Species diversification in space: biogeographic patterns
Outline

• Endemism and cosmopolitanism
• Disjunctions
• Biogeographic regions
• Barriers and interchanges
• Divergence and convergence
Biogeographic patterns emerging from speciation & extinction on a dynamic Earth

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How widely is a species distributed?

- **Cosmopolitan**: widely distributed around the world

- **Endemic**: occurring in one geographic location and nowhere else
Cosmopolitan

- No species or family is truly cosmopolitan
- Certain higher taxonomic levels are nearly cosmopolitan (e.g. Chiroptera)

How do species become cosmopolitan?
Endemism

Depends on the taxonomic level and spatial scale

Rodent family Heteromyidae
Endemism

Depends on the taxonomic level and spatial scale
Why are species endemic?
Lack of dispersal
Shrinking range
Endemism

Relicts
- Taxonomic
- Biogeographic

Usually occur together – “living fossils”

Tuatara, islands off New Zealand

Monito del monte

Gingko

Coelacanth
Endemism

**Provincialism** – coincident occurrence of large numbers of well-differentiated endemic forms in an area

- Endemics tend to co-occur in certain areas; not randomly distributed
- Influences of historical events
Disjunction

Closely related organisms that occur in separated areas

1. Vicariance events
2. Long-distance dispersal
3. Extinction in the intervening areas
Disjunction

*Nothofagus* forest, New Zealand

*Nothofagus* forest, Chile
Disjunction

Example: Ratite birds

Rhea

Ostrich

Cassowary

Kiwi
Disjunction

Distribution and phylogeny of ratite birds reflect:

- Tectonics
- Extinctions
What is the relationship between the history of a place (geological/climatological), species’ lineages (taxonomic history) and biogeographic patterns of biodiversity?
Biogeographic regions/realms

A region that shares species with similar biogeographic history

Helps understand evolutionary and geological factors that contributed to regional patterns of biodiversity
Evidence for Biogeographic Subdivisions

Lineage congruence

Biogeographic regions determined independently for different groups of organisms usually coincide
Evidence for Biogeographic Subdivisions

Biogeographic line/transition zone
Separate regions of distinct regional biota

Why is it difficult to draw distinct biogeographic lines?
Evidence for Biogeographic Subdivisions

Congruence between the histories of lineage and place – association between plate tectonics and development of provinciality

Morone 2002, 2009
How is a biogeographic region defined?

• First biogeographers defined them subjectively (Sclater, Wallace)

• Modern methods - mathematical classification techniques (e.g. Simpson Index), phylogenetics
Major biogeographic regions (Wallace-Sclater)
Biogeographic regions

Recent classification that incorporates phylogenetic analysis and plate tectonics

(Morrone 2002)
1. Barriers

Resistance to invasion
2. Resistance to invasion

Generalization (very controversial)
More diverse communities may be more resistant to invasion
What happens when barriers are crossed or disappear? **Biotic Interchanges**

- Two or more distinct biotas come into contact
- Little evidence to reconstruct what happened during these events in the past...
- Invasive species ⇒ good events to study mechanisms of biotic interchange
Mammals and the Great American Interchange

- Mammals evolved on Pangaea (~220 MYA)
  - Monotremes, marsupials, placentals
- South America drifted from Gondwana 160 MYA
- Shift in mammal-dominance 65 MYA
- 2.5 - 3.5 MYA – formation of the Central American land bridge
The Great American Interchange

The Great Interchange

Some of the animals that moved south from North America belonged to the camel, bear, elephant, cat, horse, dog, and pig families. Animals from the anteater, porcupine, opossum, sloth, and armadillo families were among those that traveled north from South America. Most of the animals that used the new land bridge were herbivores, or animals that eat plants.

About two million years ago, many animals, including those in the camel, horse, sloth, and pig families, lived in both North and South America. Members of the opossum family were late travelers. They reached Florida from South America just over one million years ago.
Biotic interchanges

The Great American interchange (families)

Stopped by filter
- Shrews
- Pocket mice
- Pocket gophers
- Beavers
- Pronghorns
- Bison

Crossing filter
- Rabbits
- Field mice
- Foxes
- Bears
- Raccoons
- Weasels
- Cats
- Mastodons
- Horses
- Tapirs
- Peccaries
- Camels
- Deer

Filter zone

Old barrier zone

Filter zone

Stopped by filter
- Primates
- Octodonts
- Spiny rats
- Nutrias
- Agoutis
- Capybaras
- Cavies
- Three-toed sloths
- Two-toed sloths
- Anteaters
- Shrew opossums
Why imbalanced?
1. Better migrators
2. Better survivors and speciators
3. Better competitors
4. Habitat theory (3 parts)