Paleo-biogeography

We will examine the rise of land vegetation and floras and specifically in N. America and the Great Lakes region by using information from paleobiogeography.

- paleo floras - plants moving onto land over 400 mya and becoming the dominant set of terrestrial organisms
- modern floras - diversification of land plants and especially flowering plants over the last 100 my
- ice age events (Pleistocene - last 2.5 my) and the assembly of vegetation and flora in Great Lakes region during recent times (Holocene)
Earth Time

A different perspective before taking a look at the rise and fall of floras and faunas through time . . .

Earth forms at 4.6 bya = January 1, 12:00 a.m.

First evidence of life? - 3.8 bya
Oldest fossils, cyanobacteria - 3.5 bya = late March (1/4 of earth time)

Stromatolites - CaCO₃ ppt by cyanobacteria = photosynthesis

O₂ accumulates in atmosphere - 2.0 bya = late July (>1/2 of earth time)

CO₂ + H₂O → Starch + O₂

Reducing atmosphere → oxidizing atmosphere

Anaerobe extinction → Aerobe evolution

First eukaryotes - 1.5 bya = early September (2/3 of earth time gone)
First abundant fossils in Cambrian "explosion" - 560 million ya
Many phyla of animals = early November

Age of the earth = 1 calendar year
4.6 billion years = 365 days

First land life in Ordovician - 460 mya (a liverwort?)
= November 15 (7/8ths of earth time gone!)

Age of the earth = 1 calendar year
4.6 billion years = 365 days

First flowering plant - 127 mya = December 22

Age of the earth = 1 calendar year
4.6 billion years = 365 days

Earliest civilization of Homo sapiens and assembling of Great Lakes flora - 13,000 ya
= December 31, 11:59 p.m.

Age of the earth = 1 calendar year
4.6 billion years = 365 days
Periods will be the important part of the geological time scale to reference changes in vegetation, flora, fauna.

**Know**
1. the sequence of the Periods,
2. the general time in million of years,
3. and important events, plant and animal groups.

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### Extant Land Plants

- **“bryophytes”**
  - mosses
  - liverworts

- **Lycopsidophyta**
  - club mosses
  - hornworts

- **Polypodiophyta**
  - ferns and horsetails

- **Bryophyta**
  - mosses

- **Anthoceratophyta**
  - hornworts

- **Marchantiophyta**
  - liverworts

- **Pteridophyta**
  - ferns

- **Gymnospermae**
  - club mosses

- **Magnoliophyta**
  - angiosperms

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### Extant Land Plants

- **“bryophytes”**
  - 16,000 species
  - nonvascular plants, least specialized land plants, gametophyte dominant
  - comprising 3 phyla
Extant Land Plants

Lycopodiophyta - lycopods
- 1,150 species
- vascular plants, least specialized vascular plants
- sporophyte dominant; free sporing
- comprising 3 families

Polypodiophyta – ferns
- the ferns, horsetails, whisk ferns
- 11,000 species
- diverse in habit and habitat
- spores produced in specialized sporangia

Pinophyta - gymnosperms
- 870 species
- seed plants but seeds naked or exposed
- often divided into 4 phyla

Magnoliophyta - angiosperms, flowering plants
- 275,000 – 400,000 species
- tremendous adaptive radiation on land
- seed plants with seeds encased in ovary
Cambrian Period (540 - 505 mya)

- most phyla of animals seen except chordates – all marine
- lime secreting algae in marine water
- fungi diversifying (starting at about 600 mya)
- no life on land!

Ordovician Period (505 - 440 mya)

- jawed fish diversifying in oceans
- complex green algae in marine water
- first evidence of land life at 460 mya


Microfossils of spores with sporopollenin (degradation resistant material like lignin) and similar to modern day bryophytes such as liverworts.

