Floristics

Banksia coccinea - Australia

Historical Biogeography

"What lives where and why?"

- Historical biogeography is the flipside to ecological biogeography
- Most of its practitioners are not geographers but systematists specializing on specific groups of organisms

Three phases of historical biogeography are usually seen:

1. Descriptive — distributions and areas (floristic and faunistic biogeography)

Historical Biogeography

"What lives where and why?"

- Historical biogeography is the flipside to ecological biogeography
- Most of its practitioners are not geographers but systematists specializing on specific groups of organisms

Three phases of historical biogeography are usually seen:

2. Narrative — using historical (geological and evolutionary) events and *ad hoc* assumptions as a basis for explaining a given distribution pattern (including dispersal biogeography)

Historical Biogeography

"What lives where and why?"

- Historical biogeography is the flipside to ecological biogeography
- Most of its practitioners are not geographers but systematists specializing on specific groups of organisms

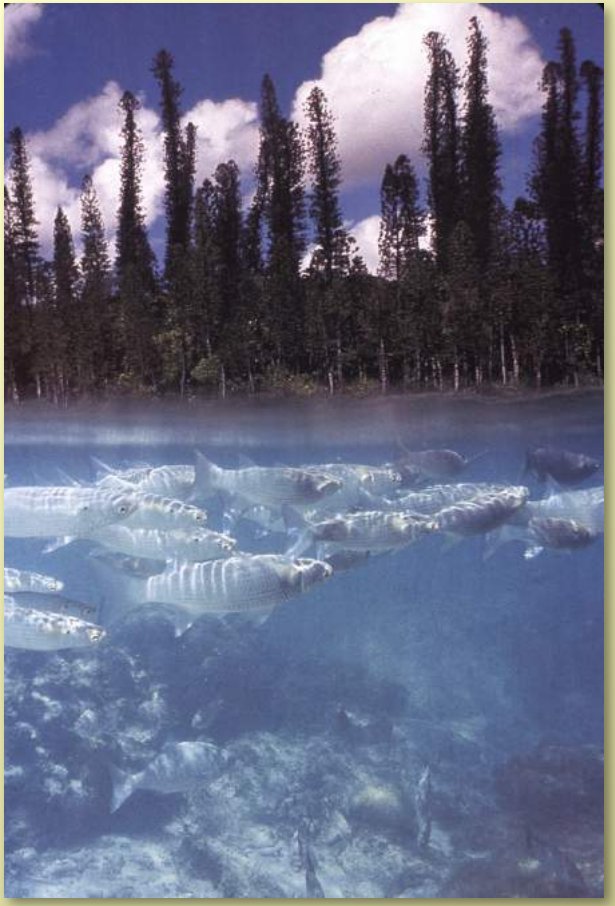
Three phases of historical biogeography are usually seen:

3. Analytical — comparison of the patterns of relationships of different groups of organisms occupying similar areas to find common biogeographic patterns
    - vicariance biogeography
    - cladistic biogeography
    - phylogenetic biogeography

Floristic Biogeography

Basic to the study of floristics is knowledge of the geographic distribution of organisms

- Geographic distributions are limited
- No species completely cosmopolitan
- Most species and genera, and even families and orders are restricted in distribution



Amborella trichopoda is endemic to New Caledonia

Floristic Biogeography

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White spruce is endemic to boreal forest of North America; *Picea* (spruce genus) is restricted to the North Hemisphere

Floristic Biogeography

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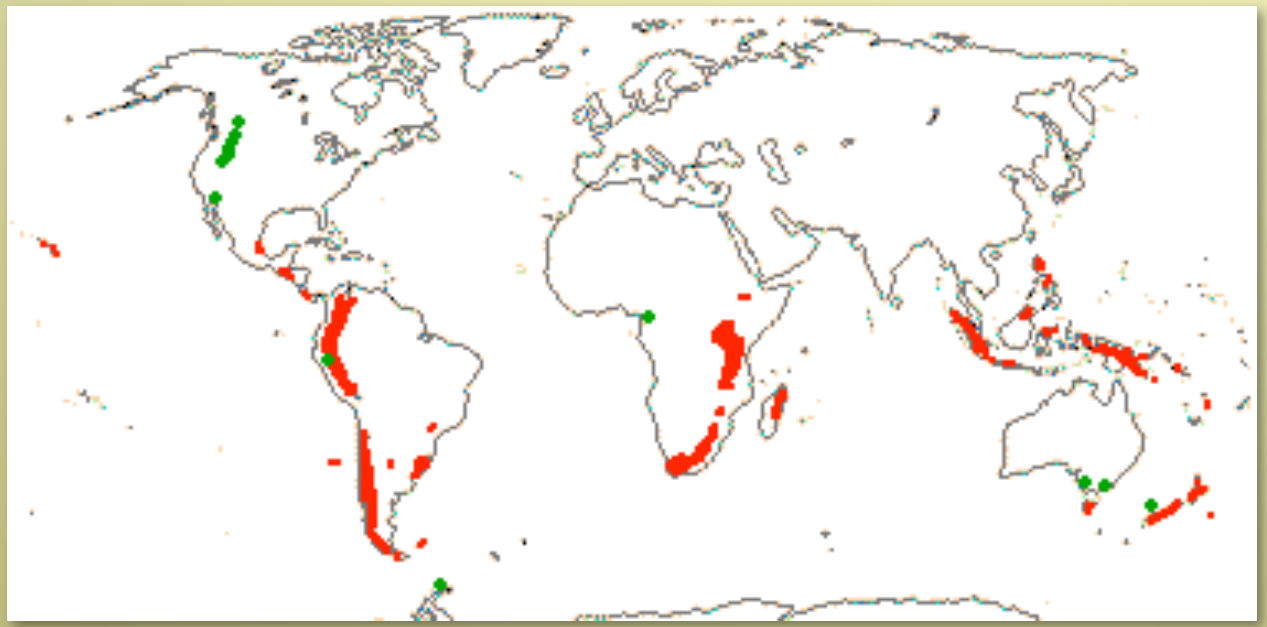

Gunnera (Gunneraceae) has a wider but still patchy distribution (Hawaiian species here)

Limits to Distributions

- **climatic**: temperature, precipitation, seasonality
- **topographic**: mountains, oceans
- **habitat**: soil, pH, water availability, sun vs. shade
- **biotic**: competition, predation, coevolution
- **history**: age, dispersal, sundering, speciation

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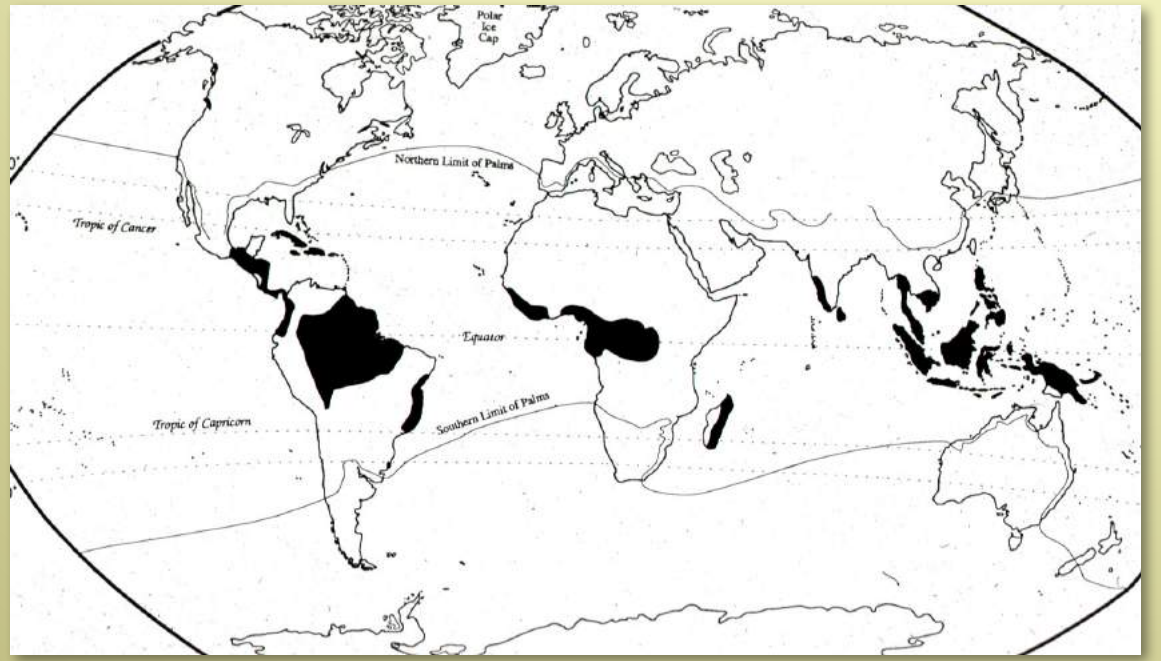

Palm family is limited by severe cold temps due to their single terminal bud at end of the stem

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Climate but also topography limits the extent of coniferous boreal forest species

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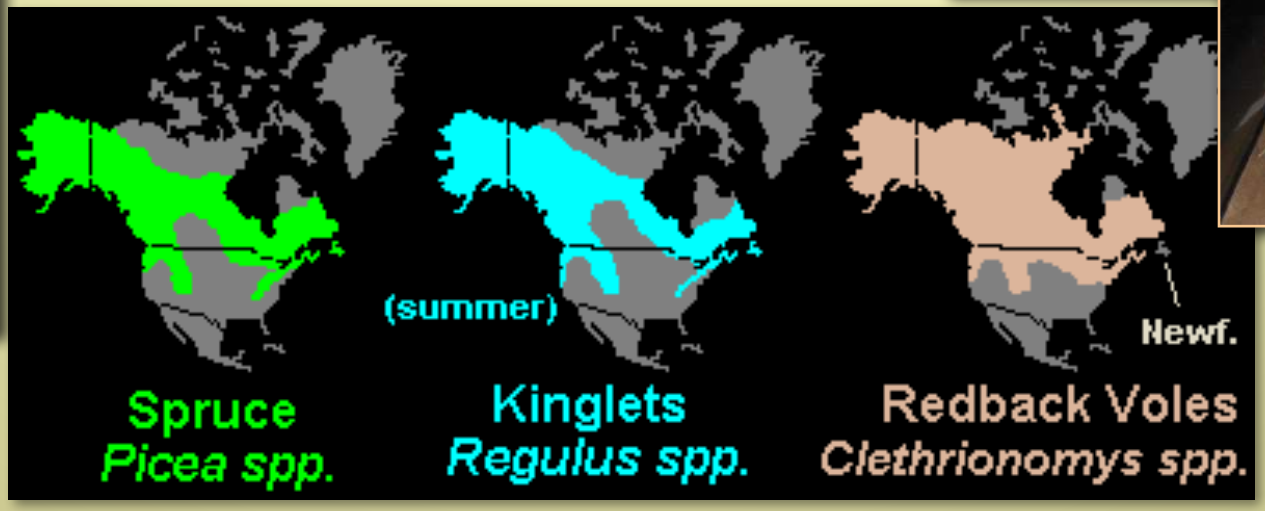

Habitat requirements force the distributions of kinglets and redback voles to match that of the coniferous boreal forests

Limits to Distributions

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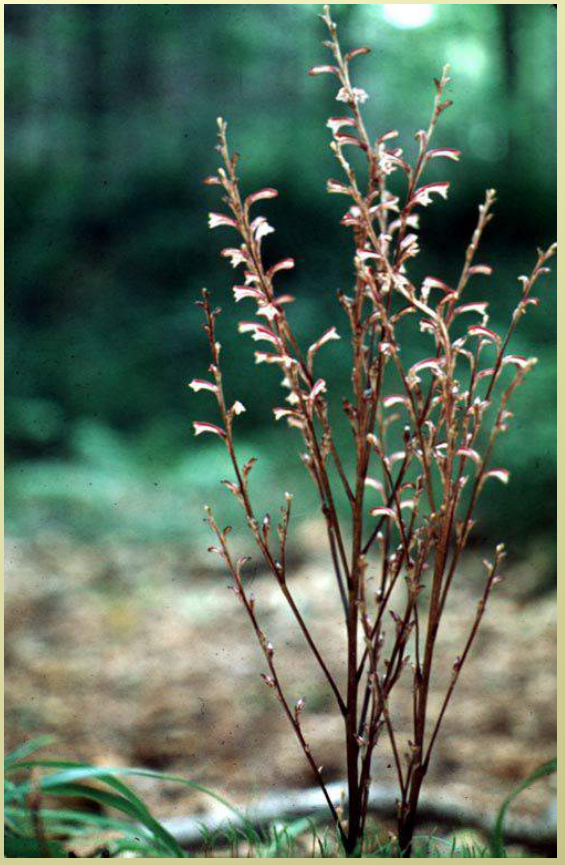
American beech – *Fagus grandifolia*

Epifagus virginiana

Beech drops

(root parasite only on American beech)



