Hybrid aspen (poplars) in Estonia

cultivation and (breeding)

HealGenCAR workshop

Estonian University of Life Sciences
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Luke, Helsinki, Finland 7.-8. February 2017

Hybrid aspen in Estonia

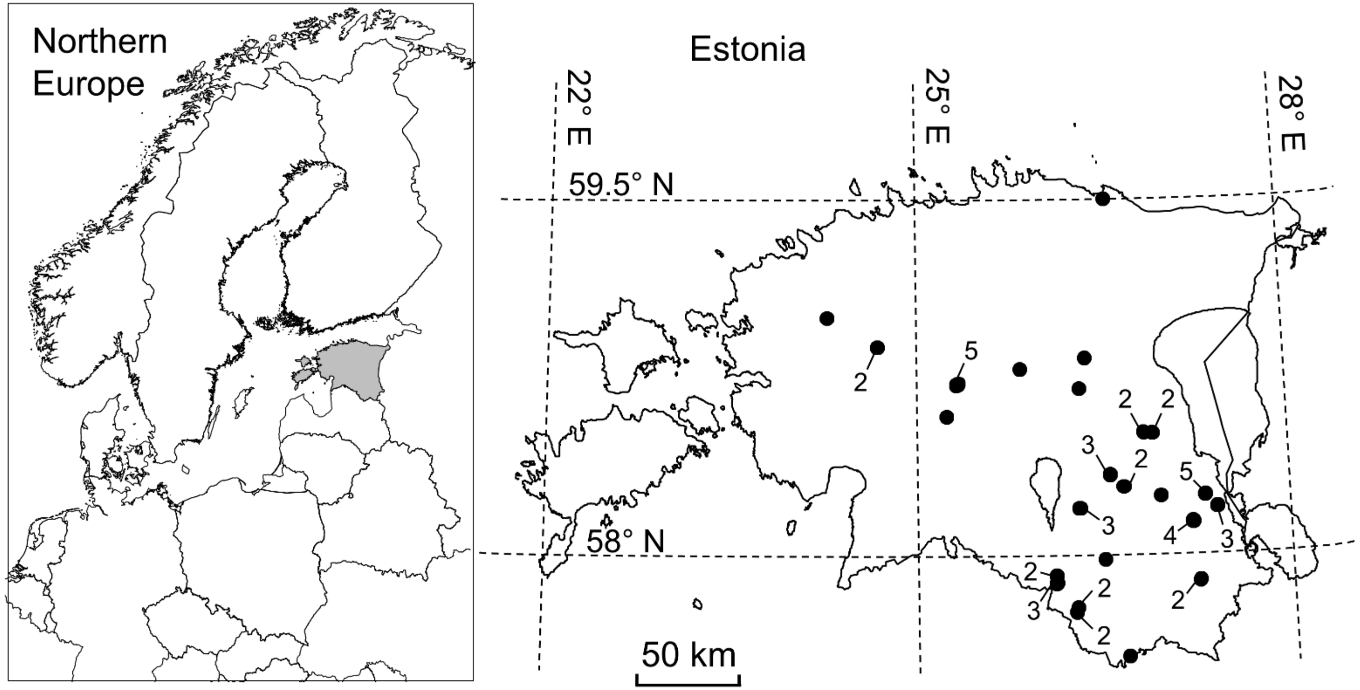
- Total area approximately 1100 ha:

1) appr. 700 ha were established in 1999-2003, Finnish origin clones;
2) appr. 400 ha in 2013-2019 (Saaremaa), Swedish origin clones

- Plantations established only on former arable lands
- Fertile arable lands are suitable, not recommended on forestlands
- Planting density 1000 – 1400 plants per ha

Research in hybrid aspen plantations

- Research programme started in 2003 (plantations established in 1999-2000)
- 51 sample plots (0.1 ha) on former crop- and grasslands
- 7 sample plots on former oil-shale quarry



Research team: Hardi Tullus, Aivo Vares, Arvo Tullus, Tea Tullus, Reimo Lutter, Heiki Hepner

Research aims: growth speed, productivity, biomass, wood properties, comparison with other fast-growing tree species, plant-soil relations, nutrient demand and pools, above- and belowground carbon, biodiversity, economy, new clones evaluation, second generation management = 25 ISI WoS database

Cooperation with Tartu University (Climate change, FAHM experiment), together more than 30 papers

Research in Estonia:
58 areas for hybrid aspen
22 for siver birch

Comparison

Hybrid aspen *(Populus tremula* L. x *P. tremuloides* Michx)

Silver birch (*Betula pendula* Roth)

