Peatland forest management – problems and solutions

Raija Laiho, Meeri Pearson, Harri Vasander
Natural Resources Institute Finland
University of Helsinki

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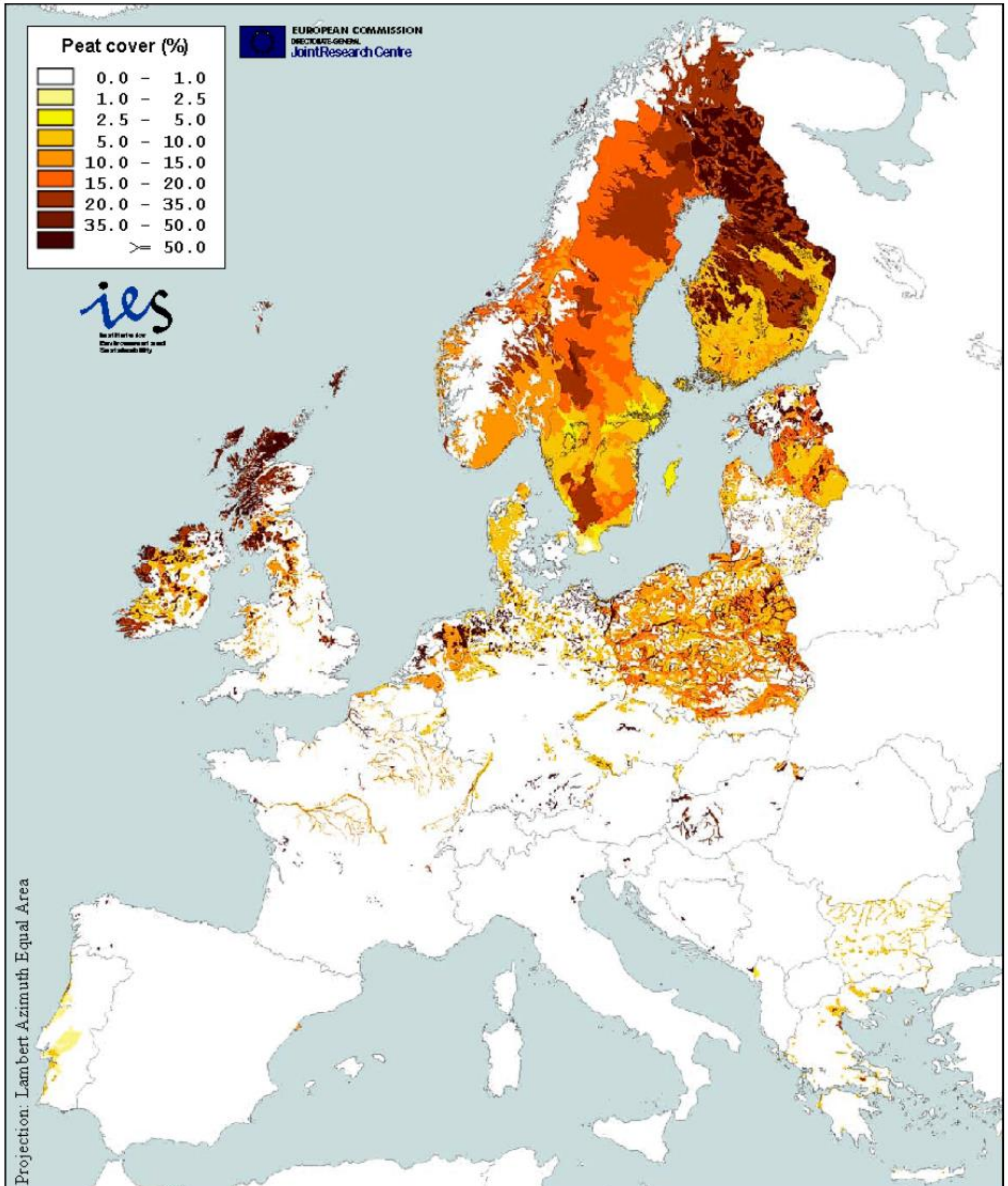


Figure 2. Relative cover (%) of peat and peat-topped soils in the SMUs of the European Soil Database.

L. Montanarella, R.J.A. Jones & R. Hiederer 2006. Mires and Peat 1, article 01.

Drained peatland forests

- Pohjoismaan ja Baltian maat, paljonko

Why do we have so much drained peatland forests in Finland?

- Peatlands covered initially about 30 % of the land area
- Much more N in peat than in mineral soil – potentially productive sites, once we get rid of the extra water
- ”Unproductive => productive”, especially during the 1960's and 1970's, when drainage intensity was the highest
  - Forest industries were growing, annual cuttings exceeded annual growth
  - State subsidies to drainage

