Coppiced downy birch on cutaway peatlands: heterotrophic soil respiration and C sequestration in tree biomass

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Coppice forests in Europe, Antwerpen 16th of June

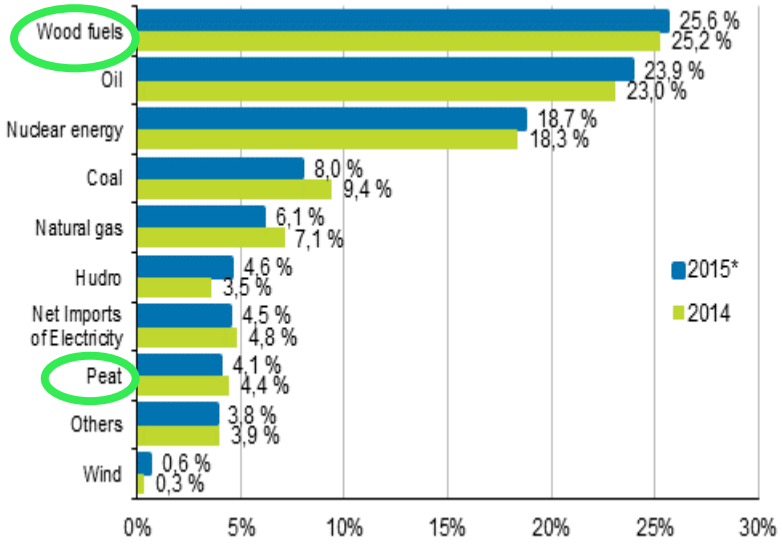
Content

- Peat and wood in energy production
- Properties of peat cut-away areas
- Material and methods
  - Experiment
  - Measurement of heterotrophic soil C
- Results
  - Biomass and C bound in biomass
- Conclusions

Photos: Jorma Issakainen, Jyrki Hytönen, Olli Reinikainen, Seppo Vihanta & Erkki Oksanen

Wood and peat energy in Finland

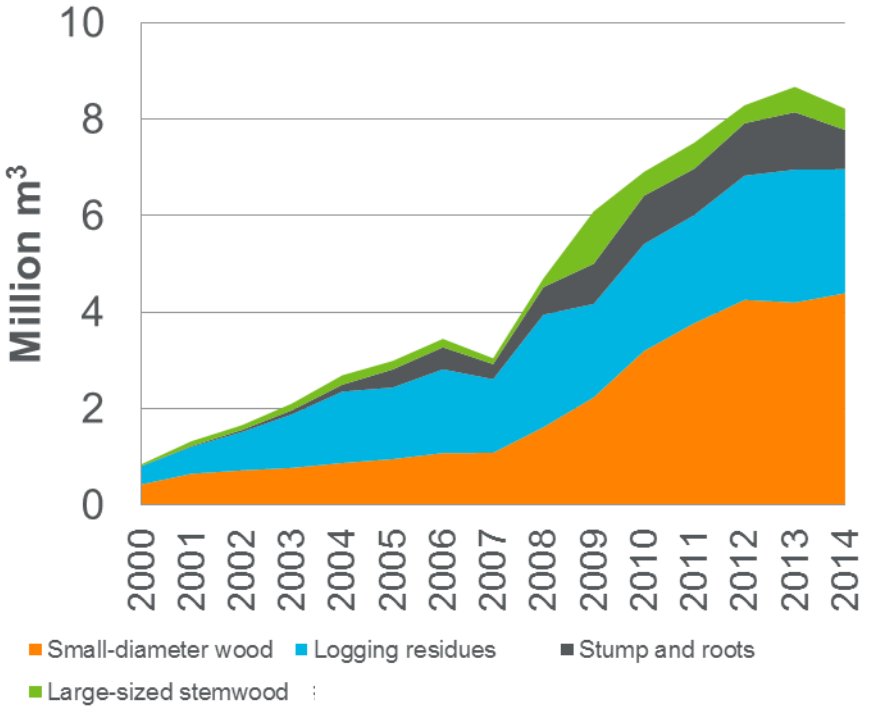
Energy sources



Total consumption 361 TWh (2015)

