Biomass production of coppiced hybrid aspen in agricultural soil in Finland - 3 year results

Ecology and Silvicultural Management of Coppice Forests in Europe

Bucharest, Romania 19-21 October 2015

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Forest energy in Finland

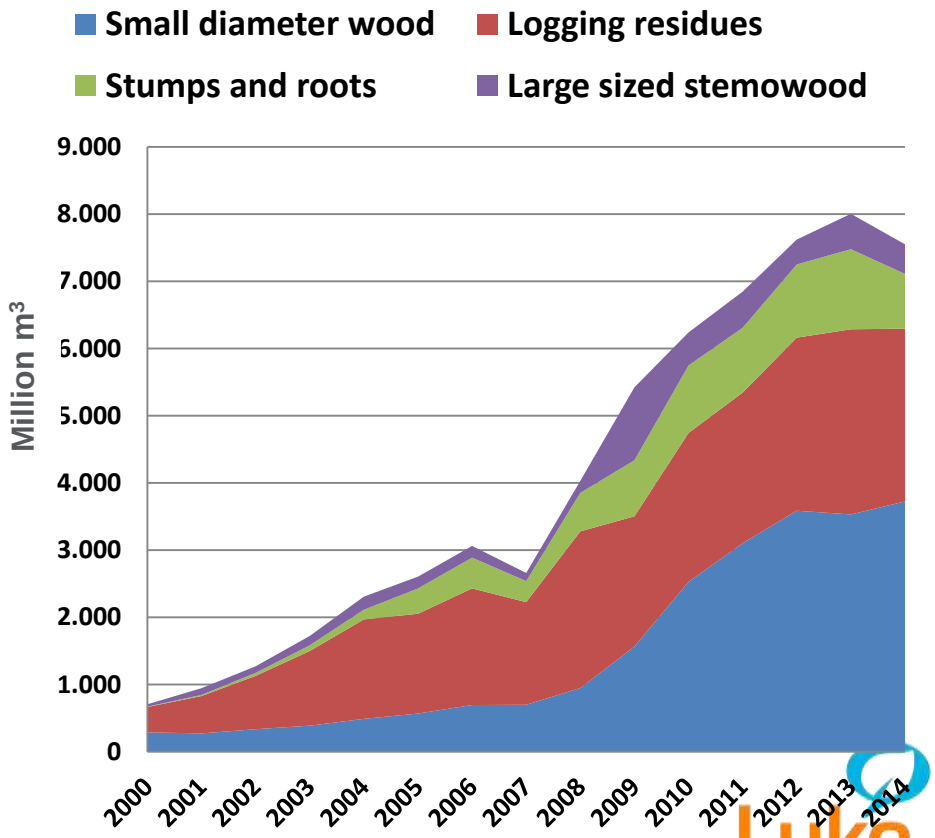
Wood-based fuels in 2014

- 25% (92 TWh) of total energy consumption (372 TWh)
- Black liquors of forest industry constitute 42% (39 TWh) of wood based fuels

Forest chip production:

- Forest chips produced mostly from logging residues, stumps and small-diameter trees
- Interest in dedicated biomass plantations increasing

Forest chip consumption by raw materials. Target 13.5 milj m3 by 2020



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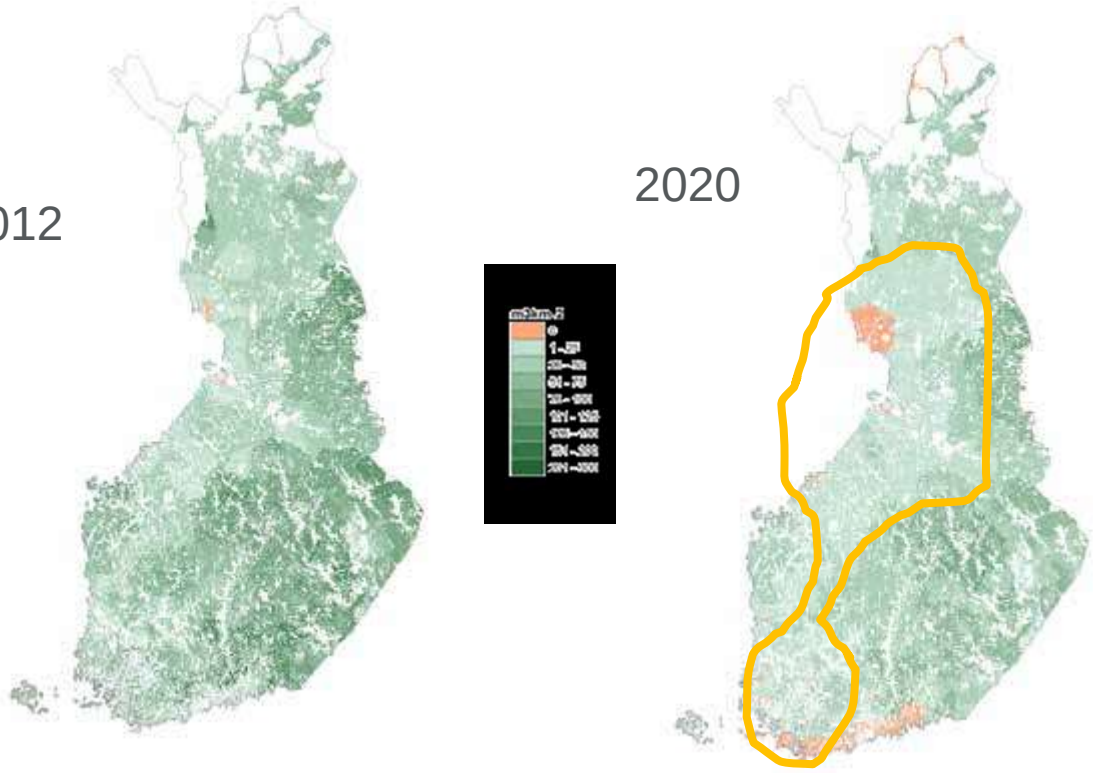
Forest chip balance (potential – utilization)
small-sized trees, logging residues, stumps

2012



2020

Harvesting of stumps and logging residues depends on normal logging operations

Anttila et al. 2014. Metsähakkeen alueellinen käyttöpotentiaali ja käyttö 2020.

