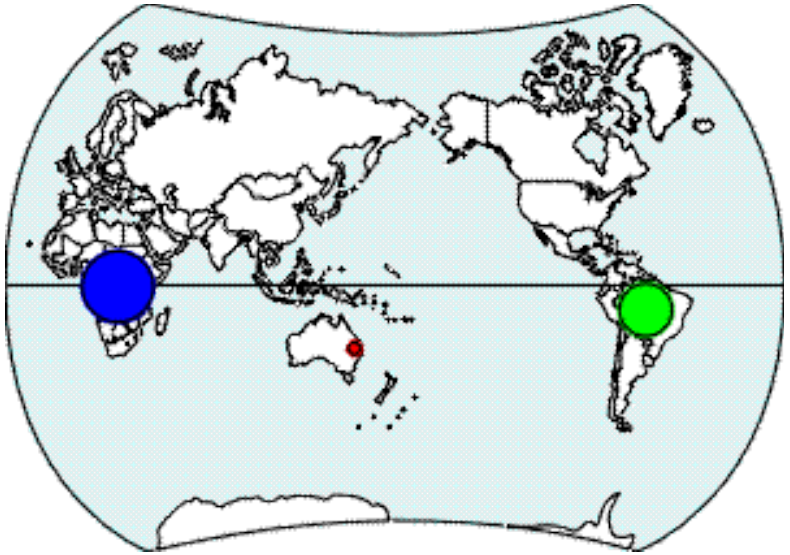
Endemism, Provincialism, and Disjunction



Goals and learning objectives

1) Understand the concept of endemism and how it is influenced by scale, history of place and history of lineage

2) Assess how endemism and provincialism are related, and how this can be reflected in biogeographic patterns of species diversity and distributions

3) Be familiar with different potential causes for disjunct distributions

4) Consider the different ways a species can be rare, and the consequences for correlations in rarity

Considering the geography of diversification and regionalization, different 'histories' have shaped contemporary biotas

History of place

Reflects the history of Earth: changes in geography, geology, climate and environments

The environmental template that biotas experience during their own unique evolutionary history

History of lineage

Series of changes that have occurred in characteristics of populations, species or higher taxa

Descendant lineages that share a common ancestor also share a history of lineage

Endemism, Provincialism, and Disjunction

Major kinds of distribution patterns:

Endemism: the occurrence of taxa with native distributions restricted to a particular geographic location (e.g., taxon X is endemic to location Y).
Endemism can be variable in scale from a small area (e.g., a species of fish that is endemic to a specific lake) to whole continents (e.g., endemic to Australia).

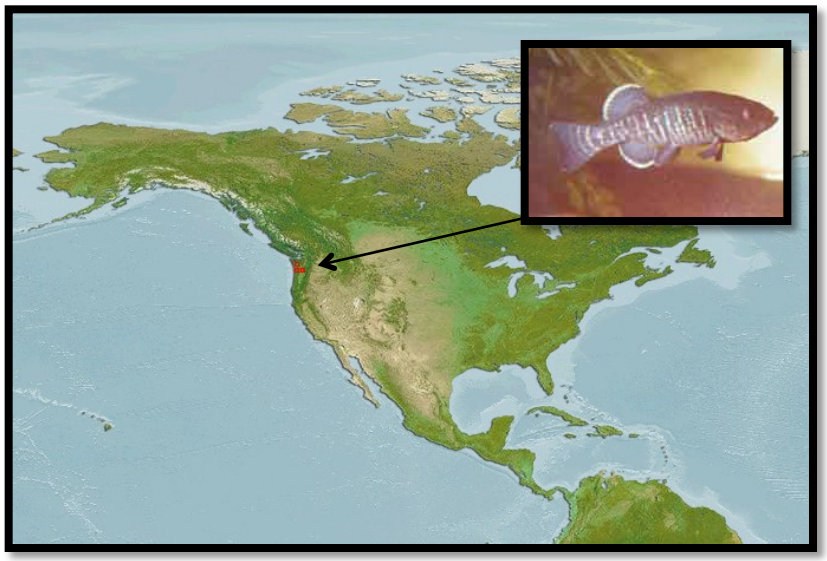
Provincialism: geographic overlap of endemism across multiple taxa.
Or, the delineation of geographic areas based on distinctive species assemblages.

Disjunction: two or more closely related taxa or populations occurring in geographically separated areas (and absent from an intervening area).

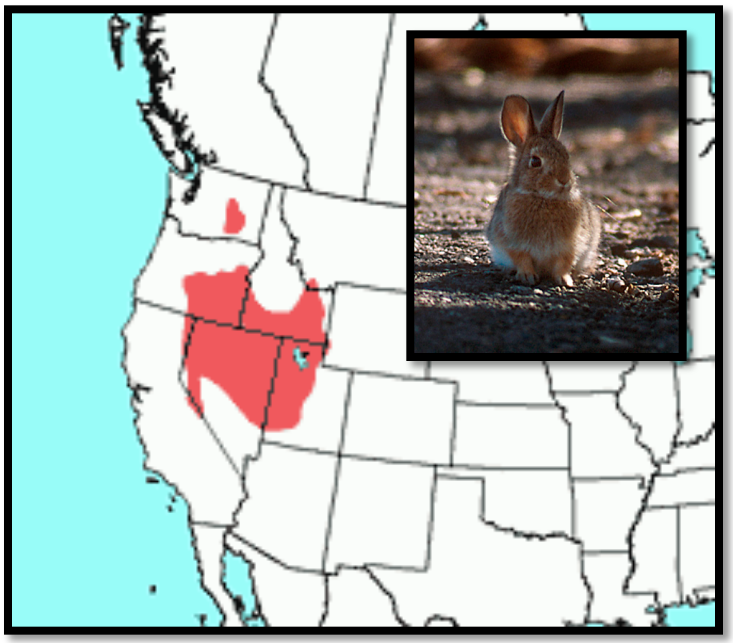
A species can be part of a *disjunct* distribution within its genus or family, can be *endemic* to a specific area, and along with other endemic taxa with similar distributions, can characterize *provincialism* for that area

* Think about how these terms and patterns apply to focal groups in your term paper

Endemism is applied across spatial scales



Olympic mudminnow (*Novumbra hubbsi*)



Pygmy rabbit (*Brachylagus idahoensis*)

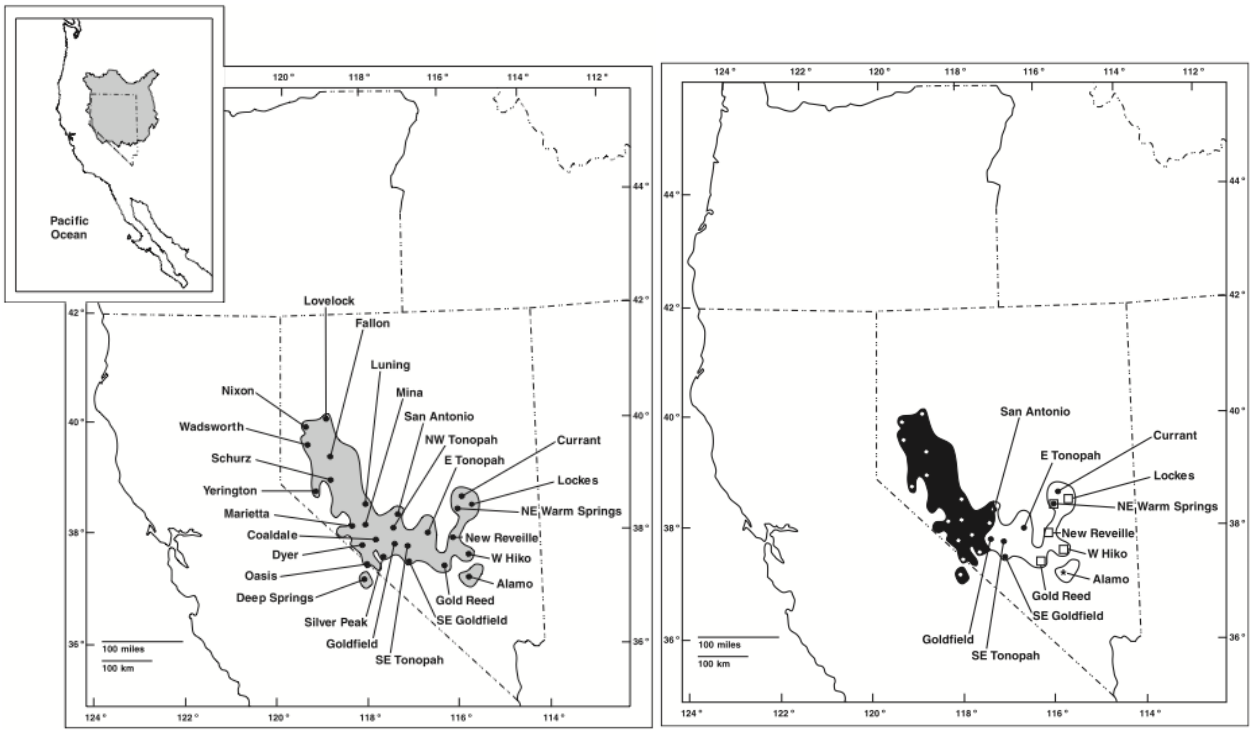
Olympic mudminnow is confined to coastal lowland wetlands around the Olympic Peninsula

Pygmy rabbit occurs throughout the Great Basin and neighbouring intermountain areas in sagebrush habitat with an isolated (disjunct) population in central Washington

Endemism can be hierarchical (or nested)

Kangaroo rats, kangaroo mice, and pocket mice (family: Heteromyidae) are endemic to southwestern North America, Central America, and extreme northwestern South America.

- → Within Heteromyidae, kangaroo mice (genus: *Microdipodops*) are endemic to the Great Basin Desert region in western North America
  - → Within *Microdipodops*, the pale kangaroo mouse (*M. pallidus*) is endemic to sandy habitats of the Lahontan Trough in south-central Nevada.
    - → Within *M. pallidus*, two separate mitochondrial DNA lineages are endemic to western and eastern portions of the range.