Hybrid aspen: 20-30 years
Silver birch: 35-45 years

15 years old

H_{max}: 25,2 m

DBH_{max}: 22 cm

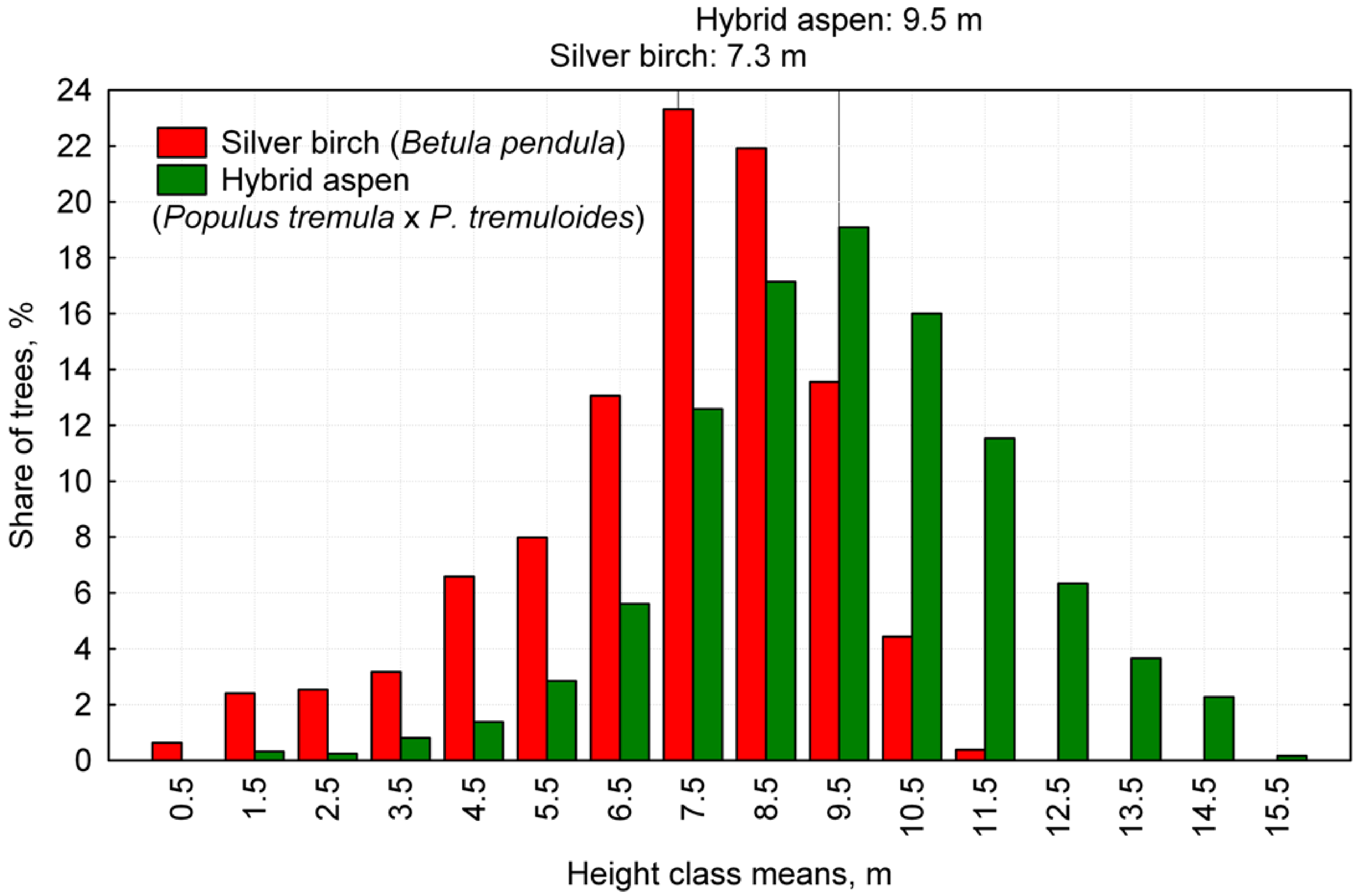
Volume: 150–170 tm/ha, max 200

CAI: 20–27 tm/ha

17 years: 0,1 ha plot max 246 m3/ha

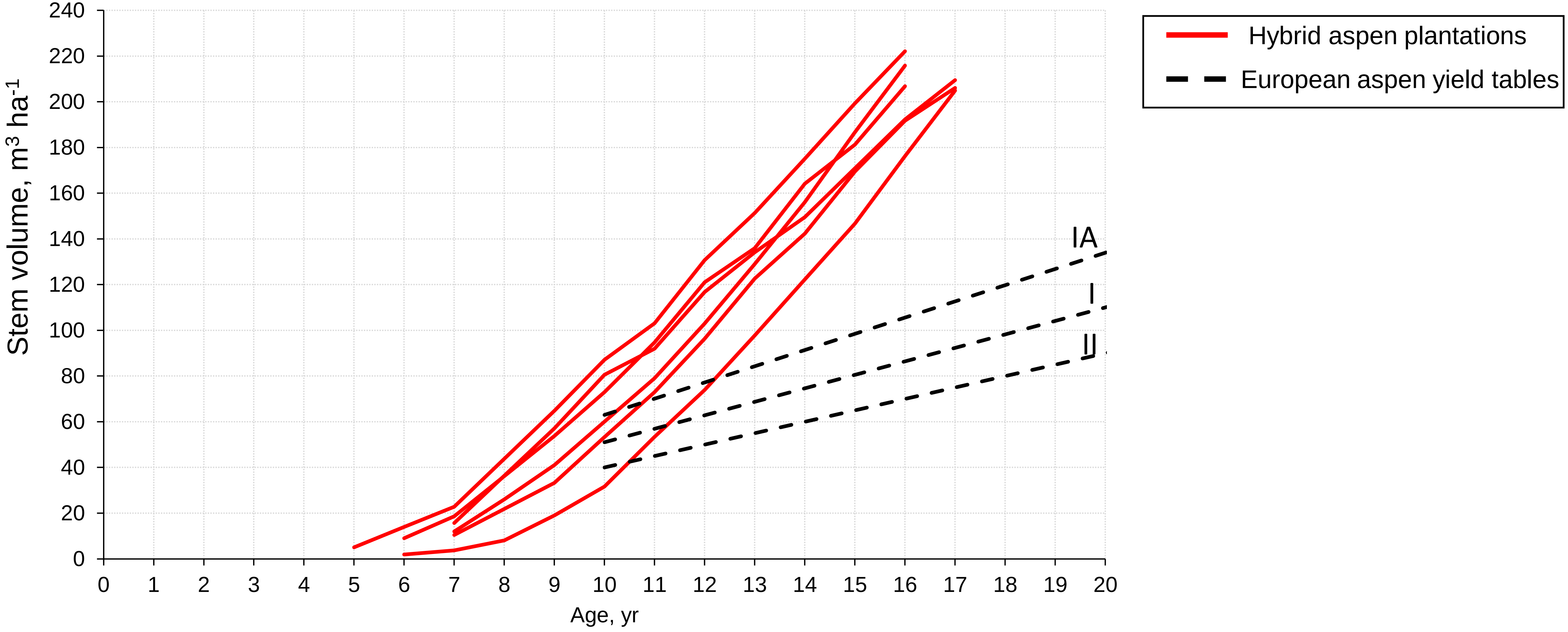
18 years: max CAI 36 m3/year ha, 241 m3/ha