Source: Statistics Finland, Energy supply and consumption

Forest chip consumption by raw material



Target: 13.5 million m^3 by 2020

Source: Natural Resources Institute Finland

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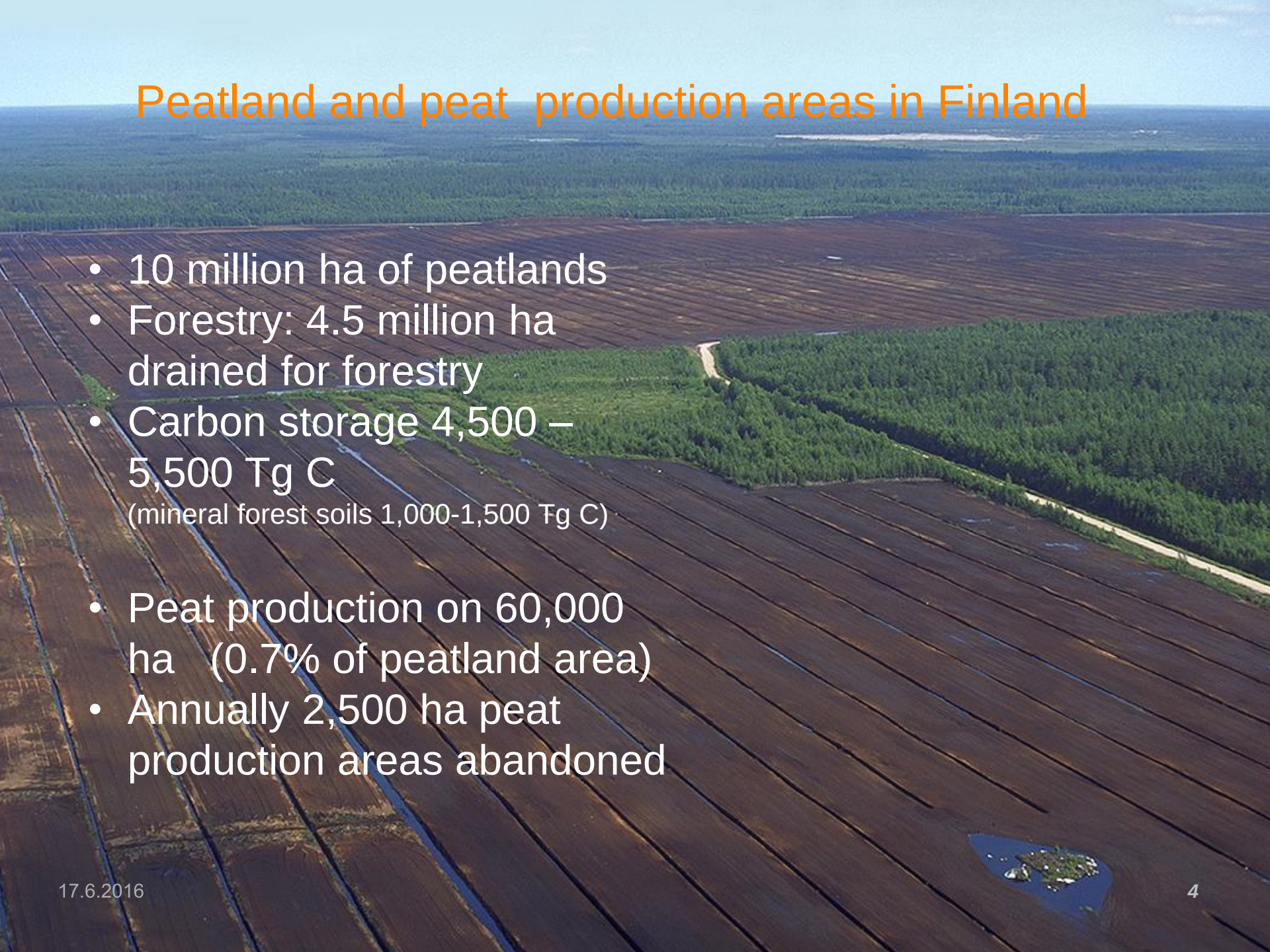
Peatland and peat production areas in Finland



- 10 million ha of peatlands
- Forestry: 4.5 million ha drained for forestry
- Carbon storage 4,500 – 5,500 Tg C
  (mineral forest soils 1,000-1,500 Tg C)

- Peat production on 60,000 ha (0.7% of peatland area)
- Annually 2,500 ha peat production areas abandoned

