How forest carbon sequestration is affected by management and climate change?

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Outline

- Introduction and national scale carbon inventories
- Forest C assessment at stand scale
  - Methods
  - Responses to management and climate change
- Conclusions

Introduction

- Mitigation for climate change by forest carbon sequestration is one of the ecosystem services that will be accounted in the future forest planning
- Effects of management on forest carbon are evaluated with various stand simulators that rely on empirical data, but their applicability is limited to conditions from where we have observations
- Current challenge is to understand how ecosystem services (e.g. carbon sequestration, timber production, ecosystem functions maintained by diversity of species) can be managed in the changing environment i.e., in the condition from which we do not have observations

Forest carbon inventories at national scale

- Provide information on role of forests in mitigation of climate change
- Compiled on the basis of the forest inventory data[a] and modelling of biomass[1], litter production[2] and dynamics of soil organic matter[3].

[a]forest inventory data (NFI) on

- growing stock, area (forest land, no peat), growth indices, harvests, natural mortality

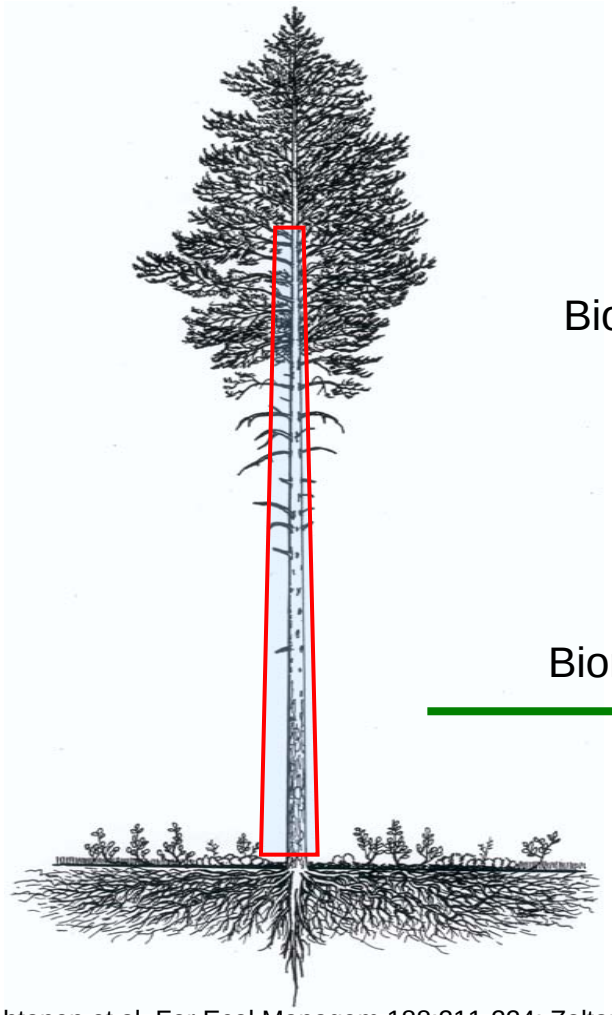
[1]*Lehtonen et al. 2004. For Ecol Managem 188: 211-224;* Muukkonen et al. 2006 Silva Fenn. 40: 231-245; Muukkonen & Mäkipää Boreal Env. Res. 11: 355-369

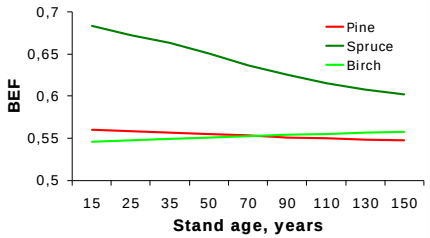
[2]*Lehtonen et al. 2004. Ecol.Modelling 180: 305-315; Muukkonen & Lehtonen 2004. CJFR 34: 2517-2527; Muukkonen 2005.Trees – Struct. Funct. 19: 273-279; and references in Liski et al. 2006. Ann For Sci 63: 687-697.*

[3] *Liski et al. 2005. Ecol. Modelling 189: 168-182; Palosuo et al. 2005. Ecol. Modelling 189: 183-198; www.syke.fi/yasso*

Biomass carbon estimation

Stem Volume, m^3



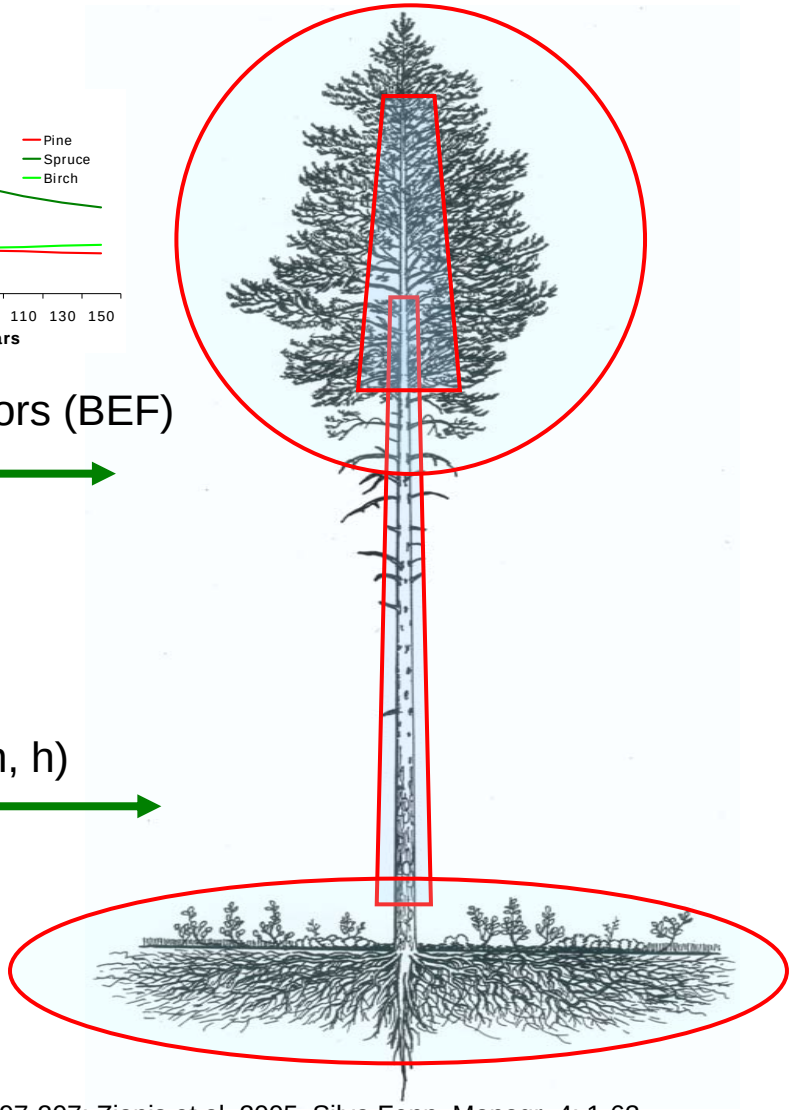


Biomass expansion factors (BEF)

