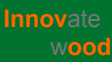




Chemical composition of wood


Variations, models

Dag Molteberg, Södra Cell R&D



Goal:

- Analyse the chemical composition of wood:
 - Ash content
 - extractives
 - lignin
 - cellulose
 - hemicellulose (glucomannan and xylan)
- Describe the variation of the different chemical components with models
 - Differences within and between trees



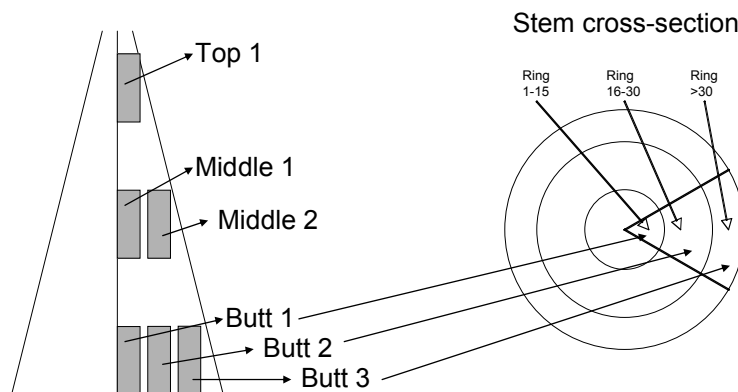


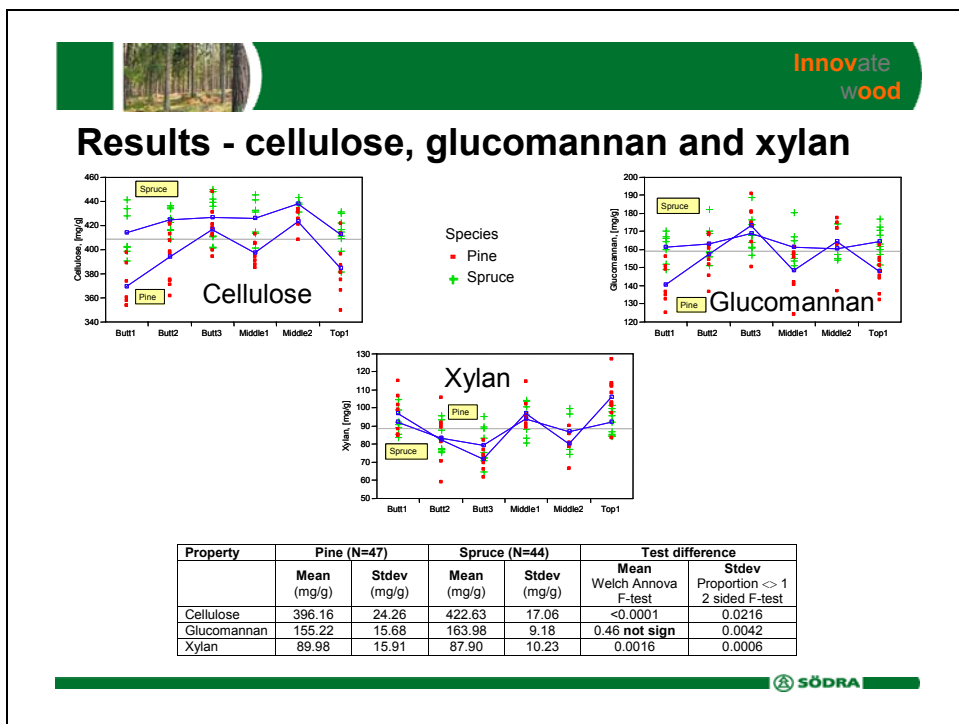
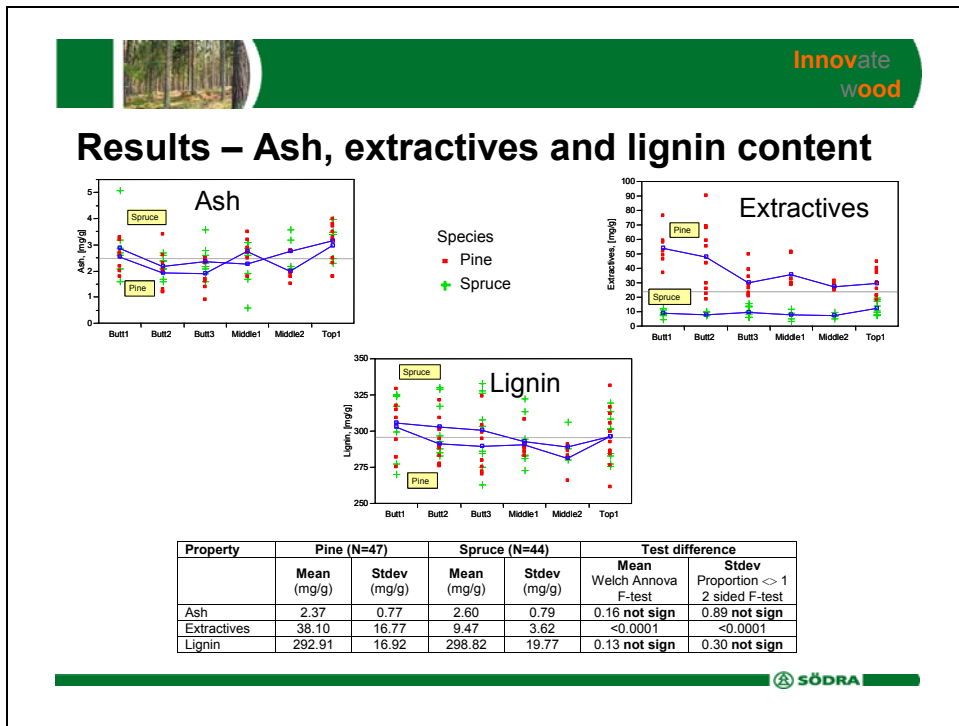
Material analysed


