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Forestry in Sweden

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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

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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

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Forest Stock and production

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)

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Empirical Production Models for Poplar Plantations in Sweden

Birger Hjelm
Department of Crop Production Ecology - SLU

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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

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Poplars in Sweden

- Exotic
- Average annual production on farmland:
  20-25 $m^3\ ha^{-1}\ yr^{-1}$ (Norway Spruce: 8-12 $m^3\ ha^{-1}\ yr^{-1}$) 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)

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Objectives

To develop and evaluate models to improve the predictions of:

- volume,
- biomass
- yield/assortments
- wetwood properties

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The Models

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

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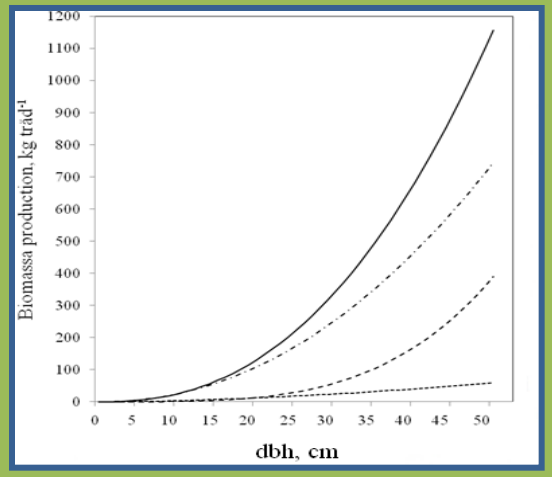
Biomass and Volume models for individual Poplar trees

- The biomass equations estimates the dry weight (kg) of stem, twigs and leaf fractions
  Independent variable: dbh*
- The constructed Stem volume (dm3) equations were compared with published equations
  Independent variables: D = dbh* and H = Total Height

* diameter at breast height



Production of dry tree biomass (kg/tree) at dbh (total , stem , branches and leafs).

The three best ranked stem volume equations

Equation	Expression	Absolut Bias (dm3)	Absolut Bias %
1)Constructed (Hjelm & Johansson 2011)	$V = b_1^{(2+(D/H))} + b_2 H^2 + b_3 D H^2$	**25.13**	**3.8**
2) Fowler & Hussain (1987)	$V = b_1 + b_2 D^{b3} H^{b4}$	**25.07**	**3.8**
3) Opdahl (1992)	$V = b_1 + b_2 D - b_3 D^2 + b_4 D^2 H$	**26.86**	**4.1**

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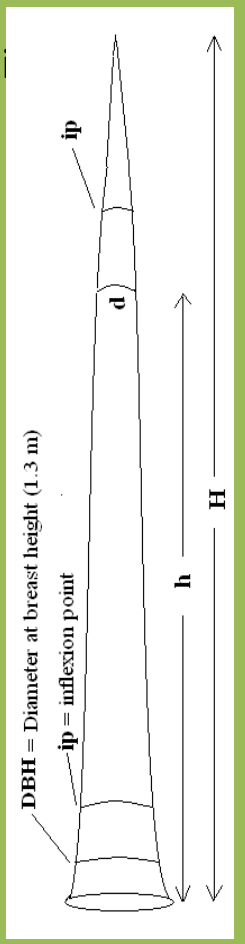
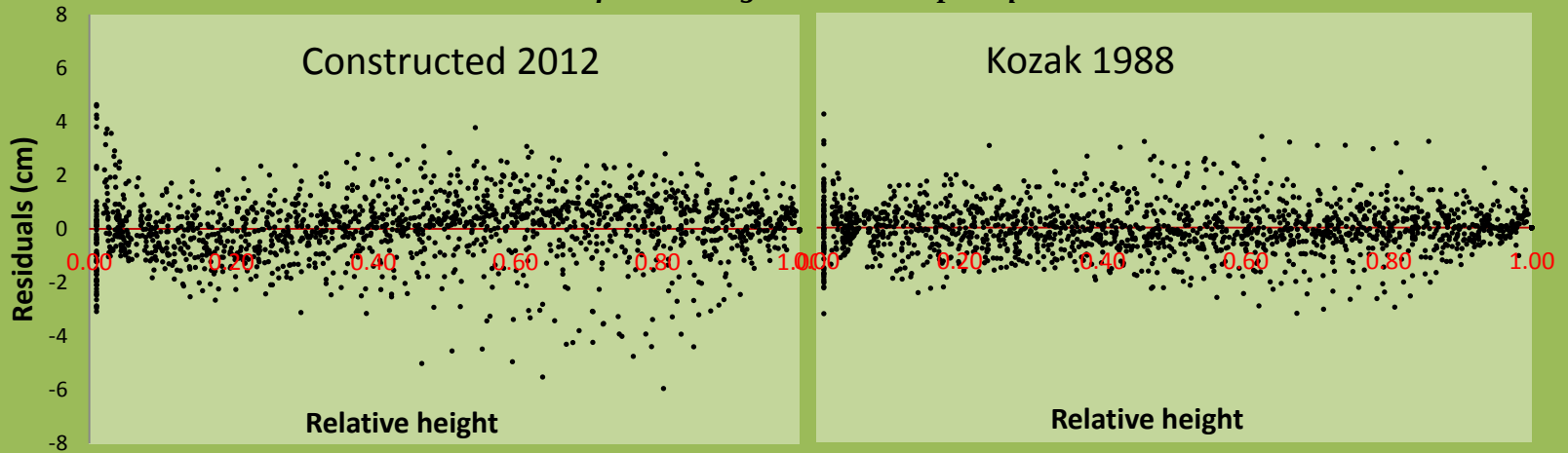
Taper models for individual Poplar trees