Properties of cutaway peatlands for biomass production

N

Thicknes of remaining peat layer

Water, ditching

Quality of mineral soil: P, K, Ca, Mg,

Different biomass production options on cutaway peatlands

After-use considerations

- land-use change
- production of renewable biofuels
- GHG balance

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Growing of downy birch thicket

Cutaway peatlands released 2500 ha annually

Profitability

Experiment at Aitoneva cutaway peatland

- Dense downy birch stand established naturally was clearcut
- Fertilization treatments applied on stumps
  - Control
  - PK 575 kg/ha (P 50, K 95 kg/ha)
  - Wood ash 5 t/ha (P 108, K 339 kg/ha)
- Trees were grown for 21 years

Aitoneva is one of the oldest peat harvesting areas in Finland

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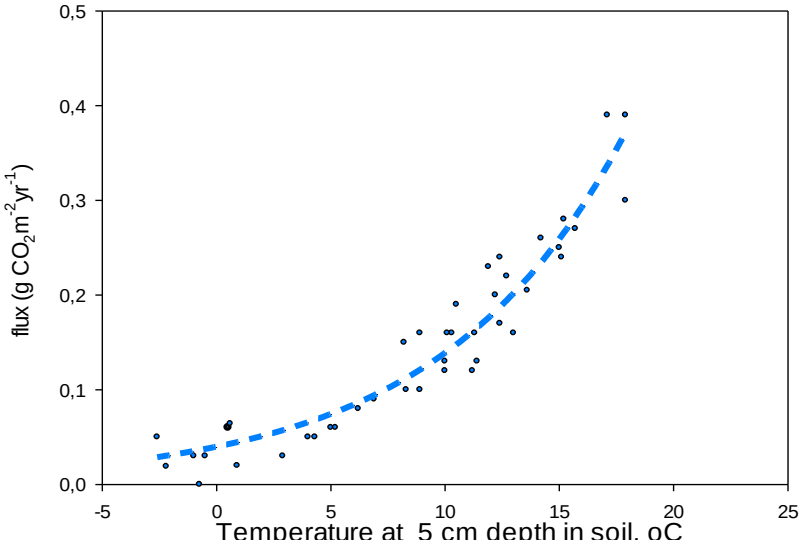
Peat decomposition (heterotrophic soil respiration)

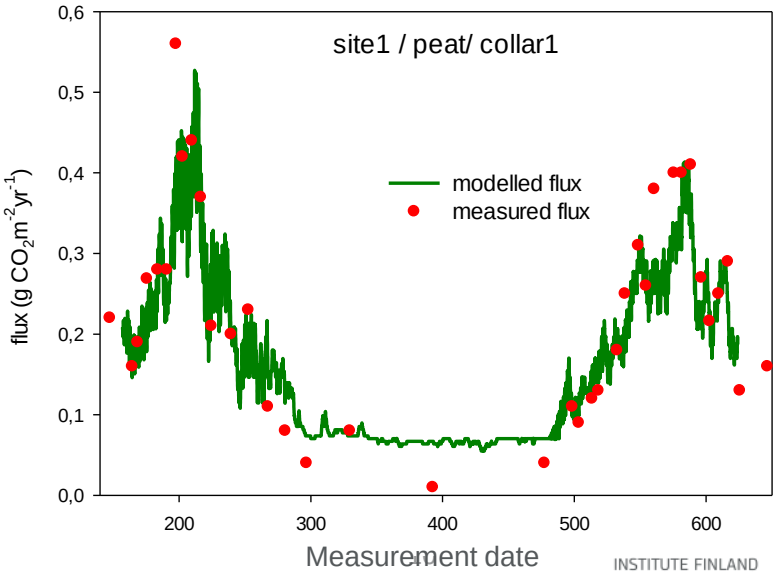
- Measurement points trenched (30 cm) to cut root connections
- Green vegetation cut > measurement of heterotrophic soil respiration
- Soil CO_2 exchange measured with EGM-4
- Measurements 2-years weekly during the growing season and once a month during the winter
- Soil temperature, WT and soil moisture measured simultaneously
- Continuous soil temperature measurements (data loggers)

Modelling soil respiration

- Non-linear regression between measured soil temperature (5 cm depth) and soil respiration for each sample plot separately
- flux = a* EXP(b*T5)
- Temperature at 5 cm depth explained 57-95% of the variation in soil respiration