10x10m = max 330 m3/ha

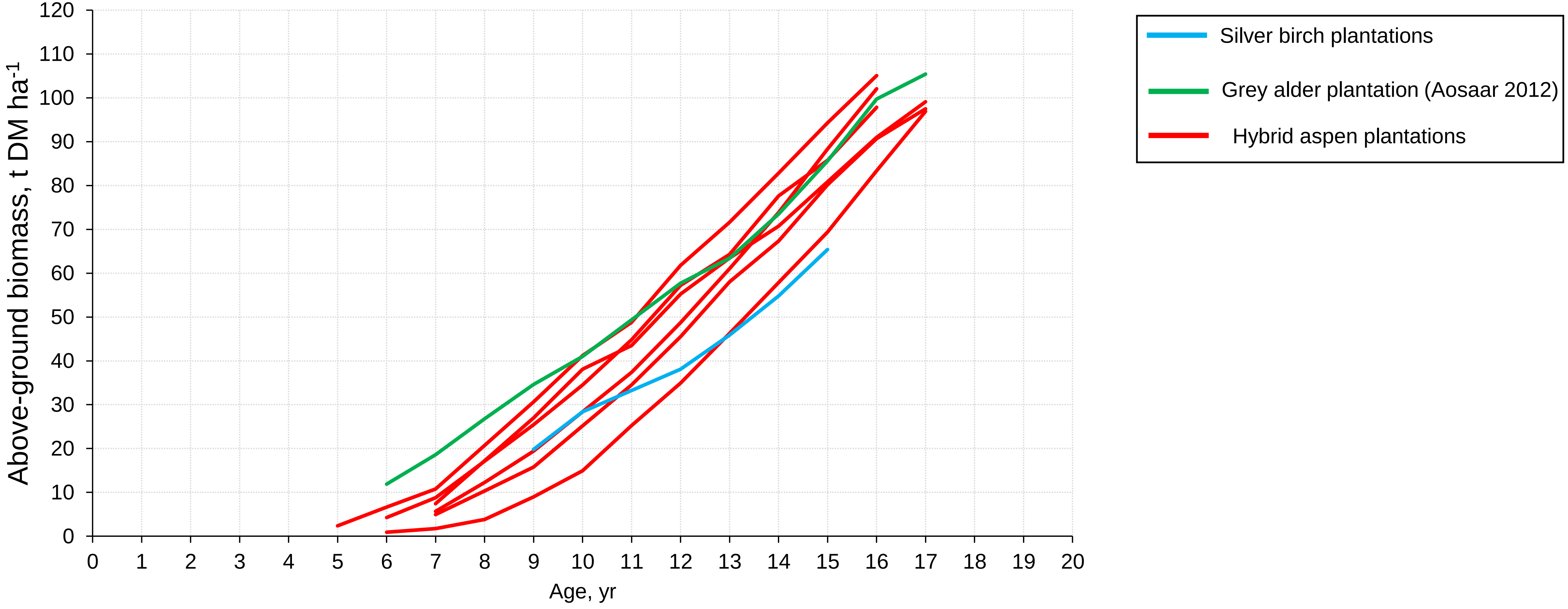


Distribution on trees into height classes in 9-yr-old *Betula pendula* and hybrid aspen plantations on abandoned agricultural land

Hybrid aspen total stem volume and comparison with fertile forestland soils European aspen yield tables (Kiviste 1997)



Hybrid aspen above-ground biomass (with branches) comparison with other fast-growing tree species on former arable lands

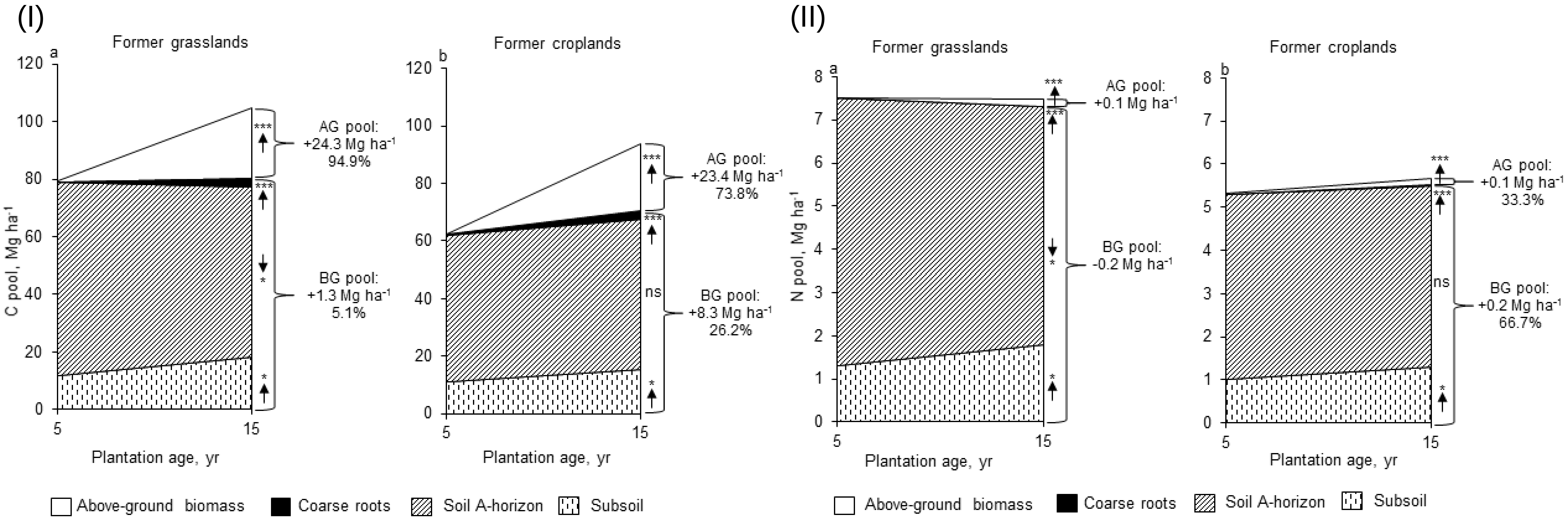


The observed significant changes of soil A- and B-horizon acidity (pHKCl), soil organic carbon (C_{org}), macro (NPKCaMg)- and micronutrients (CuMnB) between young (5-yr-old) and midterm (15-yr-old) hybrid aspen plantations

Soil property*	Soil horizon	5-yr-old	15-yr-old	Relative change	Absolute change	p-value