OR

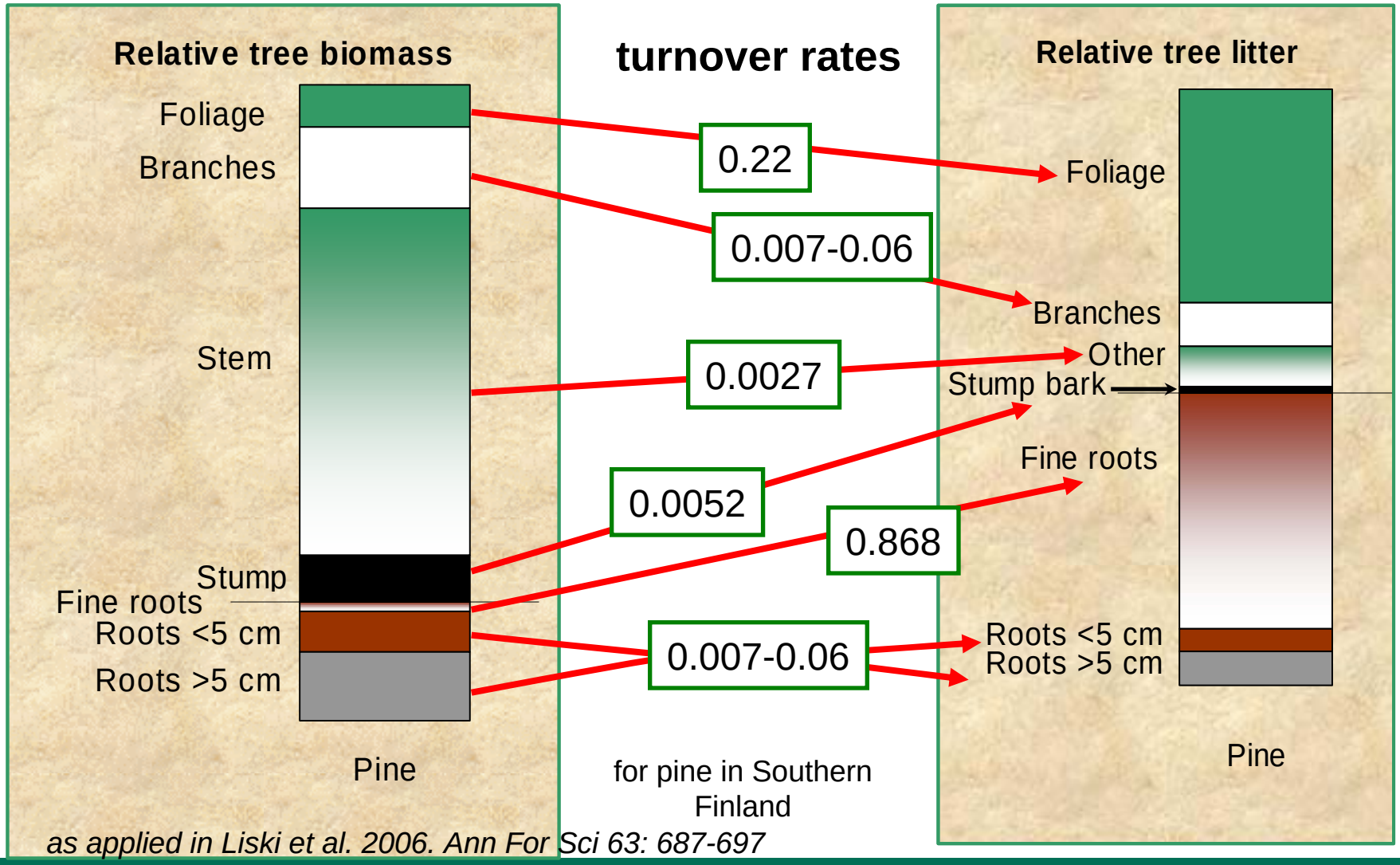
Biomass equations, f(dbh, h)

Tree Biomass by compartments, Mg



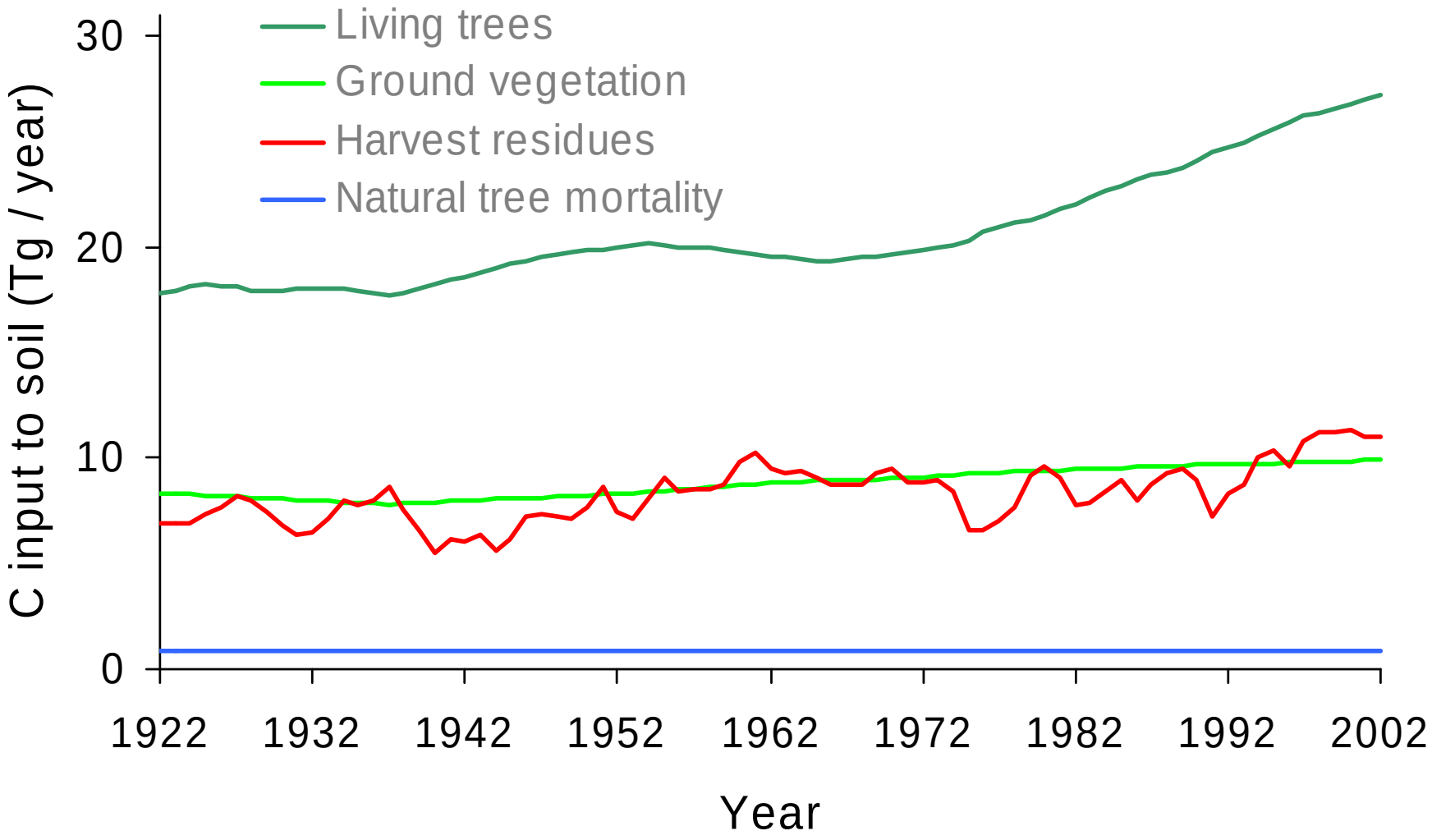
Lehtonen et al. For Ecol Managem 188:211-224; Zoltan et al. European J For Res, 126: 197-207; Zianis et al. 2005. Silva Fenn. Monogr. 4: 1-63