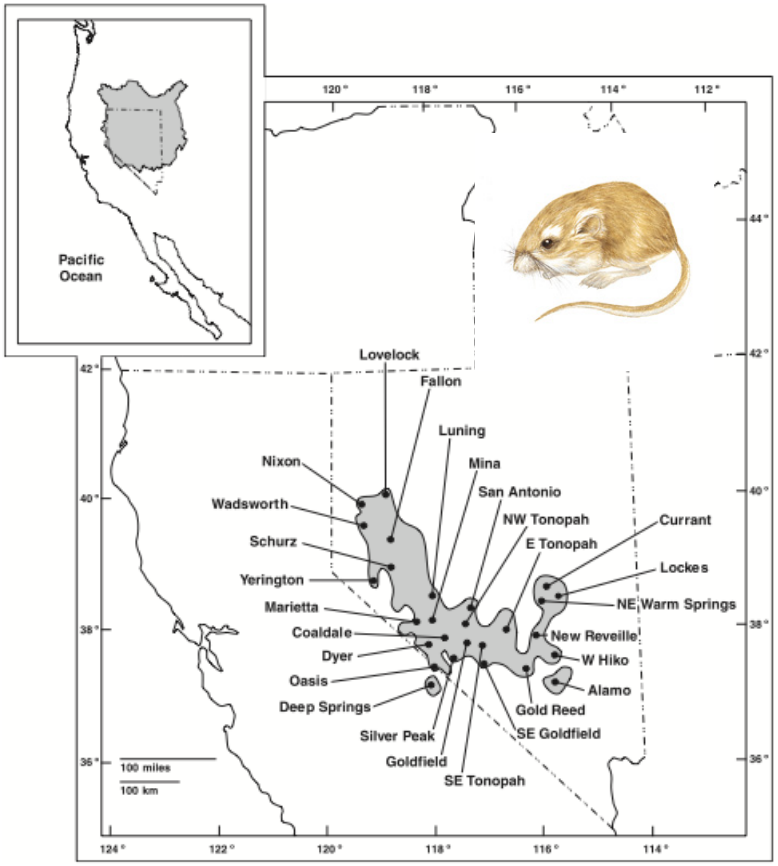


(Hafner *et al.* 2008)

Endemism

Endemics can be classified by their location of origin:

Autoendemics: evolved in an area within their current distribution.



Alloendemics: originated somewhere else, dispersed to their current locality and subsequently have gone extinct elsewhere. Also known as *relicts*.

Many alloendemics include species whose ranges shifted dramatically in response to Pleistocene climate change

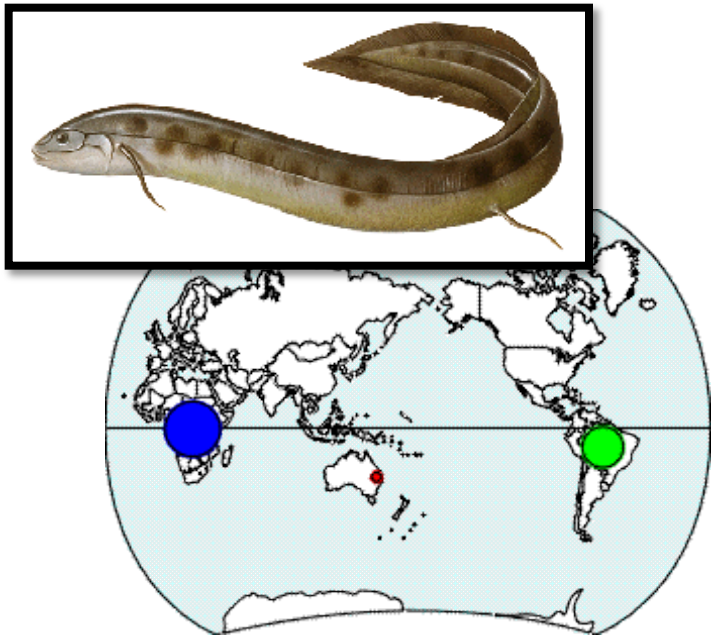
Endemism

Endemism can be related to long-term temporal patterns of diversity:

Taxonomic relicts: remnants of, at one time, a much more diverse taxon. (e.g., coelacanth, ginkgo)

Biogeographic relicts: taxa that at one time had much wider geographic distributions. (e.g., lungfish)

Ginkgo is native to eastern China, now planted across the world, the sole survivor of primitive conifers that was diverse in Mesozoic



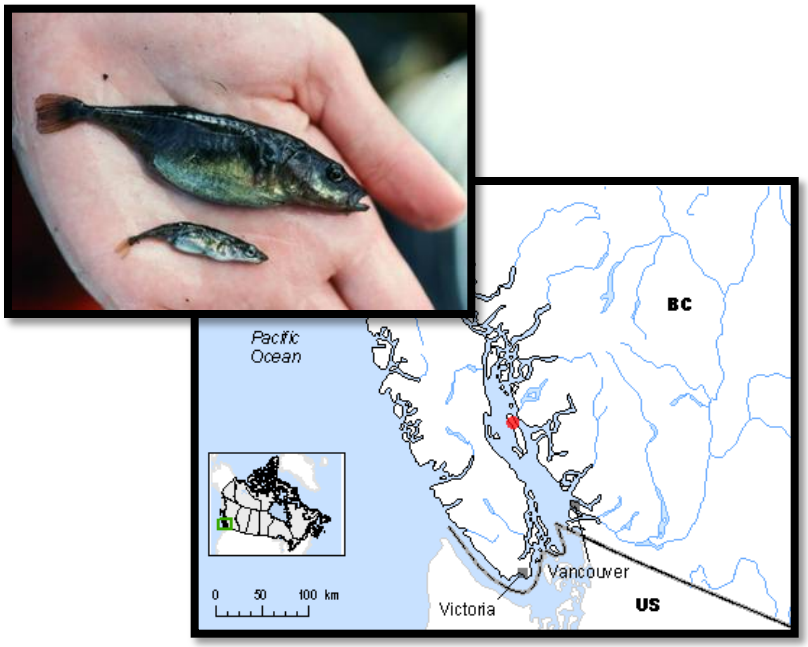
Fossil record of lungfish suggests prior cosmopolitan distribution, but lineages went extinct following breakup of continents (currently 6 extant species in 3 families)

Coelacanth occurs in deep waters of tropical Indian Ocean but was once a diverse group found in freshwater, oceans and shallow seas during Paleozoic

Endemism

Endemism may have originated recently or long ago:

Neoendemics: endemics of recent origin (e.g., stickleback benthic and limnetic species pairs)



Paleoendemics: endemics that originated long ago (e.g., Olympic mudminnow)

Endemism

"Any overview of endemism should recognize the complex interweaving of biotic and abiotic processes that have occurred throughout the histories of both *lineage* and *place* to determine why a taxon exists where it does today."

- Lomolino et al 2017

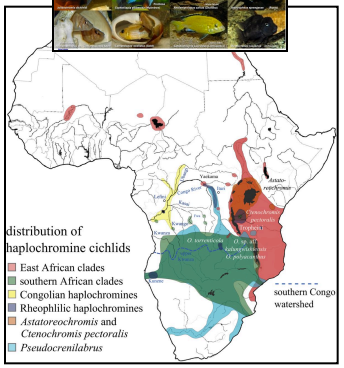
Hoatzin

a monotypic family

Ovenbirds

65 genera; 300 species

African cichlids



>1400 species in 12 lakes

Red-finned blue-eye

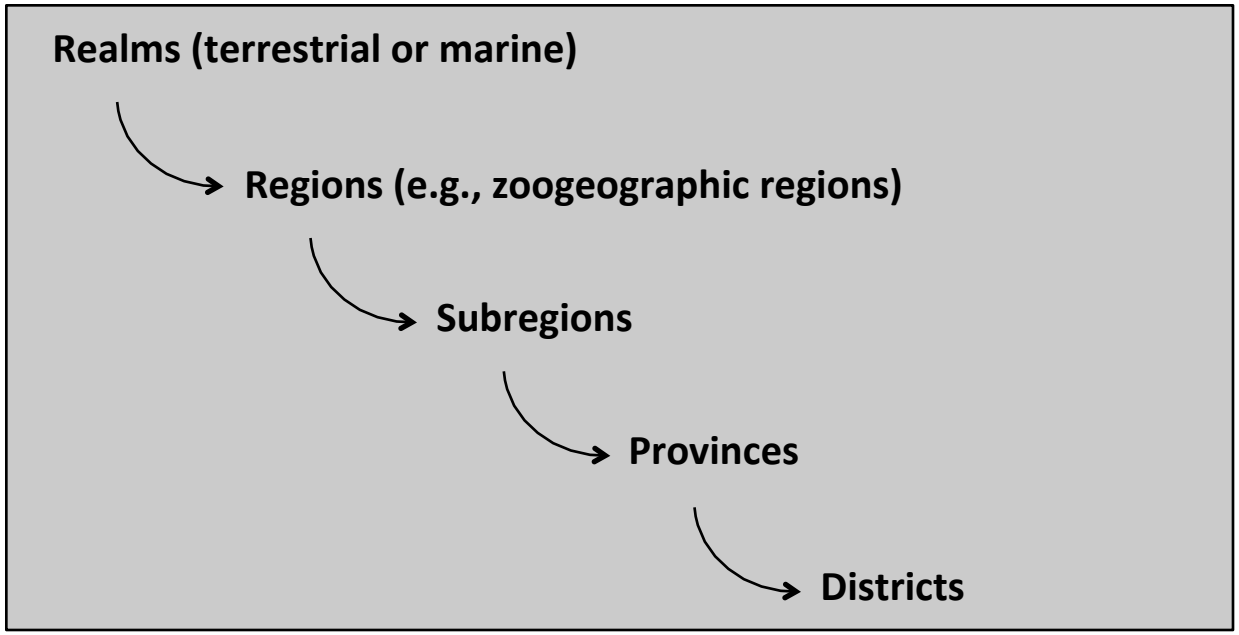
a monotypic genus

Provincialism

Endemic taxa in different groups of organisms tend not to be randomly distributed, but rather tend to co-occur in specific areas.