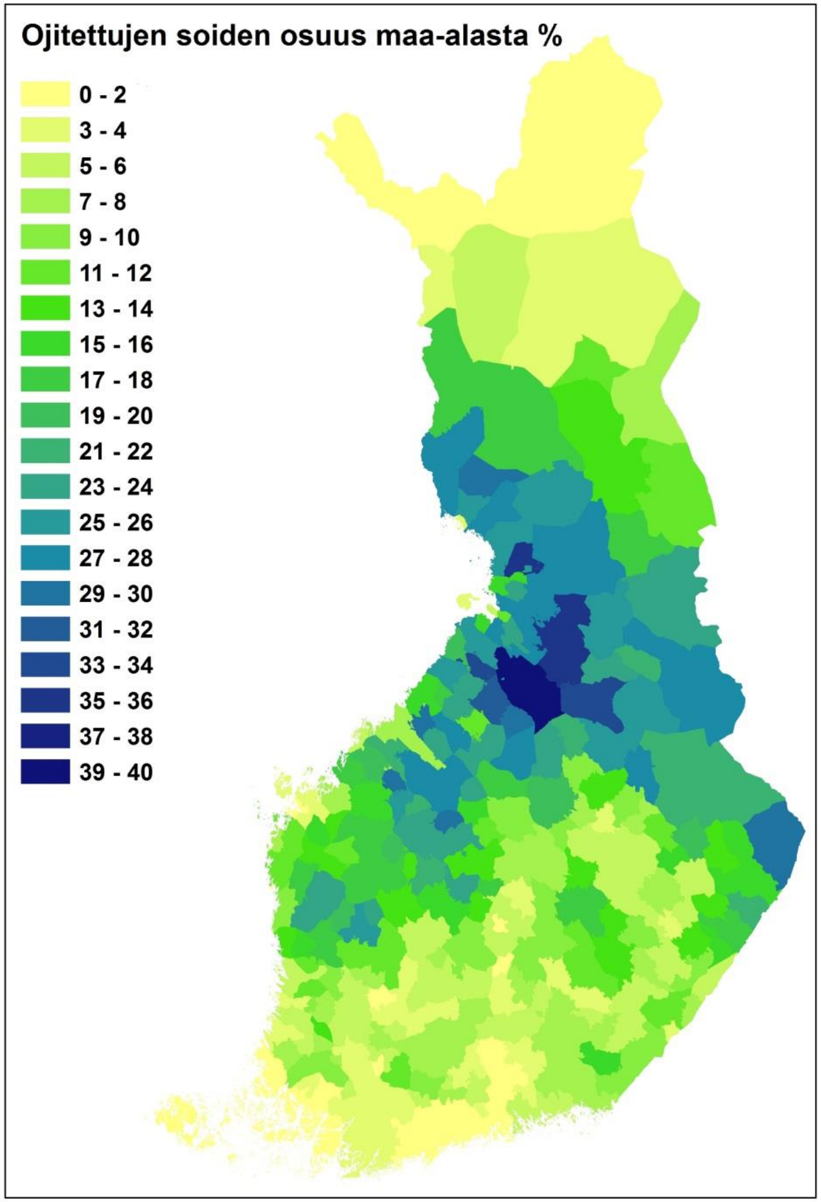
”Traditional” management

- The first tree generation consisted of pre-drainage trees plus natural ingrowth
- Thinnings aiming at more even structure
- Commonly clearcut + site preparation and planting, or shelterwood and natural regeneration for spruce

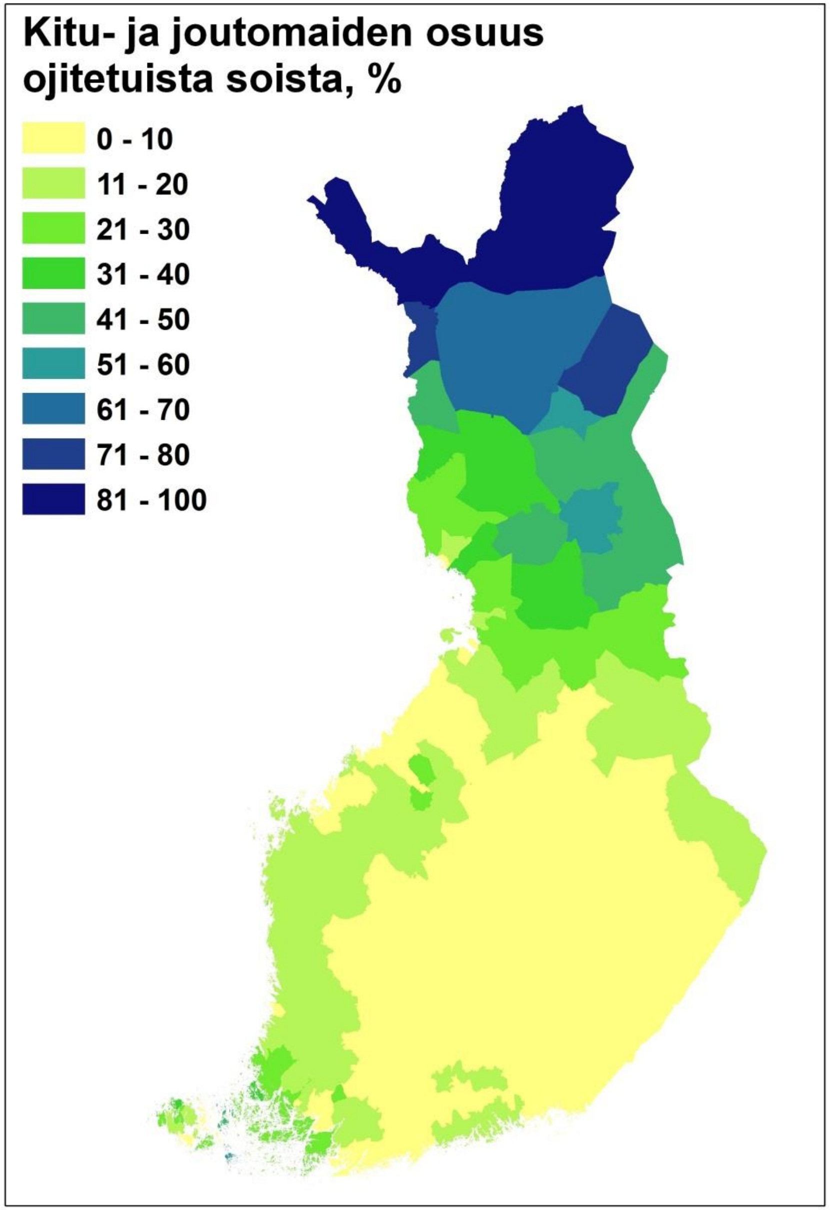
How successful?

- Currently, about 1/5 of productive forest land, 1/4 of total tree volume and annual growth, 1/6 of allowable/planned cuttings (and increasing)
- 551 mill. m^3 (drained 445); 11-12 mrd (billion) € (drained 10)
- 0.5 – 1 million hectares, 1/10 to 1/5 of total area, not productive enough to be maintained in active forestry (depending on definitions and assumptions)
  - Low N availability the main reason
  - Also nutrient imbalance situations (low K and/or P relative to N)
  - Sometimes failed drainage

