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

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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

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

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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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- Geographic distributions are limited
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- Most species and genera, and even families and orders are restricted in distribution

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

**Limits to Distributions**

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

Beech drops

(root parasite only on American beech)

American beech – *Fagus grandifolia*
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
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.
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 aggregated 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
Nothofagus (southern beech) is endemic to several temperate southern hemisphere areas, thus disjunct.
Osmorhiza chilensis (sweet cicely) shows an amphi-tropical disjunction and a western N. American - Great Lakes – eastern N. American disjunction.
Empetrum (crowberries) of boreal and tundra and Larrea (creosote) of deserts also show amphi-tropical disjunctions.
1 species of *Pitcairnia* in west Africa

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.
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.
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.
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 **endemic** patterns?

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

Three patterns are observed:

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

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

Banksia candelleana

Banksia coccinea

Banksia epica

Banksia marginata
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 — **allopatic**, **vicariant**
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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

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!

<table>
<thead>
<tr>
<th>Family/genus</th>
<th>Af</th>
<th>M</th>
<th>SA</th>
<th>Aus</th>
<th>Tas</th>
<th>NZ</th>
<th>NG</th>
<th>NC</th>
<th>Others</th>
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<td>+</td>
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<td>+</td>
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</tbody>
</table>

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.

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

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**Areas of Endemism** -

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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.
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 1858

- 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:

- **Kingdom** (Realm) — distinctive floras; endemic families
- **Region** — generic endemism high
- **Province** (Domain) — species endemism high
- **District** — subspecies endemism only
Floristic Systems

Provincialism and Floristic Kingdoms

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

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
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

- Platanaceae
- Paeoniaceae
- Ginkgoaceae
- 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
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)