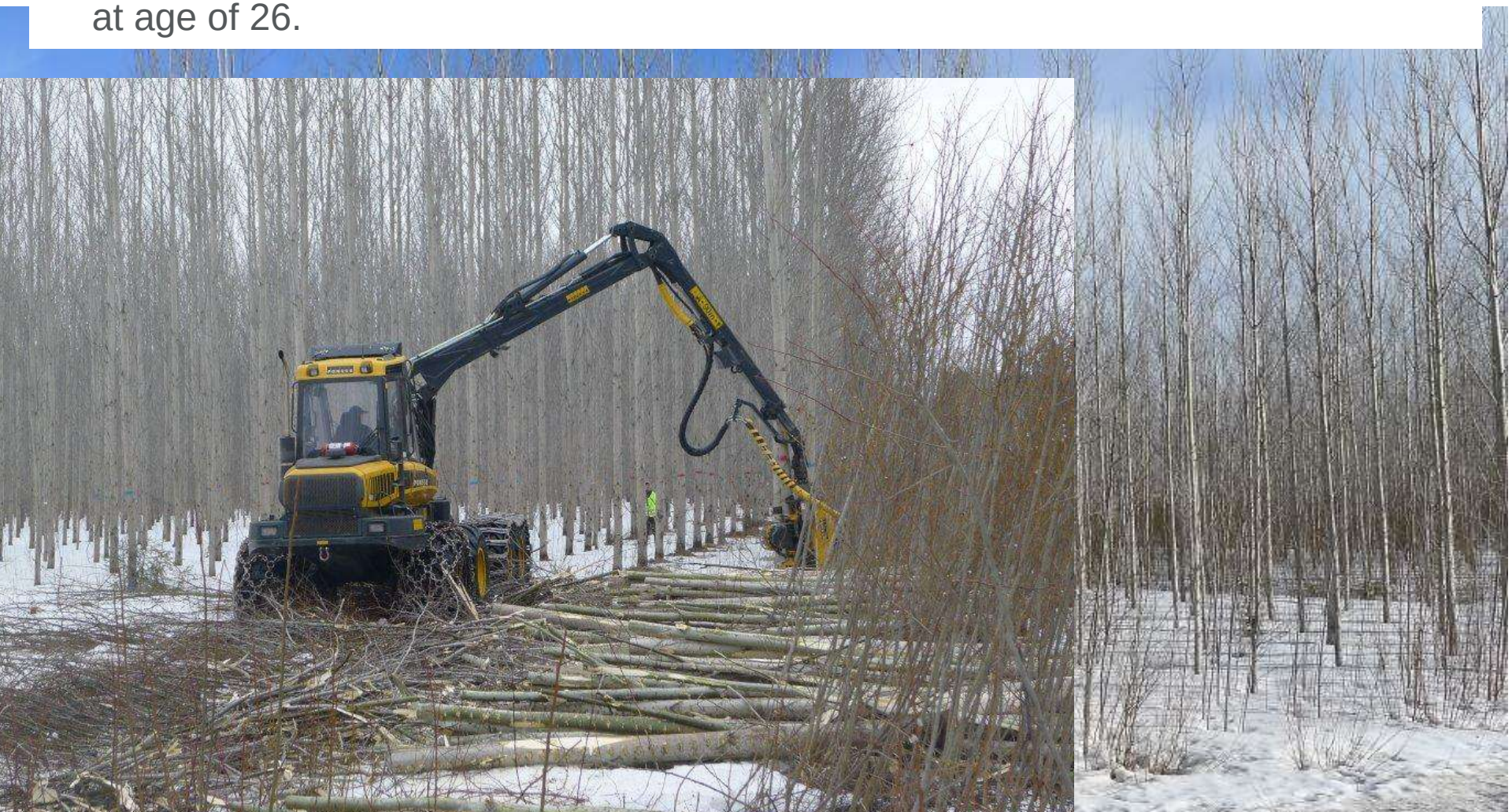
Short-rotation coppice for energy

Hybrid aspen in Finland

- Hybrid aspen (*Populus tremula x P. tremuloides*) was crossed in Finland in 1950.
- It is considered to be the fastest growing tree species in Finland on fertile soils yielding about 300 m^3 in 25 years.
- The area of hybrid aspen was 500 000 ha at end of 70's.
- Match industry closed down, vole and moose damages > interest declined.
- In mid 1990's new plantations for pulpwood using short rotation principles. Area of plantations reached 1 500 ha, but demand for aspen for pulpwood decreased.
- Could aspen be grown for biomass energy?

Study stand: Mother stand

- Hybrid aspen seedlings planted in spring 1988 on a 17 ha agricultural soil at Vilppula, southern Finland. Vole protection with tubes, vegetation control by trampling, stand cleaning in 2003 (other tree species removed)
- The stand (900 trees/ha) was measured in 2012 and was clear-cut in winter 2013 at age of 26.



Experiment: Treatments

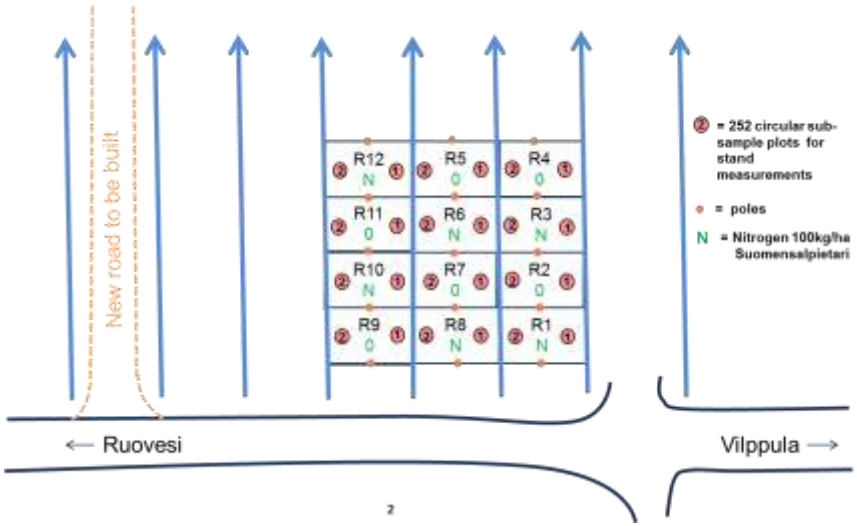
BIOMASS PRODUCTION

1. Unfertilized.
2. Nitrogen fertilization (N 100 kg/ha)

PULP WOOD PRODUCTION

3. Thinning of sprouts at age 5-8
4. Thinning of sprouts at age 5-8 + Nitrogen fertilization (100 kg N/ha)

N 100kg/ha 2014 (May) and 2015 (May)



12 sample plots (25 m x 25 m), randomized blocks, four treatments.

First fertilization when sprouts were 1-year-old

Measurements and sampling

Sprouts

- Height, vitality, browsing damages (1-, 2- and 3-year old sprouts), origin of sprouts (stump sprout/ sucker).