Drained peatlands of total land area, %



Non-productive of drained area, %





Kuva: Hannu Nousiainen/Metla

Problems: economic point of view

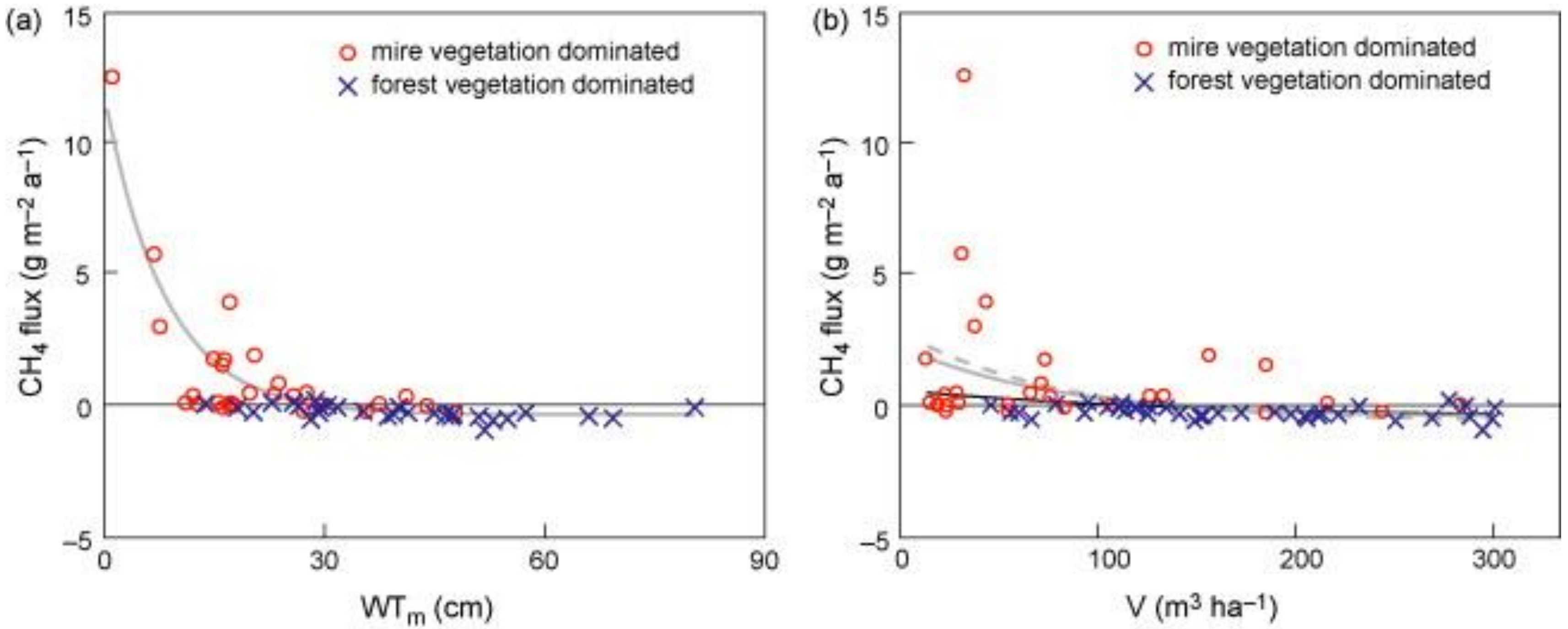
- Cutting costs are higher: Soft soils, ditches, uneven structure with small trees
- Costs of ditch network maintenance and structures for water protection
- => not favored cutting areas => delayed operations => stand quality
- Soil nutrient imbalances become more common after the first tree generation
  - Leaching of K and P after clearcuts; fertilization may be needed

Problems: environmental point of view

- Lost diversity
- GHG balance of the drained soils
- Leaching of C and nutrients following clearcutting
- Leaching of suspended solids following ditch network maintenance

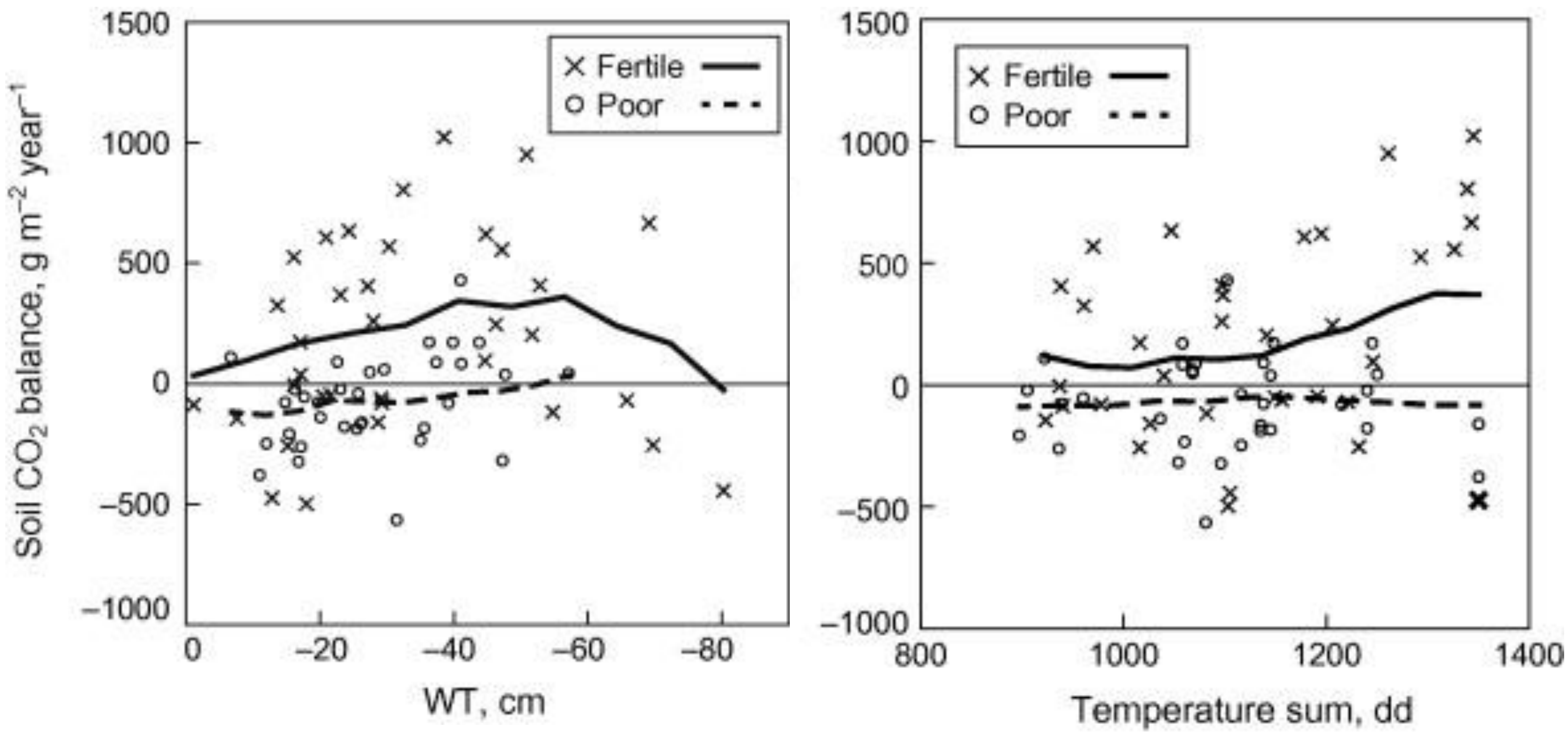
Soil CH_4 balance in drained peatland forests

- Drainage decreases methane emissions



Ojanen et al. (2010) Forest Ecology and management

Soil CO_2 balance in drained peatland forests



- Rich sites (deciduous, spruce) => source
- No high emissions from poor sites (pine-dominated, shrubs)

