Impacts of Atmospheric Deposition of N on NJ Pine Barrens Forest Soils and Ectomycorrhizal Communities

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N Deposition and Ectomycorrhizae

- European studies have shown us that both fruitbody and mycorrhizal root tip communities are altered by N deposition.
- Many of these studies in the field show responses to high levels of deposition (13 – 50 kg ha$^{-1}$ y$^{-1}$).
NJ Pine Barrens

- In the NE corridor of the USA we expect high levels of N deposition from industrial interior states.
- Pine barren ecosystems are oligotrophic.
- Pine barrens soils are not nutrient retentive.
- Pine barrens ecosystems may respond differently to other forest ecosystems to atmospherically deposited N.
Questions

• Is there a N deposition gradient within the NJ pine barrens?
• Does this natural gradient produce visible effects of the ectomycorrhizal community of pitch pines?
• Can we mimic any changes in mycorrhizal communities by greenhouse studies of plant responses to increasing N levels?
Hypothesized potential gradient of N deposition
Site Selection

- Three sites selected on a SW – NE transect
- All sites on upland pine-oak communities with similar tree density and vegetation cover
- Random pitch pine trees within each site were tagged and became sample units within sites
N Deposition

- Four bulk precipitation collectors were installed at each site and monthly composite samples were analyzed for NH$_4$-N and NO$_3$-N.
Annual N Deposition at Each Site Measured in Bulk Precipitation

- NO₃-N
- NH₄-N
- Inorg-N

<table>
<thead>
<tr>
<th>Site</th>
<th>NO₃-N (kg ha⁻¹ y⁻¹)</th>
<th>NH₄-N (kg ha⁻¹ y⁻¹)</th>
<th>Inorg-N (kg ha⁻¹ y⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belleplain</td>
<td>a</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>Lebanon</td>
<td>b</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td>Collier's Mills</td>
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</tr>
</tbody>
</table>
• We have established that there is an N deposition gradient through the NJ pine barrens
• Annual deposition is considerably less than many sites where ectomycorrhizal studies have been made.
Abundance of Ectomycorrhizal Root tips at Each Site

Number of Mycorrhizal Root Tips

Belleplain  Lebanon  Collier's Mills

0  250  500  750  1000

A  A  B
Ectomycorrhizal Morphotype Abundance at Each Site

Number of ECM Morphotypes

- Belleplain
- Lebanon
- Collier's Mills

A

AB

B
Ectomycorrhizae in the Field

• The total number of ectomycorrhizal root tips per soil core sample significantly decreased with increasing N deposition

• The number of ectomycorrhizal fungal species associated with roots (morphotypes) significantly declined with increasing N deposition
Greenhouse Study

• A greenhouse study of pitch pine seedling growth and ectomycorrhizal community development with increasing N additions was set up.
• 5 cm diam. intact soil cores to 20 cm depth in PVC pipes.
• With or without tree seedling
• Grown for one season
• 0, 35 or 140 kg ha\(^{-1}\) equivalent addition of N as ammonium nitrate
Ectomycorrhizal Morphotype Abundance in Relation to N Additions

Number of ECM Morphotypes

N Addition (kg N ha$^{-1}$)

0 35 140

A

AB

B

0 1 2 3 4 5 6

Ectomycorrhizal Morphotype Abundance in Relation to N Additions
ECM Morphotype Abundance

• Abundance of ectomycorrhizae on seedling trees significantly declined with increasing N addition
• The pattern of decrease follows that seen in the field, but at much higher levels of N addition
Mycorrhizae as Bioindicators of N Deposition
## Potentially Nitrophobic Ectomycorrhial Morphotypes in Seedling Study