		Mean ± S. E	Mean ± S. E			
pH_{KCl}	A	5.9 ± 0.1	5.7 ± 0.1	-58.5%	-0.2	0.0001
Total N (%)	A	0.121 ± 0.009	0.128 ± 0.008	+5.8%	+0.007	0.0026
C_{org} (%)	B	0.29 ± 0.09	0.34 ± 0.08	+17.2%	+0.05	0.0042
Ca (mg kg^{-1})	A	2050 ± 240	1653 ± 237	-19.4%	-397	<0.0001
	B	1346 ± 153	1031 ± 144	-23.4%	-315	<0.0001
Mg (mg kg^{-1})	B	187 ± 32	163 ± 29	-12.8%	-24	0.0059
Cu (mg kg^{-1})	A	0.69 ± 0.04	0.83 ± 0.05	+20.3%	+0.14	<0.0001
	B	0.39 ± 0.04	0.60 ± 0.06	+53.8%	+0.21	<0.0001
Mn (mg kg^{-1})	A	61 ± 5	74 ± 6	+21.3%	13	<0.0001
B (mg kg^{-1})	A	0.62 ± 0.08	0.46 ± 0.08	-25.8%	-0.16	<0.0001
	B	0.20 ± 0.02	0.11 ± 0.02	-45.0%	-0.09	<0.0001

Lutter *et al*. 2016. Forest Ecology and Management, 362, 184-193.
Lutter *et al*. 2016. Forest Ecology and Management, 378, 79-90.