Provincialism: geographic overlap of endemism across multiple taxa.
Or, the delineation of geographic areas with particular biotic characteristics based on distinctiveness of species assemblages.

Generally, provinces fit into a hierarchy of areas of endemism:



Provincialism

C*oncordance* suggests common historical events have shaped biotas within a given area (e.g., geological, climatological or oceanographic events).

Example: 91% of Australian mammal species are endemic to Australia (compared to 19% for the holarctic).

Long term isolation of Australia from other landmasses has likely driven high endemism.

Provincialism

C*oncordance* suggests common historical events have shaped biotas within a given area (e.g., geological, climatological or oceanographic events).

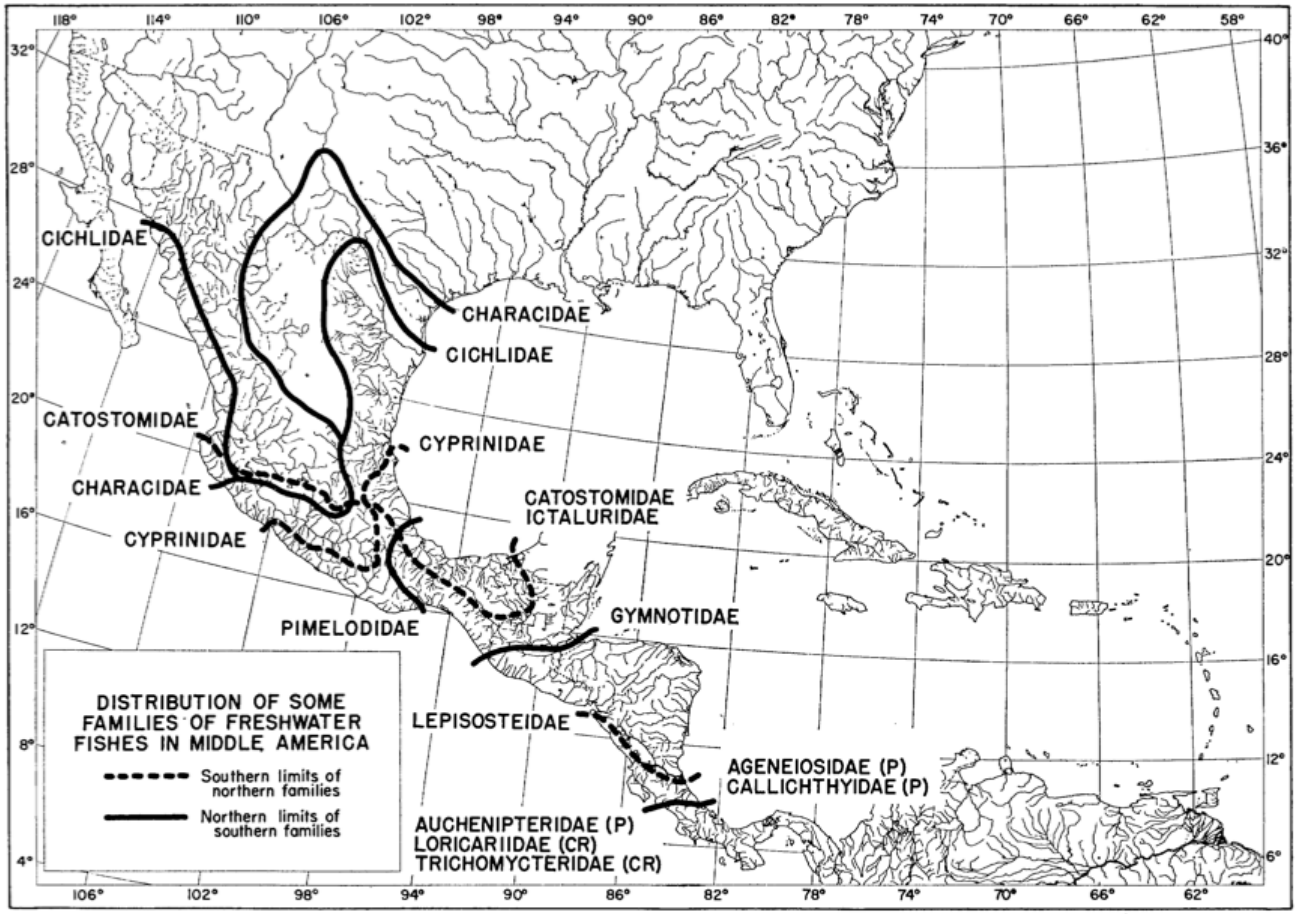
Example: High degree of endemism in the North American Great Basin.

Great Basin has large mountainous regions and high elevation "sky islands" surrounded by seas of desert.

Due to its higher latitude and elevation – it is a cold desert, or shrub-steppe environment

Provincialism

Provinces may be separated by *biogeographic lines*

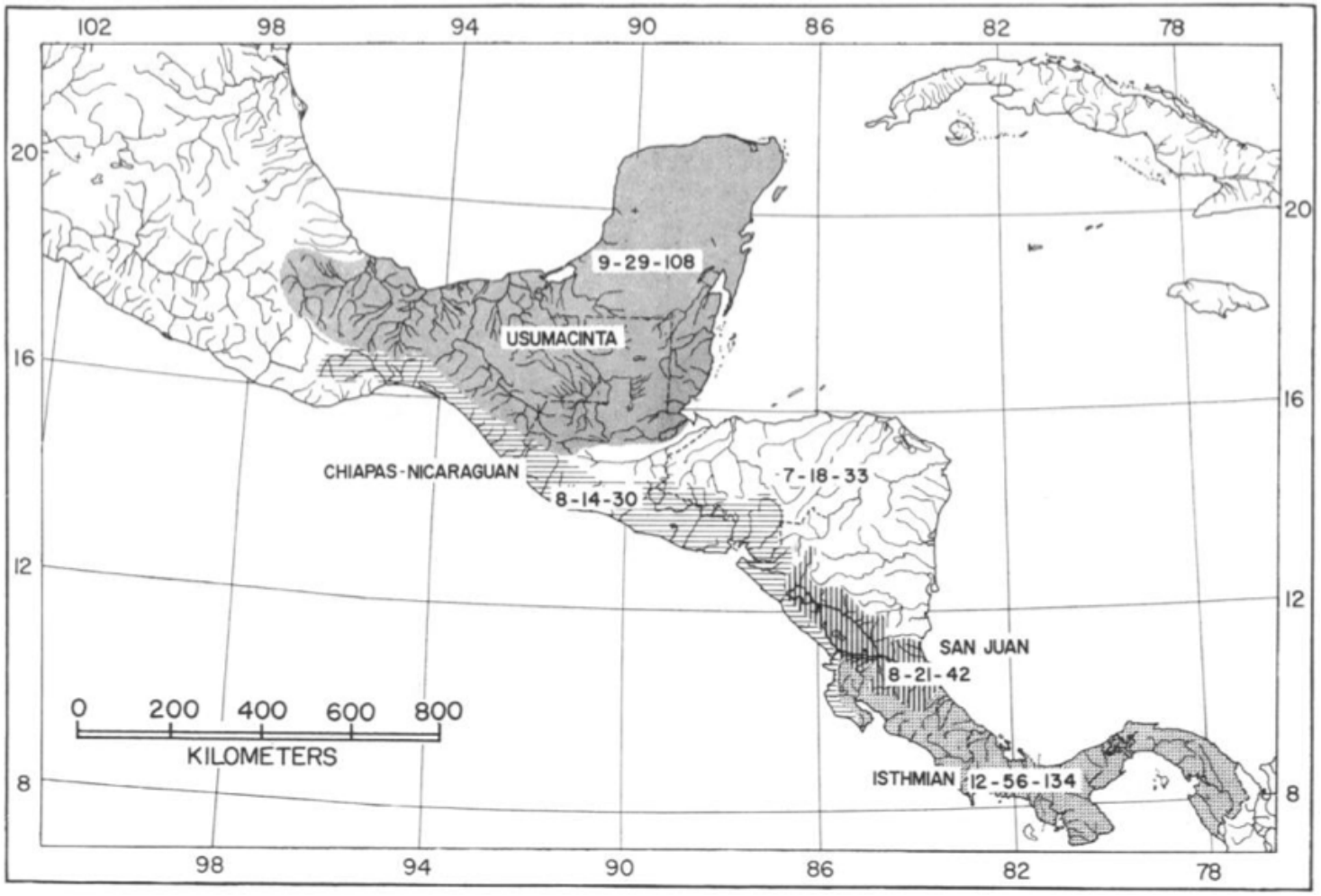


Distribution limits of freshwater fish families of North American (dashed) and South American (solid) origin. Two species of obligate freshwater fishes of South America have reached the US; North American forms extend no farther south than Costa Rica

(from Miller 1966)