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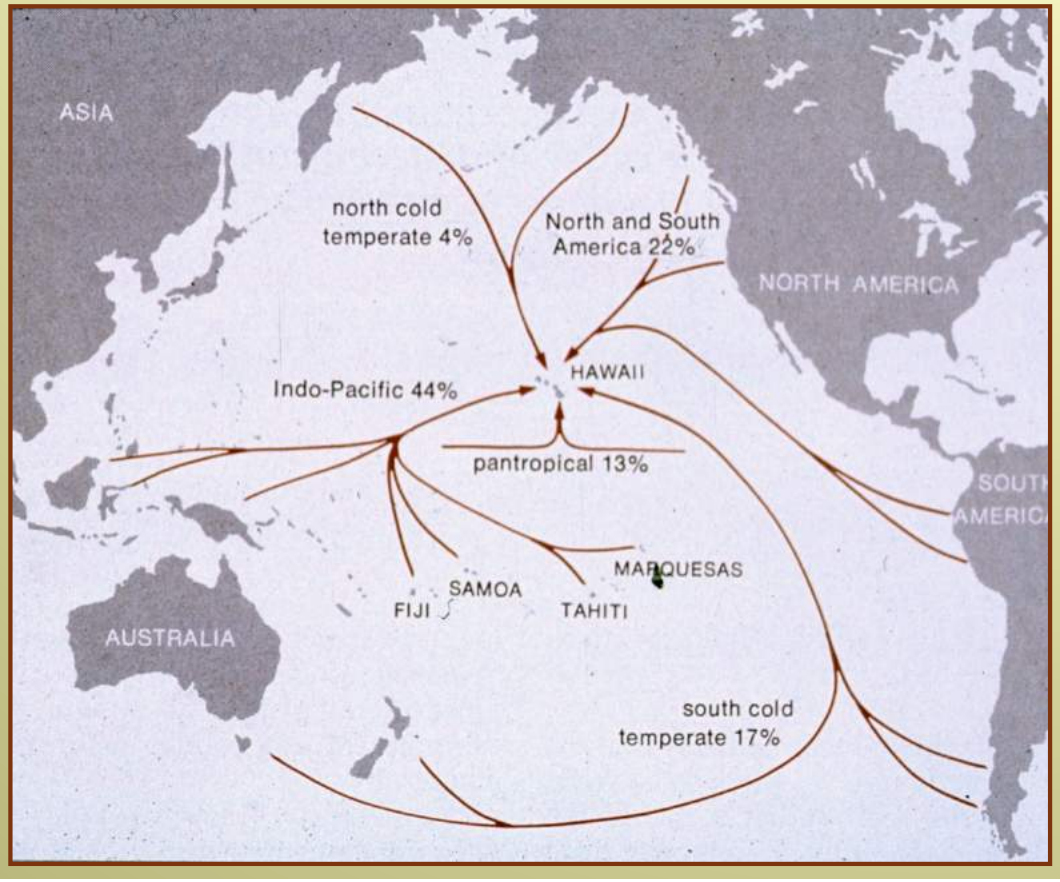
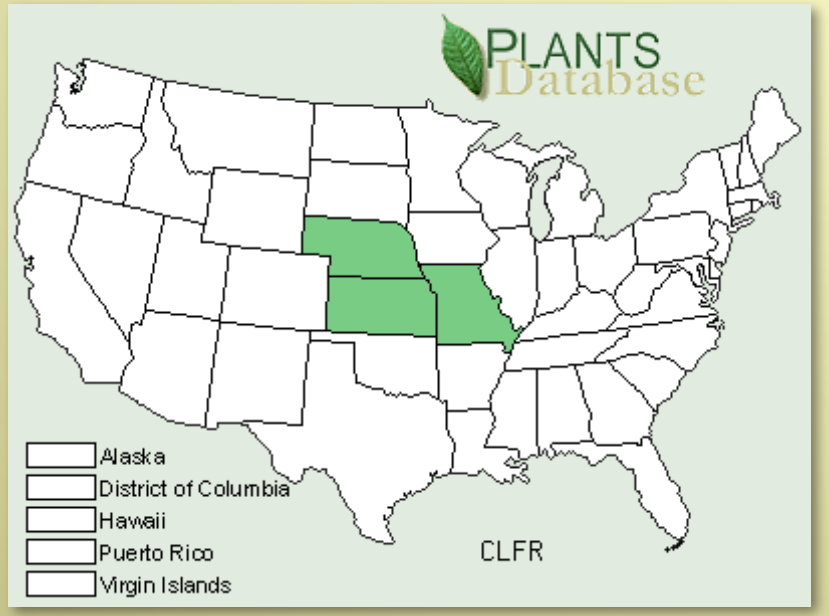


Argyroxiphium - silversword

Distribution Patterns

Every species (or higher taxa) has a particular distribution that varies in three important features:

- range: entire region or area of occurrence

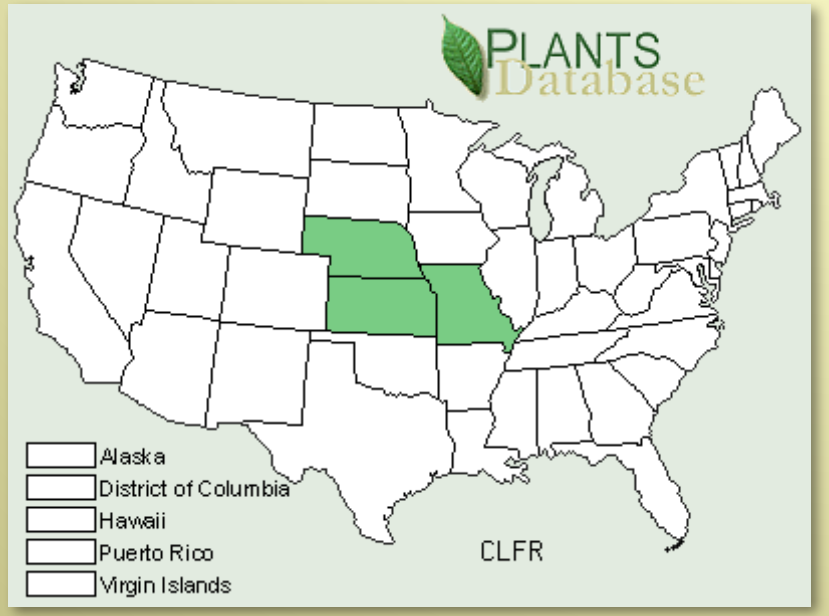


Clematis fremontii (leatherflower) is restricted to three midwestern states

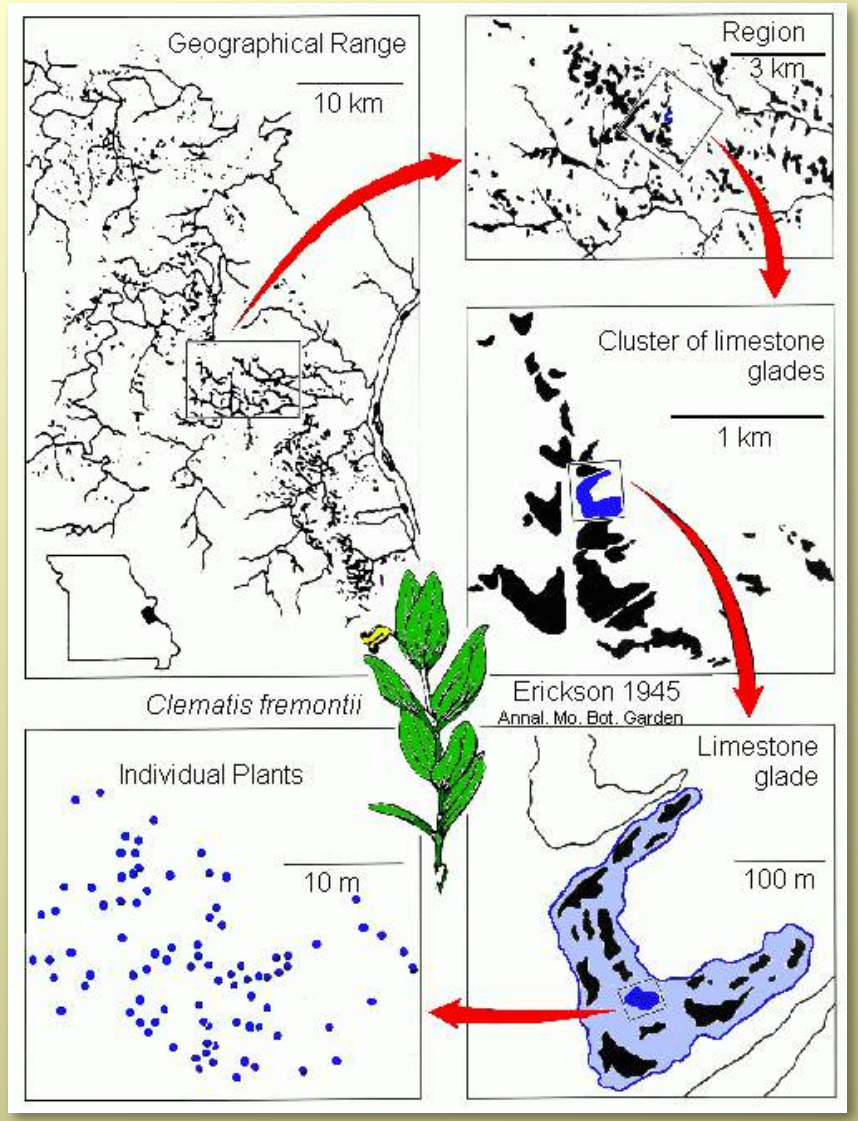
Distribution Patterns

Every species (or higher taxa) has a particular distribution that varies in three important features:

- degree of geographical continuity



Clematis fremontii (leatherflower) is discontinuous in distribution across its range as it is restricted to limestone glades

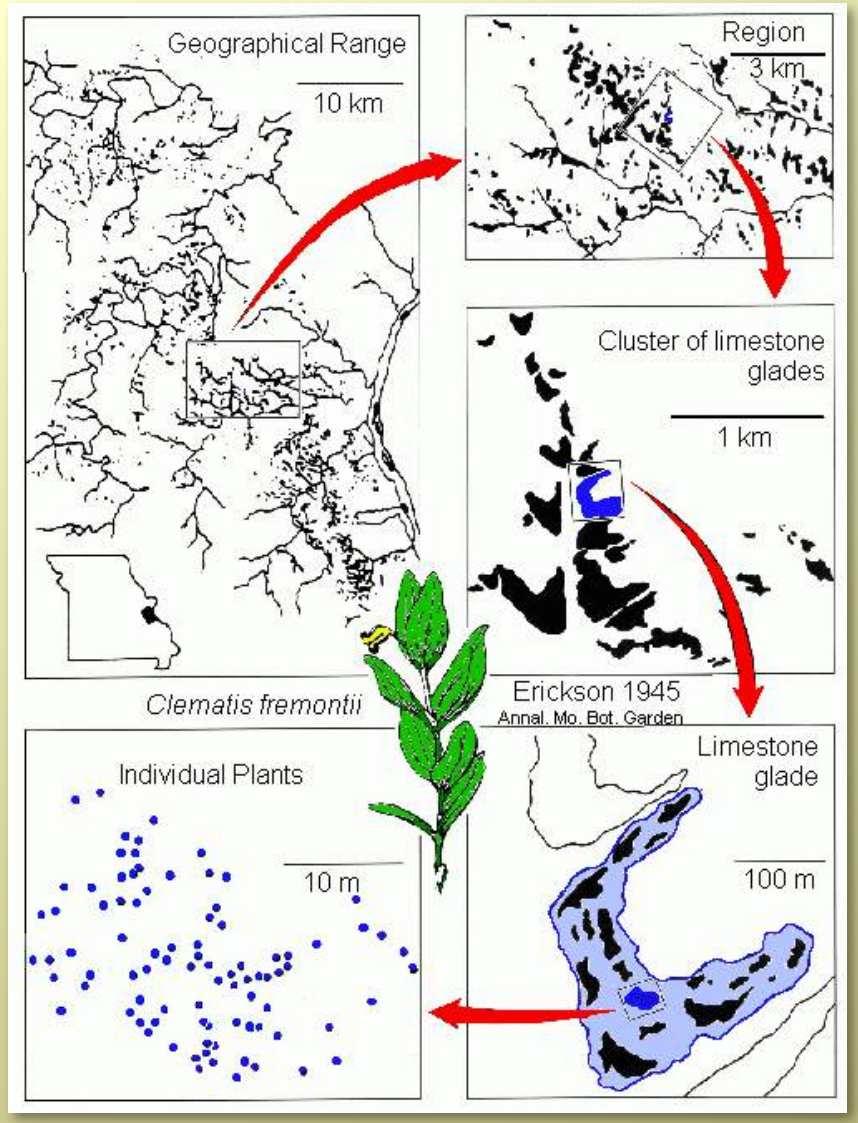


Distribution Patterns

Every species (or higher taxa) has a particular distribution that varies in three important features:

- frequency of occurrence

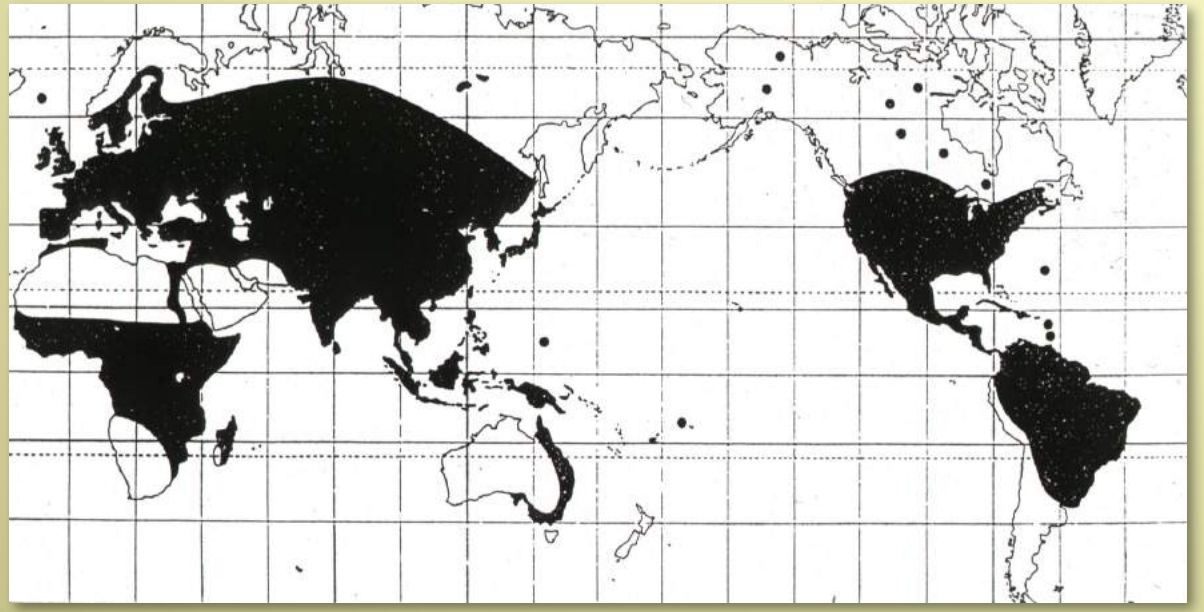
Clematis fremontii (leatherflower) is frequent but aggregrated in individual limestone glades



Distribution Patterns

What kinds of distribution patterns?