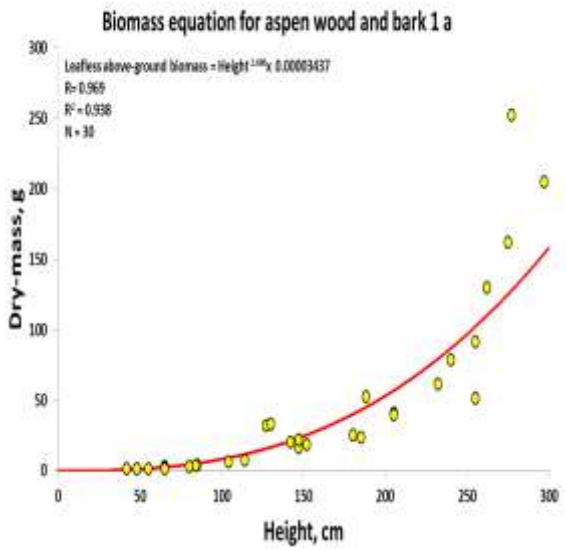
Sample sprouts for dry-mass equations and nutrient analyses

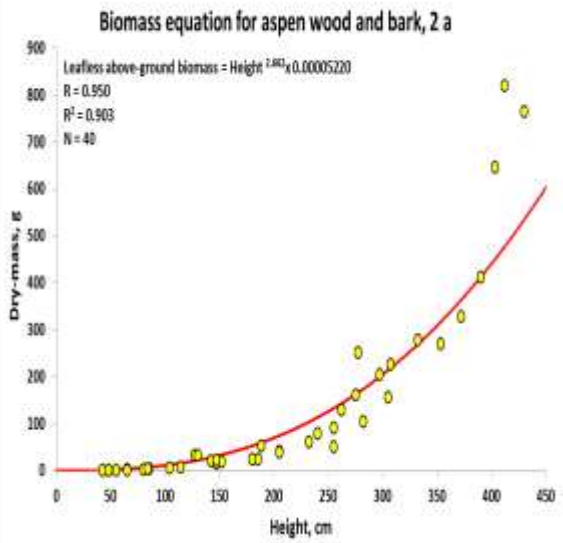
- 60 aspen sprouts (h and d, wood and bark dry weight).
- Bark and wood samples analyzed for nutrient contents and heating value.

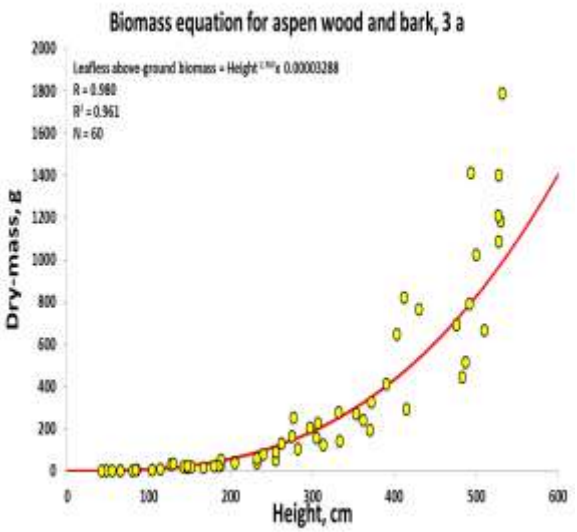
Soil samples

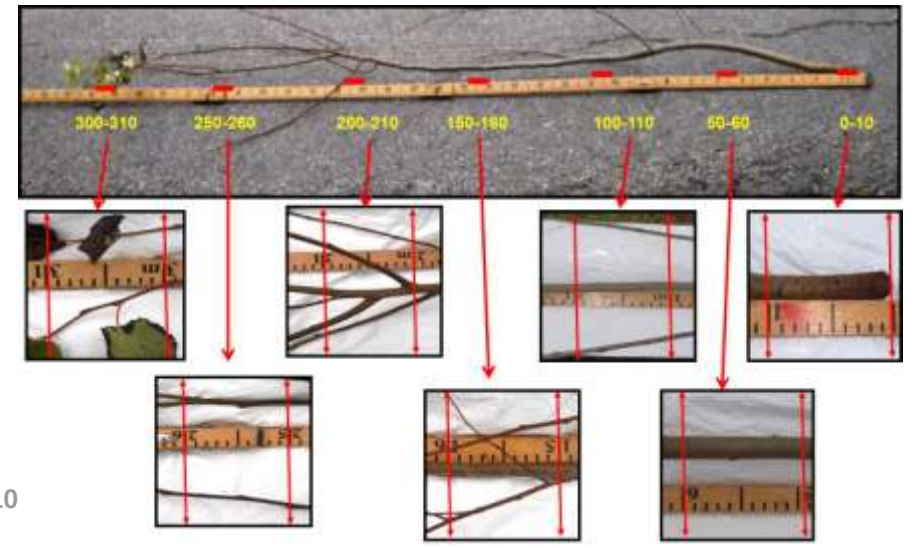
- Samples from 0-10 cm depth. Total nutrient amounts determined
- Soil bulk density 702 g/l, OM content 14.9%, pH 5.25 (water)
- Nutrient amounts in 0-10 cm layer: N 2730 kg/ha, P 372 kg/ha, K 1362 kg/ha, Ca 3778 kg/ha, Mg 2107 kg/ha, B 1.2 kg/ha
- Subsoil silty clay, content of fine fractions (< 60 µm) 91.9%

