What drives decomposition rates of coarse woody debris (CWD)?

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Background

Decomposition

- complex organical structure of biological material is reduced to its mineral form
- **biochemical decomposition**: Respiration of sugar molecules (Swift 1977)
- **physical-chemical weathering**: fotodegradation, leaching, fragmentation

- The microbial activity is dependent on controlling factors such as temperature, moisture and substrate quality.
Objectives

- Assessment of the decay rate of lying CWD in relation to:
  - tree species (*Fagus sylvatica*, *Picea abies*, *Pinus sylvestris*)
  - climate (temperature, precipitation)
  - size (3 diameter classes: 10-20, 20-40, >40cm)
  - decay stage (4-5 classes)

- Modeling the decay dynamics and carbon release for the species under investigation
Experimental Design

- **Incubation of wood samples in the lab:** Assessment of the current decay rates of the different decay stages dependent on temperature and wood moisture content via respiration measurements.

# Lab experiment

<table>
<thead>
<tr>
<th></th>
<th>T1 (5°C)</th>
<th></th>
<th>T2 (10°C)</th>
<th></th>
<th>T3 (20°C)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DS 1</td>
<td>M 1</td>
<td>M 2</td>
<td>M 3</td>
<td>M 1</td>
<td>M 2</td>
<td>M 3</td>
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<tr>
<td></td>
<td>x 4</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>DS 3</td>
<td></td>
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</tr>
<tr>
<td>DS 5</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Results - Lab experiment

Fagus sylvatica, DC 3, density 0.344 g cm$^{-3}$, n = 108

- av. moisture: 181 % dry weight
  - $y = 0.0289x + 0.0052$
  - $R^2 = 0.9968$

- av. temp.: 11.7 °C
  - $y = 0.1466e^{0.0044x}$
  - $R^2 = 0.9951$
## Results - Lab experiment

<table>
<thead>
<tr>
<th>Model</th>
<th>R-Square</th>
<th>Influencing variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.174</td>
<td>%</td>
</tr>
<tr>
<td>2</td>
<td>0.280</td>
<td>%, °C</td>
</tr>
<tr>
<td>3</td>
<td>0.363</td>
<td>%, °C, species</td>
</tr>
<tr>
<td>4</td>
<td>0.404</td>
<td>%, °C, species, DC</td>
</tr>
</tbody>
</table>
Experimental Design

• Inventories in the field:

Dependent parameters:
• Decomposition Class
• C density
• Mass
• Content of nutrients and organic constituents

Independent parameters:
• Species
• Diameter
• Average annual temperature
• Average annual precipitation
• Time since tree fall
Study-Area

Freiburg
# Field experiment

<table>
<thead>
<tr>
<th>(Years)</th>
<th>H1 (ca. 100m)</th>
<th>H2 (ca. 600m)</th>
<th>H3 (ca. 900m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D1 (10-20cm)</td>
<td>D2 (20-40cm)</td>
<td>D3 (&gt;40cm)</td>
</tr>
<tr>
<td>A1 (0-3)</td>
<td>x 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2 (4-8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A3 (9-15)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>A4 (16-30)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>A5 (&gt;30)</td>
<td></td>
<td></td>
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</tbody>
</table>
Assessment of the physical and chemical wood properties
Field inventory
Field inventory
Calibration NIRS

Predicted vs. Measured / Cellulose [%] / Test set validation

Predicted vs. Measured / Lignin [%] / Test set validation

Fagus sylvatica

n = 51

Rank: 8
$R^2 = 41.26$

Rank: 10
$R^2 = 70.26$  RMSEP = 2.25
Calibration of drill resistance method

Fagus sylvatica

$y = 0.0144e^{0.6018x}$

$R^2 = 0.7661$, $n = 538$
Results - field inventory

Fagus sylvatica

$y = 0.1055e^{-0.0196x}$

$R^2 = 0.34, n = 62$
Decomposition constants (k)  
(based on mass loss)

<table>
<thead>
<tr>
<th>species</th>
<th>&gt; 40 cm</th>
<th>20 - 40 cm</th>
<th>10 - 20 cm</th>
<th>average</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Fagus sylvatica</em></td>
<td>0.041</td>
<td>0.065</td>
<td>0.079</td>
<td>0.061</td>
</tr>
<tr>
<td><em>Picea abies</em></td>
<td>0.023</td>
<td>0.033</td>
<td>0.038</td>
<td>0.031</td>
</tr>
<tr>
<td><em>Pinus sylvestris</em></td>
<td>0.022</td>
<td>0.029</td>
<td>0.046</td>
<td>0.032</td>
</tr>
</tbody>
</table>

**n** = 62  
**SD** = 0.014 0.031 0.022 0.022

**n** = 58  
**SD** = 0.007 0.012 0.012 0.01
Summary

• **Lab experiment**
  - Moisture content showed the strongest influence on respiration rates, followed by temperature, species and decay stage
  - Average respiration rates of European beech were twice as high when compared to Norway spruce and Scots pine

• **Field inventory**
  - Decreasing decomposition rate with increasing diameter
  - Average decay rate of lying CWD of European beech was twice as high as the one of Norway spruce and Scots pine

• **General:**
  - Lab incubations may be used to determine relative differences between species
  - Drill resistance measurements may facilitate rapid determination of CWD density in the field
Assessment of respirational carbon loss in the field - Case study “Conventwald”

THANK YOU!