Provincialism

Provinces may be separated by *biogeographic lines*

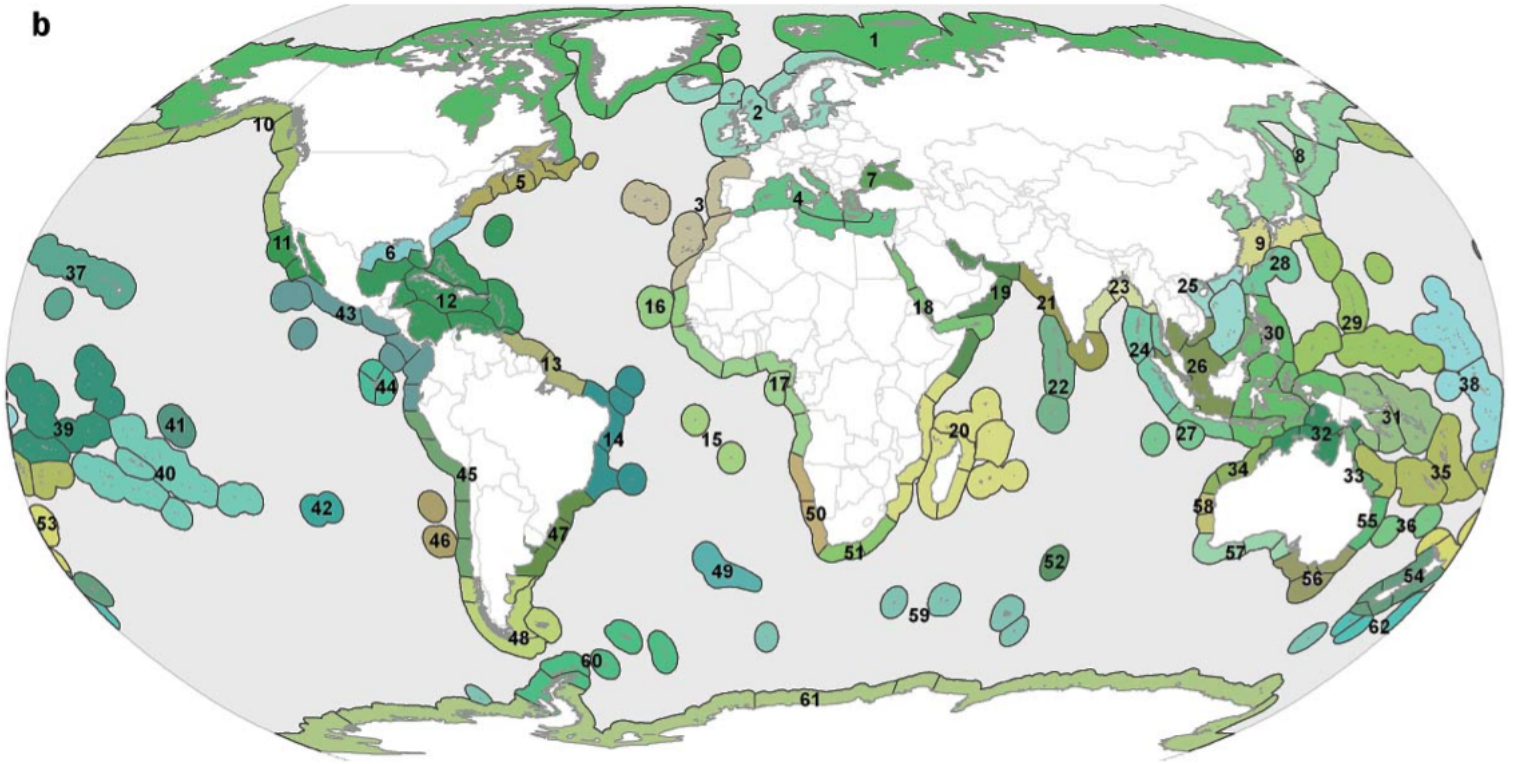


Freshwater fish provinces of Middle America, showing numbers of families, genera and species of freshwater fishes in each area (from Miller 1966).

Provincialism

Marine provincialism is generally less well developed than terrestrial provincialism

Higher connectivity among marine habitats, plus high dispersal potential for many marine organisms during particular life stages (e.g., planktonic larvae in fish and invertebrates).



Spalding *et al.* (2007) classified the world's continental shelves into a nested system of 12 realms (colours), 62 provinces (numbers), and 232 ecoregions.

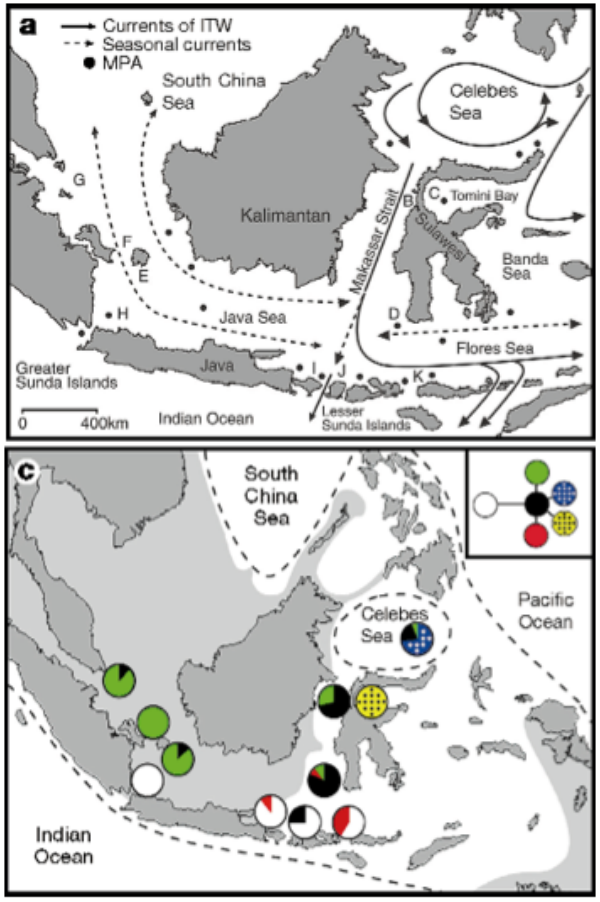
Provincialism

Marine provincialism is generally less well developed than terrestrial provincialism

Biogeography

A marine Wallace's line?

As most coral reef organisms with a pelagic larval phase are presumed to be readily dispersed between distant populations, sea-surface current patterns should be crucial for predicting ecological and genetic connections among threatened reef populations[1]. Here we investigate this idea by examining variations in the genetic structuring of populations of the mantis shrimp *Haptosquilla pulchella* taken from 11 reef systems in Indonesia, in which a series of 36 protected areas[2] are presumed to be connected by strong ocean currents. Our results reveal instead that there is a strong regional genetic differentiation that mirrors the separation of ocean basins during the Pleistocene low-sea-level stands, indicating that ecological connections are rare across distances as short as 300–400 km and that biogeographic history also influences contemporary connectivity between reef ecosystems.



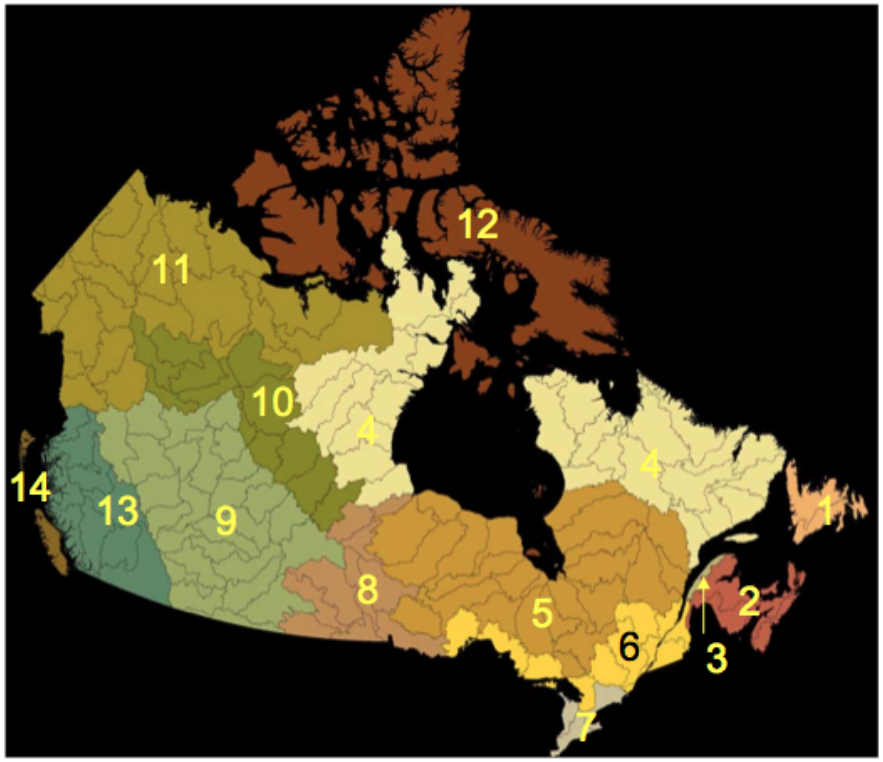
(Barber *et al.* 2000)

Mantis shrimp – *Haptosquilla pulchella*

http://theoatmeal.com/comics/mantis_shrimp

Provincialism

Provinces may be defined by geographic features and patterns of diversity



1. Insular Newfoundland
2. Maritimes
3. Gaspe
4. Northern Hudson Bay and Labrador
5. Southern Hudson Bay, James Bay, Northern Great Lakes headwaters
6. Superior, Northern Huron and St. Lawrence
7. Southwestern Ontario
8. Lake Winnipeg drainages
9. Western Prairies
10. McConnell Corridor
11. Northwestern Pacific and Western Arctic
12. Arctic Archipelago
13. Pacific Coast
14. Pacific Islands