- Annual soil respiration was calculated using hourly soil temperature data





Annual GHG emissions due to mineralisation of soil organic matter

GHG	Cut-away peatland	Cultivated agr. land (mean)	Pristine
g m^{-2} a^{-1}			
CO_2	1 397	2 072	−100 –150(2
CH_4	-0.05	0.42	2–25(1
N_2O	0.15	1.74	0–0.004

1) Turunen et al. 2002
2) Minkkinen & Ojanen 2013

1397 g CO_2 = 381 g C

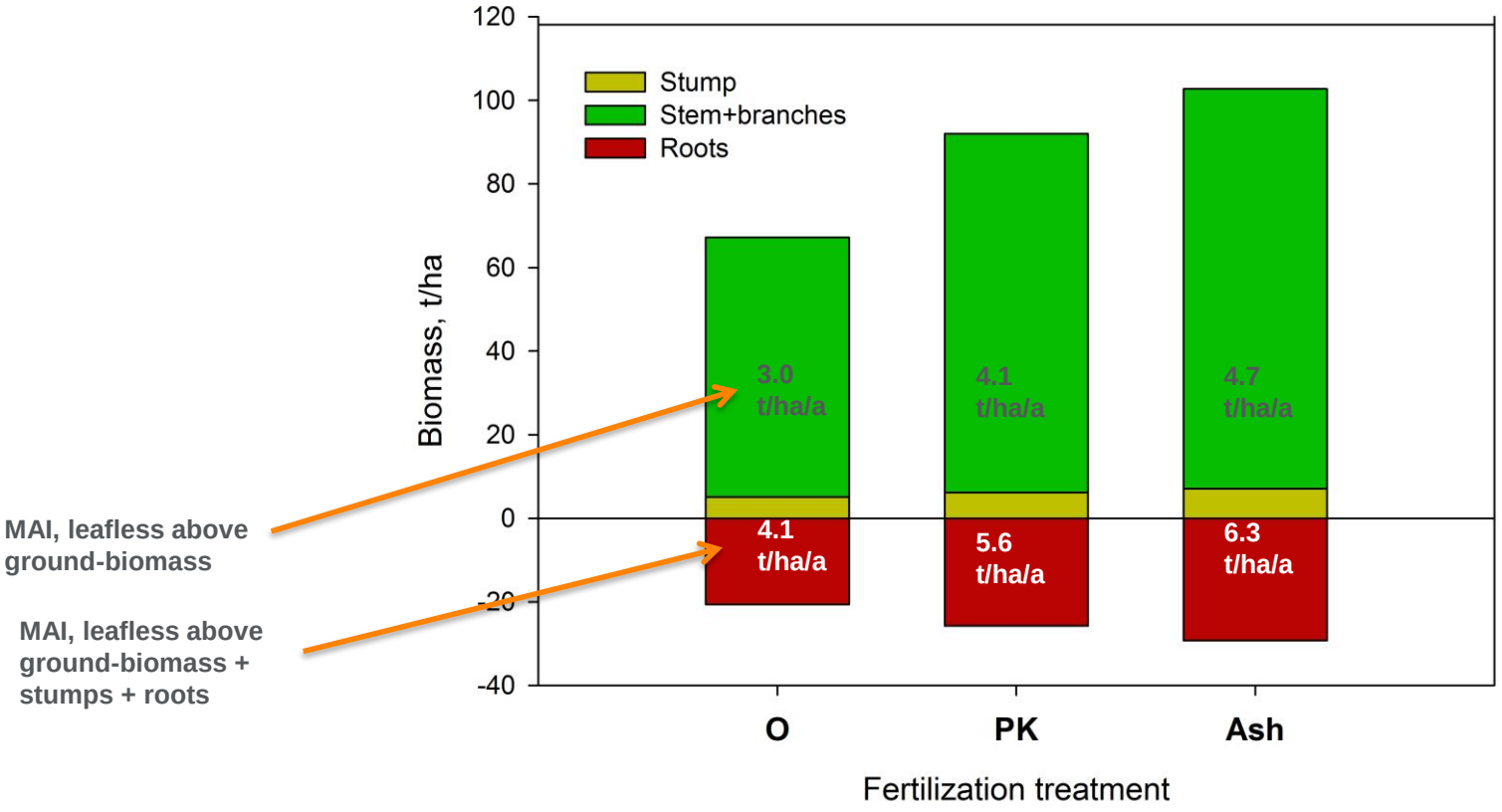
Cultivated organic agricultural land 320 000 ha > emissions 8.5 Tg CO_2 equivalent/year =14.4% of total GHG emissions reported from Finland