Found worldwide in shales that were deposited at the marine-terrestrial interface.
Extinct Land Plants - the Fossil Record

Ordovician Period (505 - 440 mya)
- Other evidence of land life

Glomales fungi seen in 460 my Wisconsin rock. Glomales today form important arbuscular mycorrhizal associations with some liverworts and hornworts and many vascular plants. Symbiosis!

Extinct Land Plants - the Fossil Record

Ordovician Period (505 - 440 mya)
- Other evidence of land life

“Sphagnum” moss seen in 455 my Wisconsin rock - 2nd diverging lineage of bryophytes

Extinct Land Plants - the Fossil Record

Silurian Period (440 - 410 mya)

Cooksonia fossils are seen in the mid Silurian growing close to water

Extinct Land Plants - the Fossil Record

Silurian Period (440 - 410 mya)

Cooksonia fossils are seen in the mid Silurian growing close to water

- very simple, stick-like, leafless plants but sporophyte dominant
- roots never seen
- terminal flat sporangia (spore producing structures)
- primitive vascular or possibly non-vascular
- first seen in Euramerica (tropical setting) and later in Australia
Late Silurian is also the first occurrence of land animals - arachnids, centipedes. Predators and thus indicate that there were unknown herbivores - community of plants, herbivores and carnivores!

Silurian Period (440 - 410 mya)

Extinct Land Plants - the Fossil Record

- underground (root) and above ground photosynthetic stem
- rhizoids (water uptake)
- primitive leaves
- internal transport - vascular tissue
- epidermis, cuticle, stomates

Early Devonian Period (410 - 390 mya)

The Early Devonian lasted some 30 million years after the first appearance in mid-Silurian of simple land plants. During this interval the critical features of land plant survival evolved:

- epidermis, cuticle, stomates
- internal transport - vascular tissue
- support tissue - lignin
- shift to sporophyte rather than gametophyte dominant
- sporopollenin to cover spores for protection

Extinct Land Plants - the Fossil Record

Early Devonian Period (410 - 390 mya)

The ‘greening’ of the earth

Abundant and exquisite fossils known from chert fossil beds in Rhynie, northern Scotland (tropical Euramerica)

Extinct Land Plants - the Fossil Record

Paleozoic

Permian
Pennsylvanian
Mississippian
Devonian
Silurian
Ordovician
Cambrian

Extinct Land Plants - the Fossil Record

Rhynia
Extinct Land Plants - the Fossil Record

Early Devonian Period (410 - 390 mya)

- Underground (root) and above ground photosynthetic stem
- Rhizoids (water uptake)
- Primitive leaves
- Internal transport - vascular tissue
- Epidermis, cuticle, stomates
- Support tissue - lignin
- Shift to sporophyte rather than gametophyte dominant
- Sporopollenin to cover spores for protection
- More complex embryo

The Early Devonian lasted some 30 million years after the first appearance in mid-Silurian of simple land plants. During this interval the critical features of land plant survival evolved:

Extinct Land Plants - the Fossil Record

Late Devonian Period (390 - 360 mya)

First "progynosperms" - believed to be ancestors of seed plants

First complex leaves - megaphylls

Extinct Land Plants - the Fossil Record

Late Devonian Period (390 - 360 mya)

First "progynosperms" - free sporing like ferns but trees like gymnosperms; first forests
Extinct Land Plants - the Fossil Record

**Late Devonian Period (390 - 360 mya)**

*Eospermatopteris* trunks from New York recently connected to *Wattieza* fern-like crown. 385 my old forests of at least 8m tall trees with primitive root systems.

First true ferns - free sporing with complex sporangia & megaphylls

*Protopteridium*

*Pteridium - Bracken fern*

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Extinct Land Plants - the Fossil Record

**Late Devonian Period (390 - 360 mya)**

*Rhacophyton* and the rarer *Gillespiea* were understory ferns in the *Archaeopteris* forests. *Rhacophyton* produced enough biomass, that the first records of forest fires are seen in the Catskill fossil sites.

