Decomposing tree stumps are long-term carbon pools and nitrogen sinks after harvesting

Marjo Palviainen¹, Leena Finér², Raija Laiho¹, Ekaterina Shorohova³,⁴, Ekaterina Kapitsa⁴ & Ilkka Vanha-Majamaa³

¹ University of Helsinki, Department of Forest Ecology, Finland
² Finnish Forest Research Institute, Joensuu Research Unit, Finland
³ Finnish Forest Research Institute, Vantaa Research Unit, Finland
⁴ Saint-Petersburg State Forest Academy, Russia
Stumps

- Constitute a large component of coarse woody debris in managed forests
- Account for 15-20 % of C and 8-15 % of N found in tree biomass in mature stands
- The importance as a nutrient source during stand development?
- The role in ecosystem C budget and nutrient cycling?
Stumps are harvested for energy

- Currently, 0.3 million m$^3$ of stumps are harvested annually in Finland
- The effects on soil C and nutrient pools, site fertility and nutrient cycling?
Stumps decompose slowly

- Mass loss 95 % ~ 60 years
- In the long-run which is best: to reduce the use of fossil fuels with renewable energy, or to offset emissions by sequestering more C in a biological system?
- Because stumps decompose slowly they might be more valuable as a C pool than as a fuel

(Melin et al. 2009)
Decaying wood may act as N sink

- Sources: fungal translocation, N fixation, deposition
- N accumulation in CWD has been suggested to be an important mechanism of nutrient retention which may diminish N leaching after disturbances and maintain site fertility and productivity.

Fungal mycelium in wood.
(Photo: http://www.theloghome.inspector.com)
A chronosequence study

- Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*) and silver birch (*Betula pendula*) stumps
- Decomposed for 0, 5, 10, 20, 30 and 40 years after clear-cutting in southern Finland
- Objectives: to study how fast C and N release from stumps, and find out whether they act as N sinks
Methods

- **Stumps**: height, base and top diameters were measured and volumes were calculated
- **Wood samples**: height, length and thickness were measured, bulk density was determined. The mass of stump wood = volume * bulk density
- **Bark**: percent cover of bark was visually estimated, total area of bark was calculated: \( S_f = f \times (\pi \times L \times (R+r)) \), where \( f \) is coverage, \( L \) is the slant height of a cone in metres and \( R \) and \( r \) are the maximum and minimum radii, in metres, respectively
- **Bark samples**: height, width and mass were determined, the specific mass of bark was calculated by dividing the dry mass of bark sample by the area of the sample. The total mass of bark = the total area of bark * specific mass of bark
- **The concentrations of C and N**: a LECO CHN-1000 analyzer
Carbon

C concentration (%)

Wood

Bark

The amount of C (% of initial)

Pine

Spruce

Birch

\[ y = a + b \times Time^c \]

\[ y = 100e^{bx} \]
Nitrogen

The amount of N (% of initial)

Pine: $y = a + bx^c$

Spruce: $y = a + bx^c$

Birch: $y = a + bx^c$

The amount of N (% of initial)
Note different scales on y-axis for conifers and birch
# C and N pools

<table>
<thead>
<tr>
<th>Pools (Kg ha(^{-1}))</th>
<th>Stumps</th>
<th>Above-ground logging residues</th>
<th>Tree seedlings &amp; ground vegetation on recently clear-cut areas</th>
<th>Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Pine: 8200-10 900 Spruce: 3900-5100</td>
<td>Pine: 10 000 Spruce: 17 000 – 20 000</td>
<td>2000-3000</td>
<td>60 000 – 70 000</td>
</tr>
</tbody>
</table>
0.6-0.9 Mg C ha\(^{-1}\) yr\(^{-1}\) and 0.2-0.3 Mg C ha\(^{-1}\) yr\(^{-1}\) was released from pine and spruce stumps, respectively, during the first 5 years after clear-cutting.

Logging residues: 1.5 Mg C ha\(^{-1}\) yr\(^{-1}\) during the first years after clear-cutting (Palviainen et al. 2004).

Annual C effluxes (heterotrophic) from clear-cut areas in Finland: 5.2 Mg C ha\(^{-1}\) (Pumpanen et al. 2004).

C release from decomposing stumps represents an important component of the C budget particularly in clear-cut pine forests.
During the first 5 years after harvesting, about two-fold increase in stump N content may occur, corresponding to 2.2-2.8 kg N ha\(^{-1}\) yr\(^{-1}\) and 1.4-1.8 kg N ha\(^{-1}\) yr\(^{-1}\) in clear-cut pine and spruce stands, respectively.

- Deposition: 1-6 kg N ha\(^{-1}\) yr\(^{-1}\)
- N uptake by vegetation 7-14 kg N ha\(^{-1}\) yr\(^{-1}\) in Finnish clear-cut areas
Conclusions

- Scots pine, Norway spruce and silver birch stumps are long-term C and, especially, N pools, and they serve as N sinks, thus potentially diminishing N leaching into ground water and watercourses after harvesting.
- The removal of stumps for bioenergy production may markedly affect the nutrient status and nutrient cycling of boreal forests.
THANK YOU!