- Continuous
- Endemic
- Disjuncts (discontinuous)



aquatic *Ceratophyllum demersum* (coons-tail, hornwort) is widespread, continuous, nearly cosmopolitan

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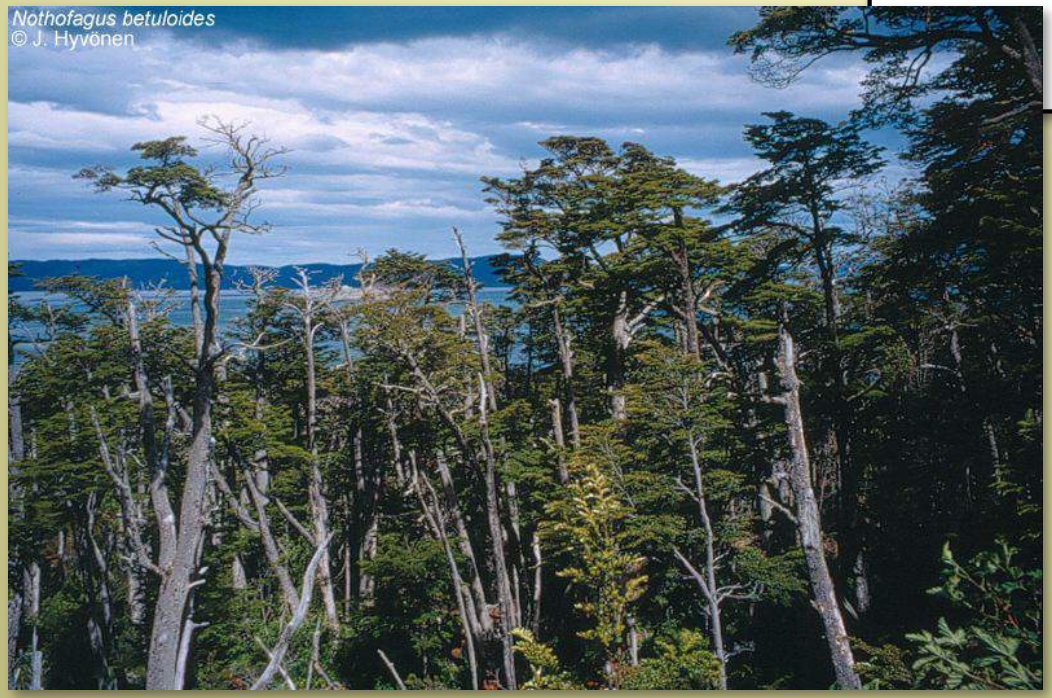

Nothofagus (southern beech) is endemic to several temperate southern hemisphere areas, thus disjunct

Distribution Patterns

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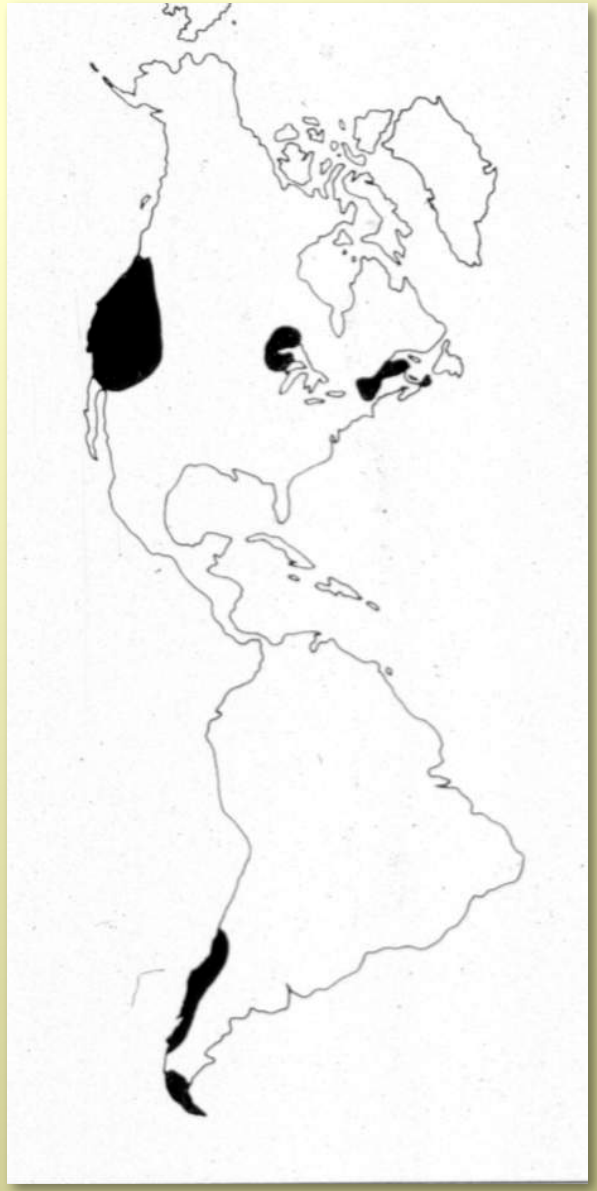

Osmorhiza chilensis (sweet cicely) shows an amphi-tropical disjunction and a western N. American - Great Lakes – eastern N. American disjunction

Distribution Patterns

What kinds of distribution patterns?

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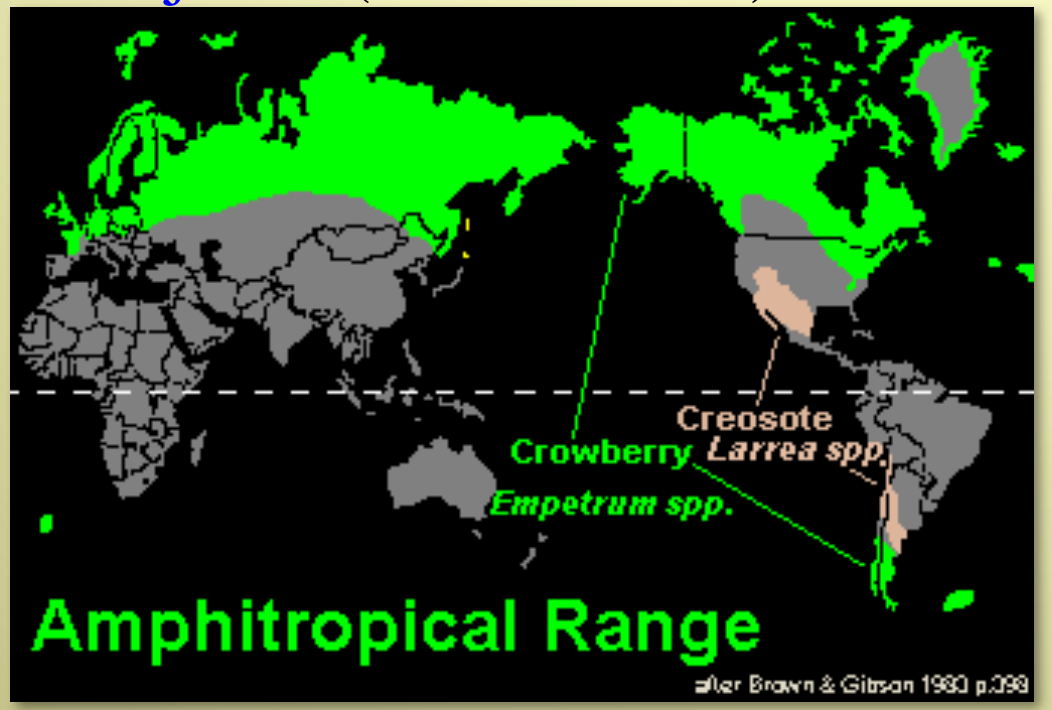
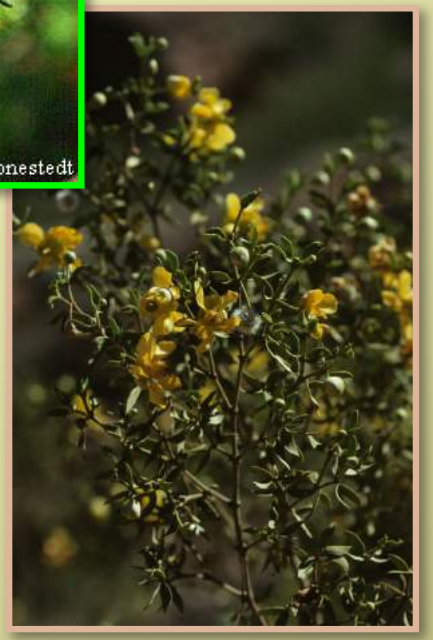


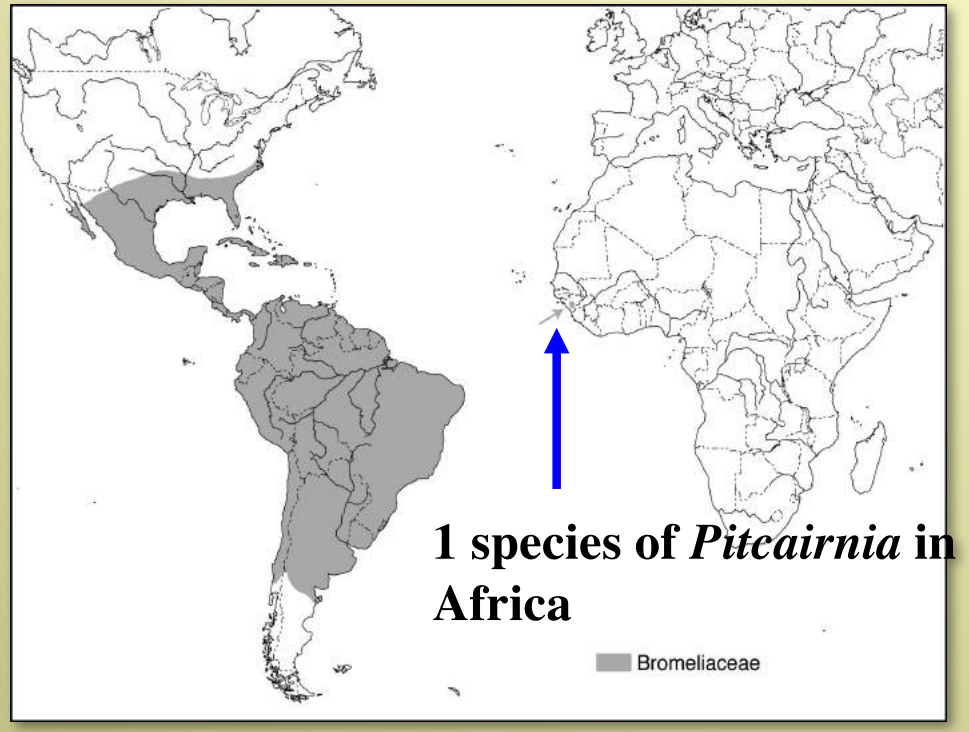


Empetrum (crowberries) of boreal and tundra and *Larrea* (creosote) of deserts also show amphi-tropical disjunctions

Distribution Patterns

What kinds of distribution patterns?

- Continuous
- Endemic
- Disjuncts (discontinuous)



Family Bromeliaceae (pineapples) shows continuous distribution throughout Americas, endemic to this region, except for peculiar disjunct in West Africa

Distribution Patterns

What kinds of distribution patterns?

- Continuous
- Endemic
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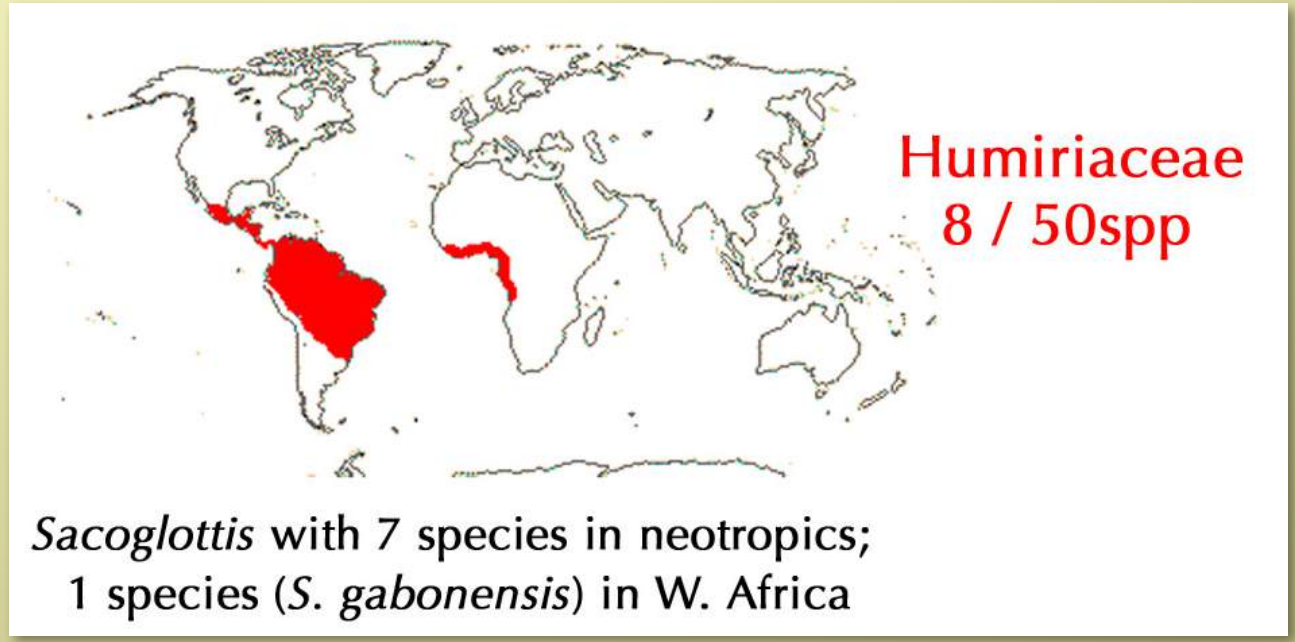
S. amazonica - water dispersed



Family Humiraceae shows same peculiar disjunct in West Africa - why? (not a *floristic* question)

Distribution Patterns

What kinds of distribution patterns?

- Continuous
- Endemic
- Disjuncts (discontinuous)
  - all nine taxa described survive and reproduce in accordance to specific environmental requirements
  - each occupies a precise area or range first determined by history (area/life)
  - actual ranges are limited by ecological or biological features
  - for invasive weeds, perhaps the opposite

Lythrum salicaria - purple loosestrife

Distribution Patterns

Types of continuous patterns?

- Cosmopolitan: distributed all over the globe - indifferent to many environmental conditions

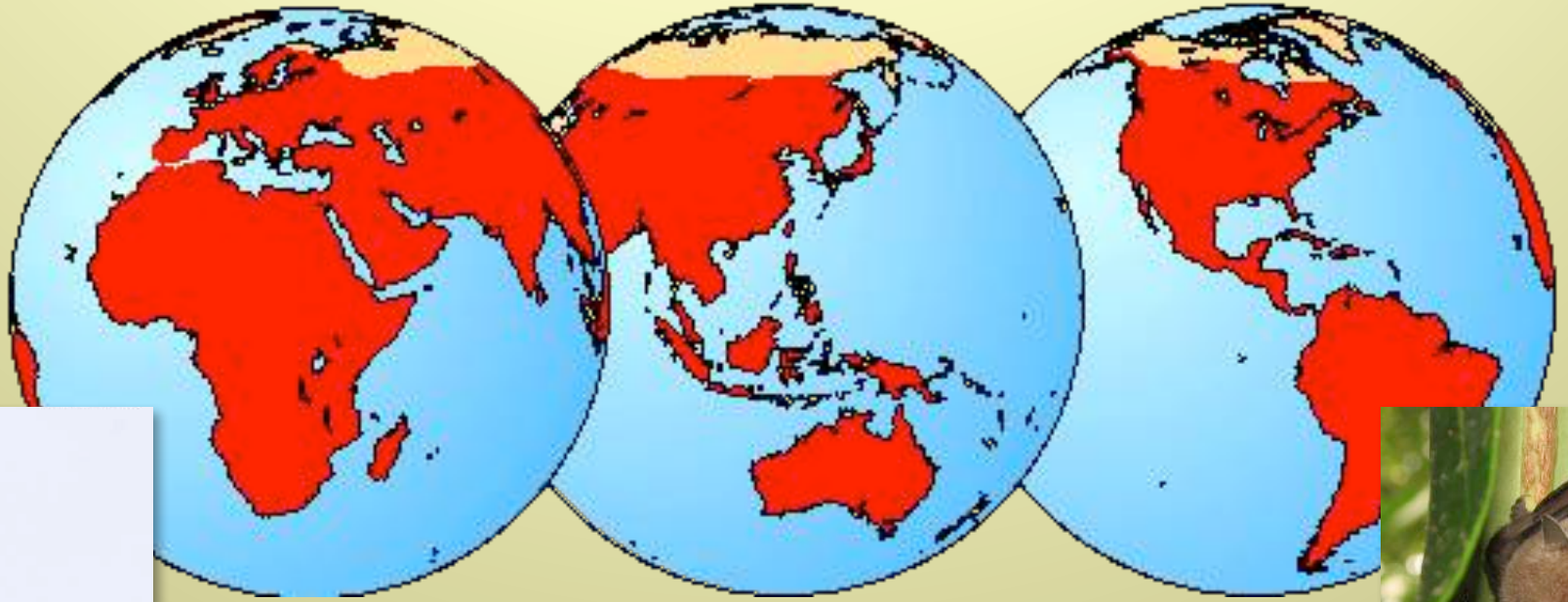
Ceratophyllum in water

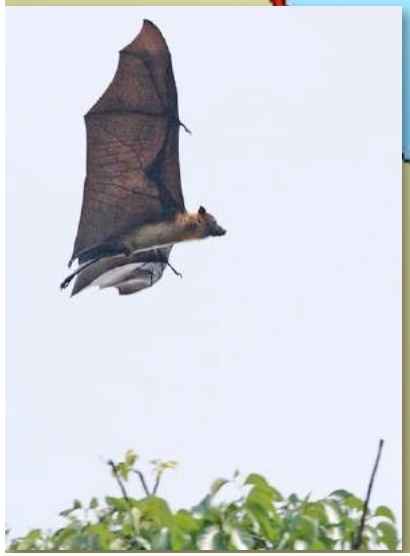
Taraxacum (dandelion) on land

Distribution Patterns

Types of continuous patterns?— can be taxa above species

- Cosmopolitan: distributed all over the globe - indifferent to many environmental conditions





Chiroptera - bats

Distribution Patterns

Types of continuous patterns?

