Forest SOC monitoring in Sweden – challenges and needs for the future

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Swedish Forest Soil Inventory

- Initiated in 1983
- Permanent plots of the NFI
- Monitors site productivity, acidification & carbon
- Soil fungal biodiversity since 2015
- Forest land, wetland, grassland, mountain areas (not arable land, mountains)
- 10 year inventory interval
Inventory tracts

- 8 plots per tract (4 plots in southwest)
- Size: 800 – 1200 meters (region 1-4), 300 meter (region 5)
- Sampling
  - Topsoil on 50% of the plots (~10 000)
  - Mineral soil on 25% of the plots (~4500)
Soil sampling (2003-)

• 3-5 samples depending on soil type
• Topsoil sampled with auger (to max 30 cm)
• Mineral soil in small pit (w. small spade)
  – Bulk density by pedotransfer functions
• Peat sampling at two depths
  – 0-30 cm and 40-50 cm
Sample preparation

• Totally ca 2000 soil samples/year
• Samples dried 3-6 months (ca 35 °C)
• Sample preparation
  – Milling of topsoil samples
  – Sieving of mineral samples
  – Fine and coarse fraction separated (2 mm)
• Archiving of soil samples
## Soil chemical analyses

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Approx. no./year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry substance (105 °C)</td>
<td>2000</td>
</tr>
<tr>
<td>pH (H$_2$O)</td>
<td>2000</td>
</tr>
<tr>
<td>pH (CaCl$_2$)</td>
<td>2000</td>
</tr>
<tr>
<td>Total C, N, S (Dry combustion)</td>
<td>2000</td>
</tr>
<tr>
<td>Base cations (NH$_4$Ac extraction, ICP/AES)</td>
<td>1500</td>
</tr>
<tr>
<td>Al (KCl extraction, ICP/AES)</td>
<td>1500</td>
</tr>
<tr>
<td>pH (KCl)</td>
<td>1500</td>
</tr>
<tr>
<td>Total Acidity (NH$_4$Ac extraction)</td>
<td>1500</td>
</tr>
</tbody>
</table>

Totally ca 14 000/year
DNA based fungal inventory since 2015

Sampling

DNA-extraction

Sequencing (PacSequel)

PCR amplification of fungal “barcodes”
Carbon stocks of Swedish forest soils

- Productive forest land
- Non-organic soils

The Swedish Forest Soil Inventory
NFI Annual Report 2017
C-stock dynamics over stand age classes

- Initial reduction – less input, faster decay
- Recovery of sink after reforestation
- Moderate decline in C-stocks
- No increase in old forests

Southern Sweden

Northern Sweden

RA=Relative age – normalized by allowed harvesting age
Sweden’s GHG Inventory (UNFCC, Kyoto)

- LULUCF sector – Land Use Land Use Change and Forestry
- Trends in uptakes and emissions from e.g. managed forest land
- Living biomass, Dead organic matter (humus+dead wood), Soil etc.
Gains and losses of CO$_2$ – LULUCF data

- Largest sink in living biomass
- Dead organic matter a source
- Large sink in the (mineral) soil
- Largest sink in ages 20-60 years
- Small increase in soil sink with age

Data NFI + SFSI, Skog & Mark 2021
Challenges and needs for the future

• How to adopt long term monitoring to new needs

• Preventing methodological bias over time
  – Maintaining methodology, e.g. sampling and soil chemical analyses
  – Introduce necessary changes without influencing time series

• Integration with other data sources
  – How to integrate soil data with remote sensing

• Scale differences in soil sampling and forest properties

• Introducing eDNA methods for soil animals and bacteria

• Adopting to methodological developments in eDNA (metabarcoding) techniques without introducing bias