Stand measurements

- Tree stand measured several times ($d_{1.3}$, h) during 21 years
- Biomass of birches (roots > 1 cm, stump, stem, branches) calculated with biomass equations (Repola, J. 2008. Biomass equations for birch in Finland. Silva Fennica)
- Biomass of willows with own allometric equations
- C content in stems 49.2% (LECO CHN-analyzer)

Fertilization increased biomass production of coppiced downy birch

Leafless above-ground biomass in 21 years



Hyvönen & Aro 2012 Silva Fennica 46(3): 377-394

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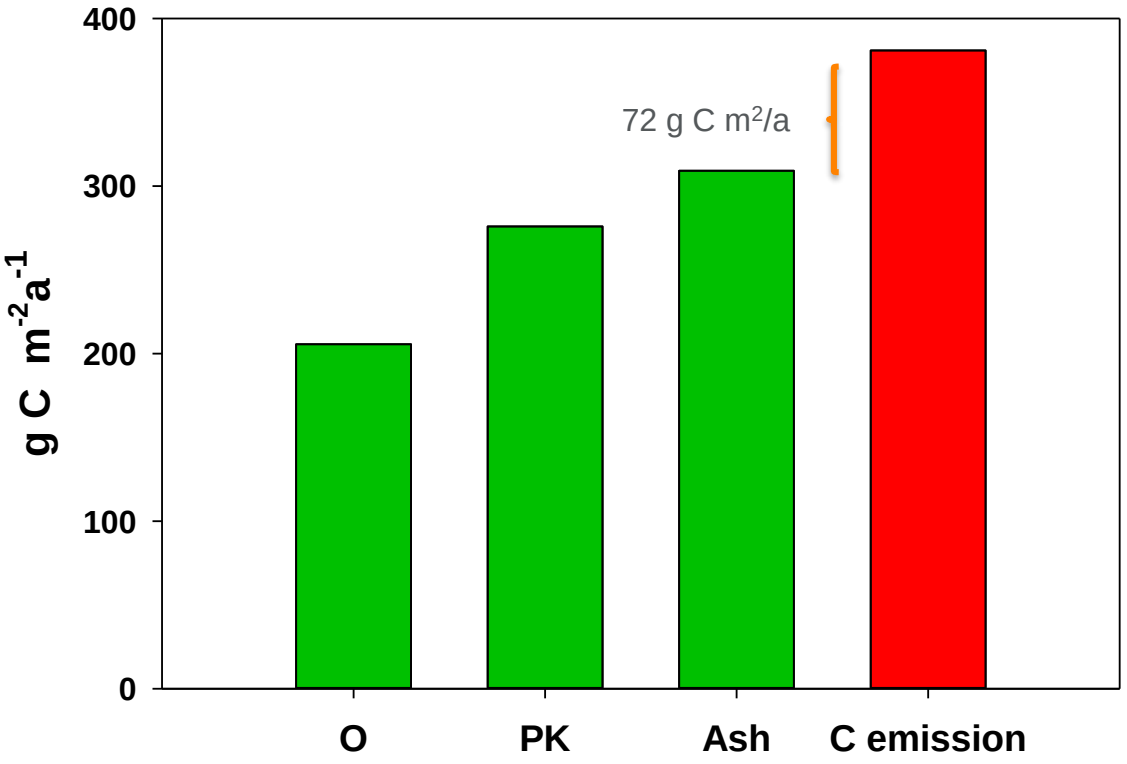
Annual heterotrophic C efflux from peat and C bound in the birch stands (stems, branches, stumps, roots, no leaves)

Sprout originated birch stand helped to compensate C loss from peat.

Adding litter layer formation would still decrease the gap



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Conclusions

BIOMASS PRODUCTION

- Fertilized coppiced birches produced 4.1 -4.7 t/ha/a (21-year rotation, leafless above-ground biomass)
- Fertilization after clear-cutting increased production

CO_2 SEQUESTRATION

- Wood energy production could offset soil CO_2 emissions from peat

ECONOMY

- Cut-away peatlands show potential for profitable production of energy biomass without subvention (Jylhä et al. 2015)
  - Low investments on wood production
  - Increased removal due to clear-cut
  - Minimum rotation more than 20 years
  - Profitability is sensitive to harvesting cost