- Circum-boreal: [circum-austral rare!]

Rhododendron lapponicum - lapland rosebay (Ericaceae)

Distribution Patterns

Types of continuous patterns?

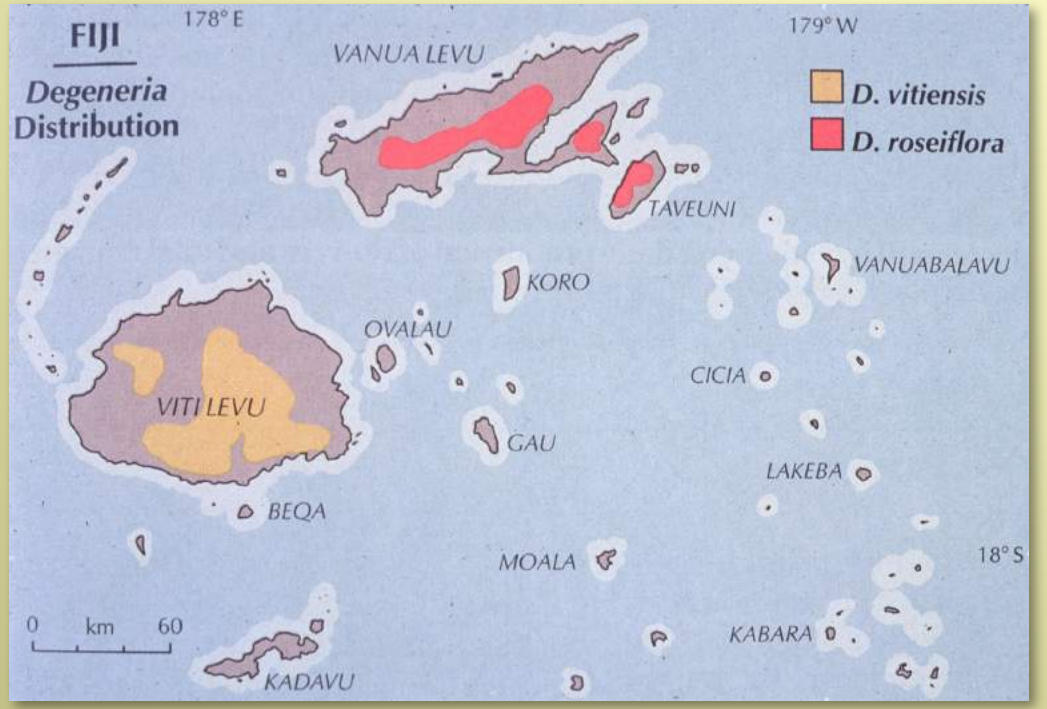
- Pantropic: distribution limited by oceans in tropical & subtropical latitudes

Palmae - palm family

Distribution Patterns

Types of endemic patterns?

- Taxonomic (evolutionary) relicts: sole survivors of once diverse taxonomic groups

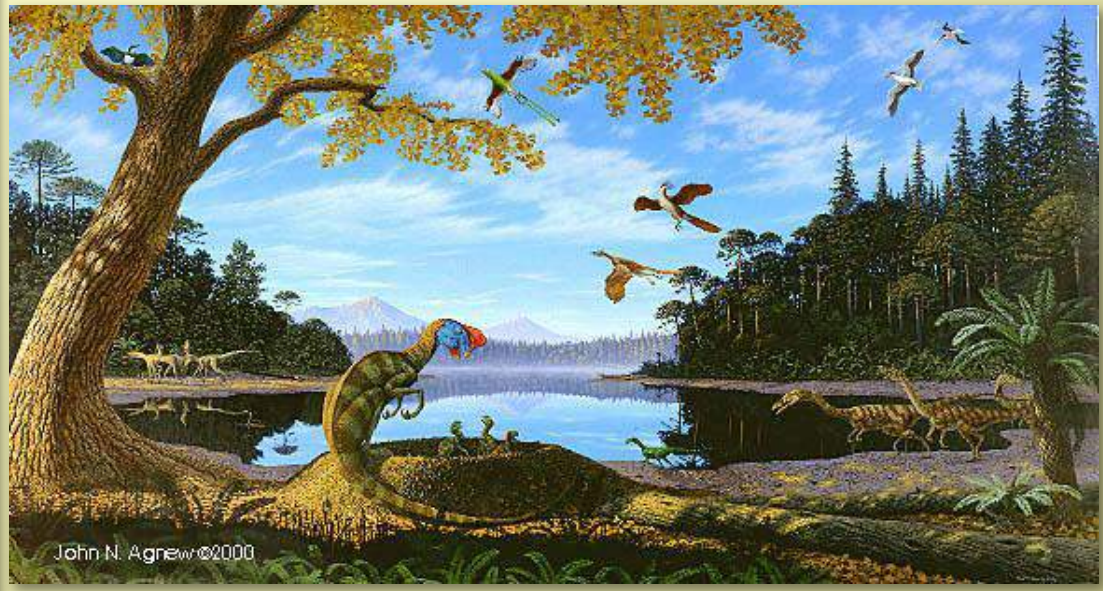


The primitive angiosperm *Degeneria* belongs to a lineage that was more species-rich as seen in the fossil record

Distribution Patterns

Types of endemic patterns?

- Taxonomic (evolutionary) relicts: sole survivors of once diverse taxonomic groups

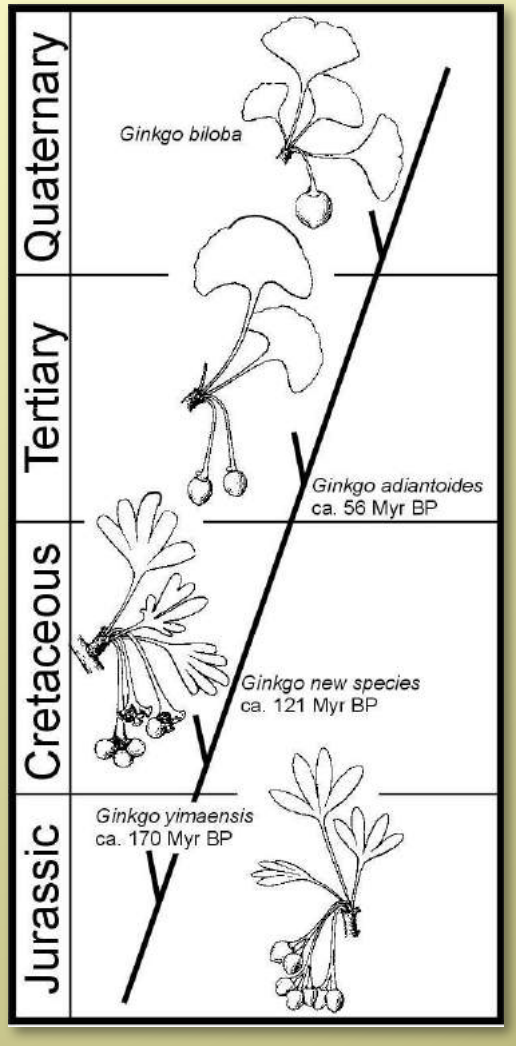


The gymnosperm *Ginkgo biloba* belongs to an ancient fossil lineage going at least to the Mesozoic Era

Distribution Patterns

Types of endemic patterns?

- Taxonomic (evolutionary) relicts: sole survivors of once diverse taxonomic groups



Ginkgoes are abundant in the fossil record, but only one species is extant, all others are extinct

Distribution Patterns

Types of endemic patterns?

- Climatic (biogeographical) relicts: narrowly endemic survivors of once widespread taxa

Ginkgo biloba is now restricted to a small area of China, but fossil evidence shows *Ginkgo* widespread in the temperate N Hemisphere as recently as the Pliocene (3 mya)

Distribution Patterns

Types of disjunct patterns?

- Many types! – we will look at several later
- Involve interplay between earth history and biological history

Classification of major distributions of seed plants (Thorne 1972; Stott 1982)

I Eurasian-North American
  1 Arctic
    1a Circum-Arctic
    1b Beringian-Arctic
    1c Amphi-Atlantic-Arctic
  2 Boreal
    2a Circum-boreal
    2b Beringian-boreal
    2c Amphi-Atlantic-boreal
  3 Temperate
    3a Circum-north temperate
    3b North-south temperate
    3c Fragmentary-north temperate

II Amphi-Pacific tropical

III Pantropical

IV African-Eurasian (-Pacific)
  1 African-Mediterranean
  2 African-Eurasian
  3 African-Eurasian-Malesian
  4 African-Eurasian-Pacific
  5 African-Eurasian-Australasian
  6 Indian Ocean-Eurasian

V Amphi-Indian Ocean

VI Asian-Pacific
  1 Asian-Papuan
  2 Asian-Papuan-Melanesian
  3 Asian-Papuan-Pacific Basin
  4 Asian-Papuan-Australasian

VII Pacific Ocean

VIII Pacific-Indian-Atlantic Ocean

IX American-African

X North American-South American

XI South American-Australasian

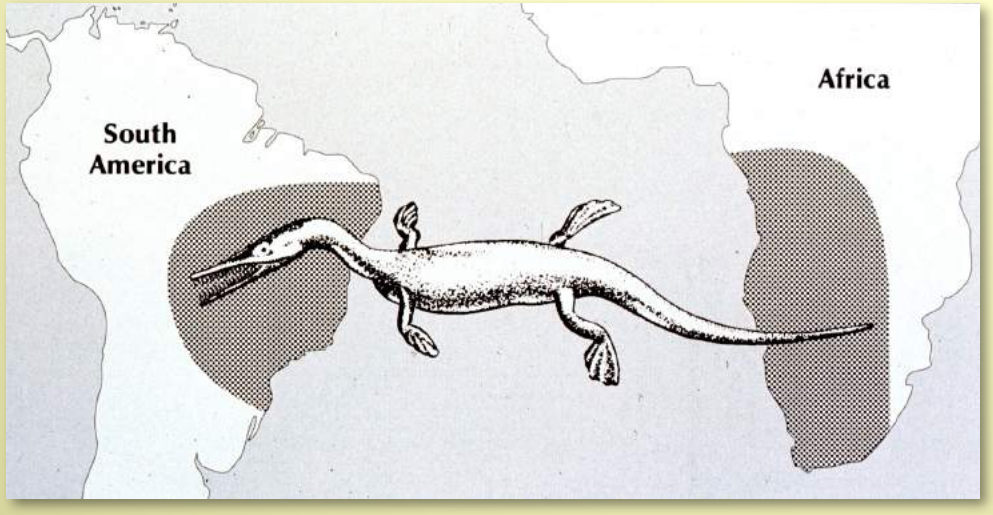
XII Temperate South American-Asian

XIII Circum-south temperate

XIV Circum-Antarctic

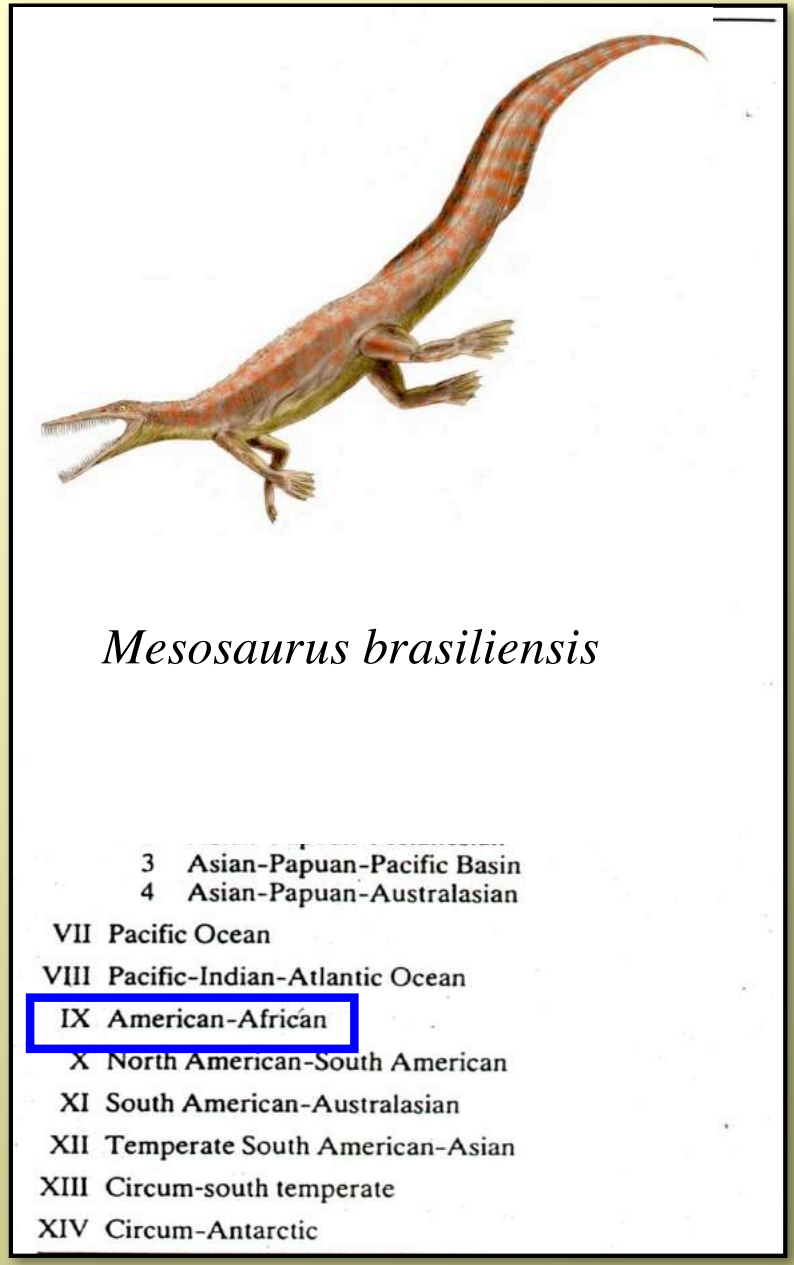
Distribution Patterns

Types of disjunct patterns?