Fish faunal regions of Canada based on similarity of species between watersheds

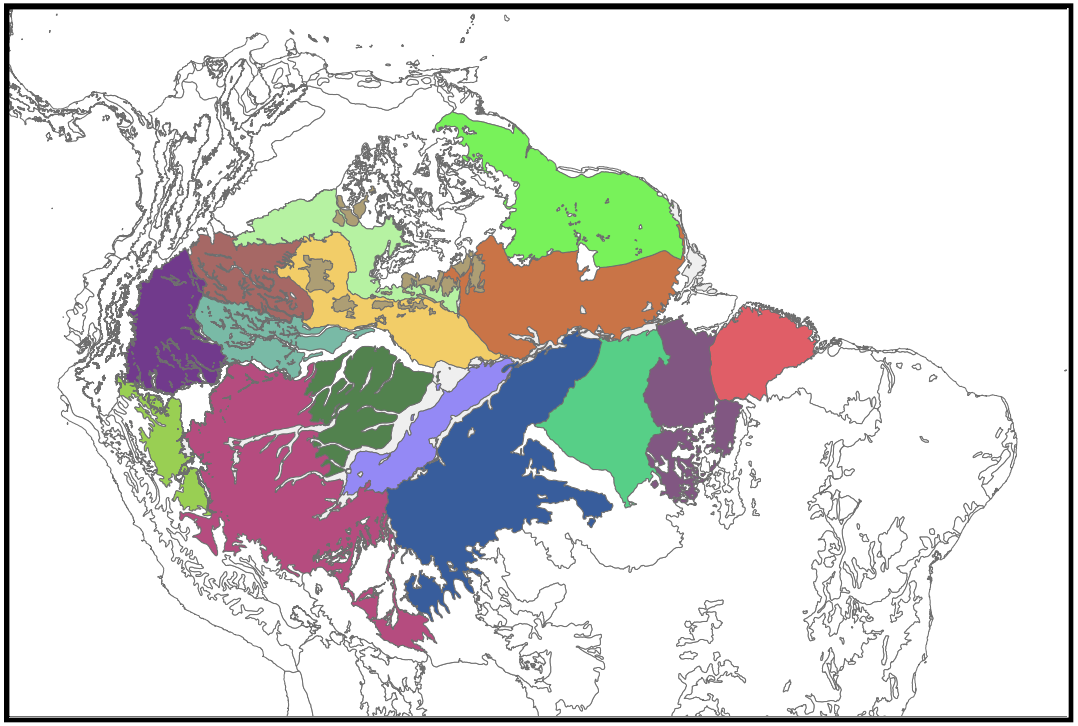
You can search and download interactive maps for freshwater ecoregions of the world (feow)

http://feow.org/maps/biodiversity

Provincialism

Provinces may be defined by geographic features and patterns of diversity

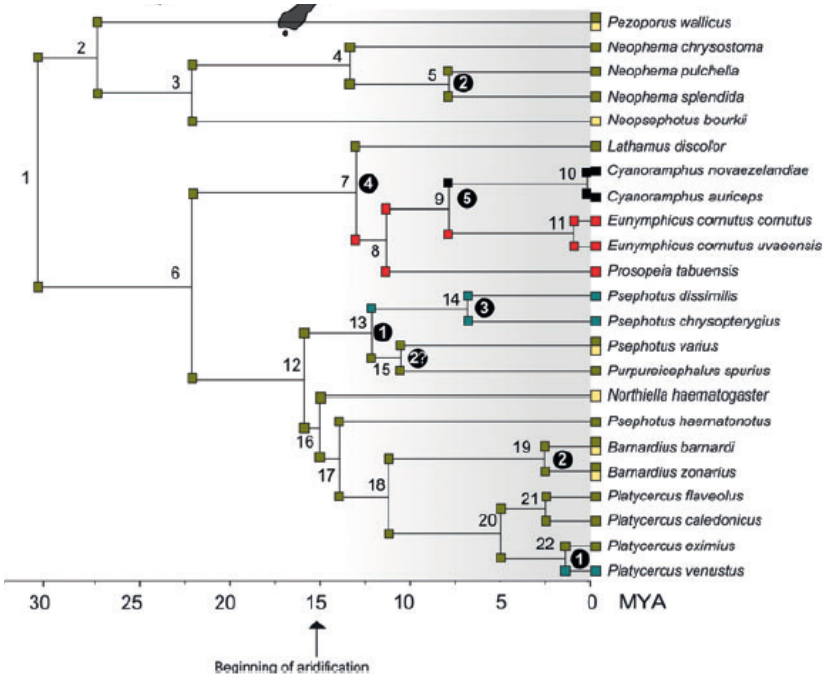
Recall Amazonian ecoregions, which are divided by large river systems and also delineate range limits across species groups



Relating endemism/provincialism to historical events

We can describe endemism and provincialism at various spatial scales (geographic, regional or local)

Biogeographic provinces shown in colours and numbers indicate hypothesized vicariance and dispersal events



Diversification of platycercine parrots is linked to aridification of Australia, through habitat changes, fragmentation and vicariance of non-arid habitats. Small oceanic islands acted as stepping stones for colonization

Relating endemism/provincialism: Important points to consider

Distributional congruence can reflect a shared history of diversification

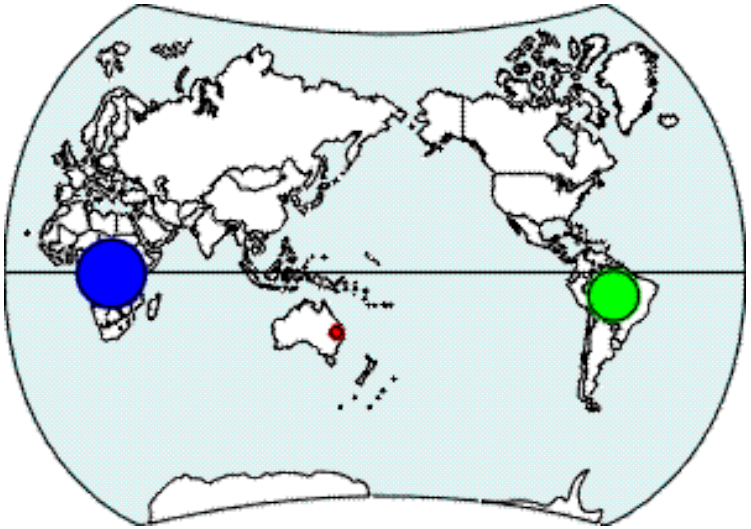
- Boundaries of provinces, determined independently for different groups of taxa tend to coincide

- Between areas with provincialism, we expect to see rapid turnover of many taxa at range boundaries between regions

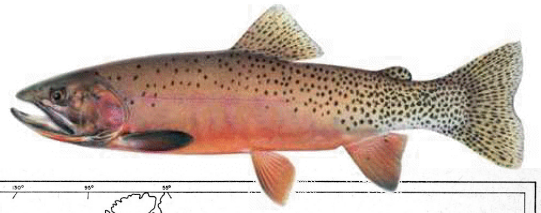
Disjunction

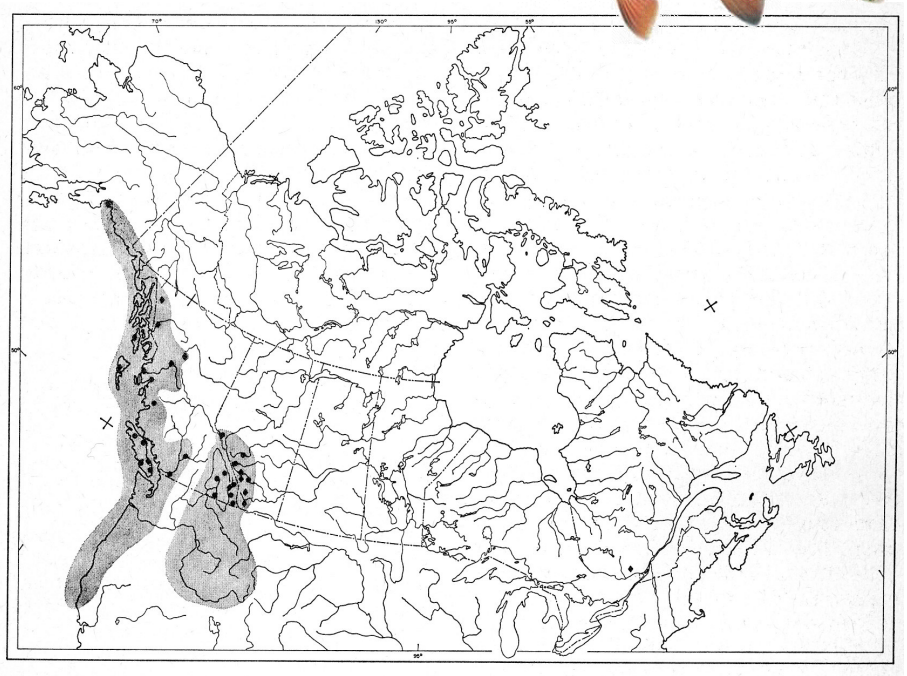
Disjunctions can occur at any spatial scale

e.g., Lepidosireniformes (lungfishes) in South America, Africa, and Australia.



e.g., Cutthroat trout in western North America.



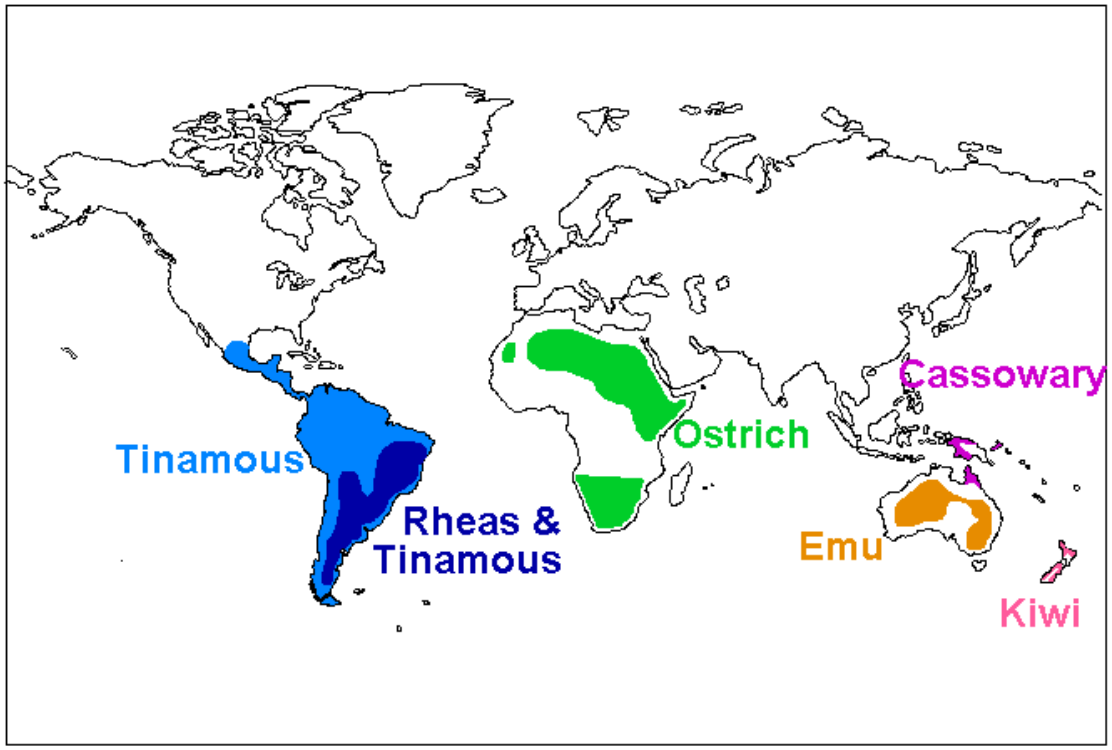


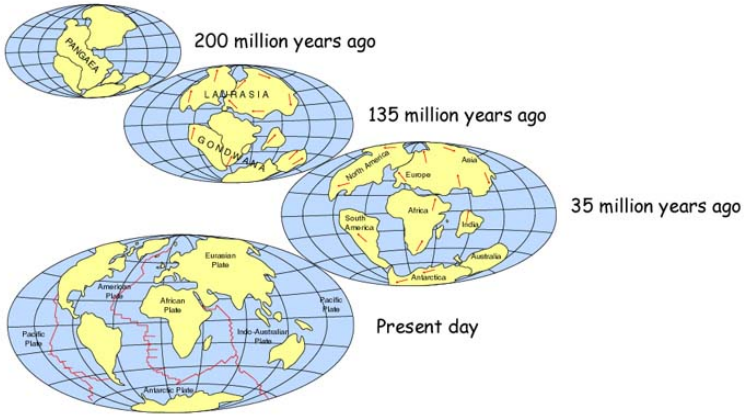
Disjunction

Three potential causes of disjunction:

1. **Vicariance** – Disjunction by tectonics – Ancestors ocurred on pieces of Earth's crust that were once united but have subsequently split and drifted apart

Flightless birds



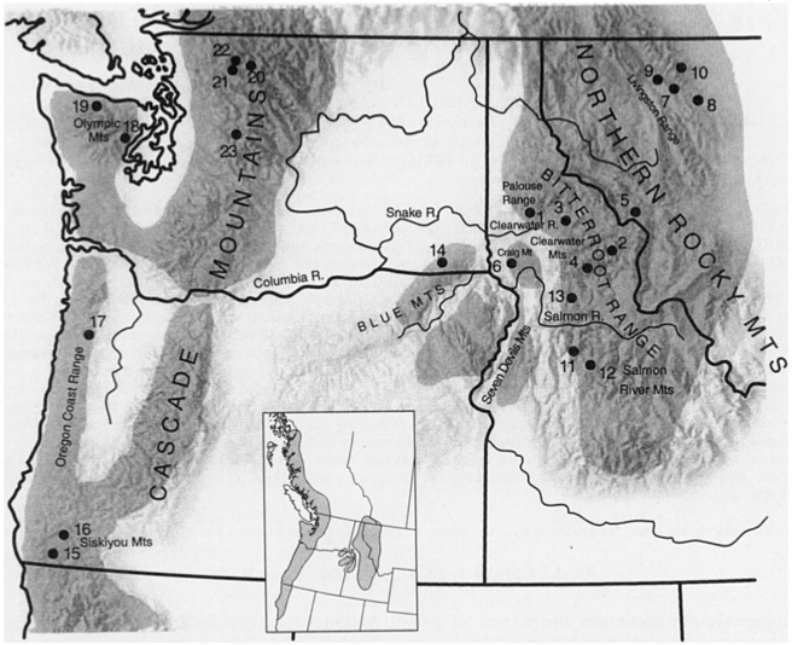


Disjunction

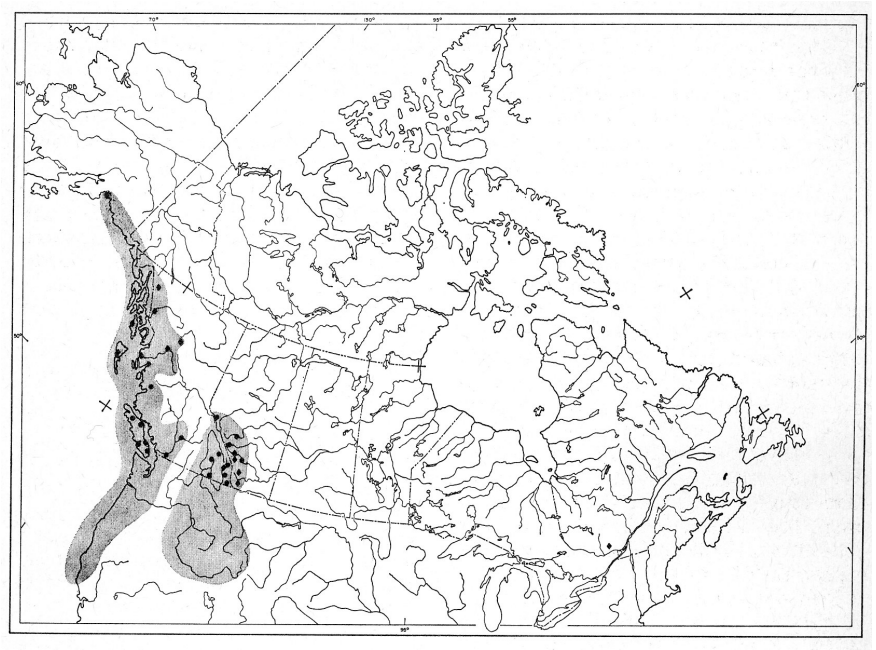
Three potential causes of disjunction:

2. **Extinctions** – Ancestors were once broadly distributed in connected populations, but populations in intervening areas have gone extinct, leaving isolate populations

Tailed frog (*Ascaphus truei*)



Cutthroat trout (*Oncorhynchus clarkii*)



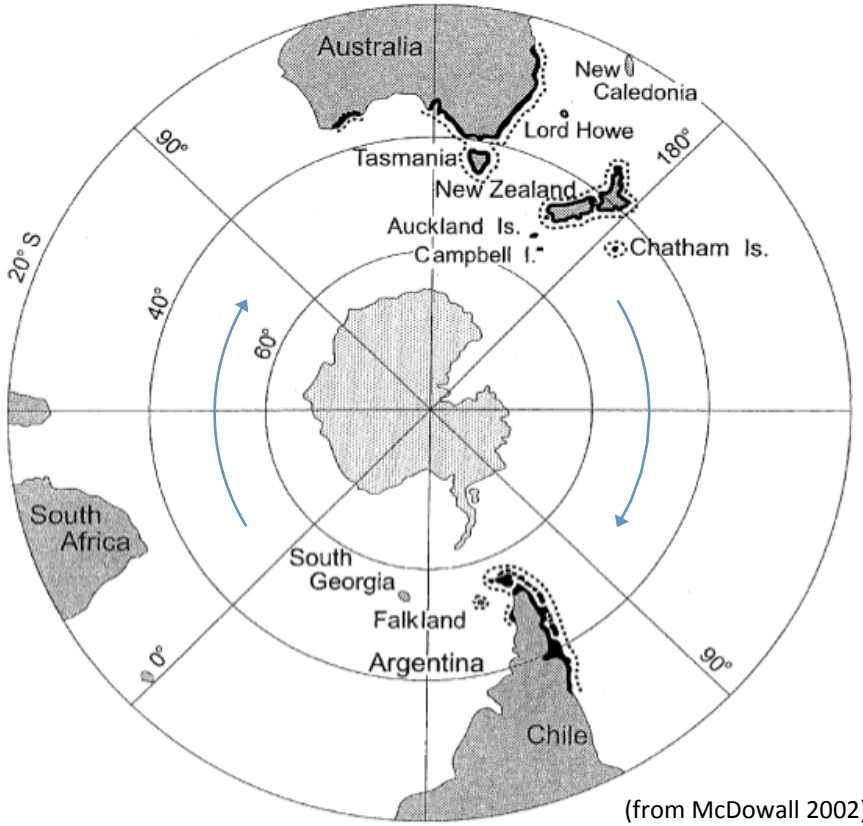
Both taxa associated with high-gradient streams in mesic forests.
This habitat disappeared with climate change following glacial retreat (now xeric).

Disjunction

Three potential causes of disjunction:

3. **Long distance dispersal** – at least one lineage dispersed a long distance from the area where its ancestor(s) originally occurred

Galaxias, aka inanga (*Galaxias spp.*)



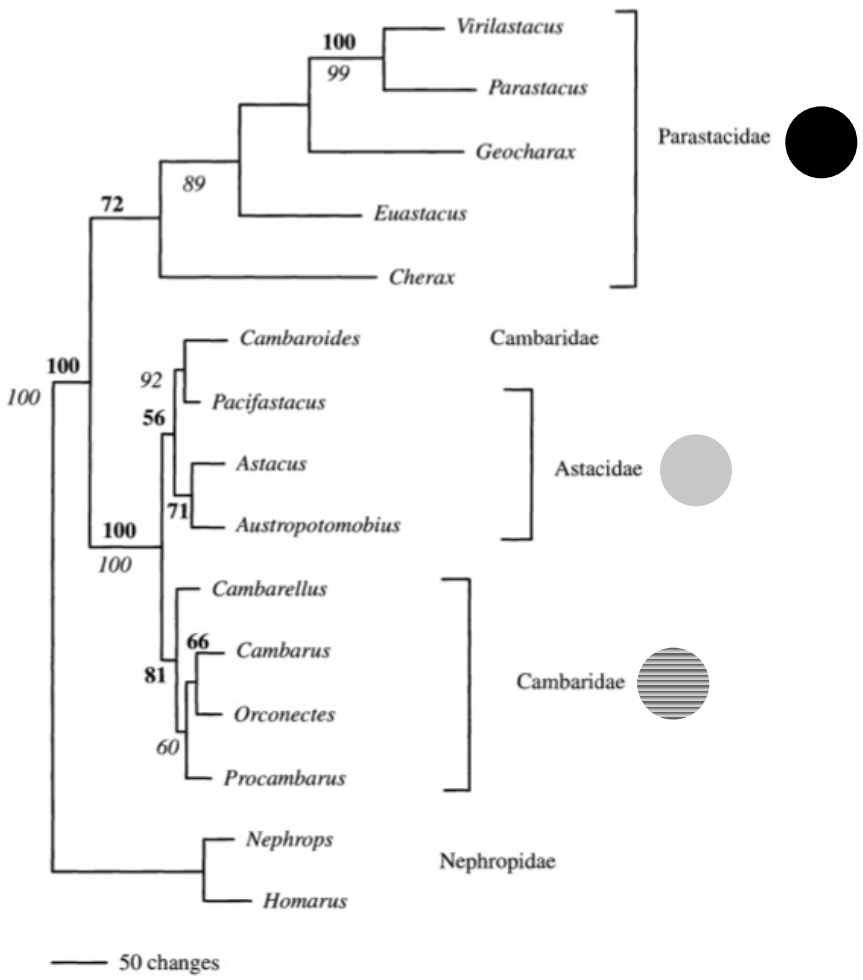
(from McDowall 2002)