<table>
<thead>
<tr>
<th>Potentially nitrophobic types</th>
<th>0 kg N ha(^{-1}) y(^{-1})</th>
<th>35 kg N ha(^{-1}) y(^{-1})</th>
<th>140 kg N ha(^{-1}) y(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown-shiny</td>
<td>72</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Br/wt -DB(Russula)</td>
<td>4043</td>
<td>1627</td>
<td>865</td>
</tr>
<tr>
<td>Br/wt –DB/YBr</td>
<td>1305</td>
<td>111</td>
<td>6</td>
</tr>
<tr>
<td>Copper (Cortinarius)</td>
<td>45</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>White-bulbous</td>
<td>38</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Y/Br. white</td>
<td>620</td>
<td>172</td>
<td>41</td>
</tr>
</tbody>
</table>
Abundance (tips per core) of potentially nitrophobic ectomycorrhizal morphotypes from field sites in relation to N-deposition

<table>
<thead>
<tr>
<th>Morphotype</th>
<th>Belleplain (3.7 kg ha(^{-1}) y(^{-1}))</th>
<th>Lebanon (5.3 kg ha(^{-1}) y(^{-1}))</th>
<th>Colliers Mills (7.8 kg ha(^{-1}) y(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown/white – DB (Russula)</td>
<td>672</td>
<td>232</td>
<td>179</td>
</tr>
<tr>
<td>Green/ yellow</td>
<td>178</td>
<td>68</td>
<td>0</td>
</tr>
<tr>
<td>Yellow (Lactarius)</td>
<td>509</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Brown, bristly pinnate</td>
<td>71</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chartreuse</td>
<td>97</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Yellow- bulbous</td>
<td>123</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Abundance (tips per core) of potentially nitrophilic ectomycorrhizal morphotypes from field sites in relation to N-deposition

<table>
<thead>
<tr>
<th></th>
<th>Belleplain (3.7 kg ha(^{-1}) y(^{-1}))</th>
<th>Lebanon (5.3 kg ha(^{-1}) y(^{-1}))</th>
<th>Colliers Mills (7.8 kg ha(^{-1}) y(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coral</td>
<td>0</td>
<td>0</td>
<td>418</td>
</tr>
<tr>
<td>Pumpkin (Suilloid)</td>
<td>11</td>
<td>24</td>
<td>49</td>
</tr>
<tr>
<td>White/brown (Rhizopogon)</td>
<td>0</td>
<td>0</td>
<td>90</td>
</tr>
<tr>
<td>Y/Br (Ascomycete)</td>
<td>693</td>
<td>1066</td>
<td>1391</td>
</tr>
<tr>
<td>Yellow/white</td>
<td>0</td>
<td>0</td>
<td>49</td>
</tr>
<tr>
<td>Yellow - tuber</td>
<td>4</td>
<td>8</td>
<td>79</td>
</tr>
</tbody>
</table>
Conclusions

• We have identified a N deposition gradient through the NJ pine barrens.
• Changes in ectomycorrhizal communities on pitch pine appear to be in response to low levels of N deposition in these oligotrophic forests.
• Similar changes in mycorrhizae are observed on seedling trees in response to higher levels of N addition.
Next Steps

• Results presented at Ecological Society of America Conference (Summer 2004)


• EXPAND Study to Include More Sites

• Applying for USEPA Grant (OAR RFA# OAR-CAMD-04-12)

• Ecological Indicators of Air Quality”
  Notice announces the availability of funds and solicits proposals that enhance scientific assessment capabilities to better understand how changes in air quality and atmospheric deposition impact entire ecosystems. The successfully funded proposal will present a methodology for developing: (1) ecological indicators of air quality (that measure air quality in relation to aquatic and terrestrial ecosystem conditions) and (2) a measurement system for using these indicators to evaluate progress in improving ecosystem condition
EPA Proposed Scope of Work

• Expand fungal indicator study to similar oak-pine ecosystems across Coastal Atlantic (e.g., Long Island, NY; Lake Wales Ridge, FL; Virginia and North Carolina)

• Use local NADN network and/or State atmospheric sampling locations for coordination and co-locating samplers.

• Expand contaminants to include major components of PM 2.5 (SOx & NOx).

• Integrate sampling across multimedia and multi-ecosystems (below ground species, aboveground and aquatic) to provide more robust response to atmospheric pollutants.
Acknowledgements

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