Biomass equations for 1-3-year old aspen sprouts









- Also separate biomass equations for bark and wood constructed

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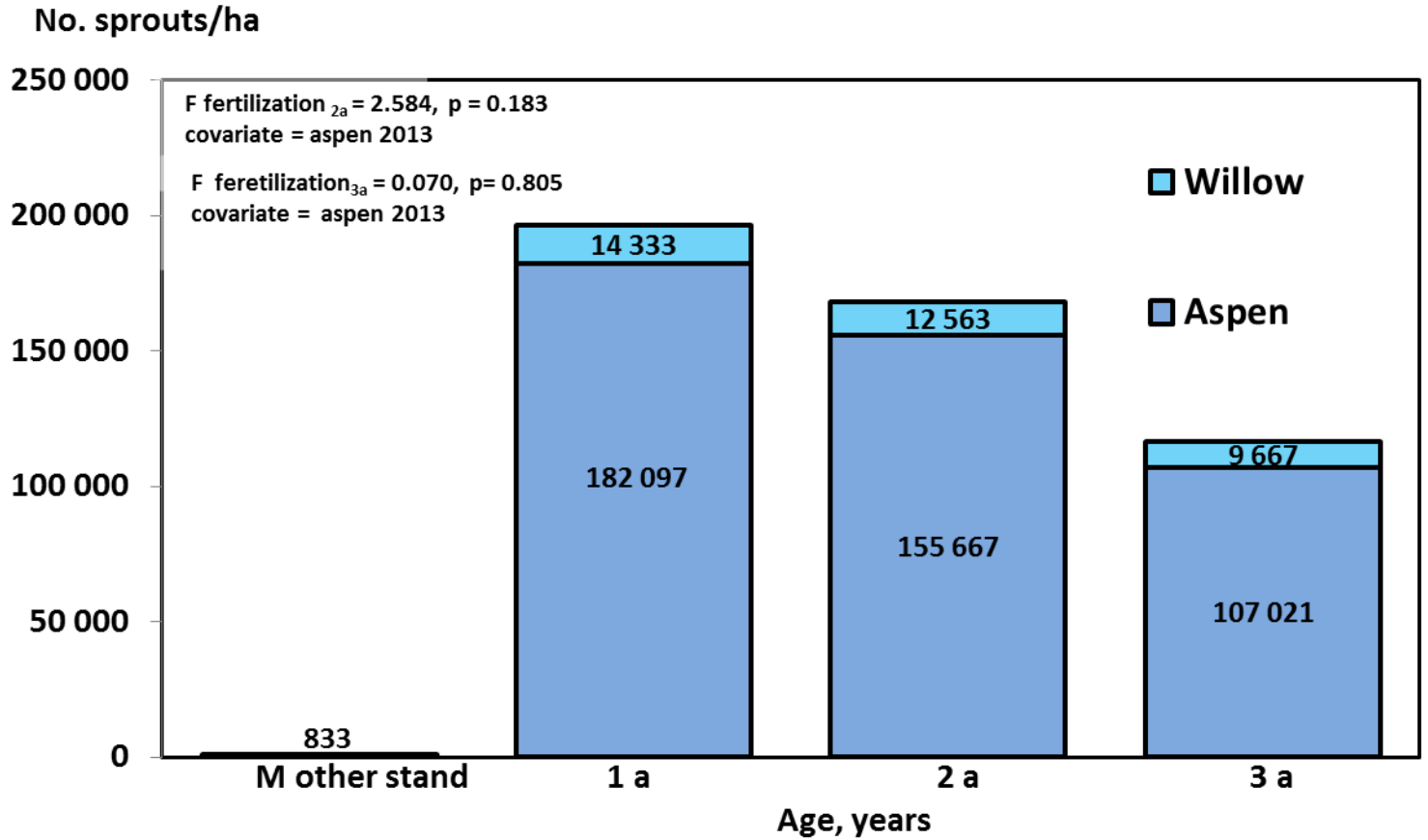
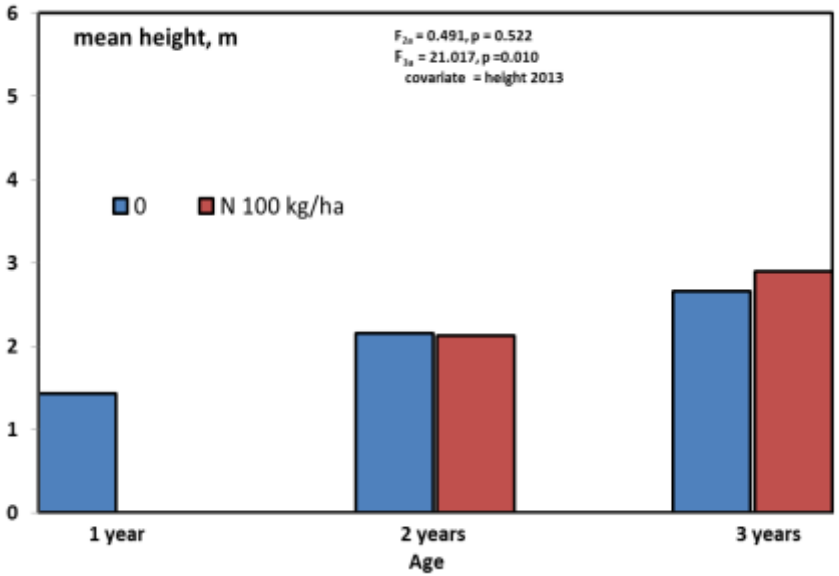
Stand density



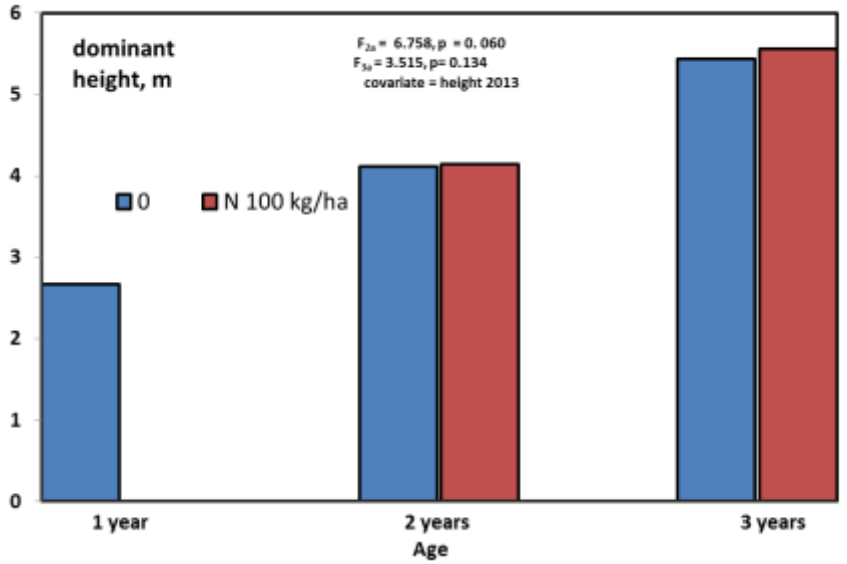
- 99% of aspen sprouts were root suckers
- Fertilization did not affect stand density