Biomass turnover, i.e. modelled litter input to the soil



as applied in Liski et al. 2006. Ann For Sci 63: 687-697

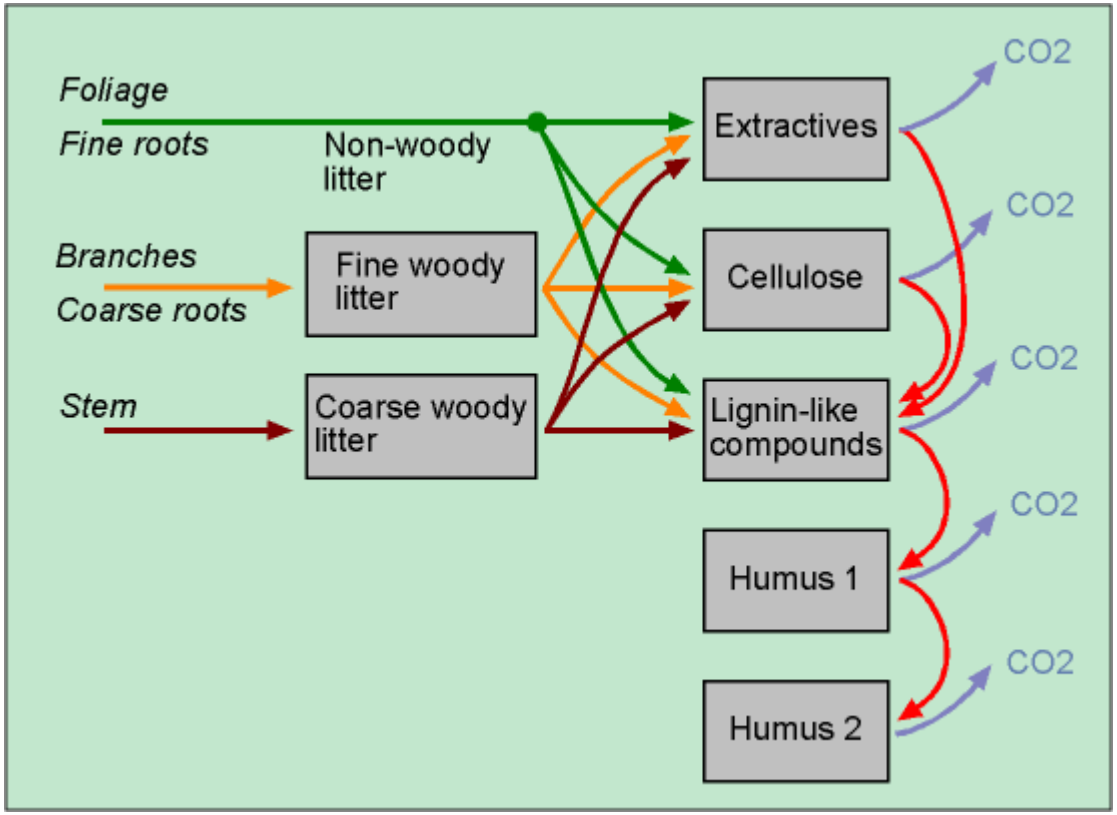
Carbon input to the soil divided by source



Liski et al. 2006 Ann. For. Sci. 63(7): 687-697

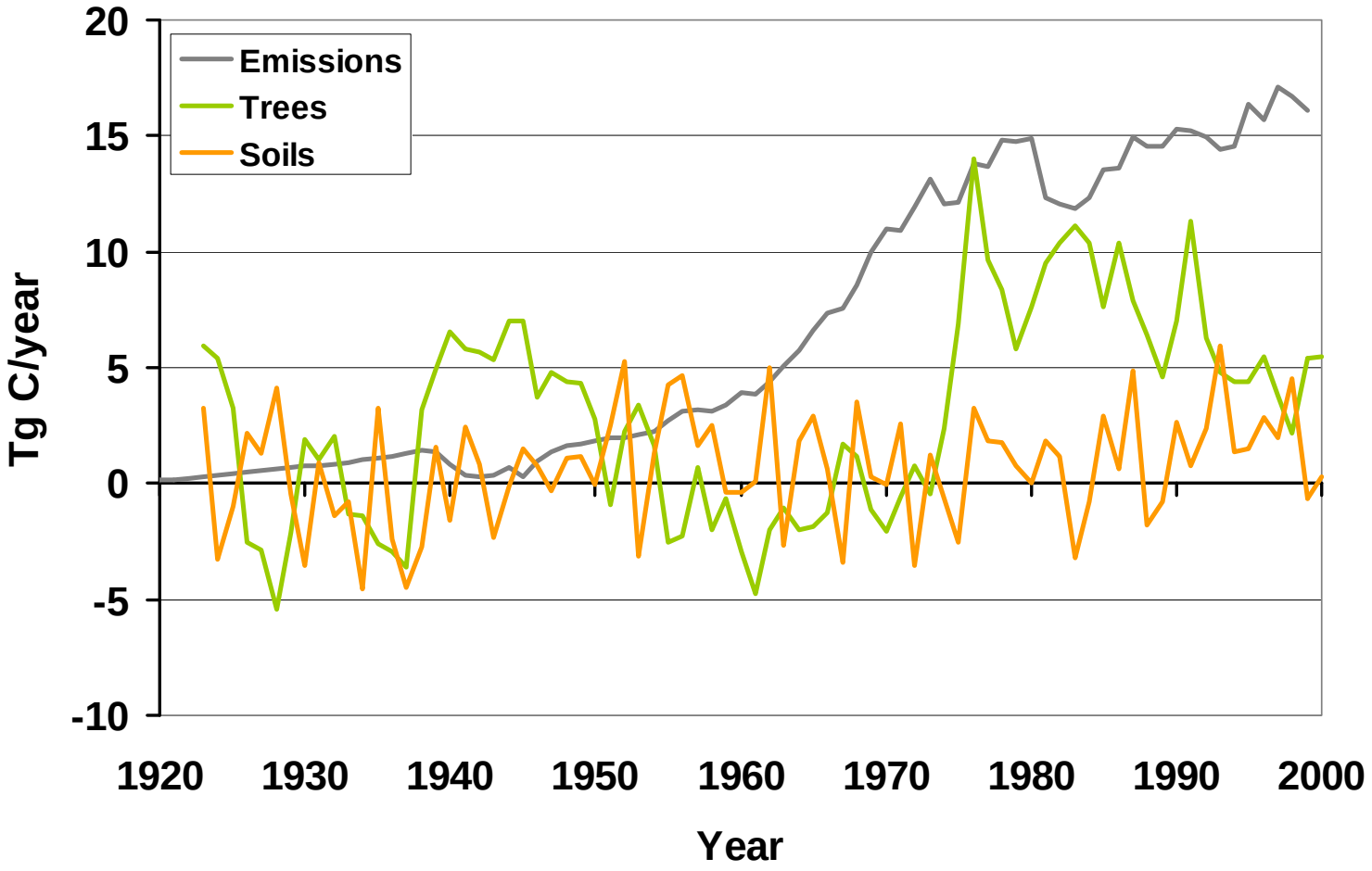
Soil carbon method

- dynamic soil carbon model YASSO
- input information
  - litter production
  - litter quality
  - climate (temperature and soil moisture)



