Forestry in Sweden
Sweden’s total land area is 40.8 million hectares (100.8 million acres),

consisting of:

- 23.1 million hectares of productive forest land
- 5.0 million hectares of bog- and marshland
- 1.0 million hectares of rock surfaces
- 6.3 million hectares of mountains and alpine coniferous forest
- 3.4 million hectares cropland and grazing land
- 1.9 million hectares urban land and other land
The distribution of productive forest land by ownership classes in year 2011 were:

- 50% individual owners
- 25% private owned companies
- 14% state owned companies
- 6% other private owners
- 3% state
- 2% other public owners
Total standing volume on productive forest land is about 3.0 billion cubic metres, of which
40 % Scots pine,
42 % Norway spruce
12 % birch
Rotation 50-100 yrs

Average standing volume per hectare on productive forest land is 134 cubic metres.
The total standing volume of Swedish forests has increased by over 80 % since the 1920s.

The average annual productivity of productive forest land is 5.3 cubic meters per hectare.
Total annual growth is approx. 114 million cubic meters (productive forest land)
Empirical Production Models for Poplar Plantations in Sweden

Birger Hjelm
Department of Crop Production Ecology - SLU
Poplar characteristics:

Belongs to *Salicaceae* (*Populus* and *Salix*: poplars, aspens and willows)

About 30 species in the world, mostly fast growing

Many hybrids of poplar species have been developed and are commercially used

Regenerates naturally (suckers and *coppices*)

Suitable for short-rotation forestry on lowlands and farmland
Poplars in Sweden

- Exotic

- Average annual production on farmland: 20-25 m³ ha⁻¹ yr⁻¹ (Norway Spruce: 8-12 m³ ha⁻¹ yr⁻¹) on farmland

- Rotation periods: ≤ 20 yrs

- Increased interest as future Bio-Energy supplier

- Ca 800 hectares (only) of “old” plantations (15-25 year)
  FAQ: After harvest, new plantation or 2nd generation coppices?

- Additional ca 500 hectares new established plantations

18 years old poplar stand in Uppland (foto Tord Johansson)
Objectives

To develop and evaluate models to improve the predictions of:

• volume,
• biomass
• yield/assortments
• wetwood properties
The Models

- Biomass and Volume models for individual Poplar trees
- Taper models for individual Poplar trees
- Biomass models for Poplar stumps
- Biomass models for 2\textsuperscript{nd} generation coppices
- Models for property estimations of Heartwood
Biomass and Volume models for individual Poplar trees

- The biomass equations estimates the dry weight (kg) of stem, twigs and leaf fractions
  Independent variable: \( \text{dbh} \)

- The constructed Stem volume (dm3) equations were compared with published equations
  Independent variables: \( D = \text{dbh} \) and \( H = \text{Total Height} \)

* diameter at breast height

The three best ranked stem volume equations

<table>
<thead>
<tr>
<th>Equation</th>
<th>Expression</th>
<th>Absolut Bias (dm3)</th>
<th>Absolut Bias %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Constructed (Hjelm &amp; Johansson 2011)</td>
<td>( V = b_1 (2+(D/H)) + b_2 H^2 + b_3 DH^2 )</td>
<td>25.13</td>
<td>3.8</td>
</tr>
<tr>
<td>2) Fowler &amp; Hussain (1987)</td>
<td>( V = b_1 + b_2 D^{b_3} H^{b_4} )</td>
<td>25.07</td>
<td>3.8</td>
</tr>
<tr>
<td>3) Opdahl (1992)</td>
<td>( V = b_1 + b_2 D - b_3 D^2 + b_4 D^2 H )</td>
<td>26.86</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Production of dry tree biomass (kg/tree) at dbh (total, stem, branches and leaves).
Taper models for individual Poplar trees

-Estimates diameter \((d)\) along stems (different assortments with diameter restrictions)
-Dependent var: DBH, corresponding height \((h)\) and total height \((H)\),
some complex models also require level of inflexion point \((ip)\)

\[
d = (b_1 q^2 - b_2 q + b_3 ((H-h)/h) + b_4) \times (D/(1-k/H))^{b_5}
\]

-Residuals of the two highest ranked taper equations

\[
d = b_1 D^{b_2 q^2}((1-q^{0.5})(1-p^{0.5}))^A
A = (b_4 q^2 + b_5 \ln(q+0.001) + b_6 q^{0.5} + b_7 e^{q} + b_8 (D/H))
\]
Biomass models for Poplar stumps and 2\textsuperscript{nd} generation coppices

Two ways to manage the remaining stumps after harvest:

1) Stump harvest by excavation

2) Management of the sprouts established on stumps (e.g. 2\textsuperscript{nd} generation coppice production)
Stump harvest, Cost for excavation, promising biomass production

Biomass production of 1000 excavated stumps could be 40-45 t d.w. ha⁻¹.
2:nd generation coppiced poplars
Low (no) cost and promising biomass production

Biomass of 7-year-old coppices on 1000 stumps could be 30-35 t d.w. ha⁻¹
False heartwood in poplar trees
Models for estimating false heart wood properties

\[
\text{VOL}_{\text{stem}} = 4 \times 0.06 \times \text{DIAM}^{2.0298} \quad R^2 = 0.98
\]

\[
\text{VOL}_{\text{false}} = 5 \times 0.08 \times \text{DIAM}^{2.3593} \quad R^2 = 0.91
\]
Publications

Reviewed articles:


Fact Sheets (in Swedish) and reports/thesis

**Missfärgning av veden i poppelstammar.** (Hjelm, & Johansson). Fakta skog nr 3-2013

**Tillvaratagande av hybridpoppelns stubbar och stubbskott – en tänkbar råvara för bioenergi-användning.** (Hjelm, & Johansson). Fakta skog nr 5-2012

**Hybridpoppelns biomassa- och volymproduktion – en framtida potential.** (Hjelm, Karacic & Johansson) Fakta skog nr 31-2011.


Thank You for Your Attention