• amphi-Atlantic distribution of the Permian reptile *Mesosaurus* was used by Alfred Wegener as evidence for continental drift

Classification of major distributions of seed plants (Thorne 1972; Stott 1982)



Mesosaurus brasiliensis

3 Asian-Papuan-Pacific Basin
4 Asian-Papuan-Australasian
VII Pacific Ocean
VIII Pacific-Indian-Atlantic Ocean
IX American-African
X North American-South American
XI South American-Australasian
XII Temperate South American-Asian
XIII Circum-south temperate
XIV Circum-Antarctic

Provincialism

— one of the most important concepts in biogeography, but what does "provincialism" mean?

Definition by Webster's Dictionary:

2. [n] a lack of sophistication

Provincialism

— one of the most important concepts in biogeography, but what does "provincialism" mean?

Definition by Webster's Dictionary:

1. [n] a partiality for some particular place

2. [n] a lack of sophistication

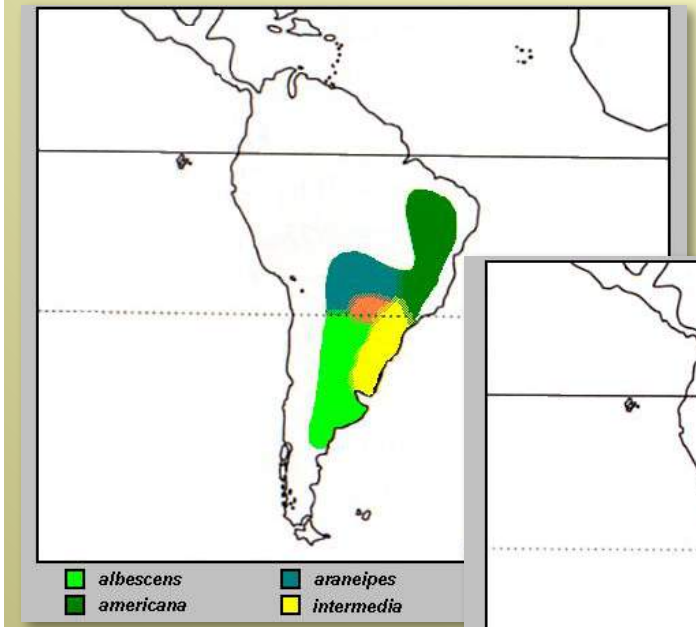
When the ranges of organisms are examined closely, it is seen that endemic forms are **neither randomly nor uniformly distributed** across the earth **but instead are clumped in particular regions.**

Provincialism

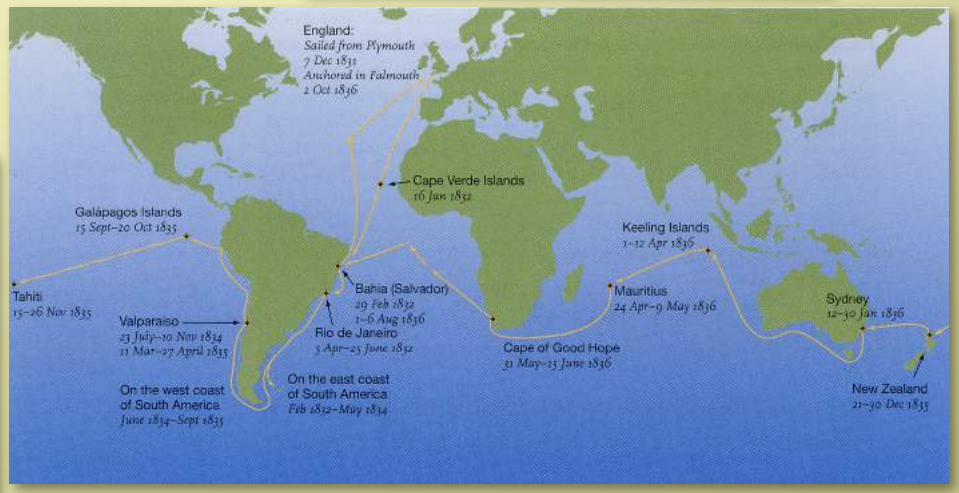
Three patterns are observed:

1. the most closely related species tend to have overlapping or adjacent ranges within restricted parts of continents **- parapatric**

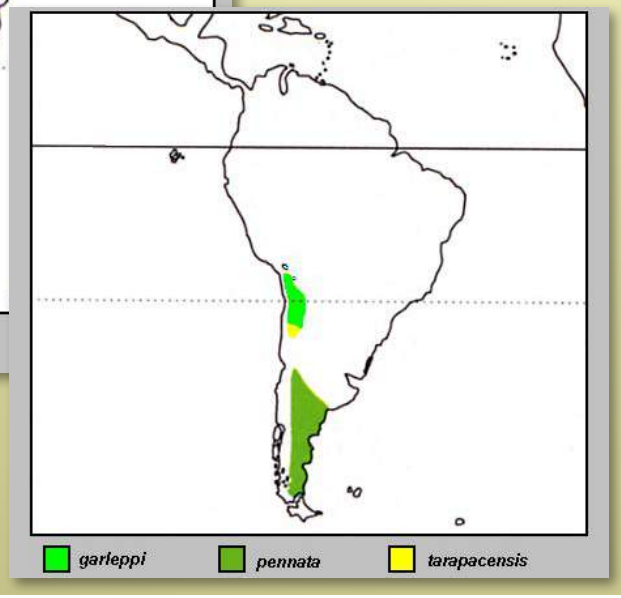
Rhea americana



Darwin noted this with rheas in 1833

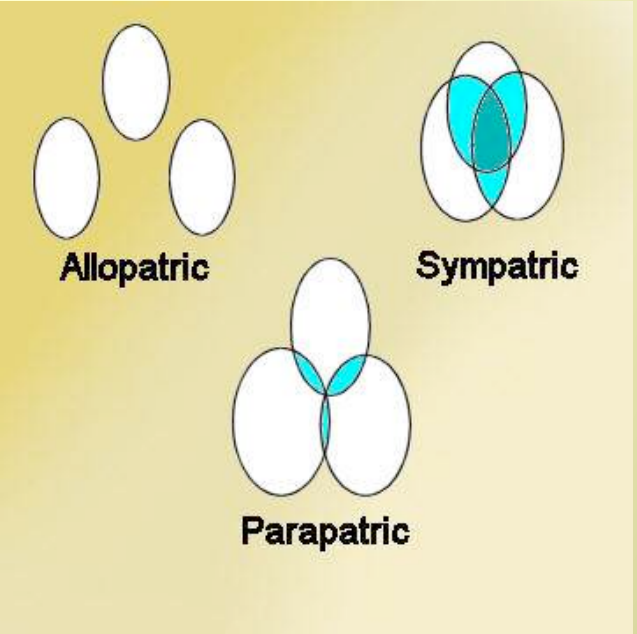


Rhea pennata (R. darwinii)



Law of Representative Species - repeated biogeographical observation

Provincialism



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Example: *Banksia* (Proteaceae) and *Eucalyptus* (Myrtaceae)

Provincialism

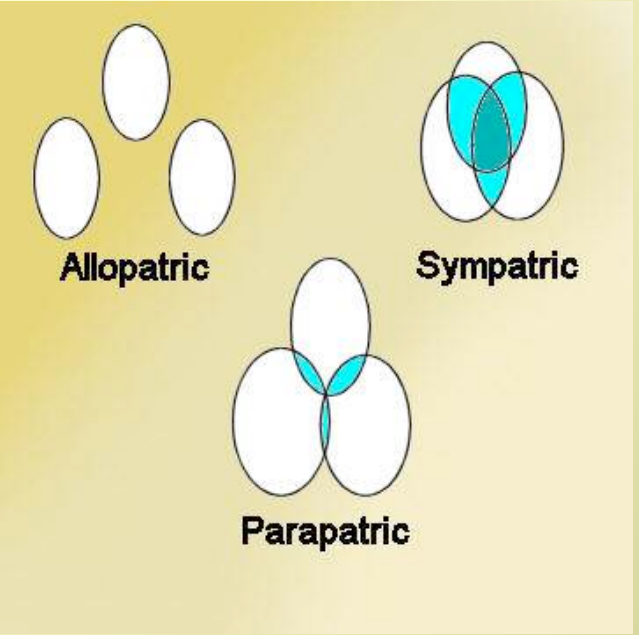
Banksia candelleana

Banksia coccinea

Banksia epica

Banksia marginata

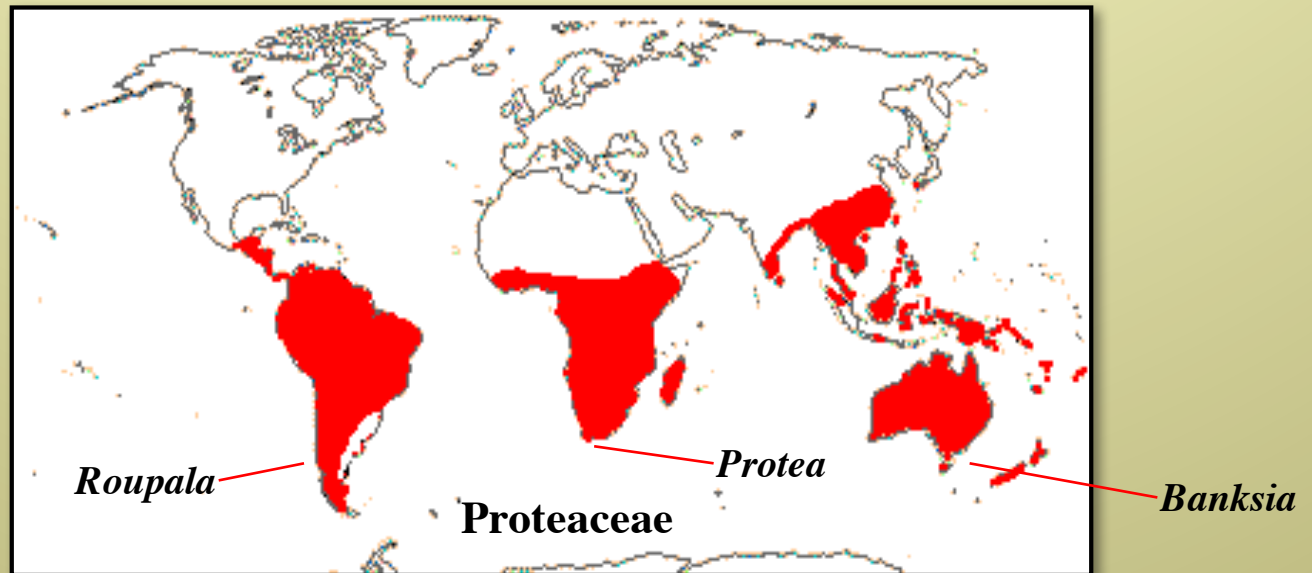
Provincialism



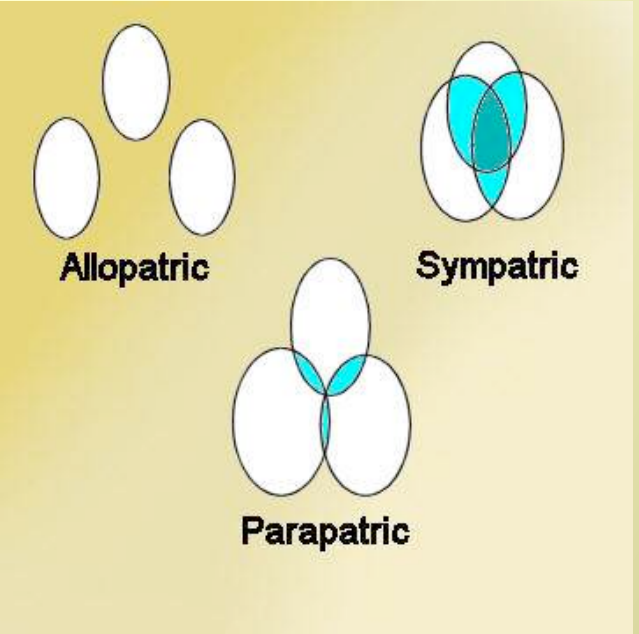
Three patterns are observed:

1. the most closely related species tend to have overlapping or adjacent ranges within restricted parts of continents - parapatric

2. a significant portion of orders or families and some genera have markedly disjunct ranges, with taxa living in widely separated regions of continents or on different continents — **allopatric, vicariant**



Provincialism



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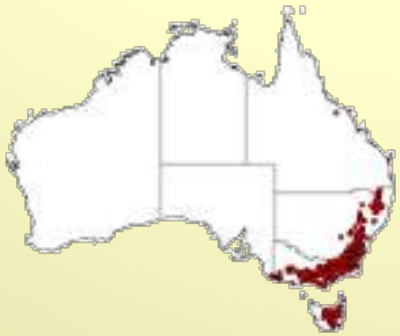
3. completely unrelated taxa, both plants and animals, show similar patterns of endemism —they share **areas of endemism — sympatric**