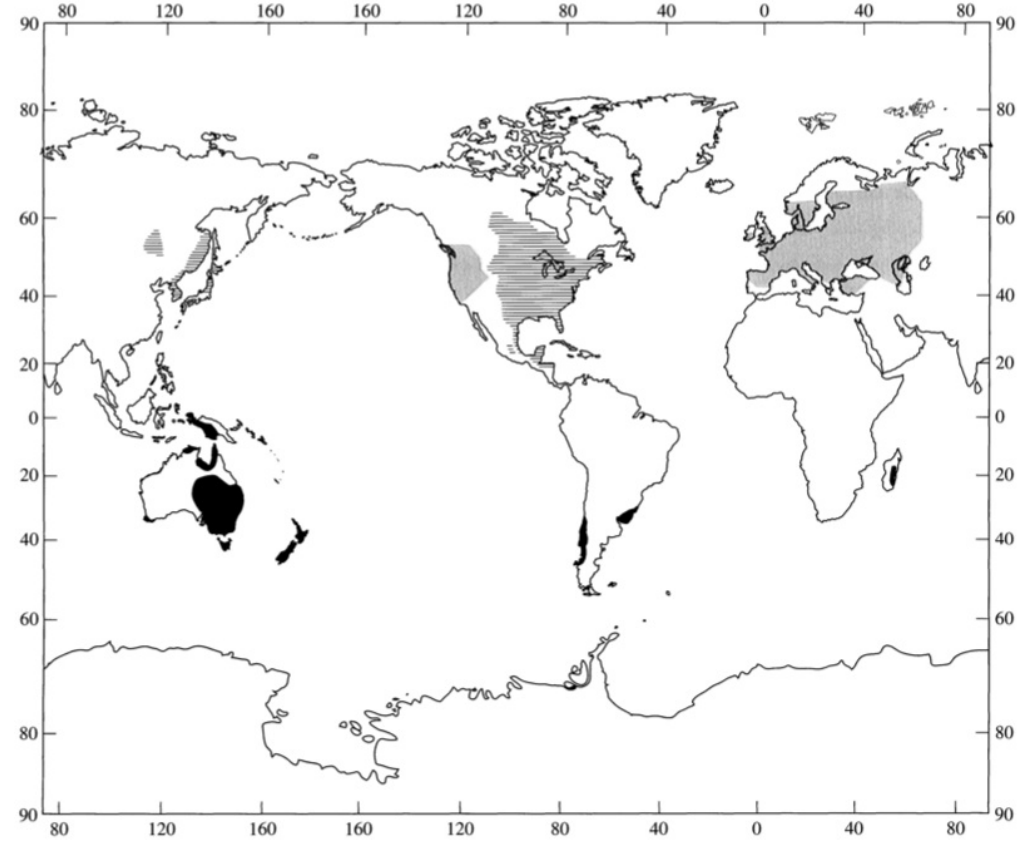
Origin likely in New Zealand 23 mya.

Disjunction

The notion of disjunction relies on the idea that taxa are closely related.

e.g., Freshwater crayfish (from Crandall *et al.* 2000):





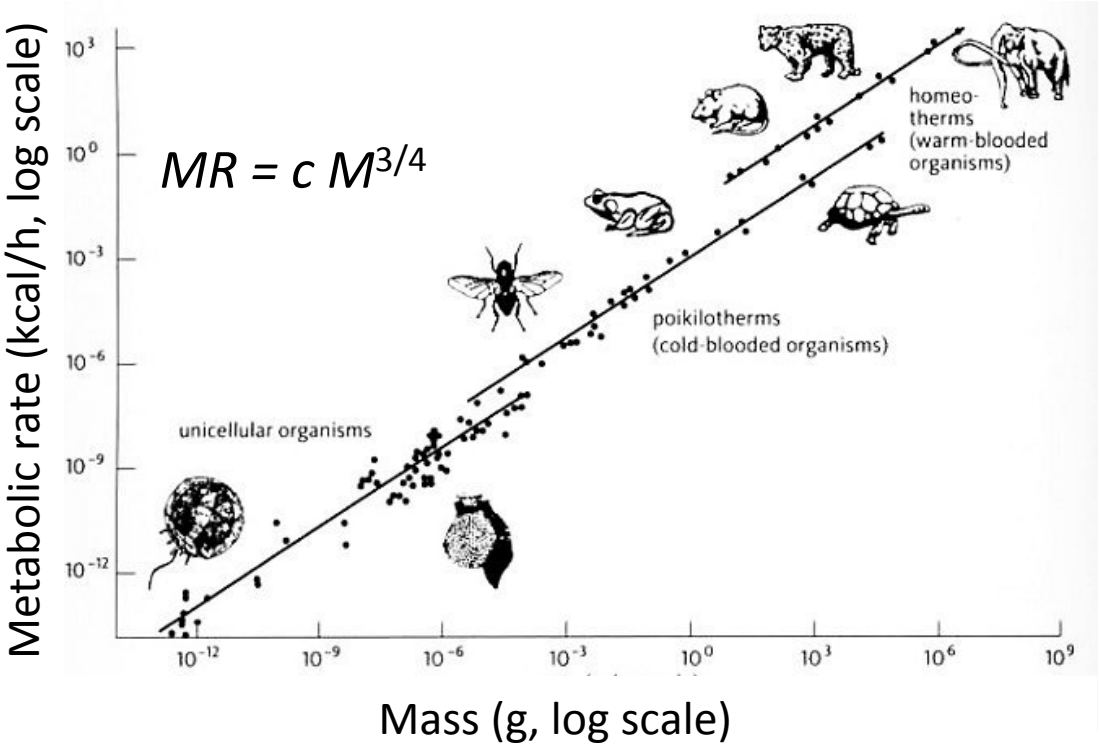
Why do we care about endemic species?

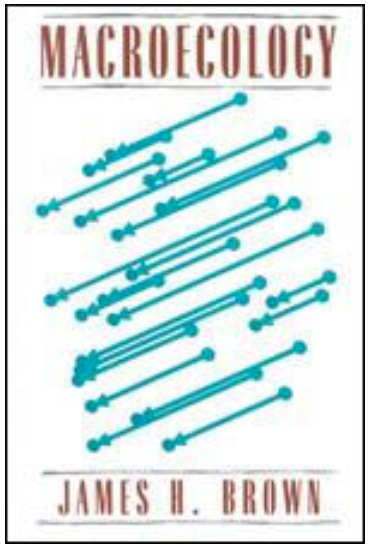
Norman Myers et al. (2000) Biodiversity hotspots for conservation priorities. *Nature*

*"Conservationists are far from able to assist all species under threat, if only for lack of funding. This places a premium on priorities: how can we support the most species at the least cost? One way is to identify 'biodiversity hotspots' **where exceptional concentrations of endemic species** are undergoing exceptional loss of habitat."*

Figure from Myers *et al*. 2000, *Nature*

Why do we care about endemic species?





James Brown - *Macroecology*

Brown has put forward some of the most revolutionary hypotheses in contemporary ecology, including metabolic scaling theory, and the **abundance-distribution hypothesis**

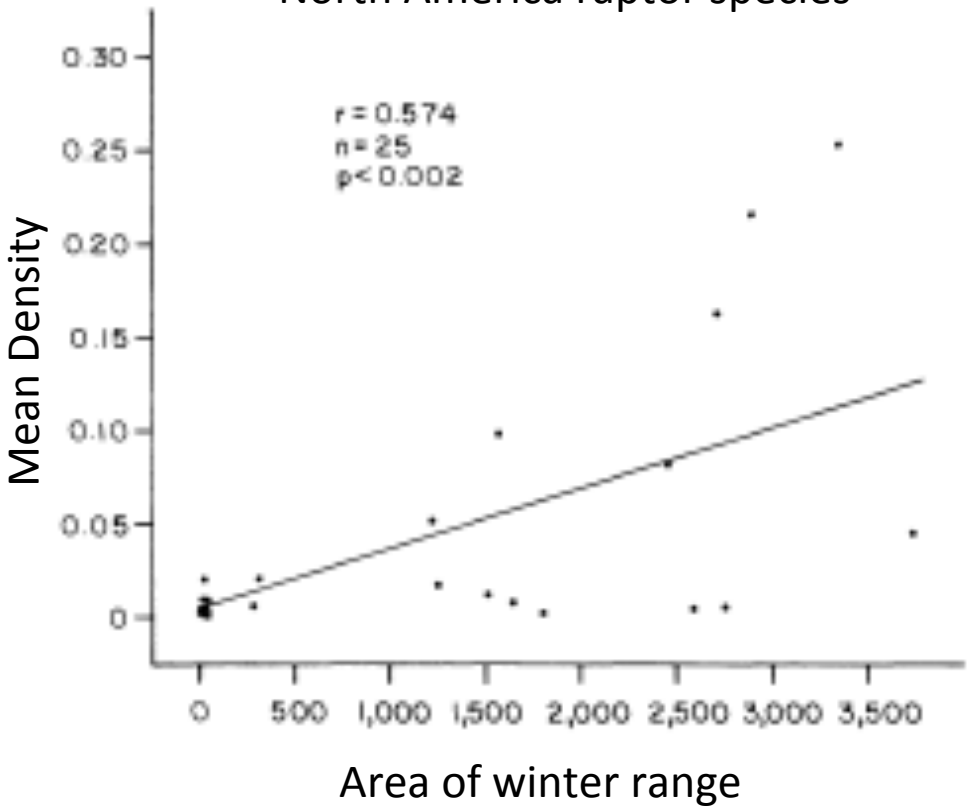
Why do we care about endemic species?

