Understanding the impacts of chestnut restoration through plant-soil feedback

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Functional loss of chestnut

- Chestnuts still present in forests
- Understory shrubs
- Rarely make it to reproduction
- Impact sig. lessened
Chestnut restoration

- Efforts are underway to understand the impacts and effectiveness of restoration
- Primarily above-ground traits and interactions
Plant-soil interactions essential to restoration

- “Plant-soil interactions are the foundation for effective and sustained achievement of [terrestrial restoration] goals” (Eviner & Hawkes 2008).

- “Future [plant-soil feedback] research will better enable prediction and mitigation of the consequences of human-induced global changes, improve efforts of restoration...” (Van der Putten et al. 2013)
Positive & Negative Feedback

Positive Feedback

• Soil conditioning promotes offspring growth
• Mutualist accumulation or reduction in specific pathogens

Negative Feedback

• Soil conditioning hinders offspring growth
• Pathogen accumulation or reduction in compatible mutualists
Evidence for P-S feedback
Fungal Interactions

• Extremely important to plant growth
  – Mycorrhizae
    • Plant-fungal mutualism
  – Fungal and Oomycete pathogens
Part 1 (nearing completion)

**Question 1** – What are the directions and strengths of species’ P-S interactions?

How does soil inoculum affect conspecific and heterospecific growth and survival?
Predictions

- Directions: Expect negative feedback
- Strengths: Expect variation
P-S Feedback experiment

• Fully reciprocal greenhouse experiment
• Quantifying strength and direction of species’ interactions
  – American chestnut (*Castanea dentata*)
  – BC3F3 chestnut hybrid
  – Tulip poplar (*Liriodendron tulipifera*)
  – White oak (*Quercus alba*)
  – White pine (*Pinus strobus*)
• Model effect of interactions on community composition over time
Experimental design

Seedling species

- American chestnut
- BC3F3 hybrid chestnut
- Tulip poplar
- White oak
- White pine

Soil Inoculum

- American chestnut
  - Tulip poplar
  - White oak
  - White pine
  - Control

- BC3F3 hybrid chestnut
  - Tulip poplar
  - White oak
  - White pine
  - Control

- Tulip poplar
  - American chestnut
  - BC3F3 hybrid chestnut

- White oak
  - American chestnut
  - BC3F3 hybrid chestnut

- White pine
  - American chestnut
  - BC3F3 hybrid chestnut

Response variables

- Dry Biomass (growth)
- Mycorrhizal colonization
- Percent mortality

Experimental design
Methods

- Chestnut and oak seeds initially grown in growth chamber for 1 month
- Transplanted into 2 L tree pots in greenhouse
- Pines and poplar direct seeded in greenhouse
Methods

Seedling or seed

- American chestnut seeds provided by TACF; other species by Sheffield’s Seeds

50 mL Inoculum Soil

- Collected from three FS chestnut plantings in the SE Appalachian Mtns

2 L Steam-sterilized Matrix Soil

- 2 parts field soil from mixed hardwood and pine forests
  - 1 part sand
  - 1 part peat
Methods – data collection & analysis

- Trees harvested after 5 months
- Dry biomass of roots and stems [in progress]
  - One-way ANOVA
  - Tukey’s HSD
- Percent mycorrhizal colonization [future]
Total Dry Biomass

White Oak roots

White pine

Control

American Chestnut

Soil Inoculum
Response Value ($B_r - B_c$)

**White oak**

- AM: b
- BC: ab
- TP: ab
- WO: ab
- WP: a

**American chestnut**

- AM: a
- TP: a
- WO: a
- WP: a

Soil Inoculum:
<table>
<thead>
<tr>
<th>Soil Inoculum</th>
<th>American chestnut</th>
<th>BC3F3</th>
<th>White oak</th>
<th>White pine</th>
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<tbody>
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<td>American chestnut</td>
<td>40%</td>
<td>-</td>
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<td>0%</td>
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<tr>
<td>BC3F3</td>
<td>-</td>
<td>10%</td>
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<tr>
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Question 2: Are the microbial communities of these species significantly different?

And is there a relationship between microbial community composition and observed growth responses?
Prediction

- I expect to see a relationship between pathogen abundance and growth response.
Microbial Community Characterization

- Soil cores collected from field sites
- Meta-genomic analysis using Illumina sequencings
Current Thoughts and Future Outlook

• Still in the midst of data collection
• Currently see some significant differences in soil treatments
• Future modeling – make predictions about community composition change
• Stay tuned!
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