Provincialism



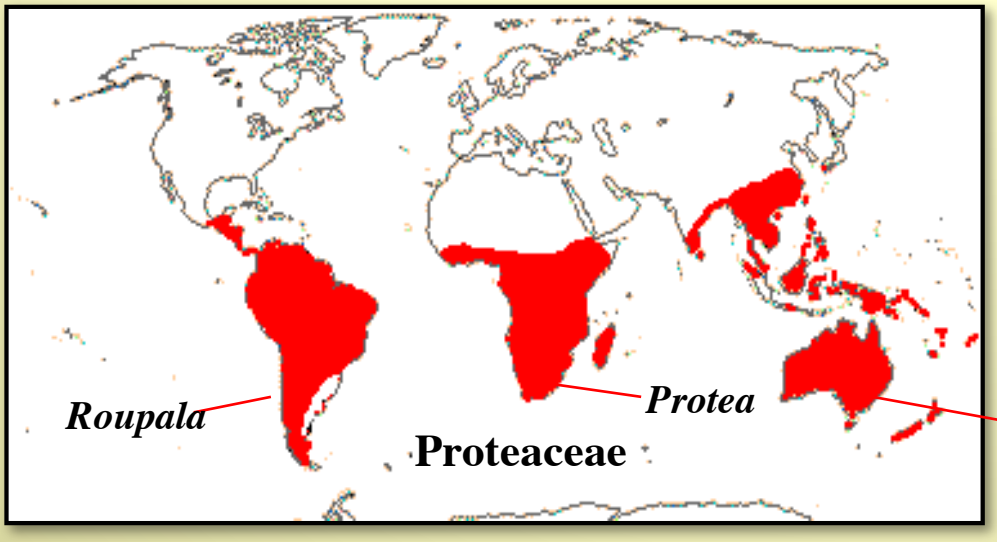
Eucalyptus pauciflora

Eucalyptus mannifera

Eucalyptus apiculata

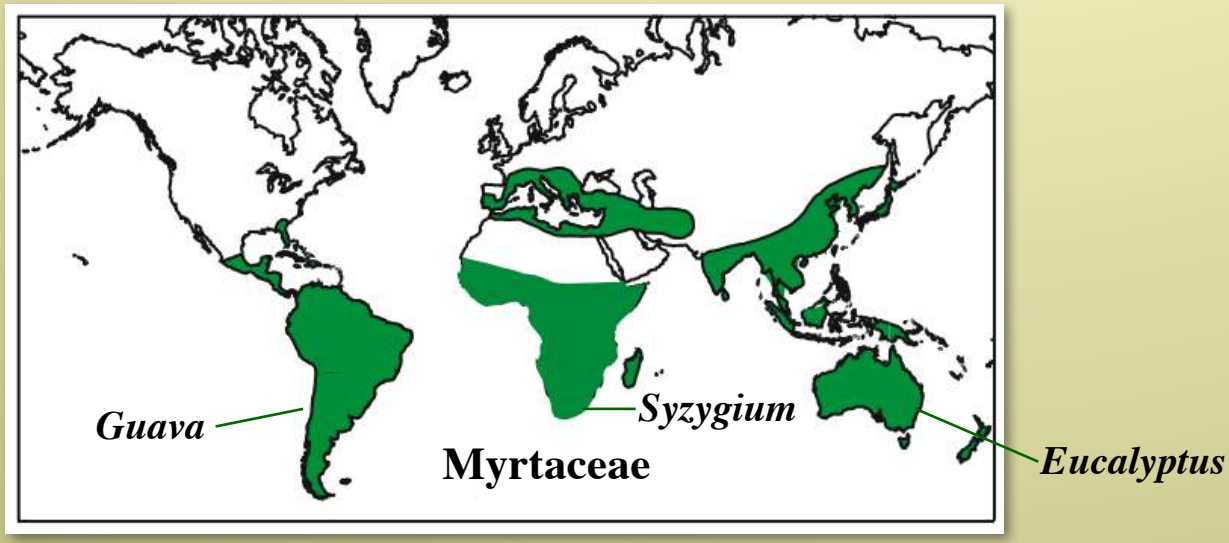
Eucalyptus curtisii

Provincialism



Allopatric (vicariant) disjunctions of **related taxa**

Sympatric occurrences of **unrelated taxa**

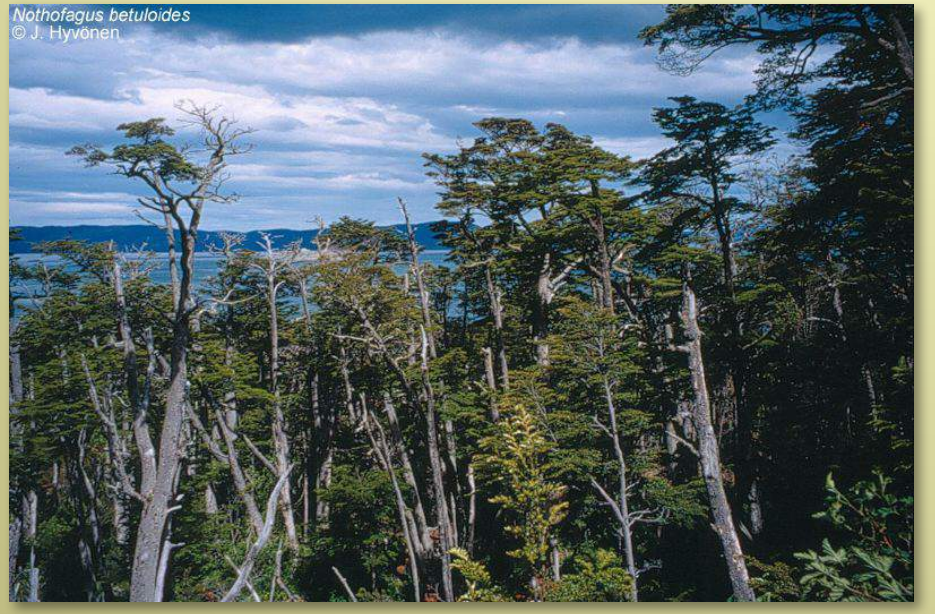


Areas of Endemism -

Shared areas by many unrelated plants, fungi, and animals

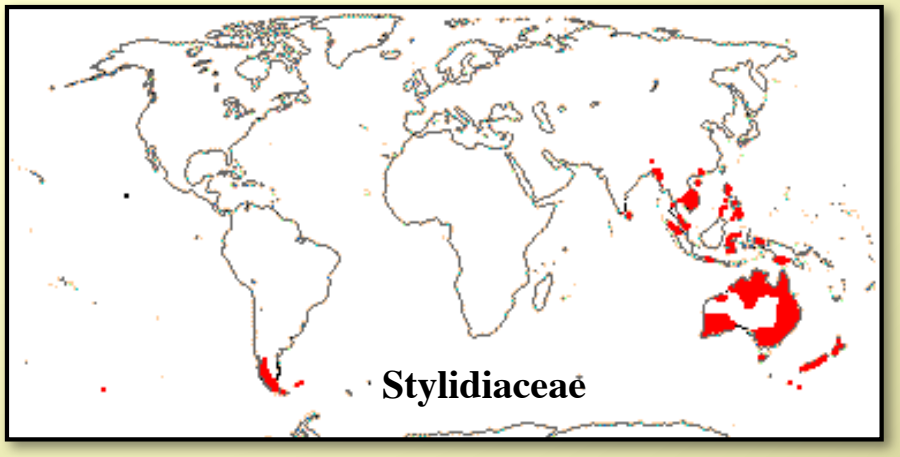
Provincialism

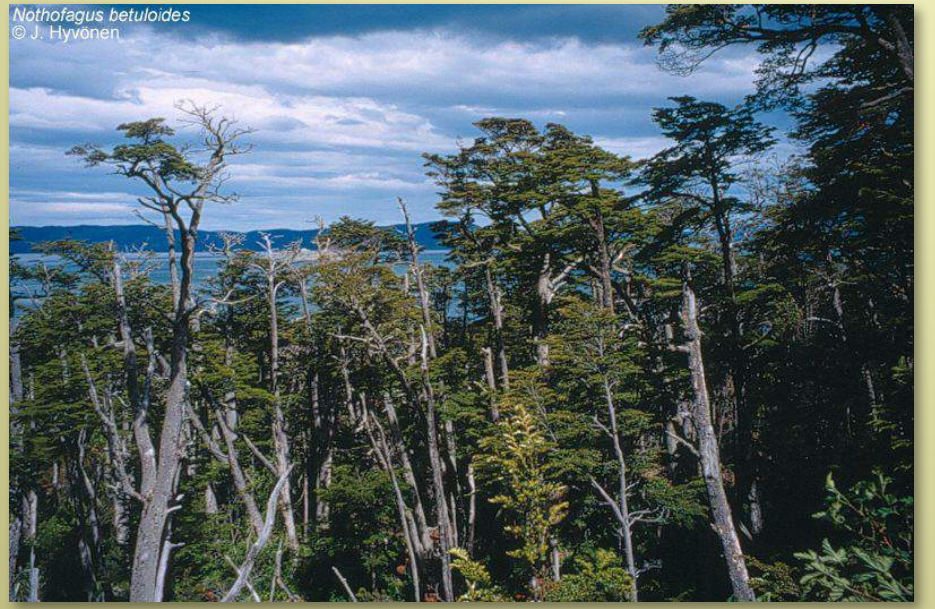
Re-examine the distribution pattern of Nothofagaceae . . .



Provincialism

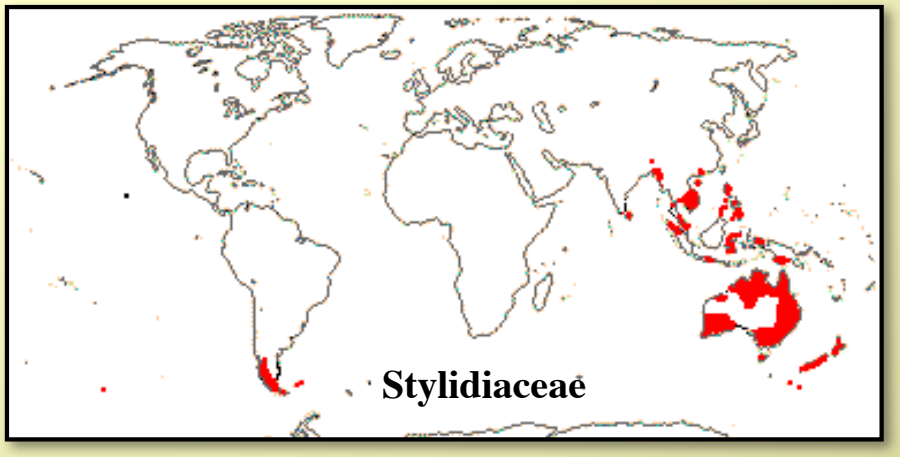
. . . a very similar distribution pattern is seen with Stylidiaceae . . .





Provincialism

. . . and with *Acaena* (Rosaceae)



- Many species of *Acaena* (Rosaceae) occur in the same areas as *Nothofagus* and Stylidiaceae

- Does this mean that these two taxa and *Acaena* have a similar history that gives rise to this pattern?

Provincialism

This same pattern of endemic distribution in the temperate southern hemisphere is repeated by many unrelated groups of organisms!

Distribution of endemic taxa in South America (SA), Africa (Af), Madagascar (M), Tasmania (Tas), Australia (Aus), New Zealand (NZ), New Guinea (NG), and New Caledonia (NC)

	Areas								
Family/genus	*Af*	*M*	*SA*	*Aus*	*Tas*	*NZ*	*NG*	*NC*	*Others*
Chironomid midges	+		+	+		+			1, 2
Winteraceae		+	+	+	+		+	+	3, 5
Coriaria			+			+	+	+	1, 2, 3, 4
Proteaceae (Gevuina; Lomatia; Oreocallis and Orites combined)			+	+	+		+		
Acaena	+		+	+	+	+	+	+	3
Osteoglosine fishes			+	+			+		
Ratite birds			+	+			+		2
Stylidiaceae			+	+	+	+			
Nicotiana			+	+				+	1
Hylid frogs and Chaleosyrphus (Syrphid flies)			+	+			+		1, 2
Marsupials (Recent)			+	+			+		1
Nothofagus			+	+	+	+	+	+	

Other areas; 1, N. America; 2, Europe; 3, Central America; 4, China/Japan; 5, Malaysia.

Provincialism

Question to ponder: What do areas of endemism mean?

- Why do southern beeches show distributions similar to chironomid midges when neither is dependent upon the other?
- Is it that both have independently dispersed and become adapted to similar southern hemisphere habitats (ecology!),
- or does history of the biotas and areas in which they occur provide a different and perhaps better answer simultaneously addressing all taxa?

Allopatric (vicariant) disjunctions of related taxa

Sympatric occurrences of unrelated taxa

Areas of Endemism -

Shared areas by many unrelated plants, fungi, and animals

Provincialism

Question to ponder: What do areas of endemism mean?

- These are questions **not** answered by *floristics* but require other information about earth history and history of the organisms

- They are answered (or attempted to!) in the *narrative* and *analytical* phases of biogeography

Allopatric (vicariant) disjunctions of related taxa

Sympatric occurrences of unrelated taxa

Areas of Endemism -

Shared areas by many unrelated plants, fungi, and animals

Floristic Systems

Provincialism and Floristic Kingdoms

• Provincialism noted by early biogeographers: **Schouw** (1823), **de Candolle** (1855), **Sclater** (1858) and **Wallace** (1876).

• Impressed by the **differences in the biotas** on the various landmasses.

• Goal was to identify these **units of different biota** and the physical or historical barriers that prevented the exchange of species.

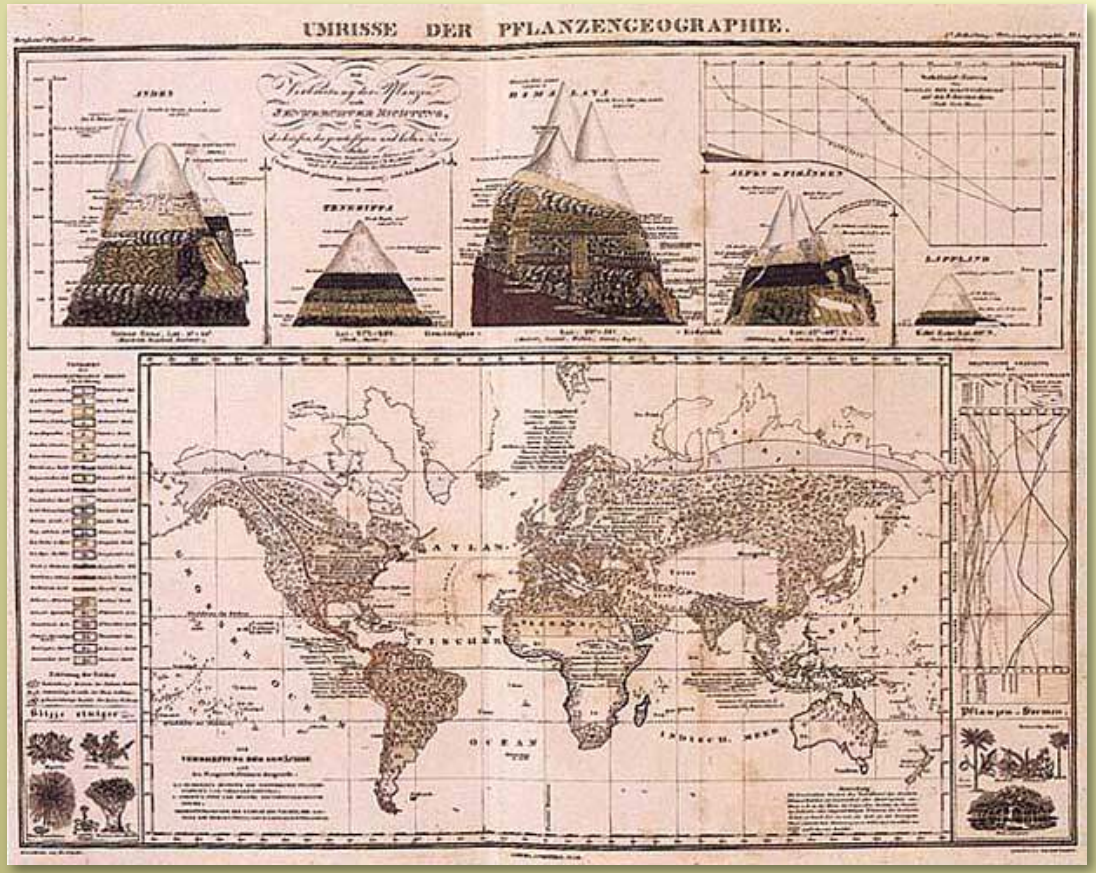
• Result was a division of the earth into a **hierarchy of regions** reflecting patterns of faunal and floral similarities.