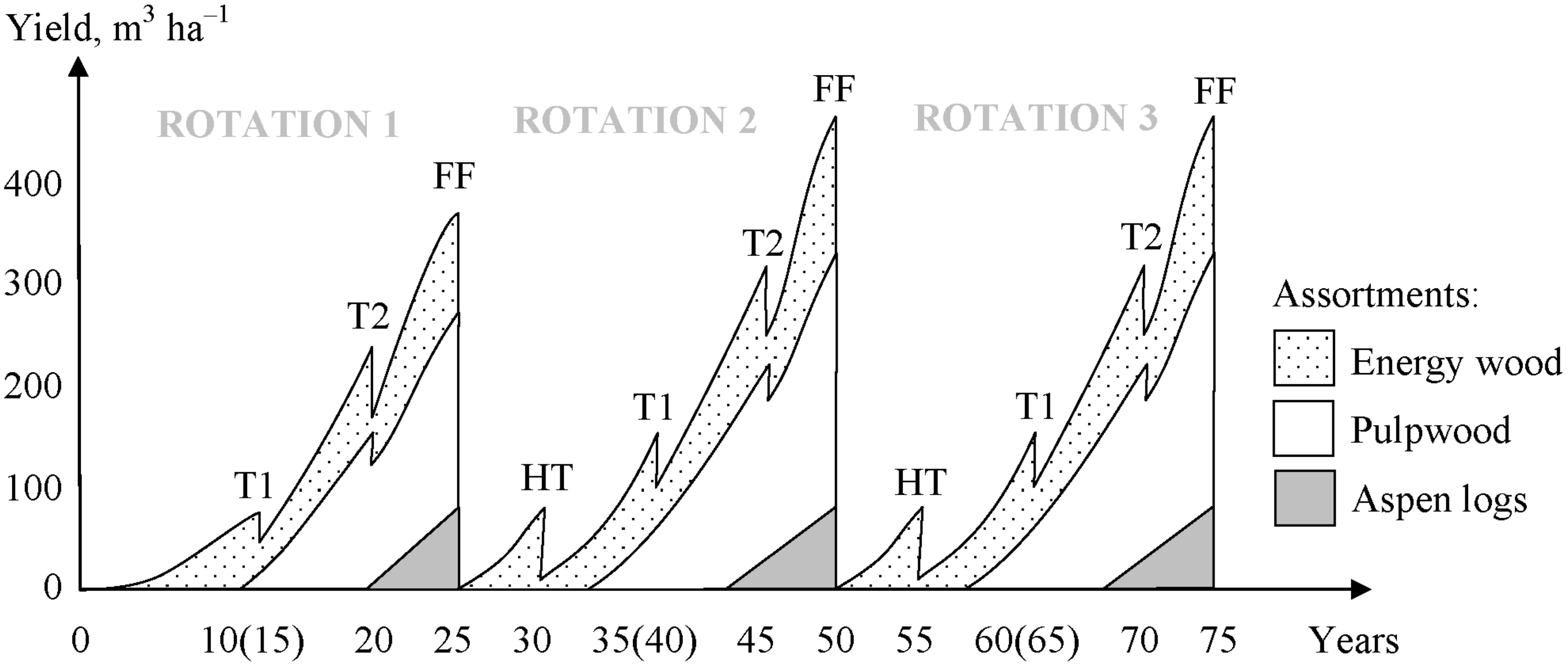
Hybrid aspen plantations total ecosystem C and N changes according to former land-use type (grass- and croplands)



The total ecosystem C (I) and N (II) change between 5 and 15-year-old hybrid aspen plantations representing different former land-use types in above-ground (AG) and below-ground (BG) pools, where arrows show the direction of the change (ns – not significant, p < 0.05*, p < 0.01**, p < 0.001***) and values next to curly brackets indicate how the total change is partitioned between AG and BG.

Lutter *et al*. 2016. Forest Ecology and Management, 378, 79-90.