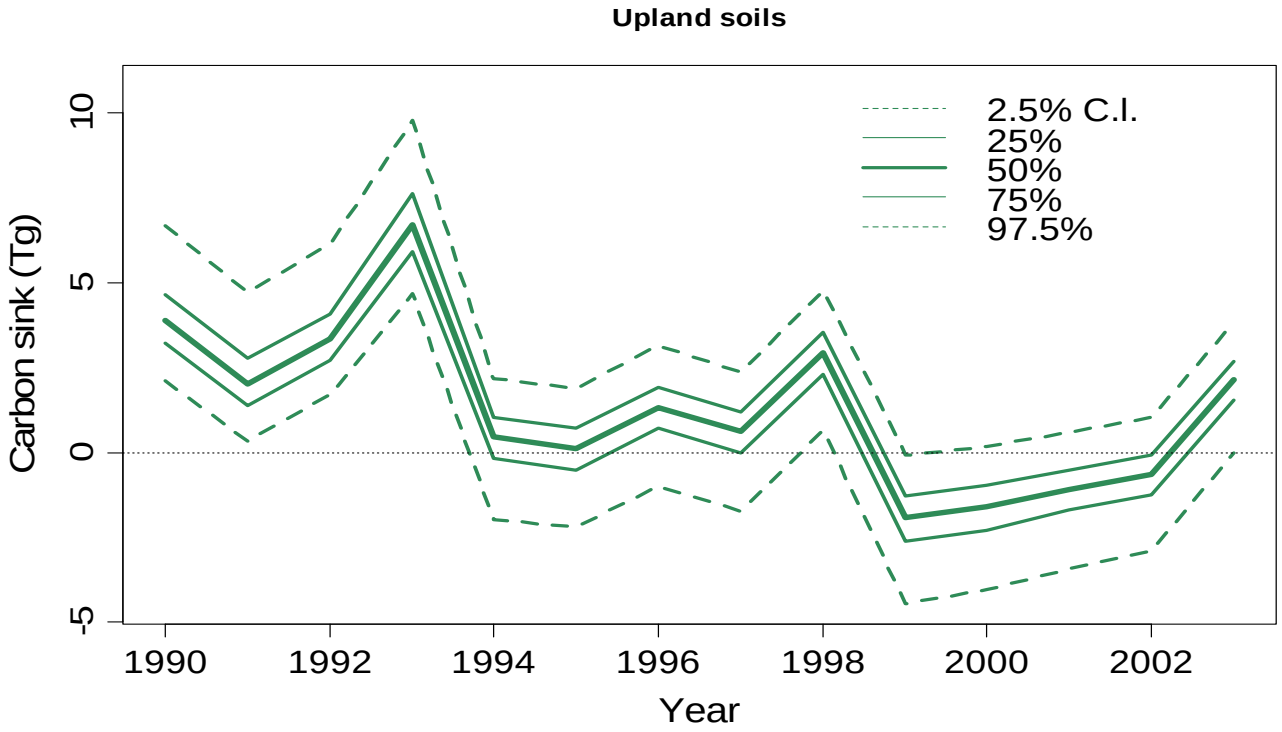
Liski et al. 2005. Ecological Modelling 189: 168-182; www.syke.fi/yasso

Forest carbon sequestration and CO_2 emissions in Finland



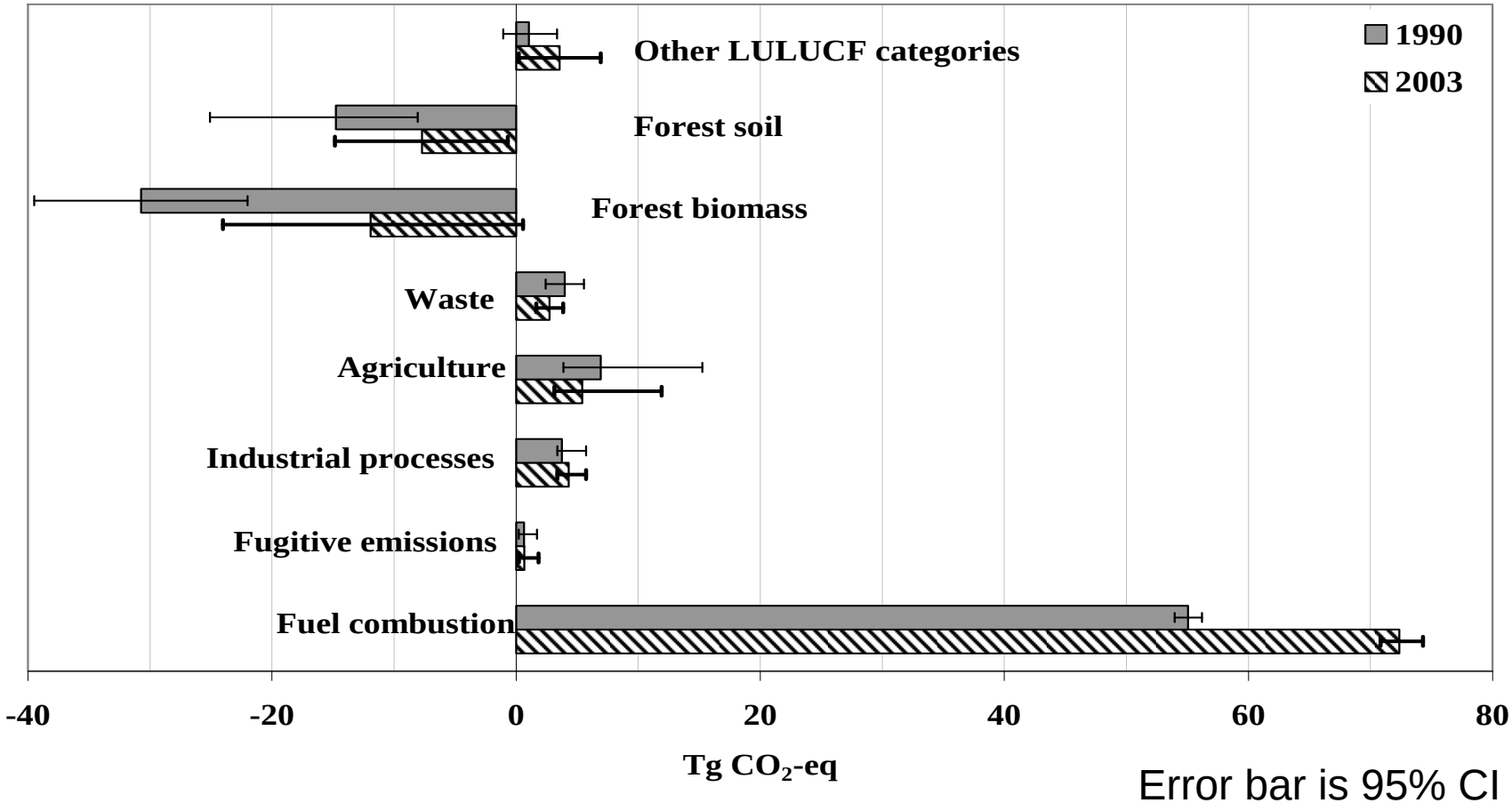
Liski et al. 2006. Ann. For Sci. 63: 687-697; Monni et al. 2003. Environmental Management 31: 401-411

Uncertainty of soil carbon sink



Monni et al. 2006. Climatic Change 81: 391-413.