Ojanen ym. (2013) Forest Ecology and Management

C balance

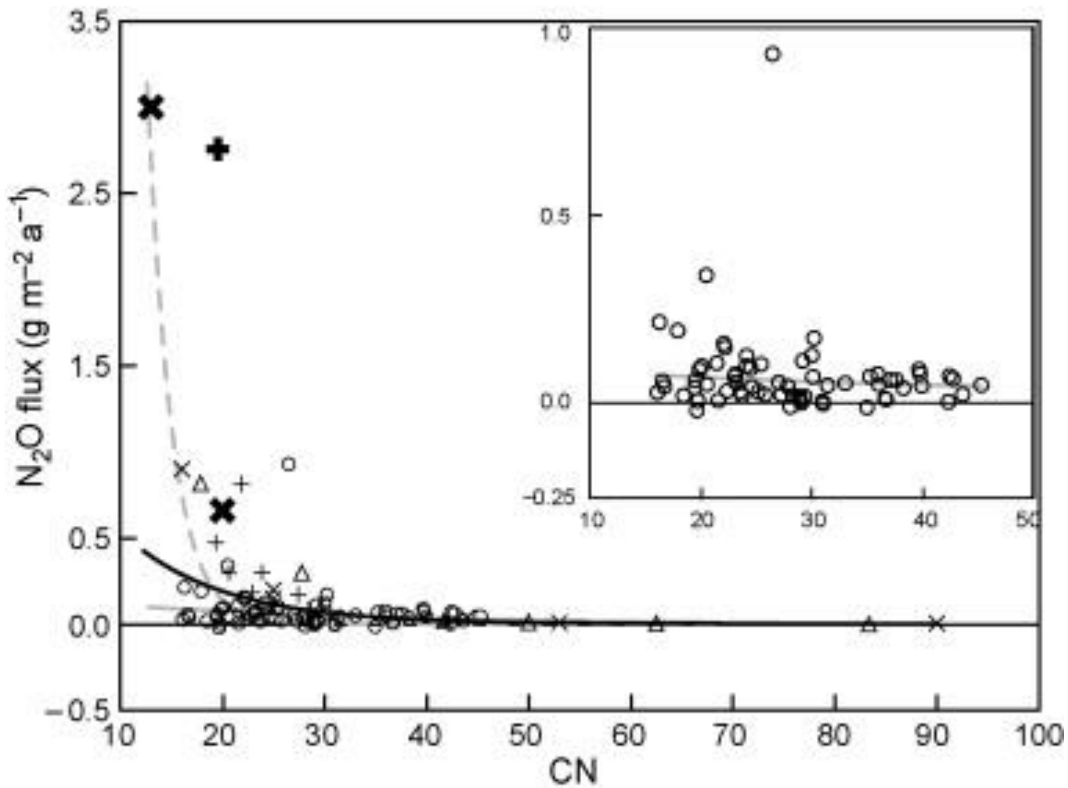
Nutrient-rich

Nutrient-poor

Ojanen ym. 2013. *Forest Ecology and Management* 289: 201–208.
Simola ym. 2012. *European Journal of Soil Science* 63: 798–807.

Soil N_2O balance in drained peatland forests

- Drainage increases emissions, especially in nutrient-rich sites
- Afforested fields show especially high emissions



Ojanen ym. (2013) Forest Ecology and Management

Drained peatland forests in Finland Altogether, as CO_2 equivalents, Tg/year:

- Soil CO_2: **±10** (Ojanen et al. 2014)
- Soil N_2O: **+1,2±0,2**
- Soil CH_4: **+0,8±0,4**
- Ditch CH_4: **+0,27±0,04** (Minkkinen & Ojanen 2013)

- **Soil total: +2,3±10**
- **Tree stand: −14 Tg**

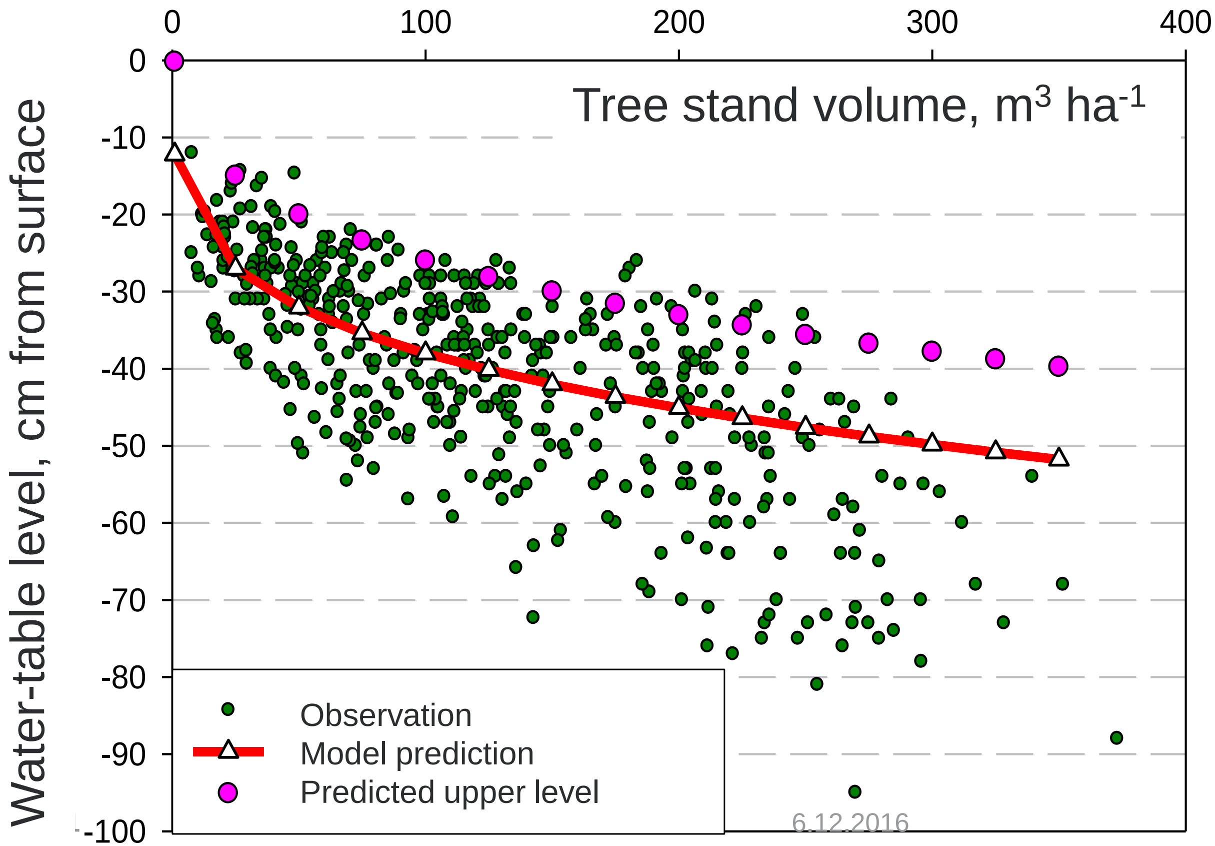
Current situation not too bad; however, net emissions from nutrient-rich peat soils will continue – how to decrease those?