Mean and dominant height

Mean height, m

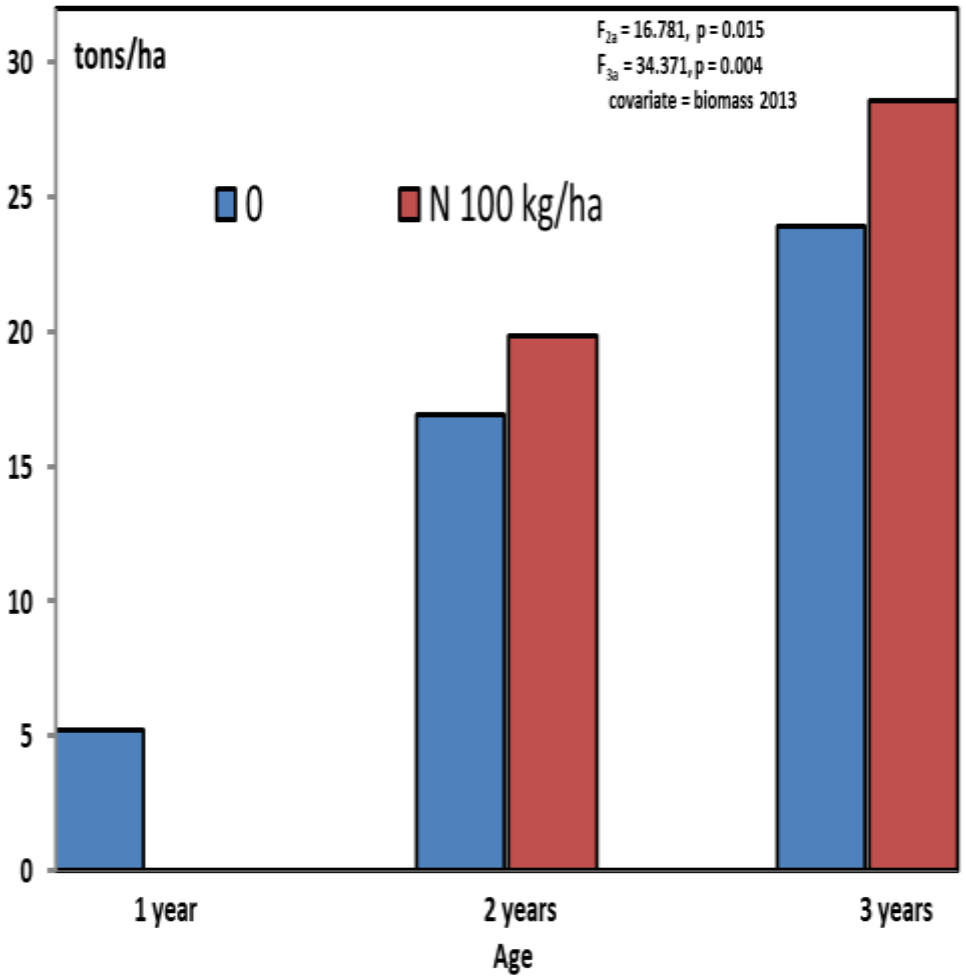


Dominant height, m



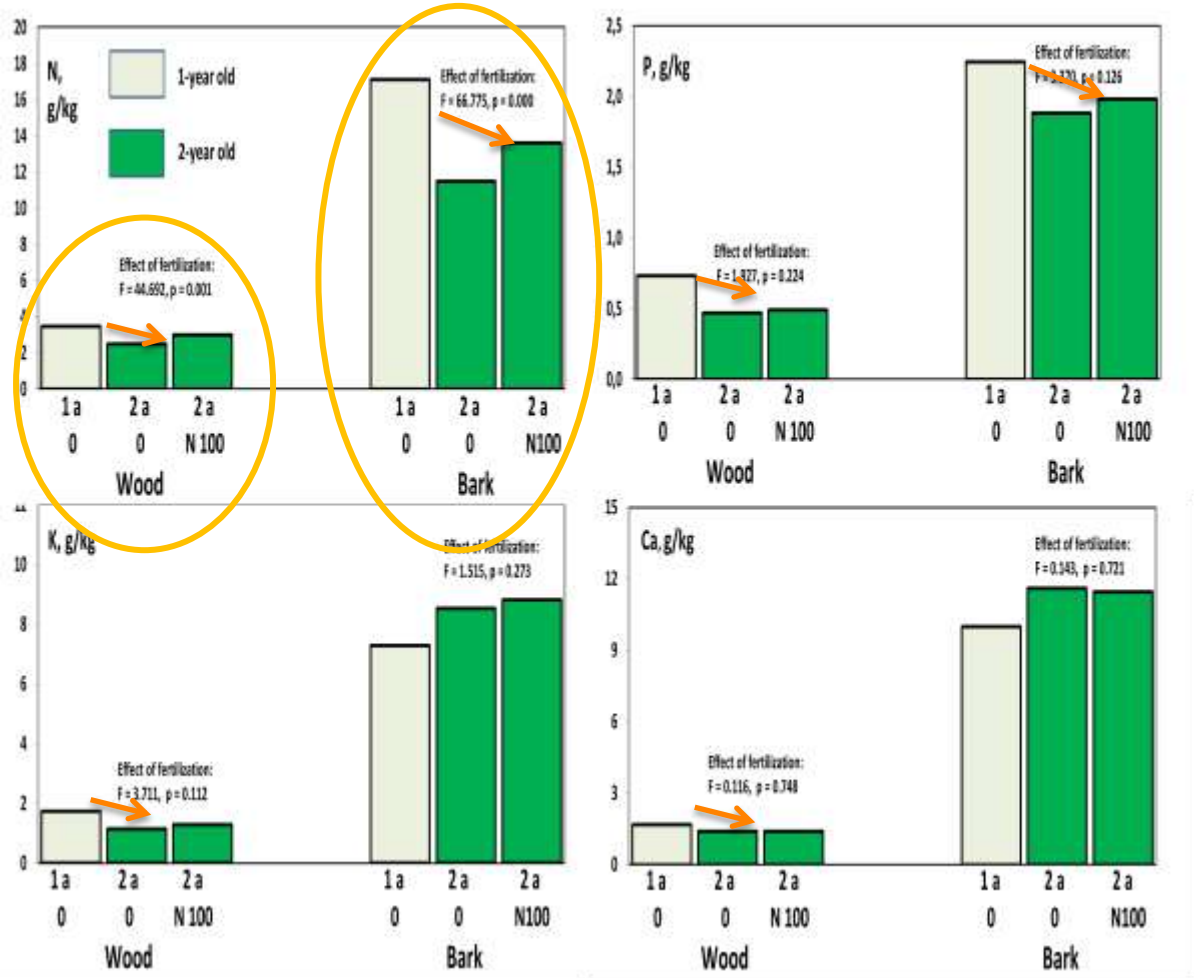
Fertilization increased mean height by 23 cm

Biomass production (leafless above-ground)