Management



Theoretical management scheme for a hybrid aspen plantation; FF – final felling providing 250–300 m3 ha–1 pulpwood incl. some aspen logs and 60–75 m3 ha–1 energy wood (tops and branches), the expected yield at the end of the second and following root sucker originating rotations is predicted to be higher (300–350 m3 ha–1 pulpwood, incl. some aspen logs and 75–90 m3 ha–1 energy wood); T1 – first thinning, providing mainly energy wood; T2 – second thinning providing energy wood and pulpwood; HT – heavy thinning of the regenerating root sucker stand providing 25–40 m3 ha–1 energy wood (Tullus at al., 2011)

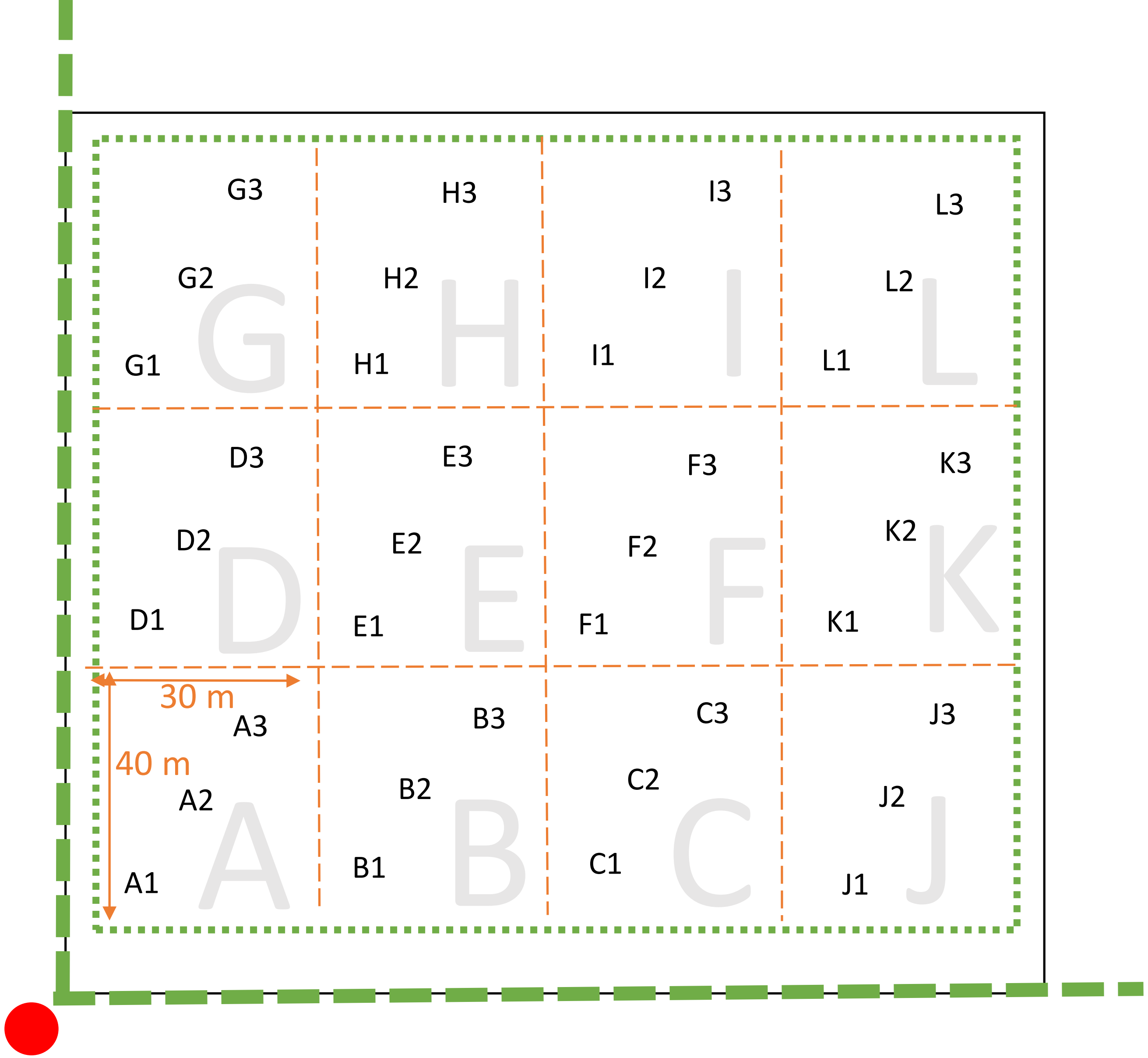
Second generation root sucker study

*2 ha hybrid aspen clear-cut area
*Established in 2014 spring
*Research aims: growth speed, biomass production, plant-soil relations, nutrient demand and management, above- and belowground carbon, natural biodiversity (including lichens), economy

Treatments:

Control: A; F; H
*Corridor harvest: D; B; I
**Cross-corridor harvest: C; E; G

Pre-commercial thinning, 2016 spring:
J (3438 trees per ha)
K (2462 trees per ha)
L (1613 trees per ha)