CO_2 emissions and removals in Finland



Error bar is 95% CI

Source: Monni et al. 2007. Climatic Change, 81:391–413

Sustainability of the carbon sinks

- Forests are known to be important carbon sinks, but how sensitive the carbon sequestration capasity is to climate change and to management

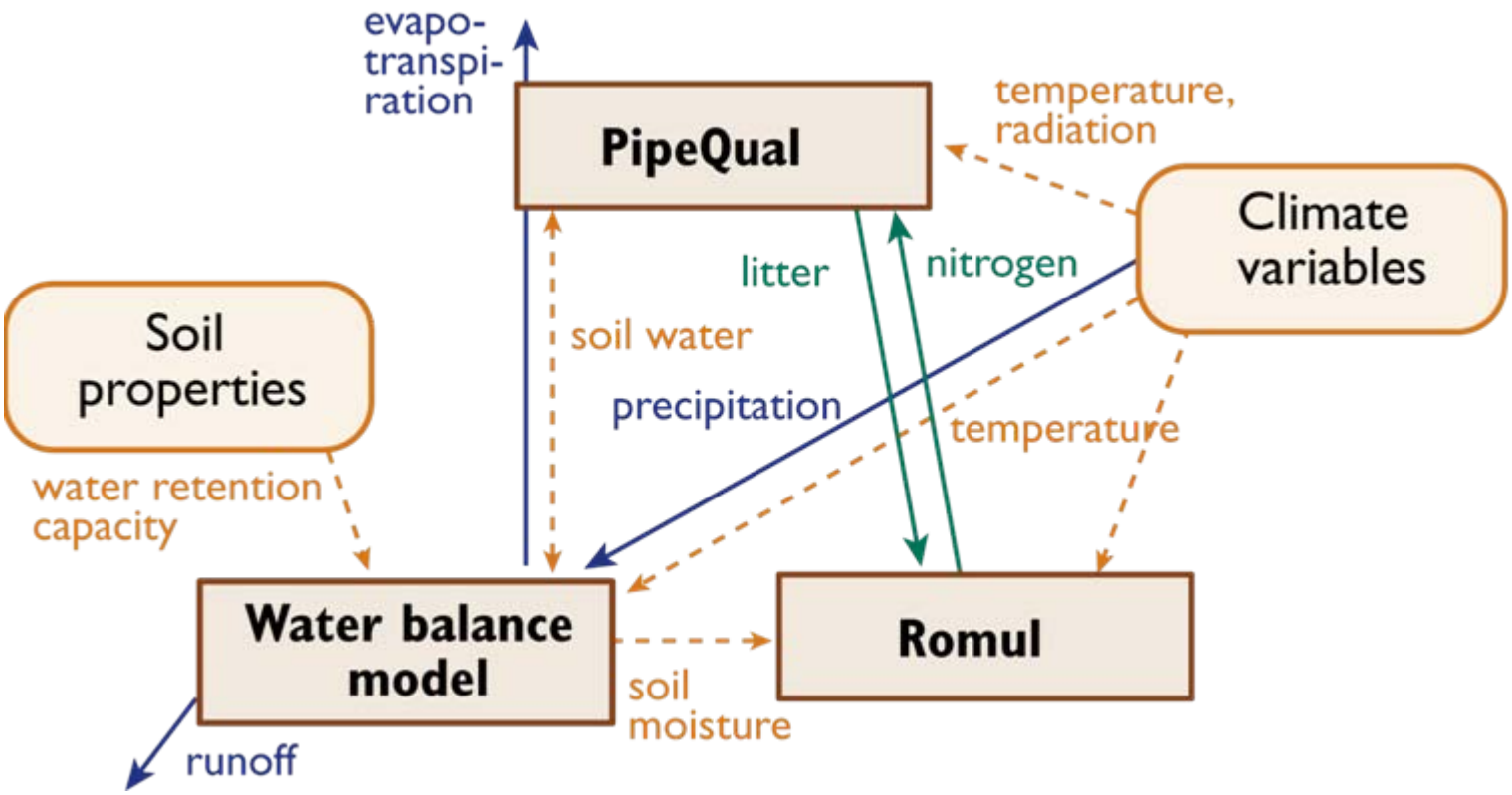
Objective

- to investigate the responses of forest carbon sequestration to climate change under different management plans.
- The management plans were
  1. thinnings from below and final harvest according to current recommendations,
  2. management plan based on economic optimization[a] (delayed thinnings from above with higher removals and early harvest)
  3. natural development without management.

- We calculated the outcome of these scenarios under
  1. current climate
  2. simulated A2 climate change scenarios (temperature +3^{o}C, precipitation +10%).