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



Residuals of the two highest ranked taper equations



$$d = (b_1q^2 - b_2q + b_3((H-h)/h)+b_4) \times (D/(1-k/H))^{b}5$$

$$d = b_1 D^{b2} b_3^{D}((1-q^{0.5})/(1-p^{0.5}))^{A}$$

$$A=(b_4q^2+b_5\ln(q+0.001)+b_6q^{0.5}+b_7e^q+b_8(D/H))$$

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Biomass models for Poplar stumps and 2nd 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. 2nd generation coppice production)

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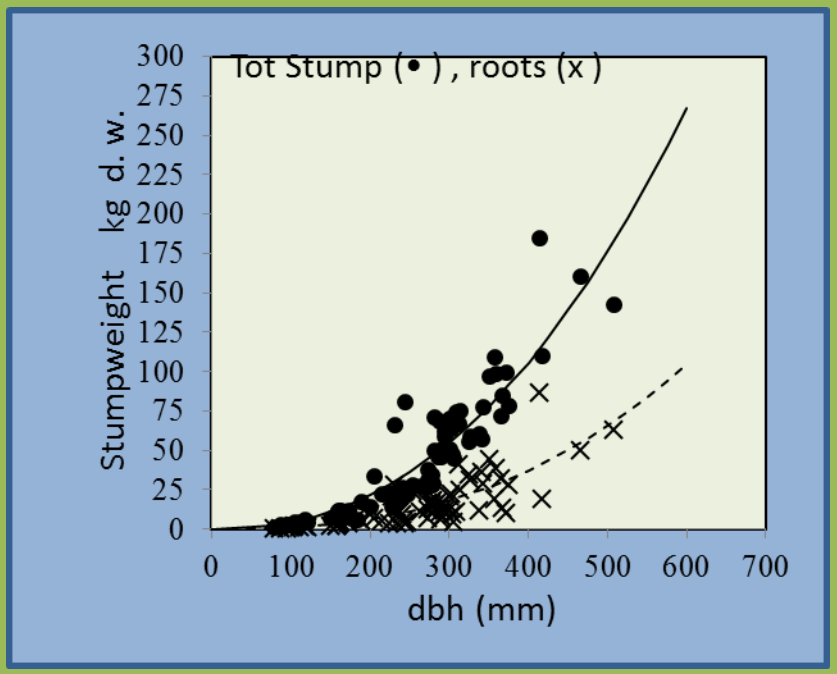
Stump harvest,
Cost for excavation, promising biomass production



Biomass production of 1000 excavated stumps could be 40-45 t d.w. ha^{-1}.

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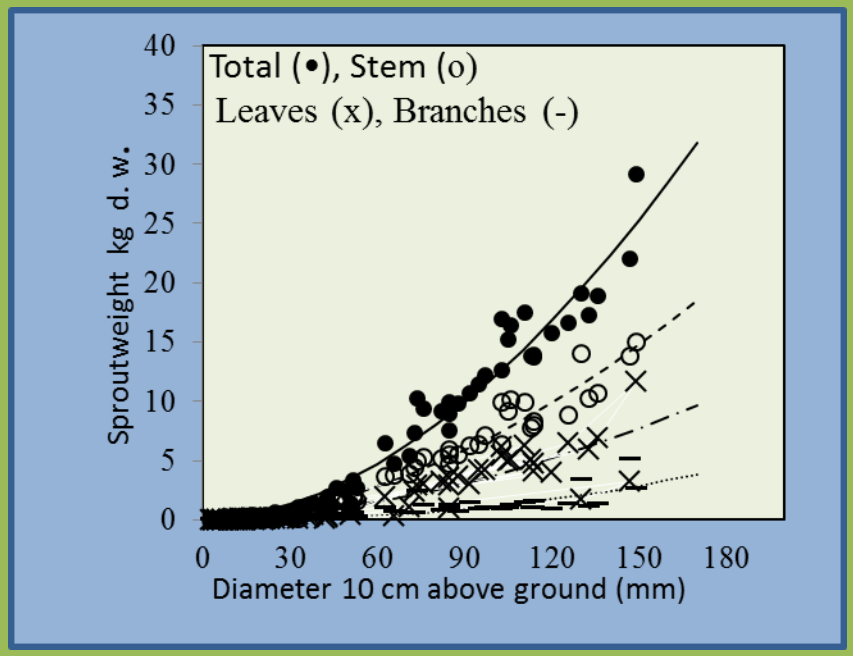
2:nd generation coppiced poplars
Low (no) cost and promising biomass production