Harvest treatments were started after the second growing season:
*Corridor harvest: 2m wide corridors were harvested, leaving 1m wide rows for trees
**Cross-corridor harvest: 2m wide corridors were harvested in both directions, leaving 1x1m patches for trees

New Estonian records of lichenized fungi in 3-yr-old second generation hybrid aspen root sucker stands

Oja, E; Gerasimova, J.; Suija, A.; Lõhmus, P.; Randlane, T. (2016). New Estonian records and amendments: Lichenized fungi. Folia Cryptogamica Estonica, 53, 123−126

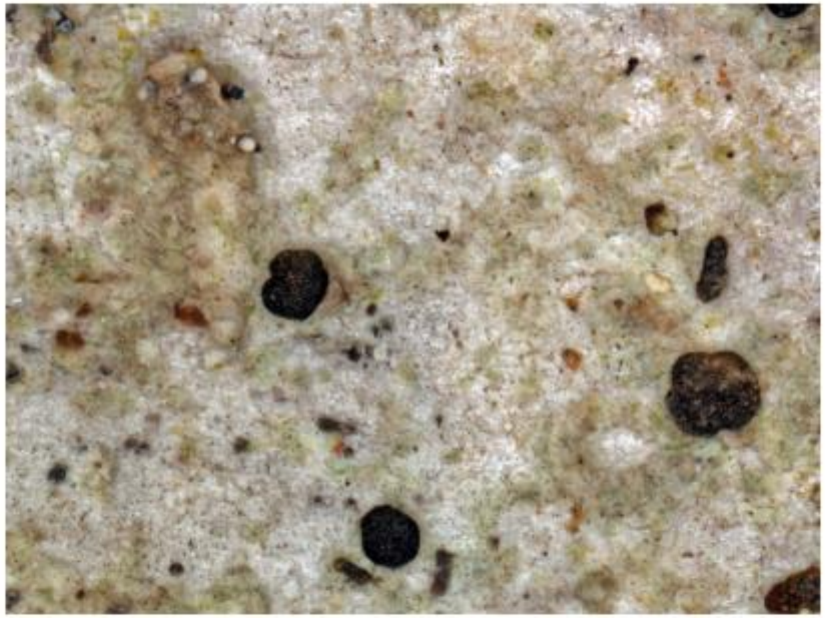


Fig. 4. *Strangospora deplanata* (dark apothecia and stalked pycnidia) on bark of hybrid aspen stump (TU79543). Photo Ede Oja.

Fig. 3. *Piccolia ochrophora* (orange-red apothecia with orange pruina) on bark of hybrid aspen stump (TU79535). Photo Ede Oja.

How does understorey vascular plant and bryophyte flora develop in hybrid aspen plantations on abandoned agricultural lands?

- In young plantations, disturbance from **previous land-use and site preparation intensity** are more important than overstorey tree growth, understorey is dominated by **light-demanding grassland species** (Soo *et al*. 2009a: For. Ecol. Man.).
- There are no substantial differences in understorey richness and diversity between hybrid aspen and silver birch plantations (Soo *et al*. 2009b: Ann. Bot. Fenn.) nor planted and naturally regenerated birch stands (Tullus *et al*. 2013: New Forests).
- Bryophyte richness and diversity is related to diversity of **available substrates**, e.g. felling residues from tendings (Tullus *et al*. 2012: Balt. For.) and tree trunks (Tullus *et al*. 2015: Can. J. For. Res.).
- In midterm plantations, a slow **succession towards shade-tolerant understorey** takes place. Inclusion of forest species is dependent of decreasing amount of canopy-transmitted light. Understorey is formed of species with different ecological requirements, ranging from fallow species to forest species (Tullus *et al*. 2015: Can. J. For. Res.).
- Hybrid aspen plantations in reclaimed oil-shale quarry sites support similar understorey diversity than plantations on previous agricultural lands.

Hybrid aspen clonal comparison trial

Table 1 The geographic origin of the parent trees of the studied hybrid aspen genotypes

P. tremula origin country	Country abbreviation	No. of entries	Plant type	Geographic origin of parents	
				P. tremula L.	*P. tremuloides* Michx.
Latvia	LV	7	Clone	♂ 56° 06′ to 57°10′ N	♀ 56°40′ N, botanic garden in Latvia (North American origin is unknown)
Sweden	SE	5	Clone	♀ 55° 53′ to 57° 31′ N	♂ 45° to 50° N, the Great Lakes region
Germany	DE	6	Full-sib families	♀ 51° 16′ to 52° 16′ N	♂ 44° N, New Hampshire
Finland	FI	4	Clone	♀ 60° 22′ N	♂ 45° 17′ N, Ontario 54° 06′ N, British Colombia