1. Descriptive Historical Biogeography! — distributions and areas (floristic/faunistic geography)

Floristic Systems

Provincialism and Floristic Kingdoms

First map of botanical geography showing 25 “kingdoms”, derived from the work of Joakim Schouw (and Humboldt)

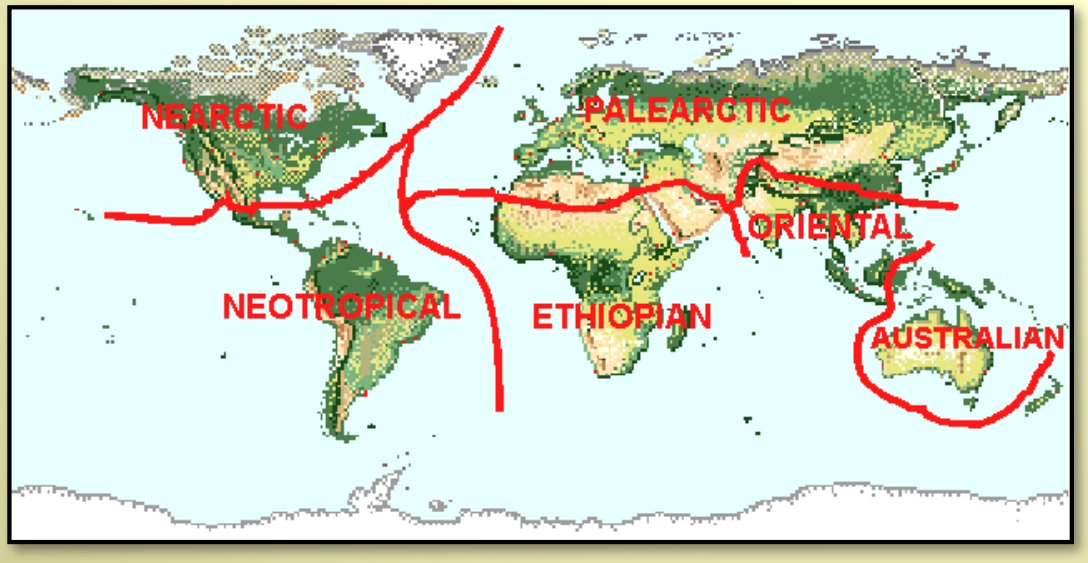


Joakim Frederik Schouw
(1789 - 1852)

Danish botanist and geographer, student of Humboldt. Produced first comprehensive textbook on plant geography.

Faunistic Systems

Provincialism and Faunistic Kingdoms



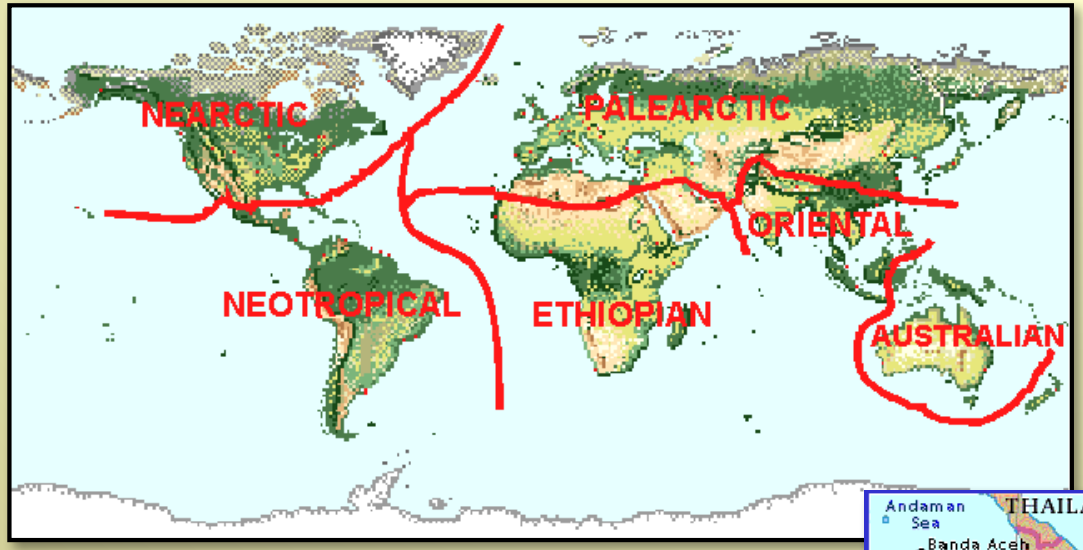
Six Faunal Provinces - Sclater 1858

- Likewise, ornithologists and mammalogists defined faunistic provinces

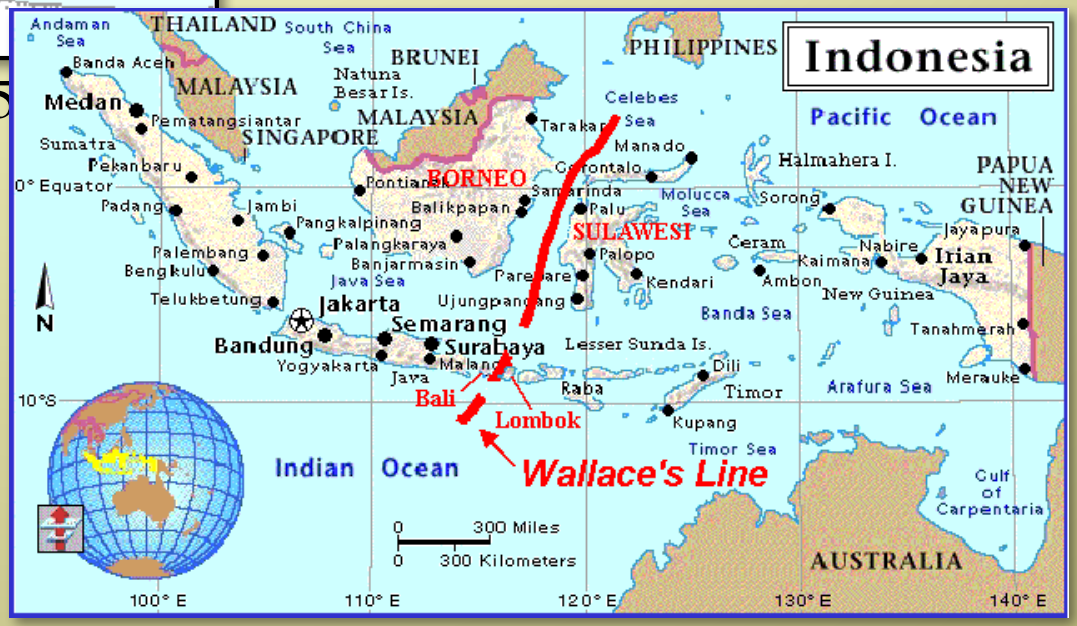
- Philip Lutley Sclater (1829–1913), British ornithologist who described 1067 species and 135 genera of birds, published in 1858 an important paper in which he divided the world into biogeographic regions on the basis of birds

Faunistic Systems

Provincialism and Faunistic Kingdoms



Six Faunal Provinces - Sclater 185



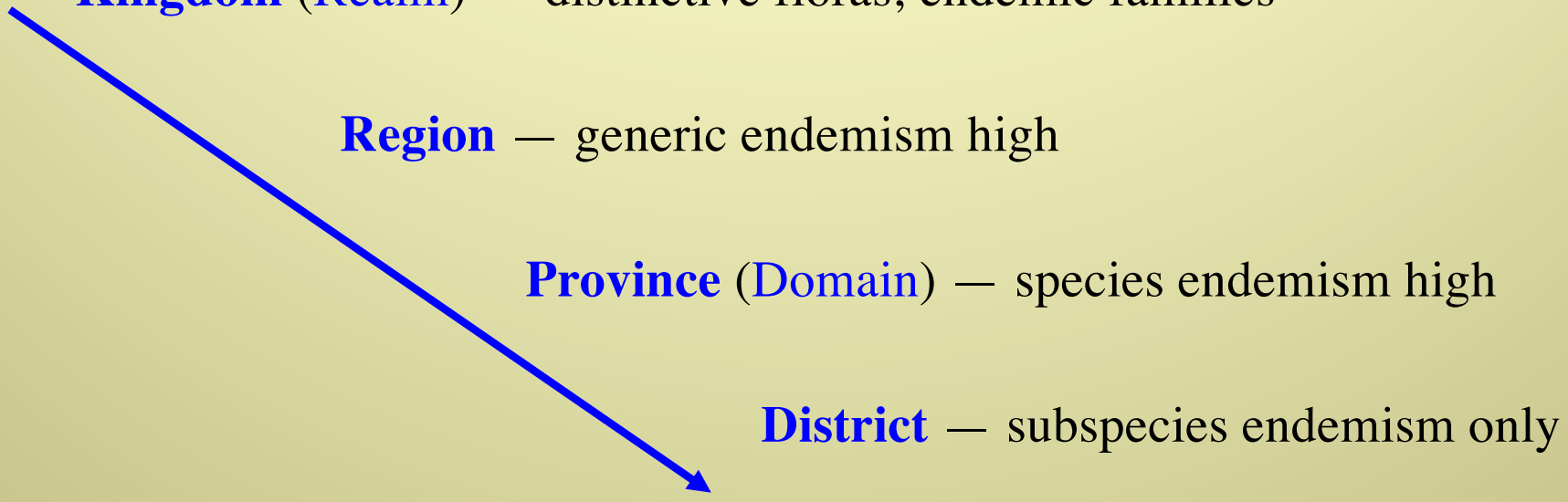
- Alfred Wallace later elaborated on the Oriental and Australian provinces in some detail based on mammals and birds

Alfred Wallace's Line (1876)

Floristic Systems

Provincialism and Floristic Kingdoms

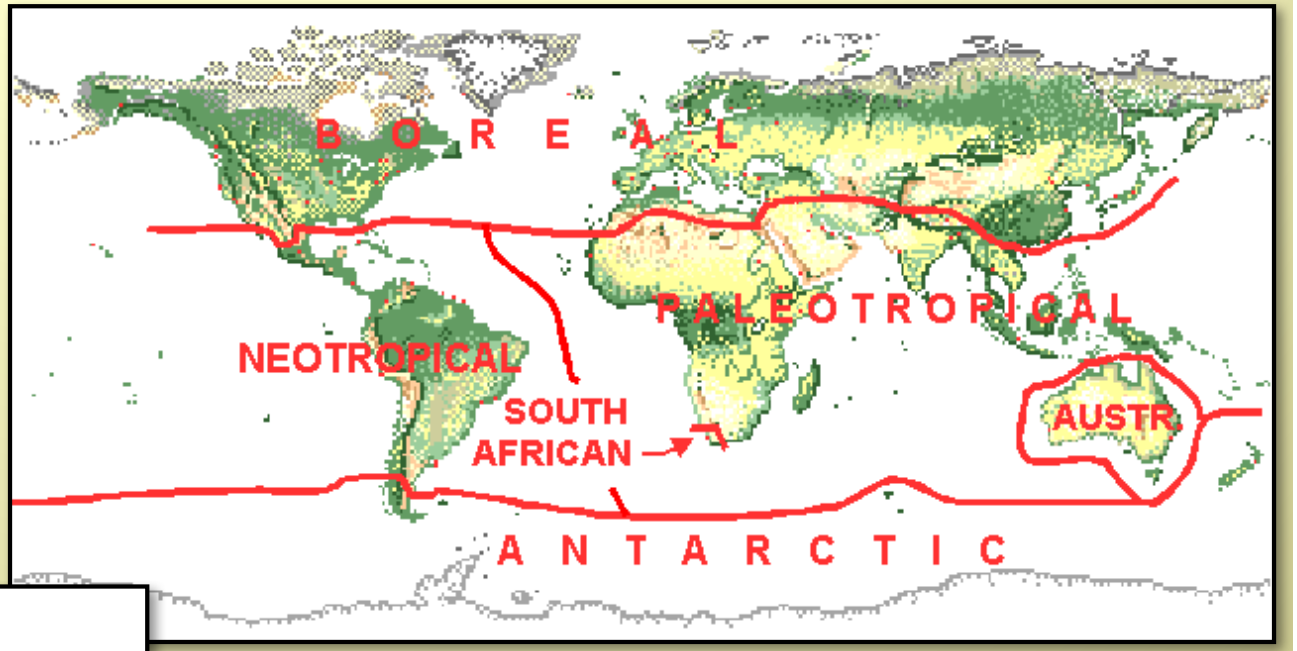
Floristics generally uses the following hierarchical scheme:

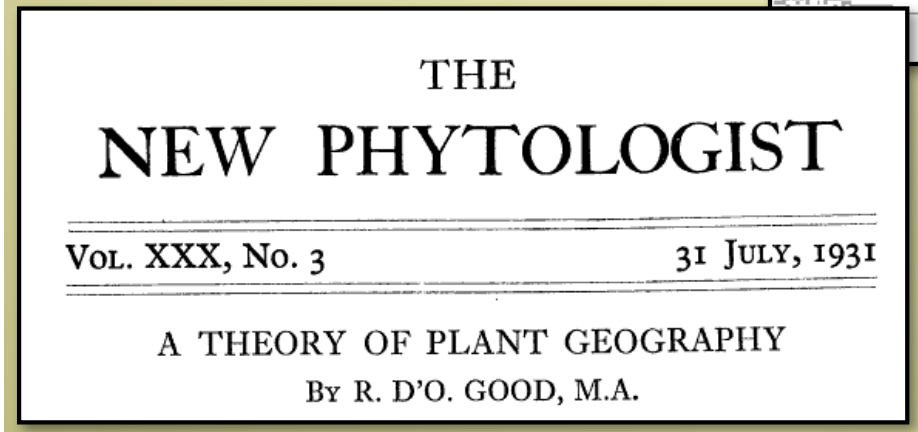


Floristic Systems

Provincialism and Floristic Kingdoms

Ronald **Good**'s floristic system is the most well known with 6 kingdoms.





THE

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VOL. XXX, No. 3 — 31 JULY, 1931

A THEORY OF PLANT GEOGRAPHY

BY R. D'O. GOOD, M.A.

Good, Ronald, 1947. *The Geography of Flowering Plants*.

