Root Morphology of Trees

Tree Biology
- Tree roots occupy a thin zone in soil
- Tree roots grow far beyond the drip-line of the tree
- Tree roots don’t always grow down, in fact third order roots often grow upward
Root Morphology

- Seedlings with a single tap root (oaks-pines)

- Lateral roots form framework close to soil surface
  - Upward swelling close to trunk
  - Roots don’t always grow downward
Root Morphology

- Root depth
  - Oxygen
  - Water
  - Compaction
  - Obstruction

- Striker/sinker roots
  - Tap root like some distance along laterals

- Fine roots
  - Mine soil
  - Most abundant near trunk
Fine Roots on Red Oak
Lyford-1980 (Harvard)

- 1 cm³ contained
  - 1000 root tips
  - 2.5 m of total length
  - 6 cm²
  - But only 3% of cube volume

- 500 million fine roots per tree
  - 90% in top 20cm of soil
  - Greatest gas exchange
  - Access to recycled nutrients
Root Hairs

• Root hairs increase surface area for water and mineral absorption

• Absent from many trees. Why?

• Kentucky Coffee Tree has long-lived root hairs
Mycorrhizal Interactions

• Essential symbiosis
  – Oaks, beech, pine—necessary
  – Maple, birch—beneficial, but not necessary

• Plant receives
  – Phosphorus, nitrogen, water
  – Increased surface area for mining
  – Antibiotic protection

• Fungi receives
  – Carbohydrates (15% of tree total)

• Most abundant on nutrient poor soils
Ectomycorrhizae

- Restricted to trees
- 90% of temperate trees
- Intercellular infection
  - Stunted, forked root tips
- Ascomycetes and basidiomycetes
  - Large fruiting bodies
    - *Russula, Amanita, Boletus, Lactarius*
- Fungi sequester nutrients from leaf litter
- High host specificity

http://www.biomedcentral.com/1471-2105/6/979
Endomycorrhizae
Arbuscular Mycorrhizae

• Intracellular infection
• Zygomycetes—fb often unknown
• 2/3 of all land plants
• Likely a contributor to the evolution of land plants
  – 350-460 MYA
• Fungi expand volume of soil by which nutrients can be gleaned
  – No digestion of litter
• Low host specificity
Nitrogen Fixation in Trees

• Most Prominent in legumes (Fabaceae-Leguminosae)
  – Most important tropical trees
  – Used in land reclamation
  – Shade grown coffee plantations

• Other families with similar systems but with different bacteria
  – *Alnus* (Betulaceae)

• Coevolved system
• Nitrogen fixation is performed by bacteria
Nitrogen Cycling

- $N_2 \rightarrow NH_4^+$
  - Energy expensive process (16 ATP)
- Anaerobic bacteria
- Leghemoglobin is an oxygen binding protein produced by legumes

- Nitrifying bacteria
  - $NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$
- Fertilizer production requires high heat and pressure—energy expensive
- Denitrifying bacteria take nitrates and convert into elemental gaseous nitrogen
Assignment for Tuesday morning
9:30 A.M

- Everyone needs
  - Typewritten table 1
  - Two graphs to describe and show interesting aspects of data
  - Typewritten interpretation of data in tables and graphs and ideas for further study of the problem (two pages)
Hypothesis: Planting conditions and location of *Tilia cordata* affects growth and vigor of trees.

- DBH (cm)
- 2012 twig length (mm)
- Canopy density (% coverage)
- Age
- Annual ring growth patterns
- Canopy height (m)

Table 1. Means, standard deviations, and *P*-values of growth traits for *Tilia cordata* at the SUNY Cortland Park Center.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Lawn</th>
<th>Interior Lot</th>
<th><em>P</em>-value</th>
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<tbody>
<tr>
<td>Age (annual rings)</td>
<td>38.7 ± 2.0</td>
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<tr>
<td>DBH (cm)</td>
<td>xx.x ± x.x</td>
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<tr>
<td>2012 Twig length (mm)</td>
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<tr>
<td>Canopy Density (%)</td>
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<tr>
<td>Canopy Height (m)</td>
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<tr>
<td>Other . . . . .</td>
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</tbody>
</table>
Figure 1. Average annual ring width (mm) for lawn (open circles) and interior (close circles) trees of *Tilia cordata* between years 2003 and 2012 at SUNY Cortland Park Center. Error bars represent the standard error of the mean (s.d. / $\sqrt{n}$). Tree identification numbers are above data points.
Shade Grown Coffee Plantation
Using legume trees does promote nitrogen enrichment of soils.
Root Grafting

- Intraspecific is common – *Ulmus, Pinus, Quercus* – Sharing of resources

- Detrimental sharing of pathogens (oak wilt, Dutch elm disease)
Buttressed Roots

- Buttresses are actually raised, flared roots on angiosperm trees in tropical rainforests and along lowland or river communities
- Tall tropical trees
- Function?
Strangler Figs (*Ficus*)

*roots grow from the canopy to the ground and form a strangling net around the support tree.*
Swamp-land Buttresses

Bald Cypress—Old Growth in Swamps

Cypress Buttressses
Bald Cypress “Knees” or Pneumatophores

-adapted to inundated environments

-roots require oxygen for respiration; and need to remove carbon dioxide

Cypress Knees “breathing” roots???
Pillar roots on a single *Ficus* tree in India (250 years old)
Black Mangrove Peg Roots for Aeration
Prop roots of Red Mangrove in Tropical Coastal Swamps.
5% of volume above water is air space
50% of volume is air space below water
prop roots for aeration and support
also trap litter and silt to build soil of mangrove area

Vivipary in Red Mangrove (*Rhizophora mangle*)

Photo stolen from [http://nemcok.sk/?pic=15639](http://nemcok.sk/?pic=15639)
Canopy Roots
Redwoods & Tropical Forest Trees

- Minimal impact on total nutrient input
- Result of being covered by moist humus
- Little to no mycorrhizae in canopy roots
Yellow Birch
Goodnow Mtn-Adirondacks
Chris Broyles-2003