[a] Tahvonen & Niinimäki 2009

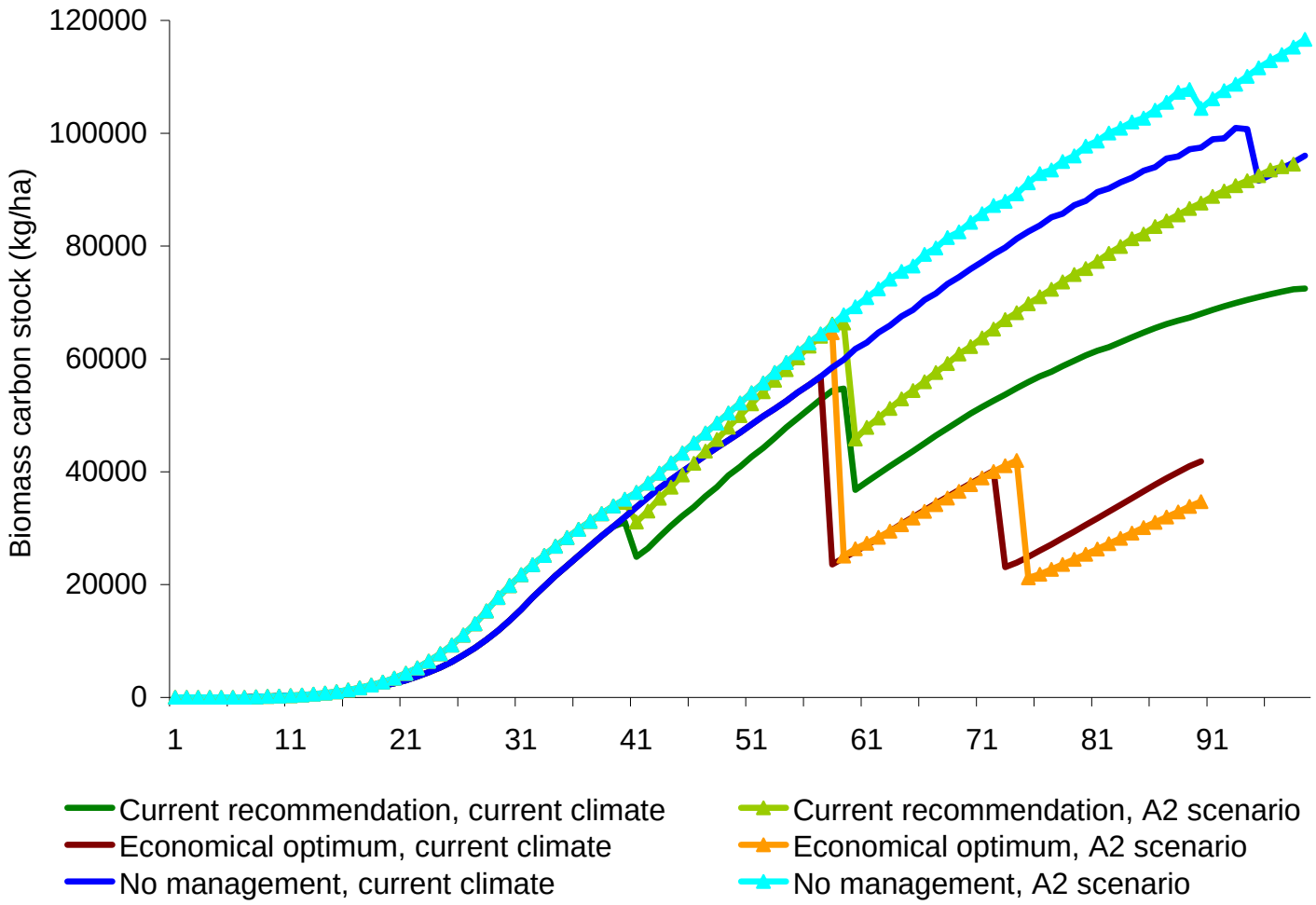
Forest carbon assessment at stand scale



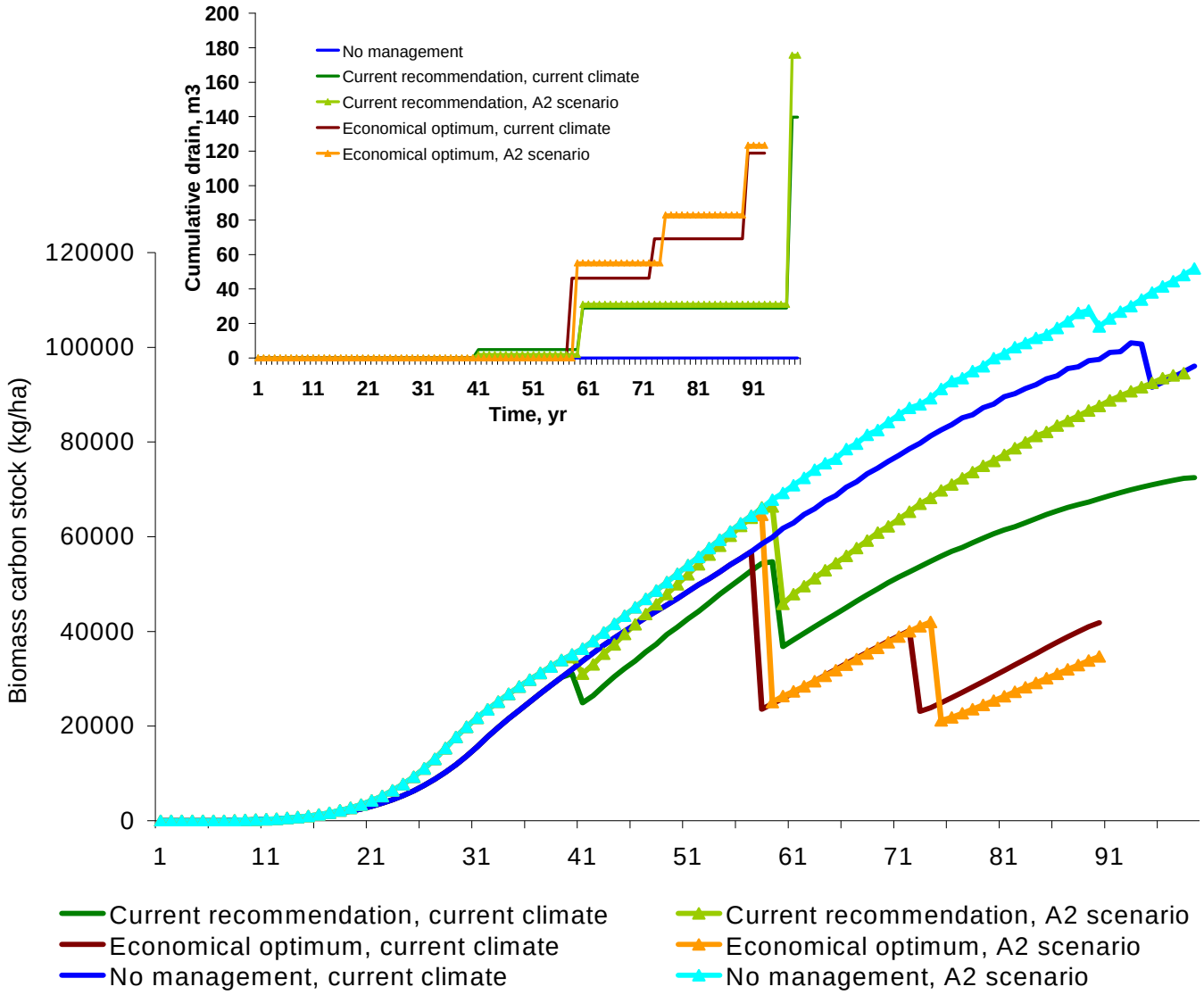
Process-based forest model[a] with modelling of decomposition[b] and soil water

[a]Mäkelä 1997 For Sci, Mäkelä 2002 Tree Phys, Mäkelä and Mäkinen 2003 For Ecol Manage, [b]Komarov et al. 2003

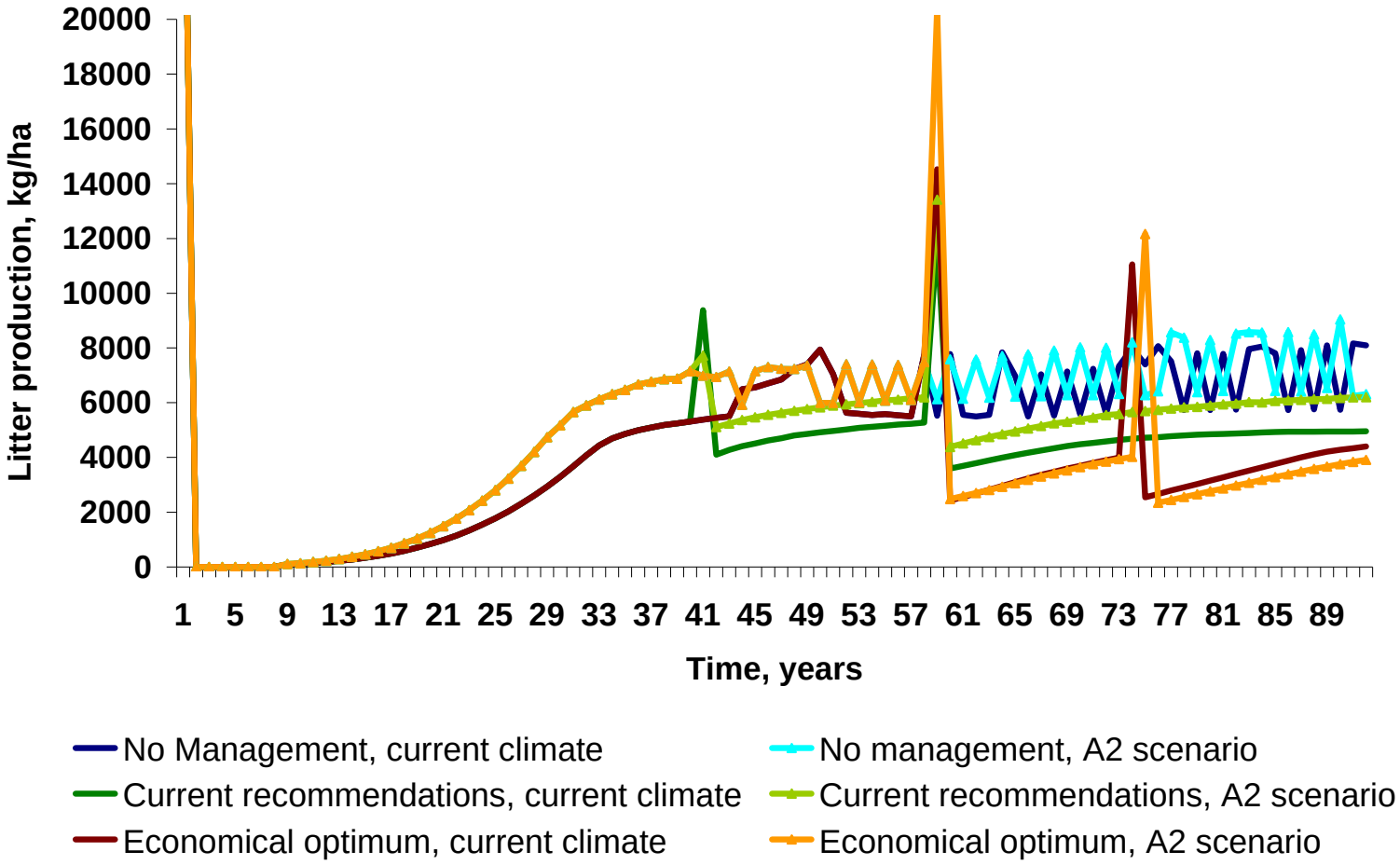
Biomass carbon stock with different scenarios