Continuous cover forestry – increased climate and environmental efficiency?

- The main principle is to keep continuous cover in the tree stand

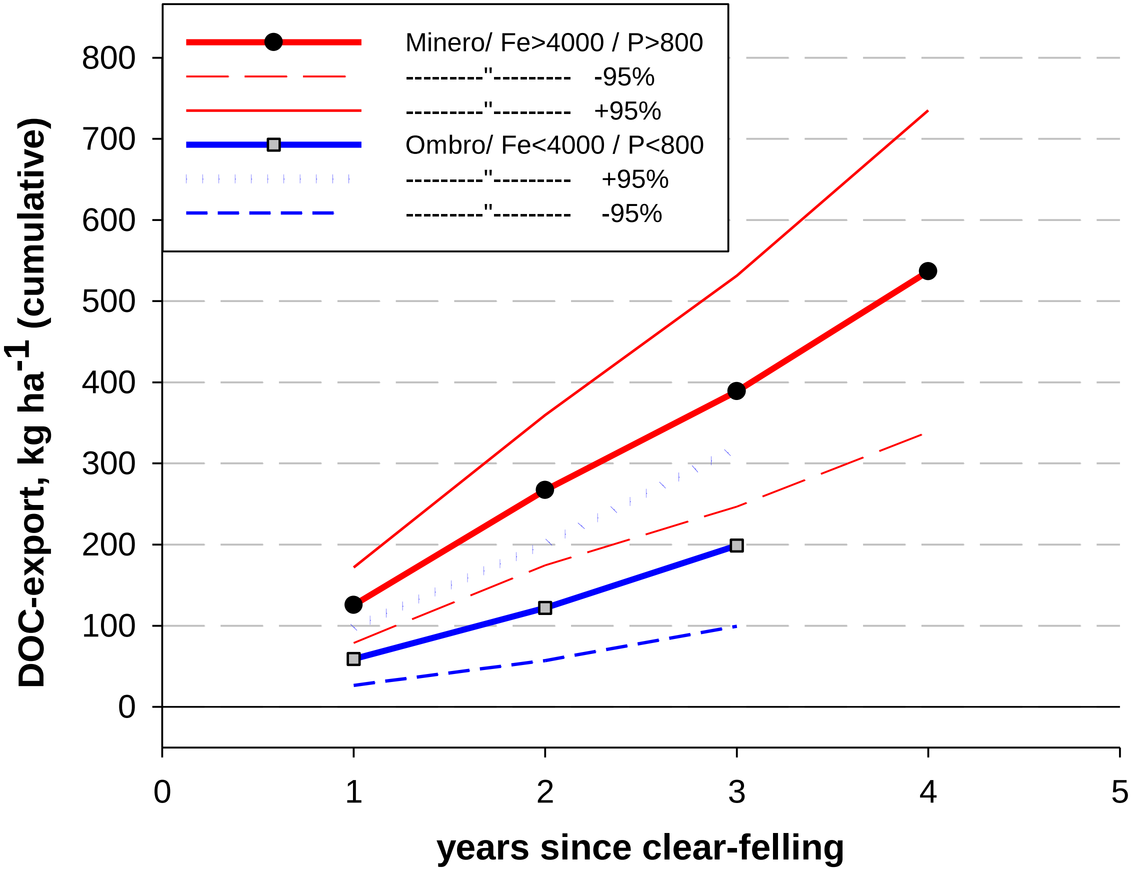
➡ evapotranspiration of the trees leads to sufficient ”biological drainage”