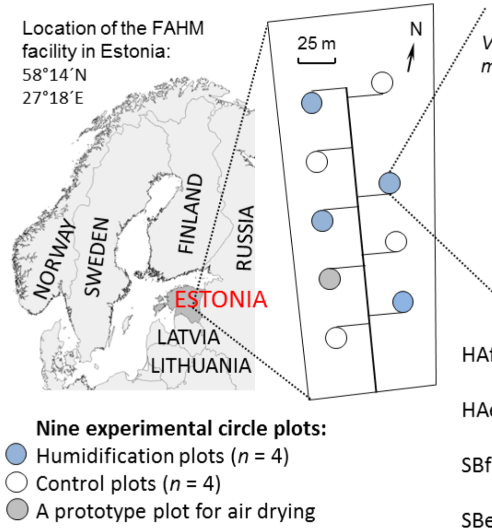
Phenological observations in hybrid aspen clonal comparison trial

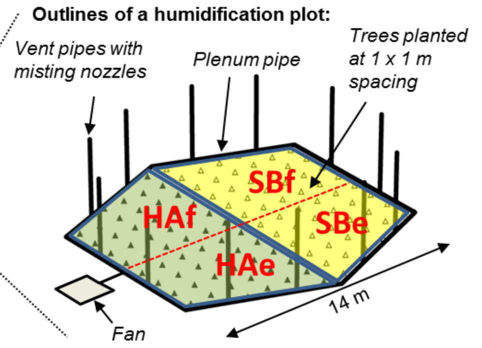
*A warming climate has already caused extension of the growing season in the hemiboreal region (a trend predicted to continue in future).
*Consequently, hybrid aspen genotypes with a southern origin responded well to a northward transfer, whereby they had a longer leafy period and greater annual height growth than southward transferred genotypes.
*The genotypes of southern origin (55° to 57°′ N) had a period from bud-burst to defoliation 27 days longer
than that of genotypes of northern origin (60° 22′ N)
*The main differences among genotypes of different geographic origin were revealed in autumn phenology, when northern genotypes started earlier defoliation and bud-set.
Lutter et al 2016

Poplars

- Populus trichocarpa (SnowTiger clones, produced by SweTree)
- Plantations in Tartu, Raasiku and Saaremaa

Second year





HAf – Hybrid aspen (*Populus tremula* x *tremuloides*) stand with forest understorey vegetation
HAe – Hybrid aspen stand with early successional understorey
SBf – Silver birch (*Betula pendula*) stand with forest understorey
SBe – Silver birch stand with early successional understorey

Relative humidity inside the experimental plots is elevated by ca 7 units (%) using misting technique (a droplet size ca 10 µm) and FACE-like technology to mix humidified air inside the plots.

The Free Air Humidity Manipulation (FAHM) experiment

http://fahm.ut.ee/main?lang=en

- At high latitudes (> 57°N) of the Northern Hemisphere climate change will bring about a major **increase in temperature and** amount and frequency of **precipitation**.
- Therefore **concurrent rise in average air humidity** is anticipated.
- FAHM experiment was construced in Rõka village in 2006-2007 to study the effects of elevated air humidity on deciduous forests, humidification manipulation started in 2008.
- **FAHM is unique**: it is the only open-air forest ecosystem climate manipulation experiment in Estonia and the only climate manipulation in the world, where elevated air humidity effects are studied.
- About **20 articles** have been published based on results from FAHM, including in top journals (Global Change Biology, Frontiers in Plant Science, Journal of Experimental Botany).
- The synthesis of the results can be found in a **review paper**: Sellin et al. (2016): Growth of northern deciduous trees under increasing atmospheric humidity: possible mechanisms behind the growth retardation. *Regional Environmental Change*, doi:10.1007/s10113-016-1042-z

Our proposed contribution in the MedRoPlan project:

To investigate the **adaptability and acclimation mechanisms** of potential medium- and short-rotation forestry species: **hybrid aspen and silver birch** with the predicted **climate change** scenarios for northern Europe.

To investigate fundamental processes of **tree physiology and ecosystem functioning** in medium- and short-rotation forests.

To investigate processes with **implications for practical forestry**: tree **growth and productivity**, formation of wood with consequences on (industrial) **wood quality**, nutrient cycling and need for **fertilization**, tree-to-tree **competition** and resource management with silvicultural tools (timing, intensity and principles of thinnings).

To investigate climate change mitigation effect of medium- and short-rotation forests: **C** balance and **GHG** emission.

Conclusion: Estonian partner is ready for:

- **Productivity, first and second generation**
- **Plant-soil, nutrients**
- **Clone comparison**
- **Management: planting-thinning-pruning-clear cut-retension trees**
- **Economy**
- **Carbon dynamics**
- **Biodiversity**
- **Climate Change**
  - **Tartu University: FAHM**
- **Contacts: Finland-Sweden-Spain-Chile-New-Zealand-Iceland-Latvia-Lithuania**
- **Cooperation**
  - **Södra**
  - **SweTree**
  - **Plantex**


Thank You!