Biomass of 7-year-old coppices on 1000 stumps could be 30-35 t d.w. ha^{-1}

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False heartwood in poplar trees

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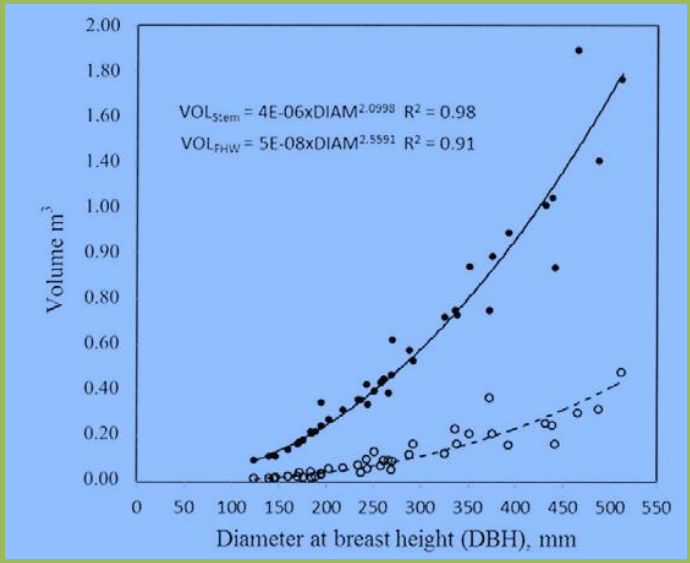
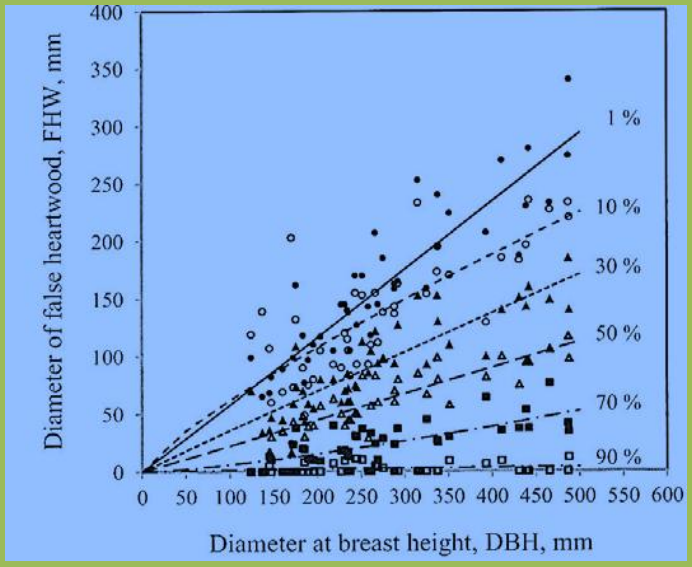
Models for estimating false heart wood properties





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Publications

Reviewed articles:

Birger Hjelm. **Stem taper equations for poplars growing on farmland in Sweden.** *Journal of Forestry Research* (2013) 24(1): 15−22

Johansson, T.; Hjelm, B. **Frequency of False Heartwood of Stems of Poplar Growing on Farmland in Sweden**. *Forests* **2013**, *4*, 28-42.

Johansson, T.; Hjelm, B. **The Sprouting Capacity of 8–21-Year-Old Poplars and Some Practical Implications**. *Forests* **2012**, *3*, 528-545.

Johansson, T.; Hjelm, B. **Stump and Root Biomass of Poplar Stands**. *Forests* **2012**, *3*, 166-178.

Birger Hjelm & Tord Johansson (2012): **Volume equations for poplars growing on farmland in Sweden**, *Scandinavian Journal of Forest Research*, 27:6, 561-566

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.

Inst för Energi och Teknik, SLU, B.Hjelm. **Taper and Volume Equations for Poplar Trees Growing on Farmland in Sweden.** Licentiate Thesis/Report 029, 2011..

Sida-SLU,B.Hjelm. **Individual Tree Volume Tables for Five Indigenous Plantation Species in Laos**. Working paper 281. 1995.

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Thank You for Your Attention

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