➡ no more drainage or clearfellings



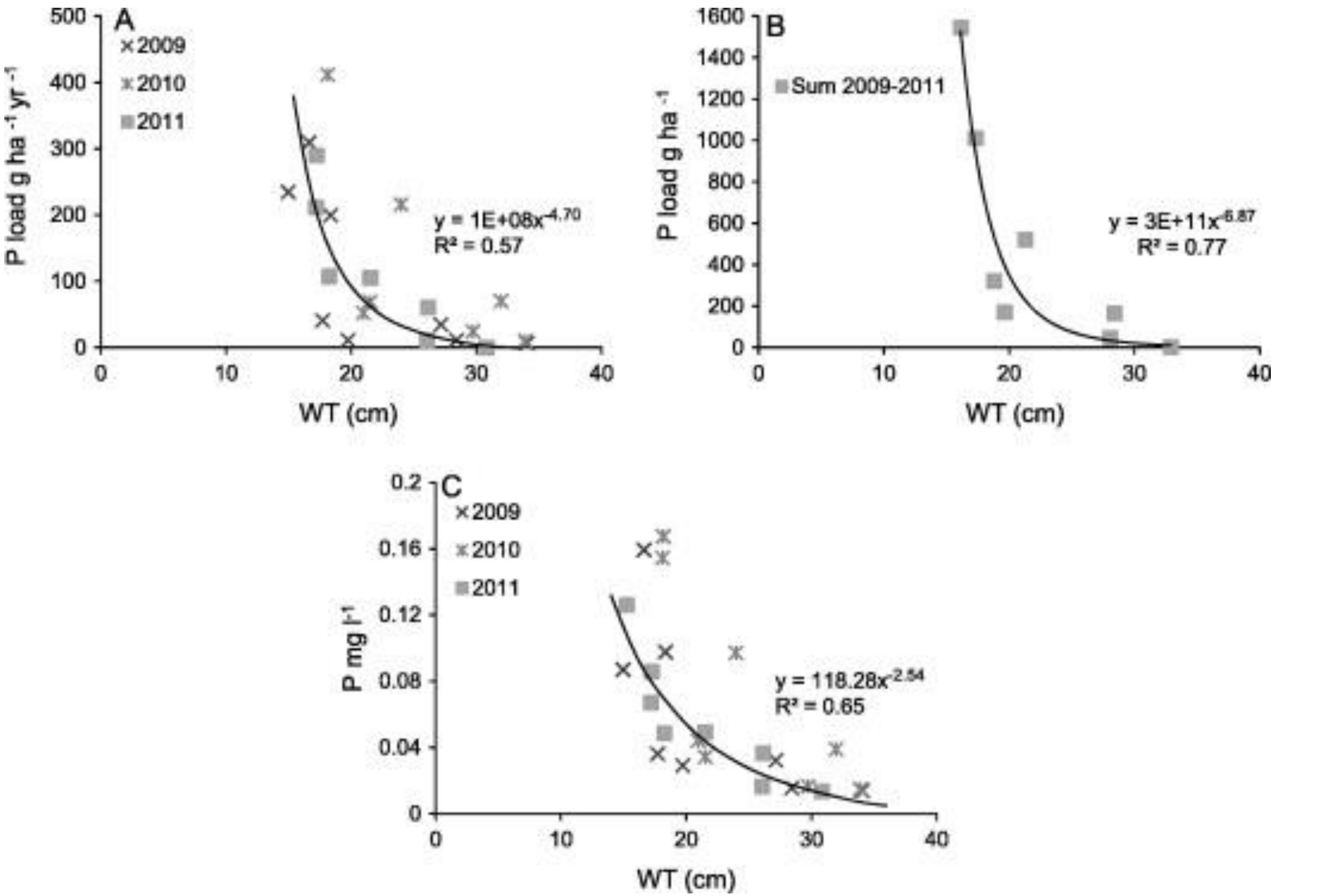
The effects of fellings: C leaching

- Clearfellings increase leaching of TOC by 80-400 kg/ha during the first 3-yr period after felling (Nieminen 2003, Nieminen *et al.* 2015)
- Felling type (stem *vs.* whole-tree felling) has no effect
- Increase in C leaching is connected to higher WTL after fellings.



Cumulative DOC-increases after clearfelling in rich and poor sites (Nieminen et al. 2015)

Water-table level rise => leaching of P



Kaila ym. 2014 Forest Ecology and Management

The effects of felling: C-balance of the soil

- Fellings and soil preparation do not increase GHG emissions from peat (Mäkiranta *et al*. 2010, Pearson *et al.* 2012)
- Not good to harvest tree stumps from *Sphagnum* peat where they may be C sinks for 300 yrs; in sedge peat they decompose faster (Pearson *et al.*, in prep.)
- Peat decomposition increases under slash piles (Mäkiranta *et al.* 2012). Thus, it is OK to harvest branches, too.
- However, we have to take care that there are enough nutrients for the future tree stands. (Nieminen *et al.* 2016, Sarkkola *et al.*, 2016)

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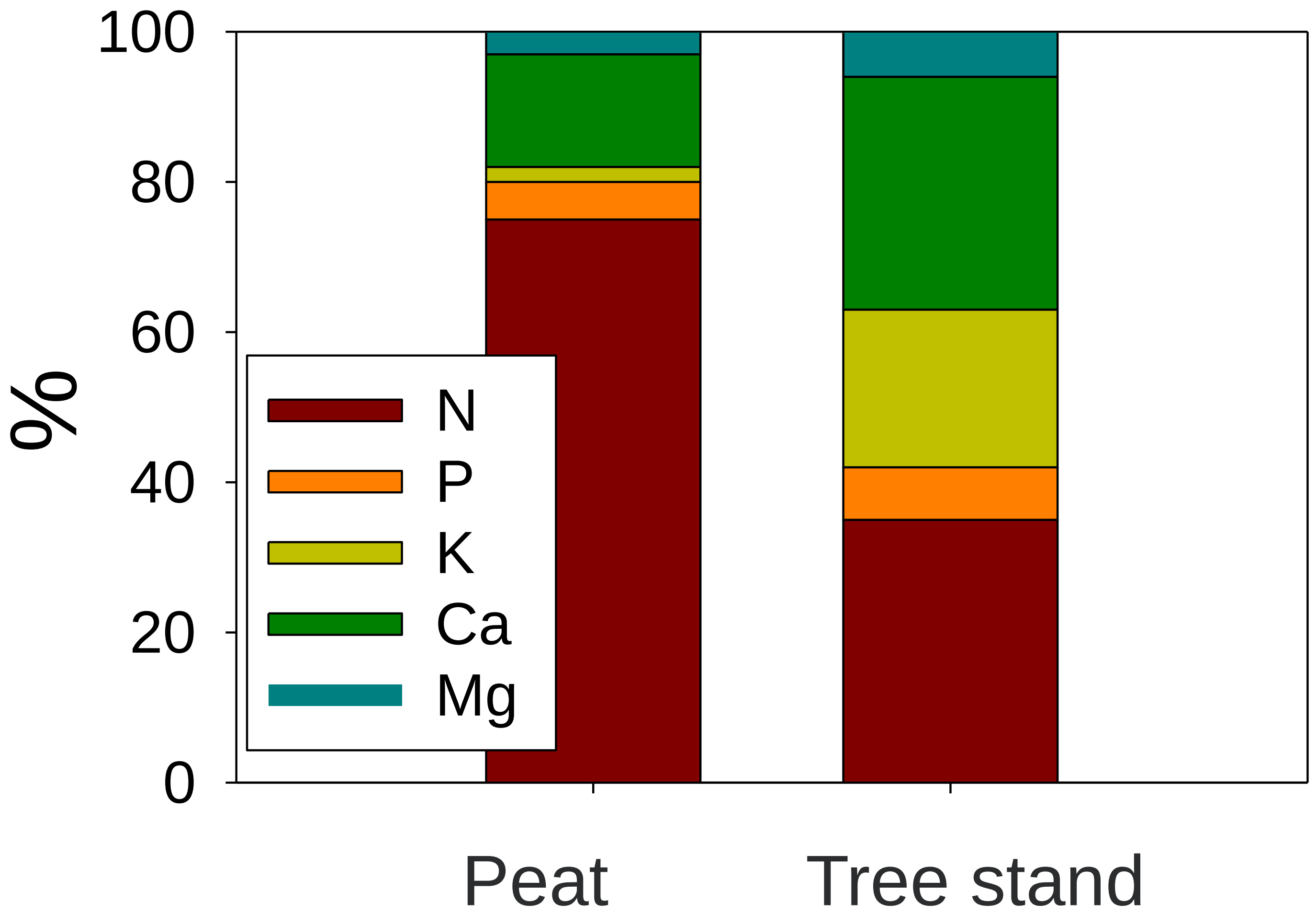
Benefits of ash fertilization

- Big growth response on suitable sites
- Long effect on tree growth
- Fellings can be done earlier
- The wood quality becomes better
- Could also decrease the need of ditch network maintenance
- Can also be used in the afforestation of harvested peatlands