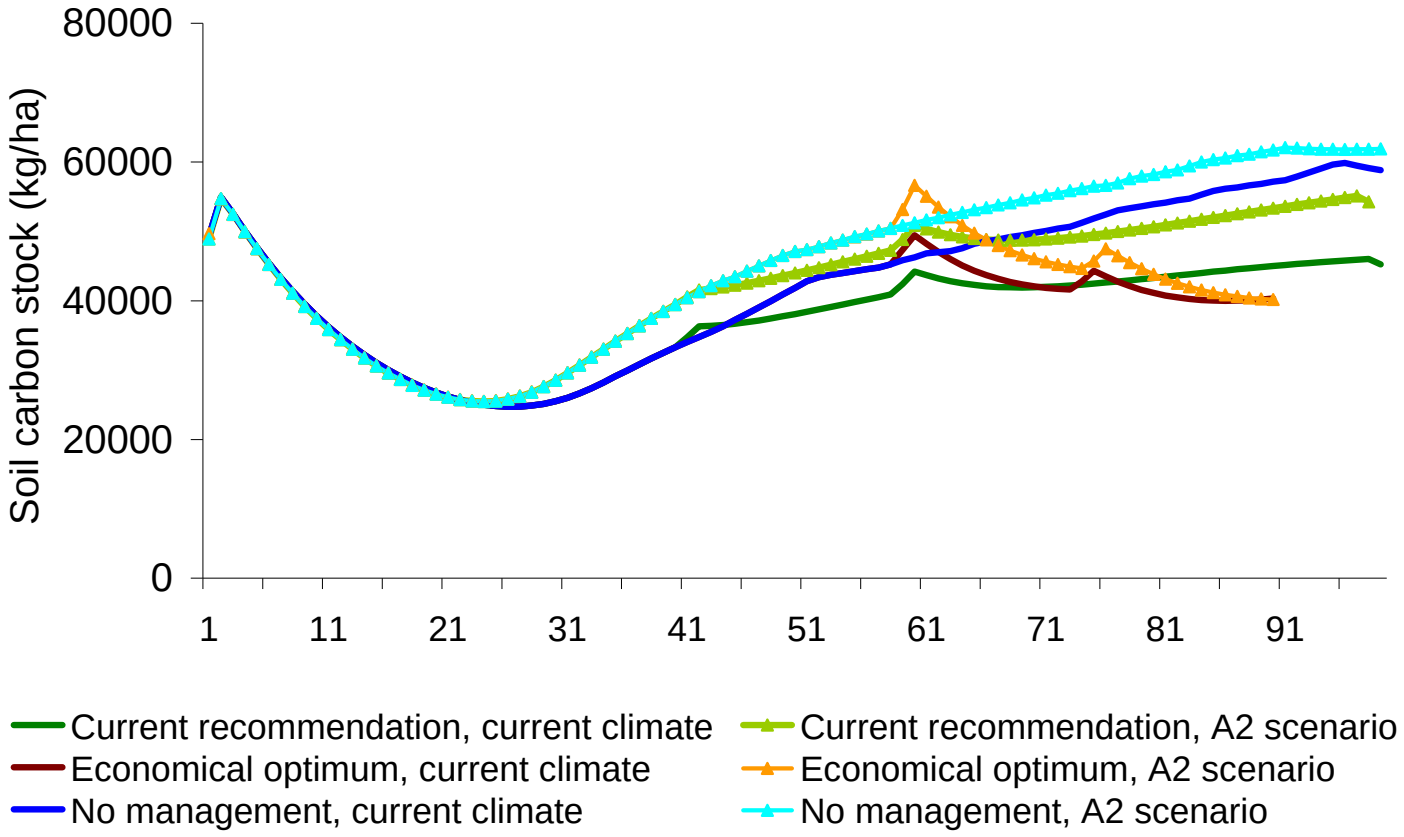
and Harvested timber in different scenarios



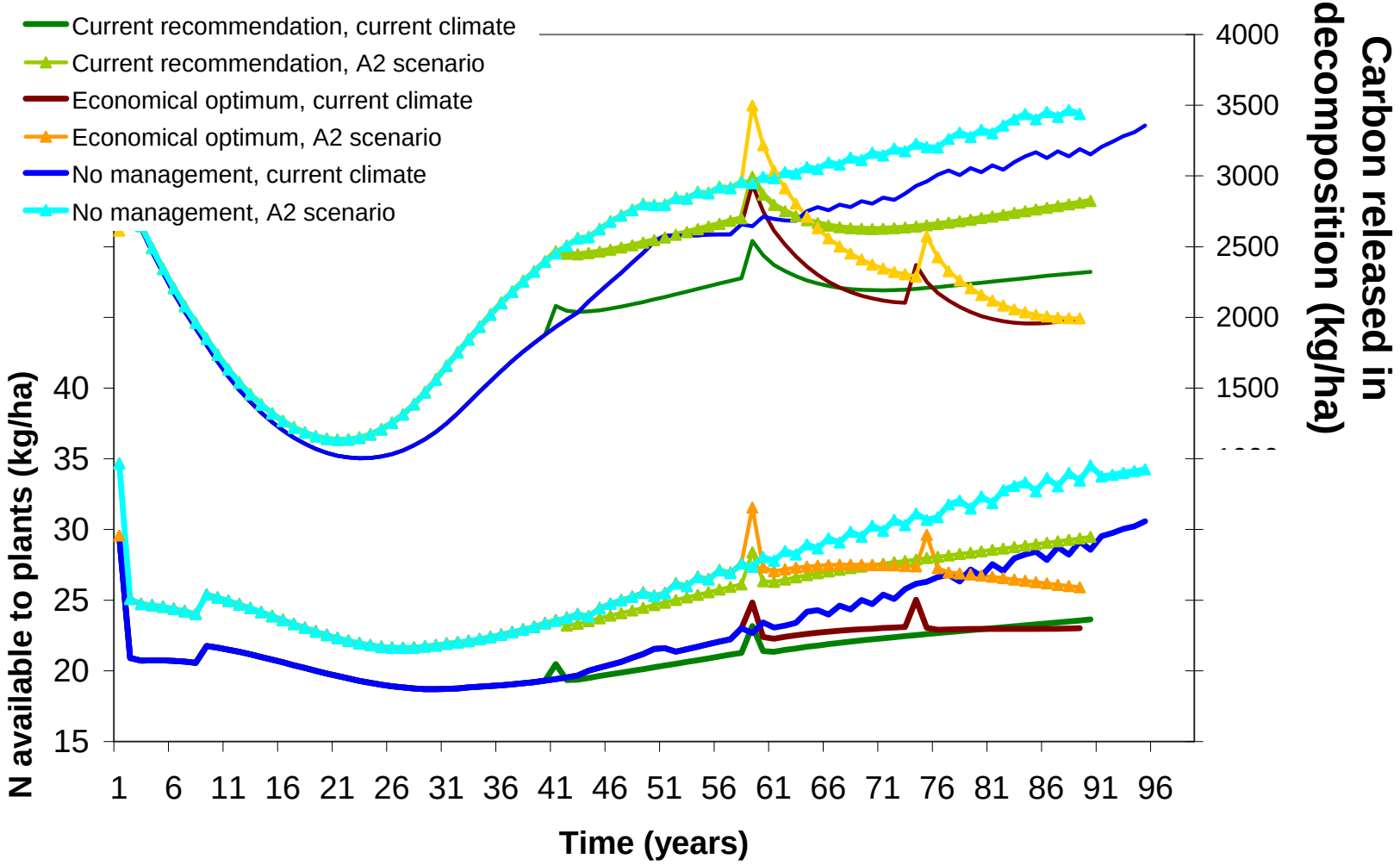
Litter production in different scenarios