Brown's Abundance – Distribution hypothesis: There is a positive correlation within most taxonomic groups between species' abundance and distribution

Species with broad geographic distributions tend to be numerically abundant within their range

Predicts that range-restricted species are also more likely to be numerically rare

North America raptor species



Example figure from Brown 1984

Why do we care about endemic species?

Shows a correlation between elevational range and geographic range size

Range-restricted species are also more likely to elevational specialists

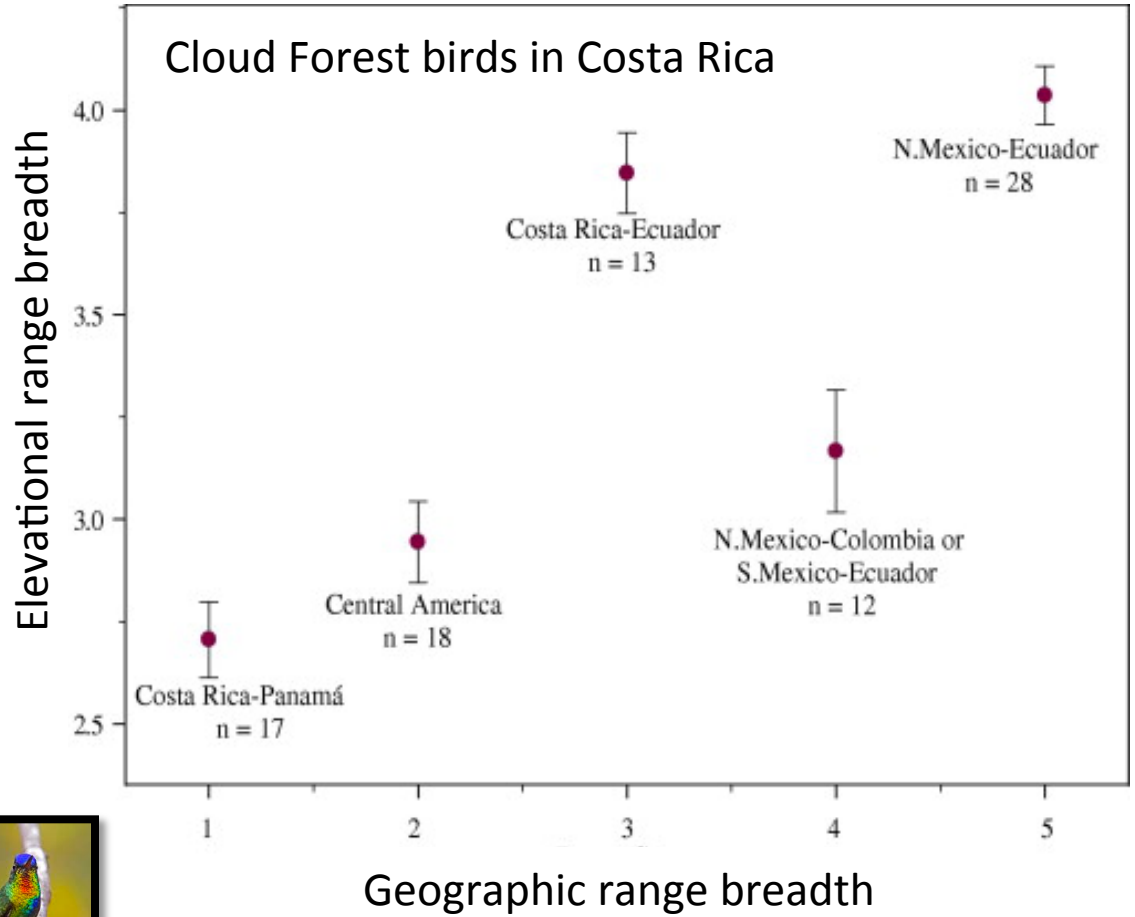


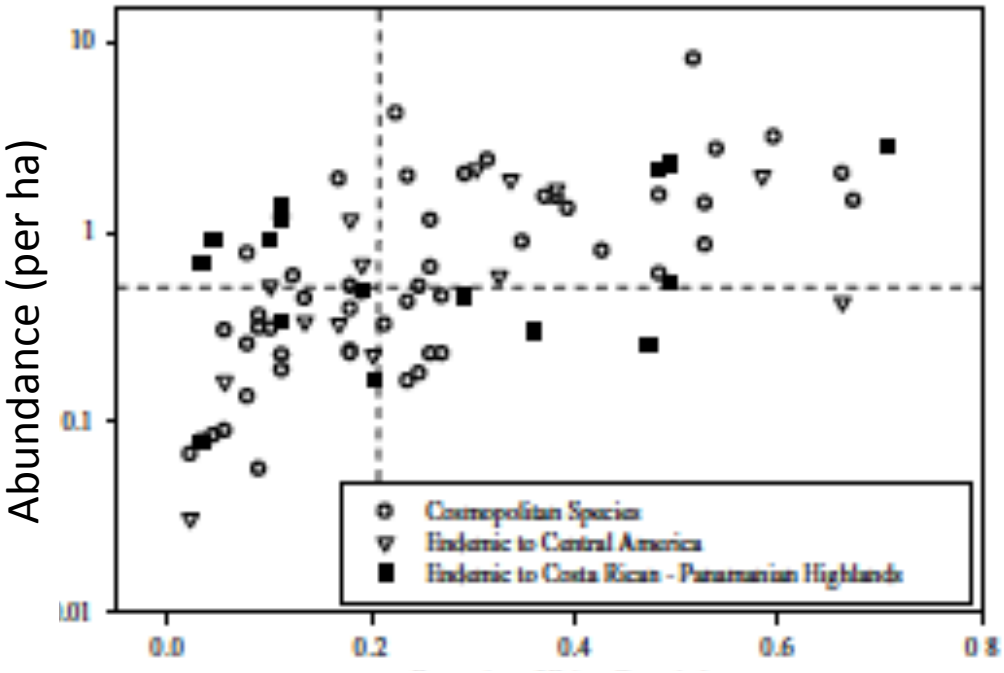
Figure from Jankowski & Rabenold 2007

Why do we care about endemic species?

Shows a correlation between numerical abundance, habitat specificity and geographic range size

Elevational specialists are more likely to be numerically rare

Cloud Forest birds in Costa Rica



Proportion of points occupied along elevational gradient

Cosmopolitan species ○

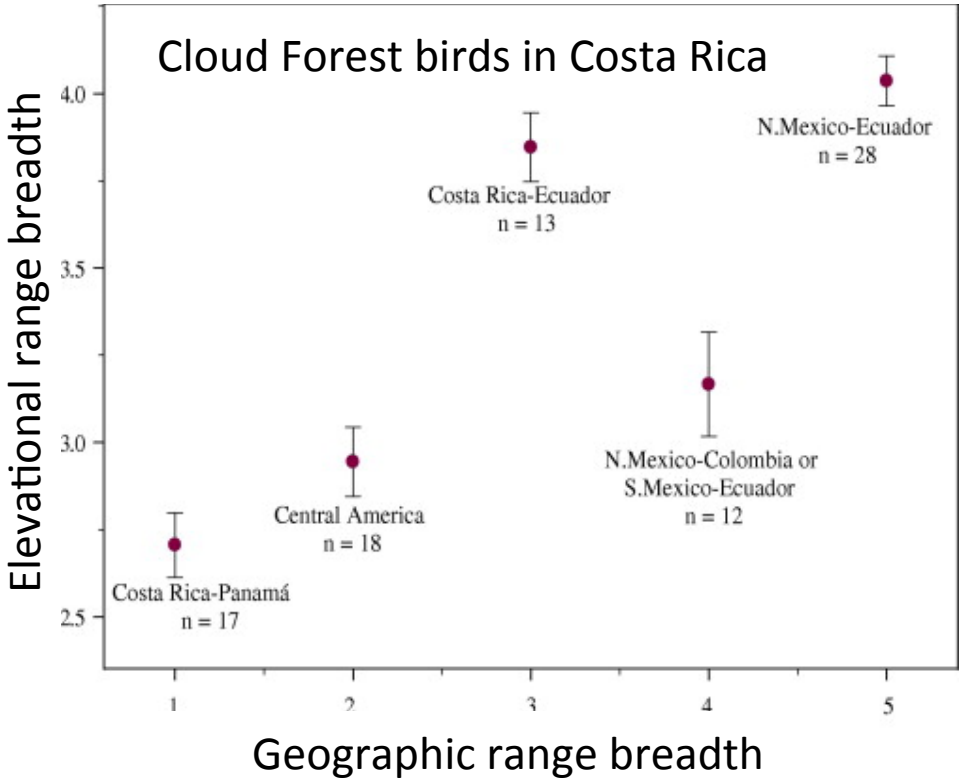
Endemic to Central America △

Endemic to Costa Rica-Panama highlands ■

Figure from Jankowski & Rabenold 2007

Why do we care about endemic species?

- Brown's Hypothesis: rarity is correlated across spatial scales



Could lead to a syndrome of rarity:

1) Restricted geographic distributions

2) Habitat specialists within the range

3) Numerically low abundance

Three "strikes" increase a species' risk of extinction

Figure from Jankowski & Rabenold 2007

Endemism, Provincialism, and Disjunction

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Your thoughts on whether communities can (or should) be defined…for Friday

Ricklefs (2008) quotes Lawton (1999) to emphasizes his perspective on the disintegration of the ecological community: "*the* major weakness of traditional community ecology, and why it has so conspicuously failed to come up with many patterns, rules, and workable continent theory, is its overwhelming emphasis on localness."

What is meant by "localness" and what additional factors that influence community composition are excluded with this view?

How can local and regional communities be viewed from a "vertical perspective" and "horizontal perspective"?

How is it useful to observe "communities" as identifiable units? What do you think is the most useful definition of the ecological community?