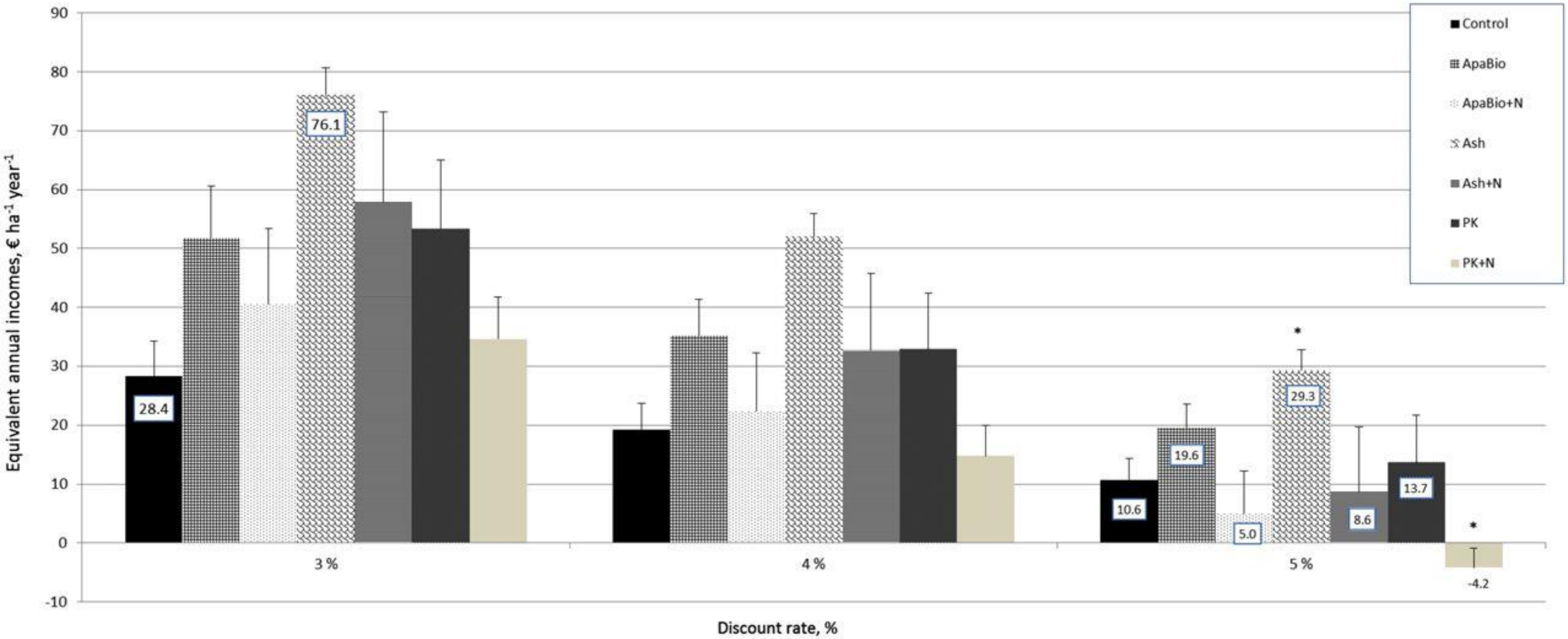
Proportions of main nutrients



Westman & Laiho 2003. *Biogeochemistry* 63: 269–298.

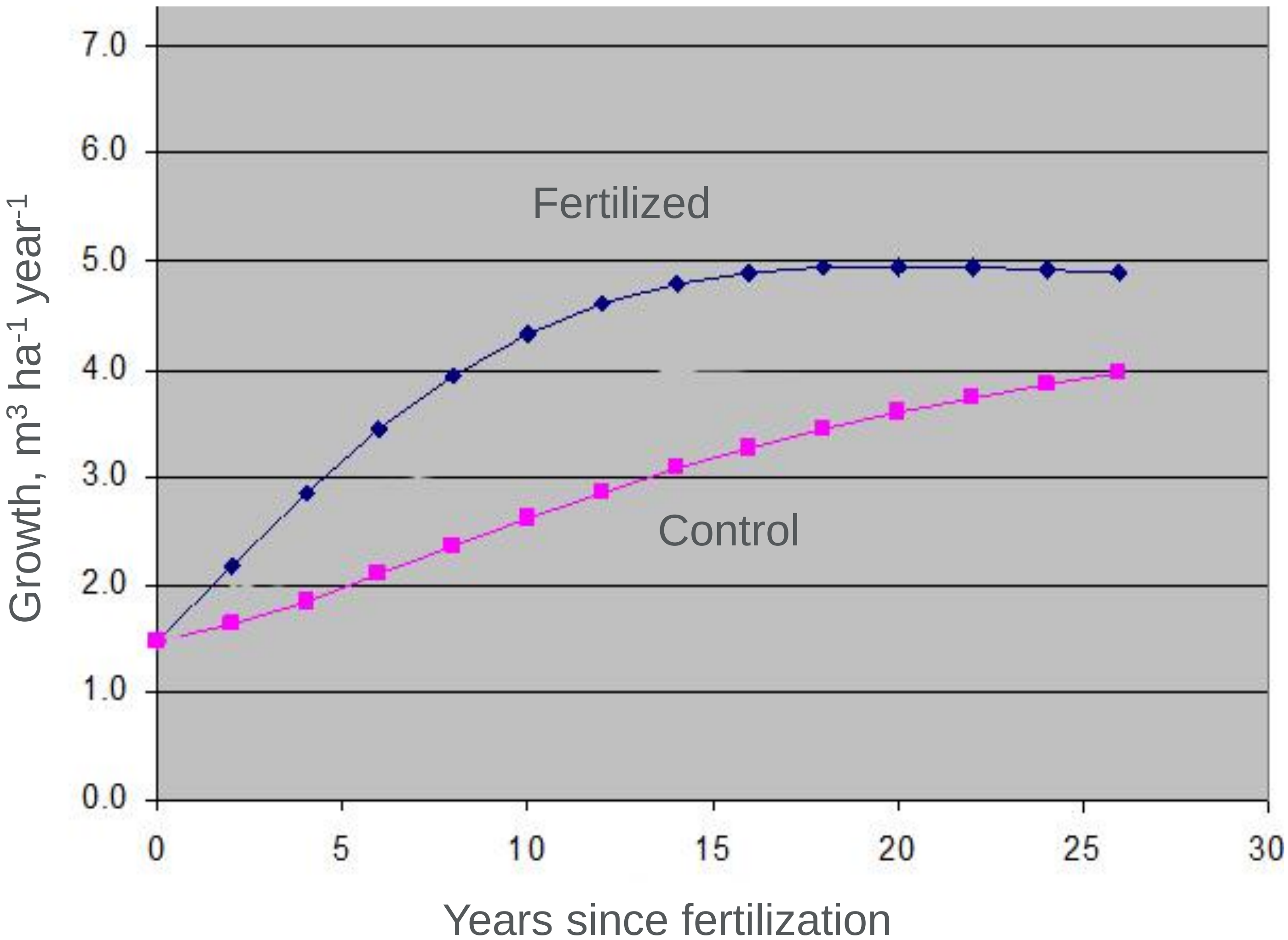
Ash fertilization has the best economic benefit