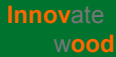
- First run: 35 samples from 8 trees (all Swedish)
- Second run: 56 samples from 20 trees (36 Finland, 20 Sweden)
- Variations in sampling
 - Pine and spruce
 - Finland and Sweden
 - Final cut, thinning
 - Dominant, intermediate and suppressed trees
 - High and low site index
 - three vertical positions: breast height [butt], 50% of tree height [mid], top [top]
 - three radial positions (ring 1-15 [1], 16-30 [2], >30 [3])
- But each sample costs “a fortune” to analyse...
- Therefore: reduced experimental design (not full factorial)
 - 91 samples from 26 trees



Sampling within trees








Modelling


- Because of reduced experimental design, the modelling is not straight forward
 - nested design
 - missing values due to reduced design
- We used nested random coefficient mixed models when modelling (JMP software from SAS Institute)
- General model for each species:

$$Y_{THI} = \alpha + a_T + b_{H(T)} + \beta \cdot RN + \gamma \cdot \ln(RN + 1) + e_{THI}$$
- Try to replace some or all random effects with fixed stand-, tree-disk- or ring-level variables

Independent variables in the models

Symbol	Unit of measurement	Explanation
RN	[]	Ring number counted from pith at position in tree
HWD	[]	Amount of heartwood in cross section at position in tree
DBH	[mm]	Diameter in breast height of tree
DiaD	[mm]	Diameter of cross section at position in tree
AgeD	[year]	Age (number of rings from pith to bark) at position in tree
TH	[m]	Height of tree
H	[m]	Height from butt end to position in tree
RWBH	[mm]	Average ring width at breast height
RWInt	[mm]	Ring width at position in tree





Pine models

	Models					
	Ash, [mg/g]	Extractives, [mg/g]	Lignin, [mg/g]	Cellulose, [mg/g]	Glukomannan, [mg/g]	Xylan, [mg/g]
Variance components						
σ_a^2 (Tree+Stand)	0.138	93.73	54.00	49.88	75.88	49.07
σ_b^2 (Height in tree)	0.140	-	10.43	-	30.86	23.71
Summary (fixed and random effects)						
R ²	0.792	0.771	0.197	0.727	0.822	0.883
RMSE	0.36	8.20	15.16	13.43	6.69	5.49
Summary (only fixed effects)						
R ²	0.390	0.471	0	0.676	0.402	0.633
RMSE	0.61	12.32	17.11	13.97	12.26	9.75
The models were:						
Ash	= 3.86 – 1.865·HWD – 0.363·ln(RN+1)					
Extractives	= 22.00 + 0.579·AgeD - 0.683·RN					
Lignin	= 293.9					
Cellulose	= 280.9 + 51.7·TH – 0.352·DBH + 20.28·RWBH + 9.70·ln(H+1) + 1.237·RN					
Glucmannan	= 140.5 + 0.700·RN					
Xylan	= 130.6 – 14.37·ln(RN+1)					



Spruce models

	Models					
	Ash, [mg/g]	Extractives, [mg/g]	Lignin, [mg/g]	Cellulose, [mg/g]	Glukomannan, [mg/g]	Xylan, [mg/g]
Variance components						
σ_a^2 (Tree+Stand)	0.177	7.23	131.41	123.86	49.33	47.32
σ_b^2 (Height in tree)	0.054	-	8.41	-	-	-
Summary (fixed and random effects)						
R ²	0.327	0.726	0.311	0.601	0.610	0.738
RMSE	0.66	1.94	16.42	11.17	5.73	5.29
Summary (only fixed effects)						
R ²	0.178	0.302	0	0.258	0	0.262
RMSE	0.72	3.06	20.00	14.87	9.29	8.89
The models were:						
Ash	= 5.22 - 0.405·RWInt – 0.579·ln(RN+1)					
Extractives	= 21.07– 0.0417·DiaD – 2.10·ln(H+1)					
Lignin	= 299.8					
Cellulose	= 342.7 + 0.1686·DiaD + 13.83·ln(H+1) + 8.44·ln(RN+1)					
Glucmannan	= 163.4					
Xylan	= 110.1 - 7.98·ln(RN+1)					