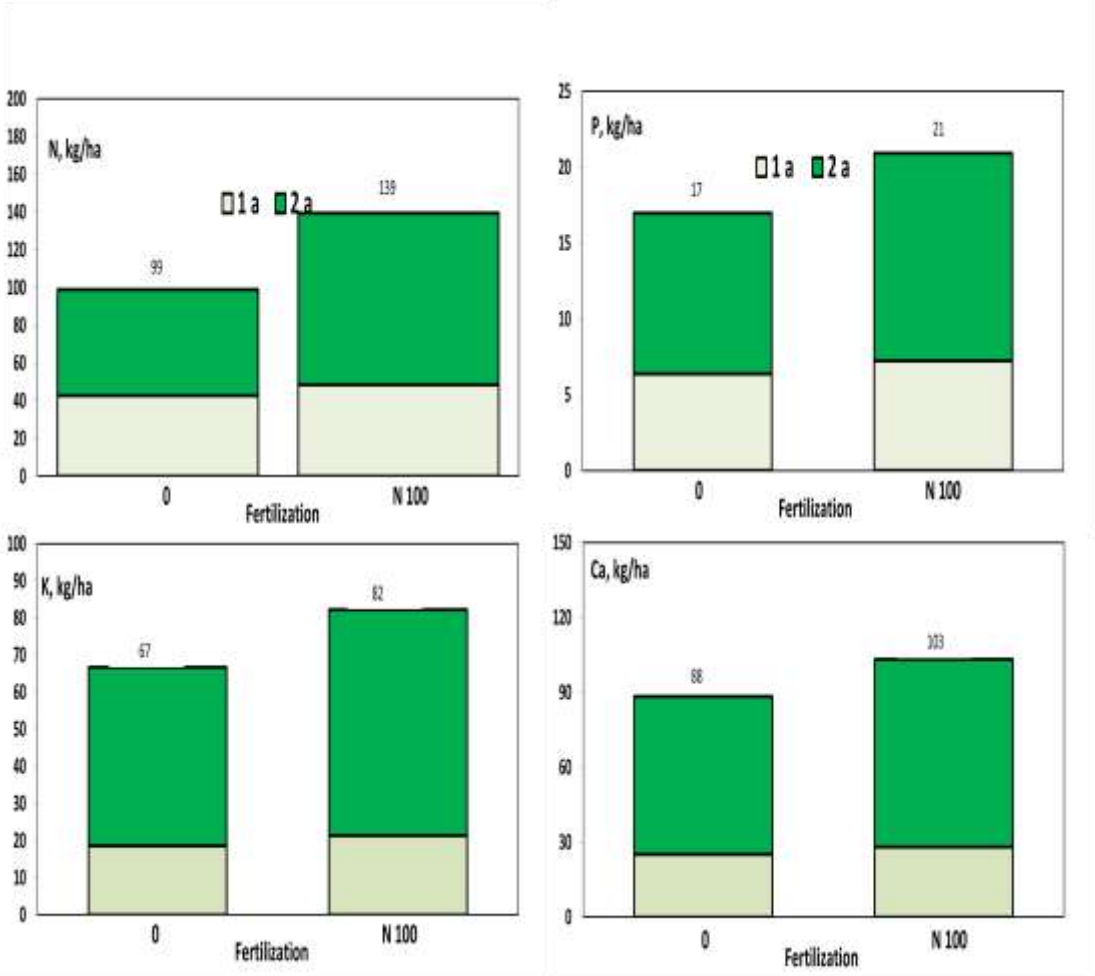
- N fertilization increased significantly biomass (3 t/ha at age 2; 5 t/ha at age 3)
- 1-year old stand 5 t/ha, fertilized 2-year old stand 20 t/ha, 3-years old stand 29 t/ha
- Share of wood out of biomass increased from 60% at age 1 to 73% at age 3

Nutrient concentrations of bark and wood – 1 and 2 years old sprouts



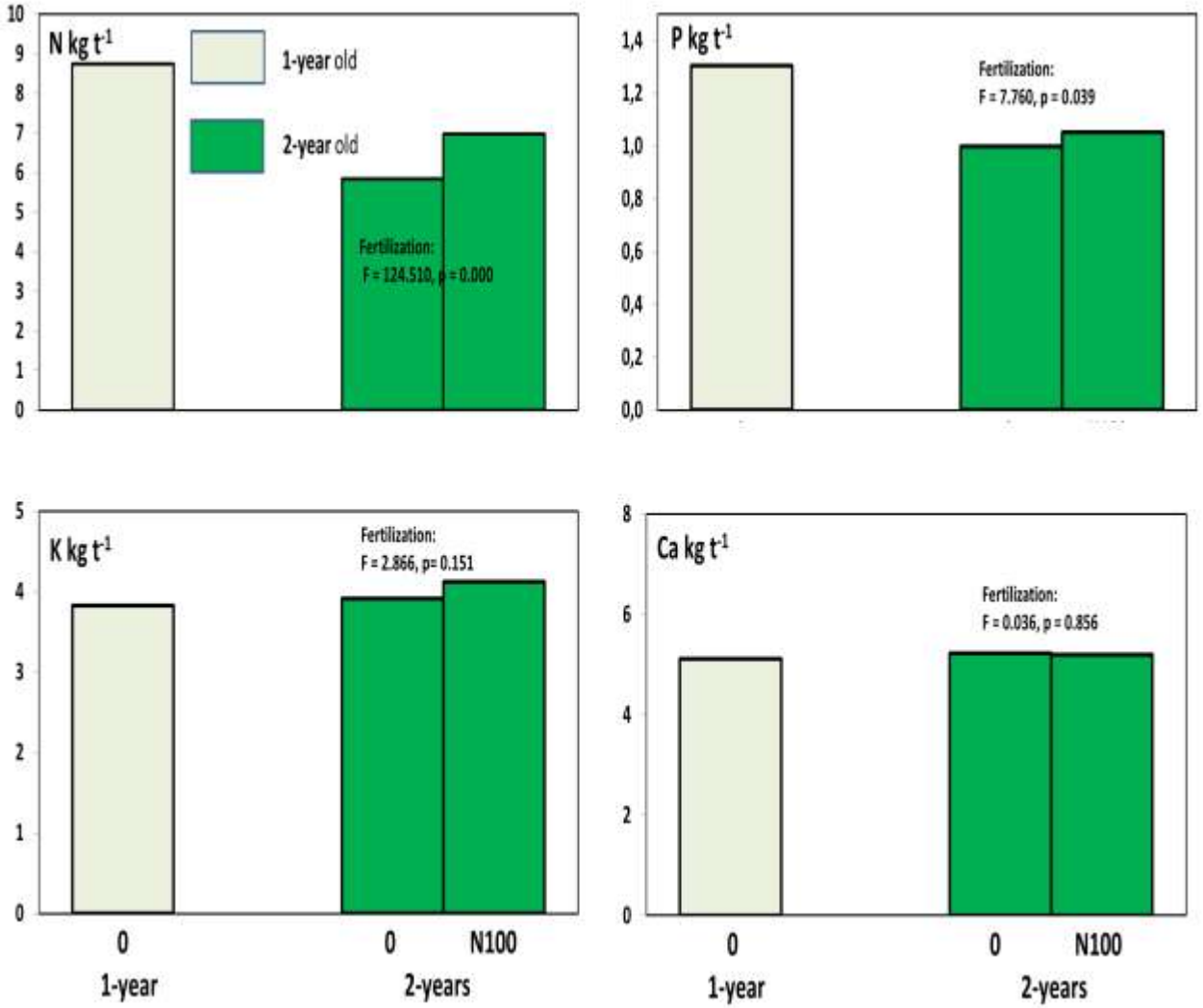
- Nutrient concentrations in bark manifold compared to wood
- Nutrient concentrations generally decreased with increase of age (except K and Ca in bark)
- Fertilization with N increased only N concentration of bark and wood
- Bark Ca concentration higher than in many other species (e.g. willow and alder 7-9 g/kg, birch 5-6 g/kg, Scots pine 3 g/kg)