(Moilanen *et al.* 2015; case study)



Moilanen *et al.* 2015

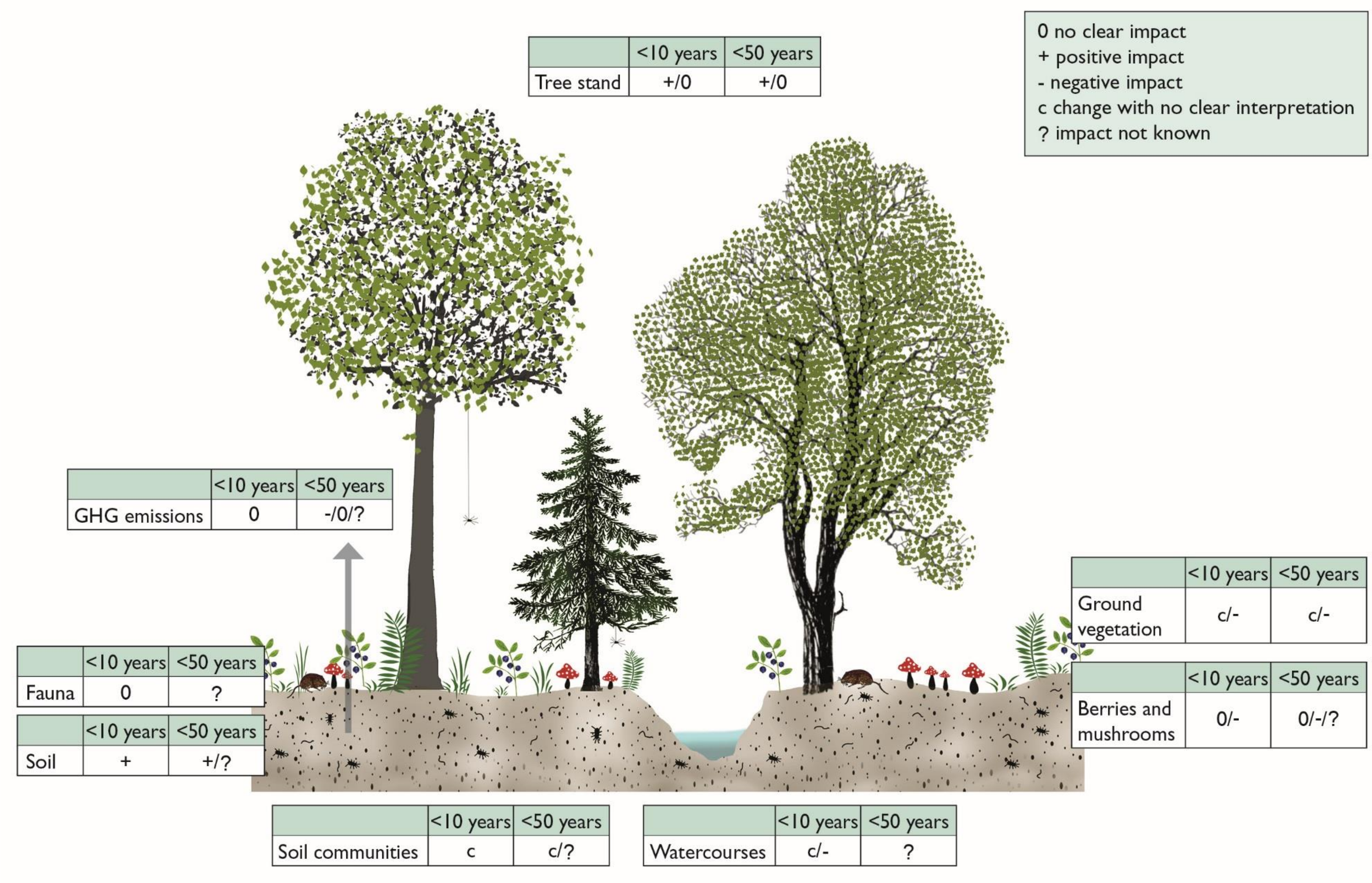
Modeled growth response in pine-dominated stands



Repola, Hökkä & Moilanen (2010)

In suitable sites a well profitable investment

Ash fertilization has little (if none) negative environmental effects (Huotari et al. 2015).

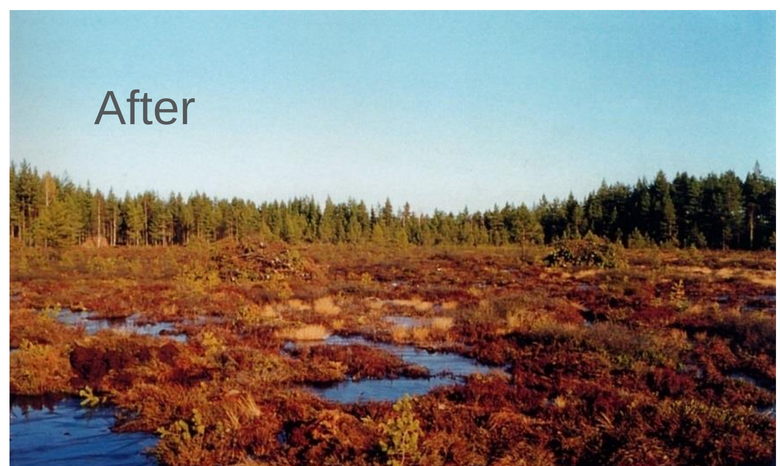


Benefits of peatland restoration on rich (productive) sites

- Functional mire ecosystem is restored slowly but DOC load may increase significantly after the first post-restoration years
  - TOC load increase during the first post-restoration year 40-1100 kg/ha/a (Koskinen *et al.* 2011)
  - The highest measured DOC load from a forested fertile site was 1100 kg/ha/a during the first year (Koskinen *et al.* unpubl.)
- Methane emissions increase
- Peat accumulation after the functional mire ecosystem has been restored
- C accumulation in trees decrease
- Climate benefits are reached with delay – no fast gains!

Benefits of peatland restoration on poor sites

- C-balance of drained peat soil varies from small source (the poorest sites) to large sink (dwarf shrub types after drainage)
- Functional mire ecosystem could recover fast, there might be some DOC-leaching but less than from rich sites
- Methane emissions increase but on poor sites they are generally
- Restoration of the poorest sites leads to an increase in C accumulation in peat
- C accumulation in the tree stand decreases but has no significance
- Climate benefit with little negative effects!



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Thank you