First "seeds" - "seed fern" lineage

Plants fern-like with dissected compound leaves, but produce naked seeds (embryo within protective coverings)

*Gillespiea*

*Archaeosperma*
Great diversity of plants in warm, wet climate and no apparent provincialism yet seen - worldwide

Arthropods diversify and first amphibians seen by late Devonian

Extinct Land Plants - the Fossil Record

Late Devonian Period (390 - 360 mya)

- Great diversity of plants in warm, wet climate and no apparent provincialism yet seen - worldwide
- Arthropods diversify and first amphibians seen by late Devonian

Extinct Land Plants - the Fossil Record

Carboniferous Period (360 - 286 mya)

- Extensive forests increased O₂ levels worldwide and saw greatest incidence of fire
- The equatorial "coal" forests were the site for the diversification of insects . . .
Hyonomus, primitive reptile, leaping after an insect in a coal swamp of Nova Scotia.

The tropical equatorial coal swamps were dominated by a diversity of lycopsids (lycopod lineage) and horsetails (fern lineage).

Lepidodendron (lycopod) was 30 m tall with 1 meter long "microphyll" leaves.

The scaly bark of Lepidodendron is distinctive as a fossil.
Lepidodendron, along with Sigillaria, were large; but other lycopsids were herbaceous and even viney.

Calamites was the dominant large tree-like horsetail (sphenopsid); but other smaller horsetails covered the ground.

"Seed ferns" continue to diversify. First indication of insect pollination - insect movement of male pollen (microgametophyte) to egg in female gametophyte in Medullosa.
At the end of the Paleozoic, Pangaea begins to coalesce. Tethys Sea forms and allows for provincial floras to develop.

Permian Period (286 - 245 mya)

Extinct Land Plants - the Fossil Record

- **Cathaysia** (equatorial)
  - Rich, rain-forest
  - Seed ferns, lycopsids, sphenopsids

- **Angaran** (Northern Hemisphere)
  - *Cordaites* conifers
  - Northern hemisphere mainly

3 provincial floras develop in response to continentality and still separated land masses.

Herbivorous insects and reptiles diversify. Lycopods and sphenopsids still dominate, but true ferns, "seed ferns", gingophytes, cycadophytes, and cone bearing gymnosperms begin to replace them.

Permian Period (286 - 245 mya)

Extinct Land Plants - the Fossil Record

Possible forerunners to modern conifers beginning to be seen with fossils such as *Cordaites* with cones.

Fossilized trunks common around *Welwitschia* sites in the Namib Desert region.

Permian Period (286 - 245 mya)

Extinct Land Plants - the Fossil Record

Continentality - mid continent aridity first seen.
Extinct Land Plants - the Fossil Record

Permian Period (286 - 245 mya)

*Delnortea abbottii* – large seed ferns from the oil rich shales of central Texas [collected in Abilene State Park]

**Cathaysia** (equatorial)
- Rich, rain-forest
- Seed ferns, lycopsids, sphenopsids

**Angarar** (Northern Hemisphere)
- *Cordaites* conifers
- Northern hemisphere mainly

**Gondwana** (Southern Hemisphere)
- Glossopterids

Continentality - mid continent aridity first seen

Remember! Wegener described both plant and animal fossil examples supporting his theory — he believed that this biogeographic data was the strongest evidence for his theory

*Glossopteris* - Permian seed plants

*Mesosaurus* - Permian freshwater reptile

*Cynognathus* - Triassic land reptile

*Lystrosaurus* - Triassic land reptile

"Gond" = site in India where Glossopterid fossils first seen
"Gondwana" = "land of Gond"
Extinct Land Plants - the Fossil Record

End of the Paleozoic Era (245 mya) By the end of Permian and the Paleozoic Era, land life had seen:

- terrestrial green algae
- Bryophytes
- early non-vascular and vascular lineages
- Lycopodiophyta
- Pteridophytes (ferns and allies)
- Pogynosperms (free sporing)
- Early seed plants including Glossopterids, seed ferns, conifers, cycadophytes, ginkgophytes