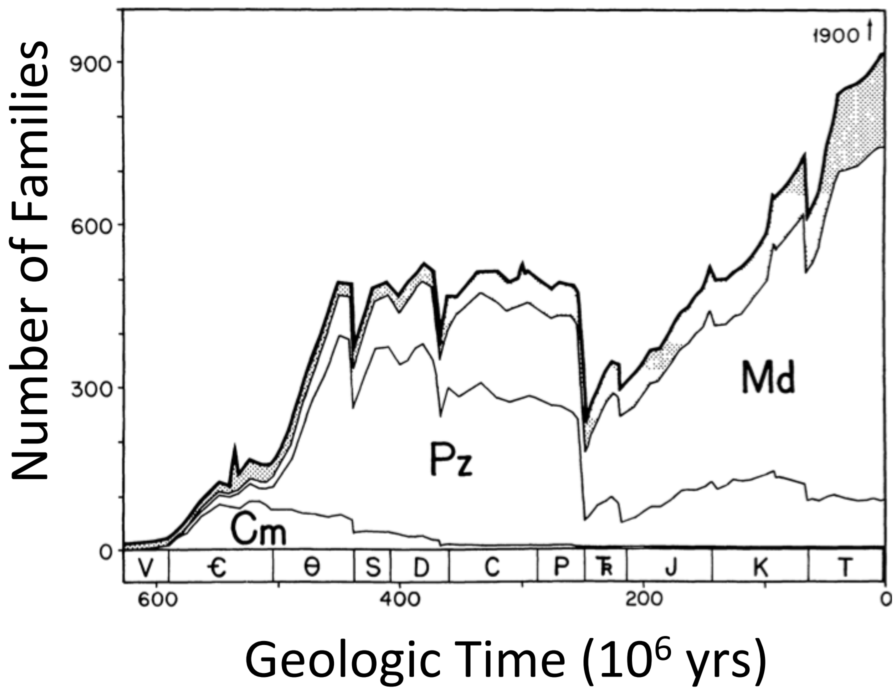


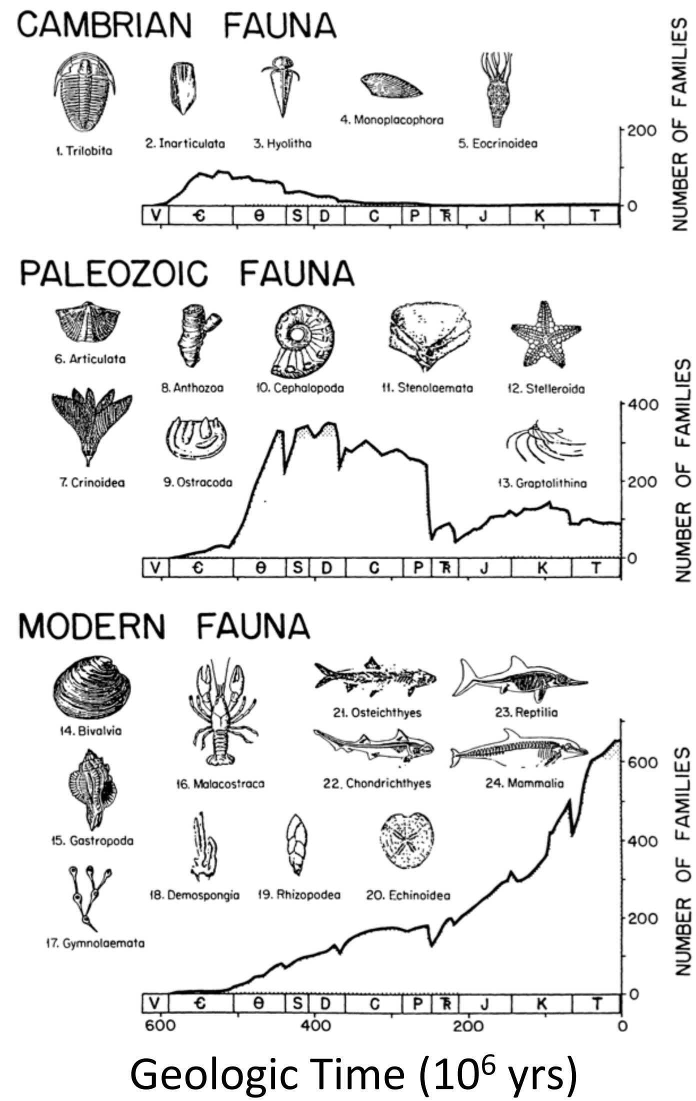

Biomes of western North America at 0, 6000 and 18,000 $^{14}C$ yr BP reconstructed from pollen and packrat midden data. Pollen sites are represented by a circle, midden sites by a triangle.

Thompson & Anderson 2000

# Communities Over Space and Time

**Assemblages of species in a location change over long periods of time**



# Interdependence of species in communities

An expanding view of communities describes coexisting species as a fluid and undefined assemblge of species, where a larger regional "pool" of species (beyond the local community) underlies species composition over space and time.

Ricklefs, R.E. 2008. Disintegration of the ecological community. *American Naturalist* 172: 741-750

"...the seemingly indestructible concept of the community as a local, interacting assemblage of species has hindered progress toward understanding species richness at local to regional scales...The local community is an epiphenomenon that has relatively little explanatory power in ecology and evolutionary biology"

-- Robert Ricklefs

# Geography of Communities

**References for this section**:

Bowers, M. A., & Brown, J. H. 1982. Body Size and Coexistnce in Desert Rodents: Chance or Community Structure? *Ecology* 63: 391-400.

Brown, J. H. 1971. Mechanisms of competitive exclusion between two species of chipmunks. *Ecology*, 52: 305-311.

Currie, D.J. 1991. Energy and large-scale patterns of animal- and plant-species richness. *American Naturalist* 137: 27-49.

Jankowski, J.E., *et al.* 2009. Beta diversity along environmental gradients: implications of habitat specialization in tropical montane landscapes. *Journal of Animal Ecology* 78: 315-327.

Jankowski, J.E., S.K. Robinson, & D.J. Levey. 2010. Squeezed at the top: Interspecific aggression may constrain elevational ranges in tropical birds. *Ecology* 91: 1877-1884.

Lomolino, M.V., B.R. Riddle, R.J. Whittaker, & J.A. Brown. 2010. *Biogeography* (4th edition). Sinauer Associates, Inc., Sunderland, Mass.

Ricklefs, R.E. 2008. Disintegration of the ecological community. *American Naturalist* 172: 741-750

Terborgh, J. & J.S. Weske. 1975. The role of competition in the distribution of Andean birds. *Ecology* 56: 562–576.

Thompson, R.S., and K.H. Anderson. 2000. Biomes of western North America at 18,000, 6000 and 0 $^{14}C$ yr BP reconstructed from pollen and packrat midden data. *J. Biogeography* 27: 555–584.

Whittaker, R.H. 1975. *Communities and Ecosystems*. 2nd ed. New York: MacMillan.

Yeaton, R. I. 1981. Seedling characteristics and elevational distributions of pines (Pinaceae) in the Sierra Nevada of central California: a hypothesis. *Madroño* 67-77.