Amount of nutrients (kg/ha) bound in 1-year and 2-year old hybrid aspen (above-ground leafless biomass)



- Fertilization (N) increased amount of nutrients bound in above-ground leafless biomass (N 40 kg/ha, P 4 kg/ha, K 15 kg/ha, Ca 15 kg/ha)

Amount of nutrients bound in one ton of leafless 1 and 2-years old aspen (above-ground leafless biomass)



- Less nutrients bound in 2-year than in 1-year shoots (except Ca)
- Fertilization increased amount of N and P bound in unit biomass

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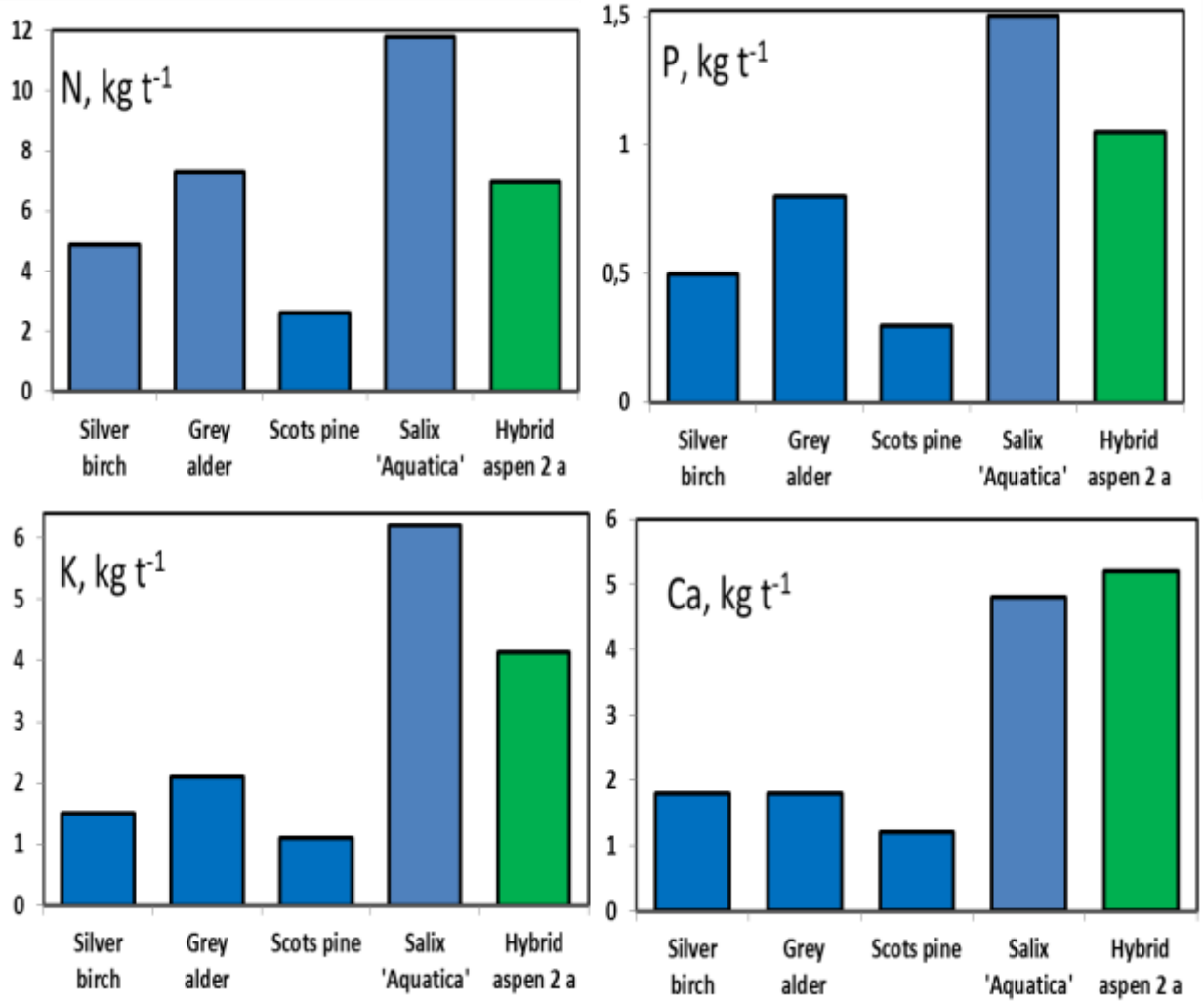
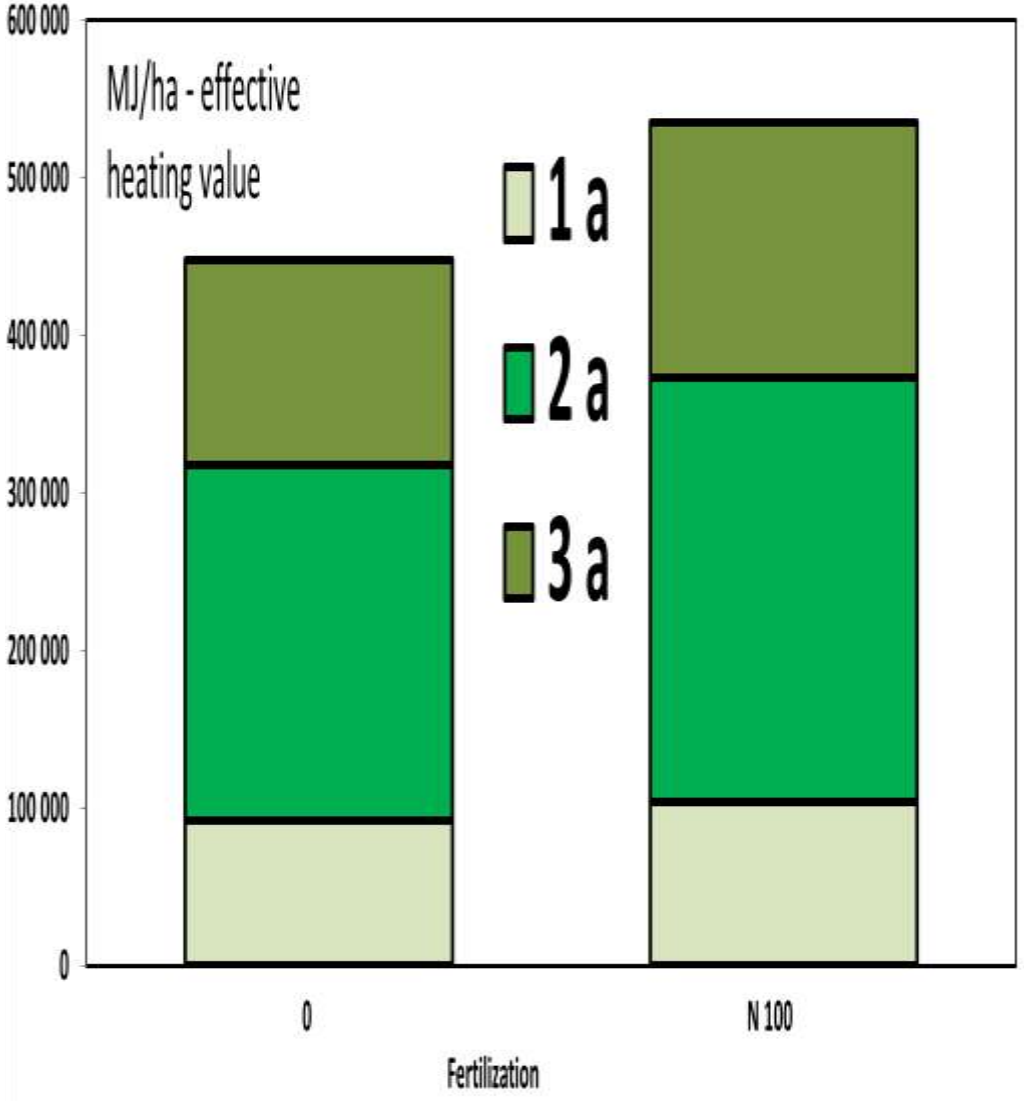
Amount of nutrients bound in one ton of leafless biomass - comparison of species