Floristic Systems

Provincialism and Floristic Kingdoms

Note that *floristic* kingdoms include **two** additional relative to the *faunistic*

1. South African or Cape
2. Antarctic

— an indication of the more remarkable levels of endemism seen in plants relative to animals

Floristic Systems

Provincialism and Floristic Kingdoms

. . . but the merging of two *faunistic* provinces into one *floristic* kingdom —

1. Ethiopian (African)
2. Oriental

= Paleotropical floristic kingdom

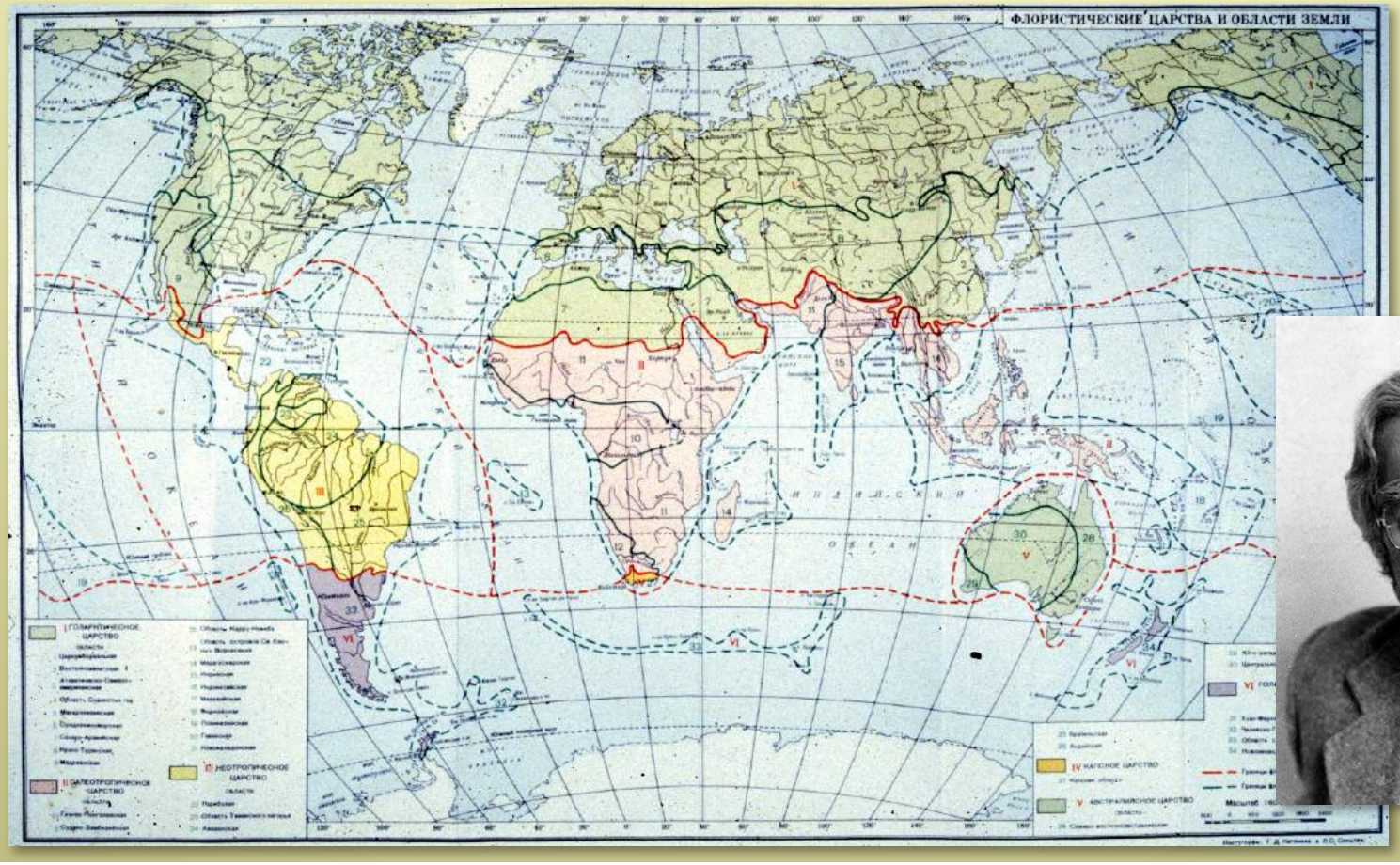
1. Paleoarctic
2. Neoarctic

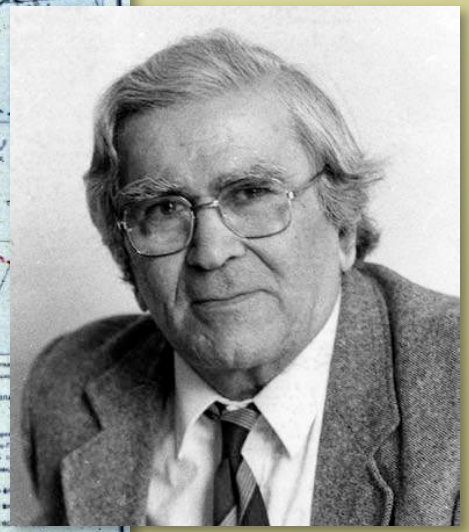
= Boreal floristic kingdom

Floristic Systems

Provincialism and Floristic Kingdoms

The six floristic kingdoms (colors, red lines) are here shown divided into 35 regions (blue lines) based on Takhtajan (1978). Note the different placements of Boreal and Antarctic lines.

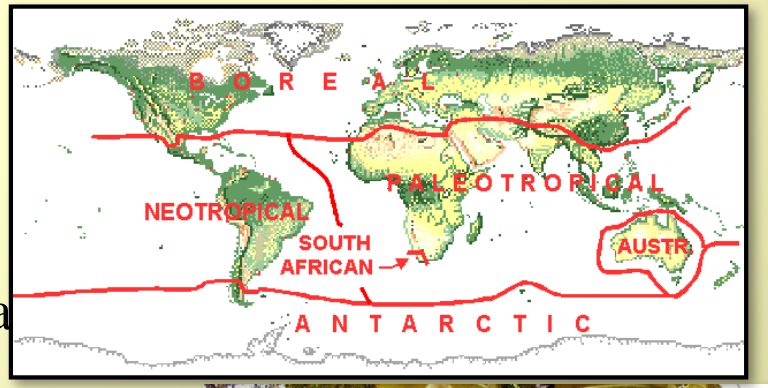




Floristic Systems

Boreal or Holarctic Kingdom (3 subkingdoms, 9 regions)

- largest of the six kingdoms, 1/2 of surface
- Europe, N. Africa, temp. Asia, N. America
- 60 families endemic



Ginkgoaceae

Platanaceae

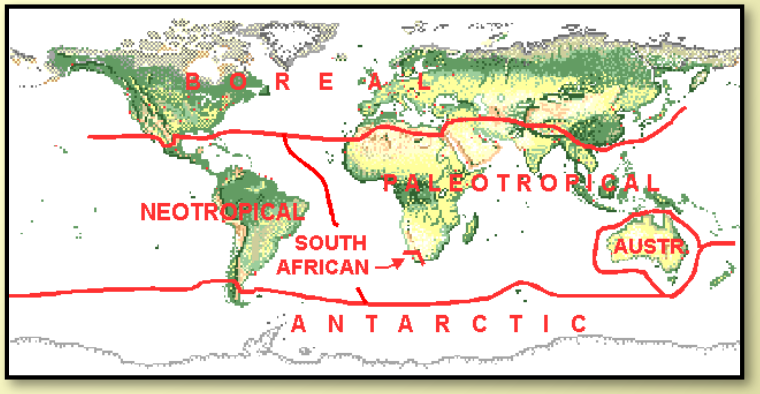
Paeoniaceae

Trochodendraceae

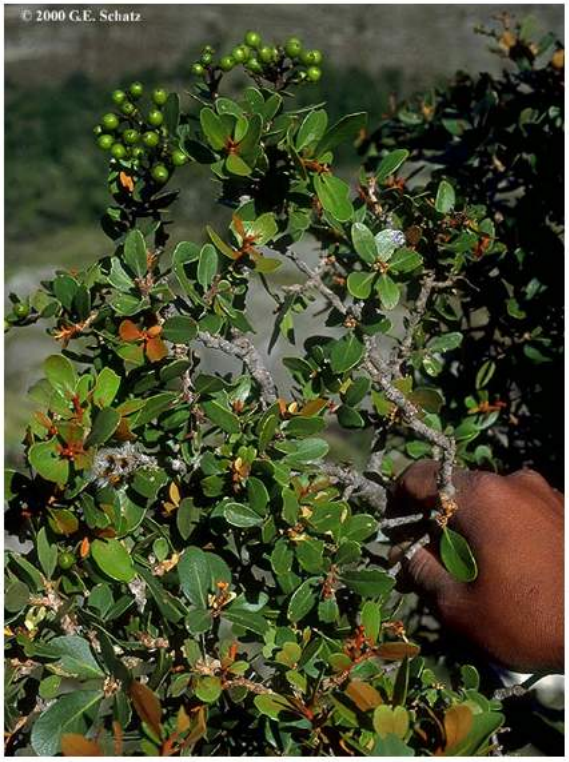
Floristic Systems

Paleotropical Kingdom (5 subkingdoms, 13 regions)

- tropical Old World, not Australia, Pacific
- 40 families endemic



Nepenthaceae



Madagascar endemics

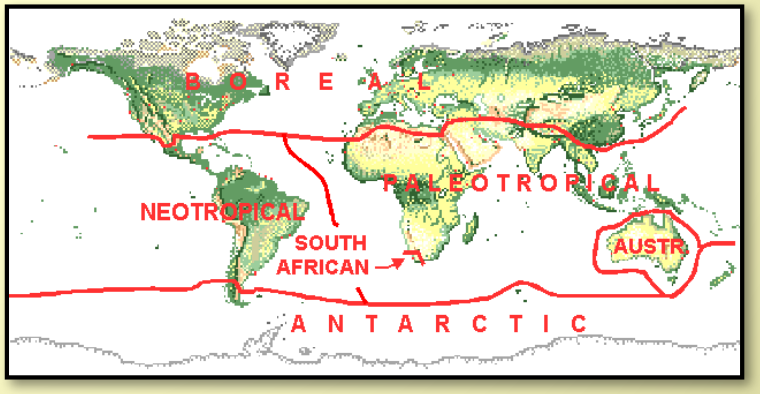
Asteropeiaceae

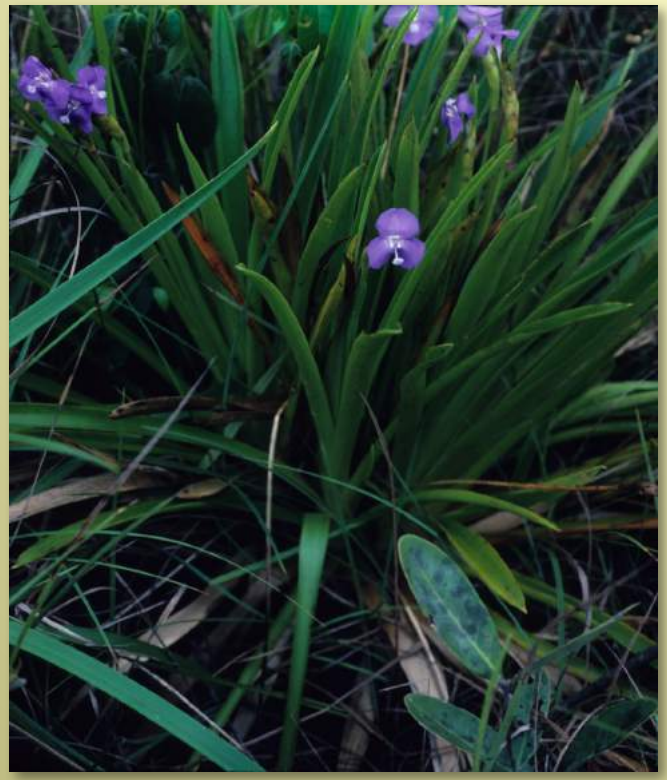
Physeneaceae

Floristic Systems

Neotropical Kingdom (5 regions)

- s. Florida, C. America, Antilles, most S. America
- 25 families endemic





Aboboldaceae

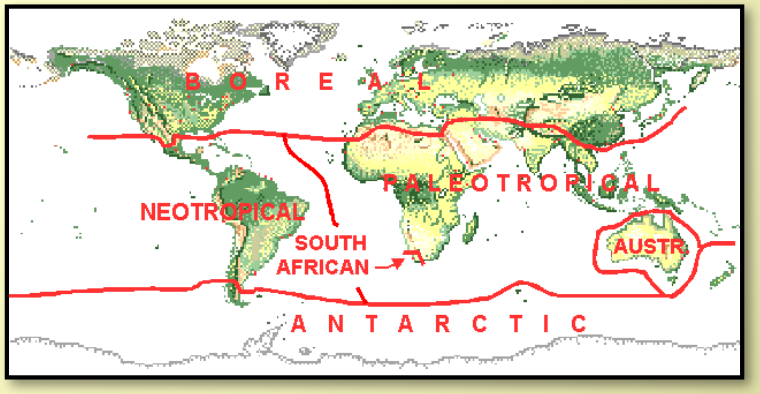
Cyclanthaceae

Tovariaceae

Floristic Systems

Cape Kingdom (1 region)

- smallest kingdom, southern South Africa
- exceptionally diverse
- 8 families endemic



Roridulaceae

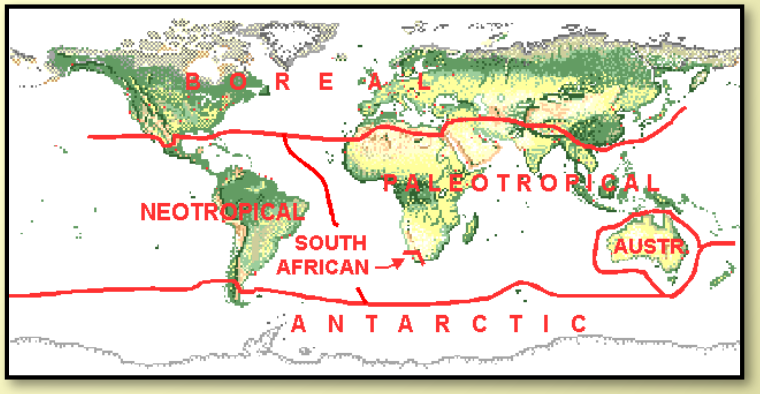
Greyiaceae

Penaeaceae

Floristic Systems

Australian Kingdom (3 regions)

- isolated island continent
- distinctive flora and high endemism
- seen in many biome types
- 18 families endemic



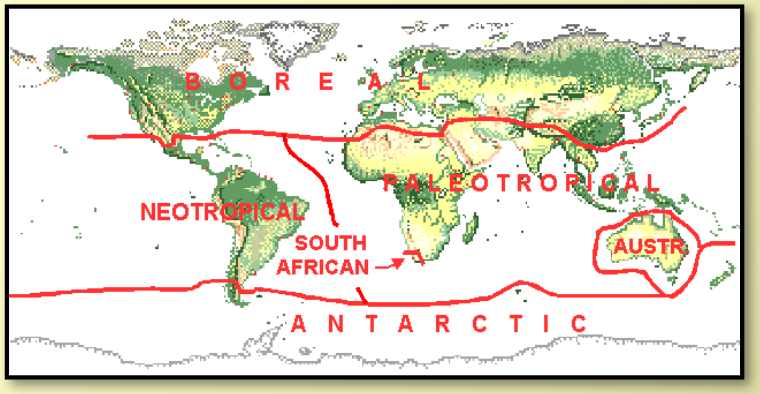
Austrobaileyaceae

Cephalotaceae

Xanthorrhoeaceae s.s.

Floristic Systems

Antarctic or Holantarctic Kingdom



- temperate S. America, New Zealand, Antarctica
- 12 families endemic

Eucryphiaceae

Nothofagaceae &
Misodendraceae
(parasite on *Nothofagus*)