Hybrid aspen demanding species
Especially K and Ca

Birch and alder: Hytönen & Saarsalmi 2013, willow: Hytönen 1995, Scots pine: Mälkönen 1974

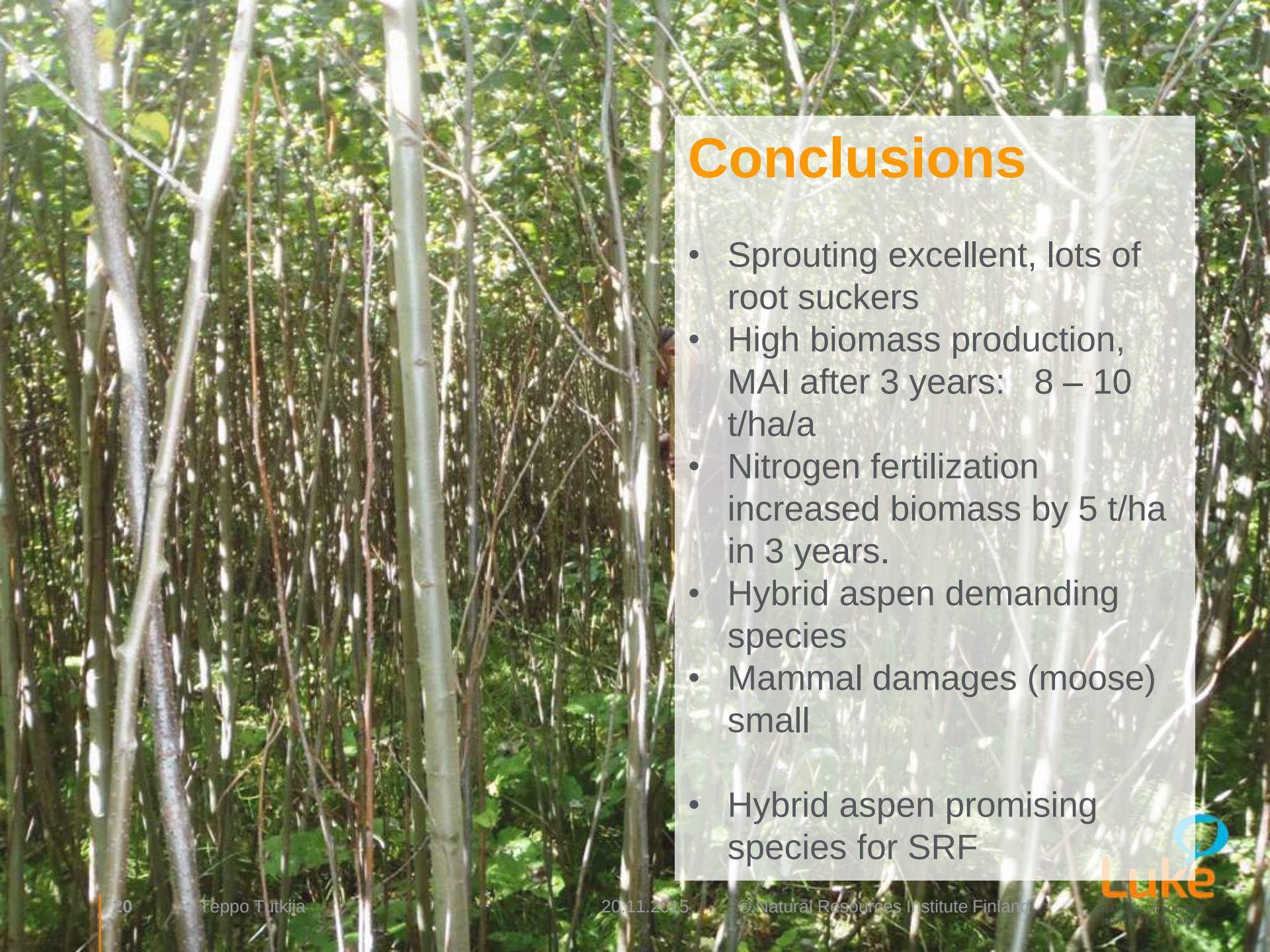
Energy production in three years



Effective heating value
1a 18.841 MJ/kg
2a 18.713 MJ/kg
Wood = 18.637 MJ/kg
Bark = 18.864 MJ/kg

Moisture content 40%
Heating of a domestic house in Finland 20 MWh/a.

With 3-year old aspen
- 0-fertilization = 4.6 houses
- N-fertilization = 5.6 houses



Conclusions

- Sprouting excellent, lots of root suckers
- High biomass production, MAI after 3 years: 8 – 10 t/ha/a
- Nitrogen fertilization increased biomass by 5 t/ha in 3 years.
- Hybrid aspen demanding species
- Mammal damages (moose) small

- Hybrid aspen promising species for SRF

Kiitos!