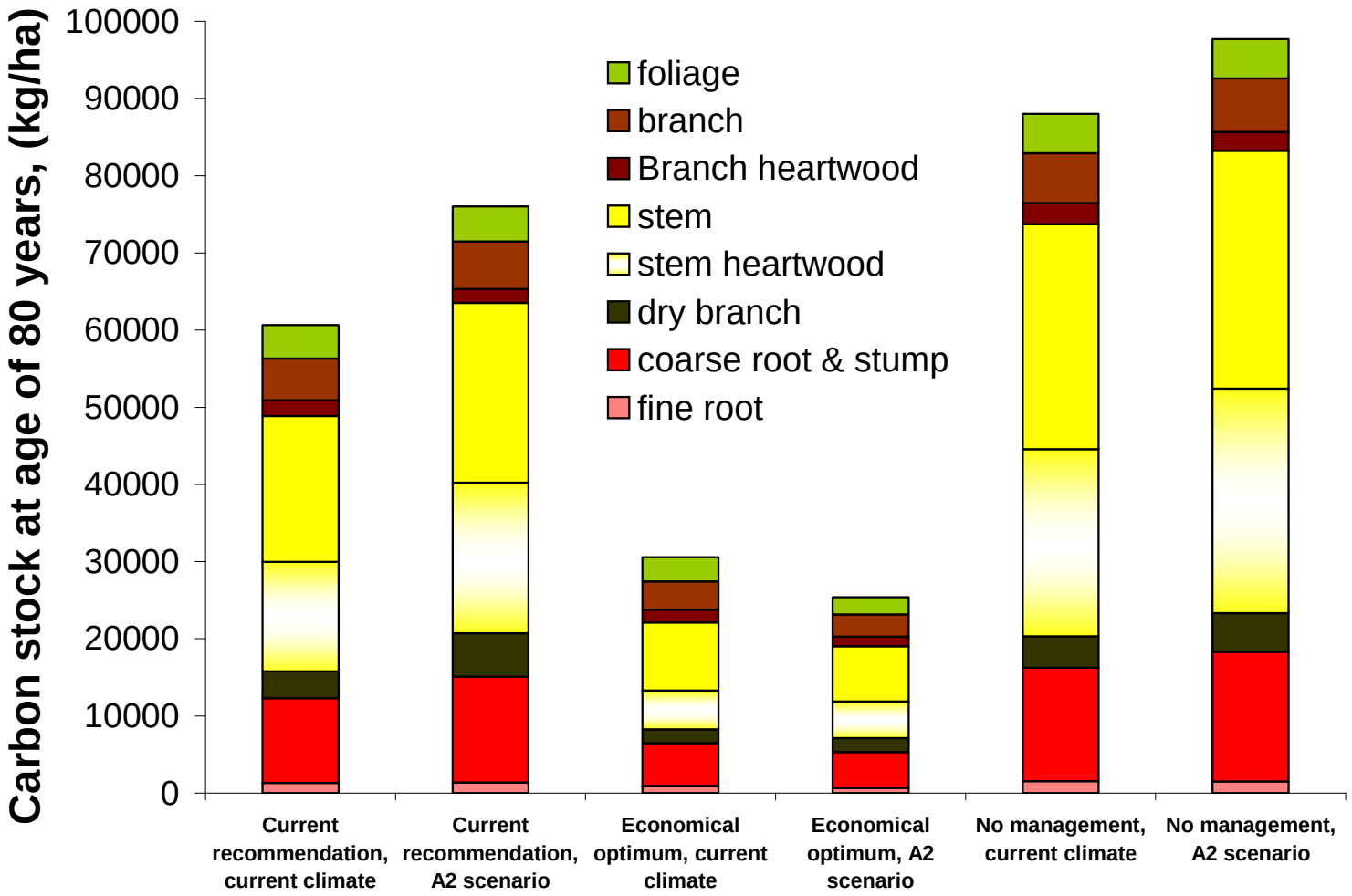
Soil carbon stock with different scenarios



Release of CO2 and N available to plants



Biomass carbon stock at age of 80 years



Conclusions

- Climate change will greatly affect forest ecosystems and their C sequestration potential, but in managed forests C accumulation is strongly driven by management decisions.
- In the changing climate rate of decomposition is increased, but increase in the litter production can be even larger. Thus, boreal forest soils may be carbon sinks in the changing climate.

Future challenges – to be done

- The simulations with the process-based growth model that is combined with a soil model can guide management by assessing forest carbon and nutrient balance and by determining a sustainable level of biomass harvest.

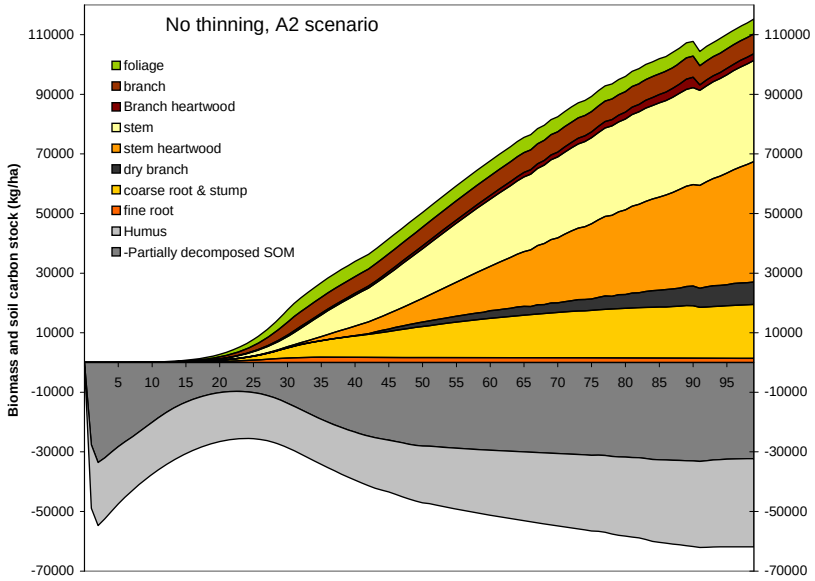
- To intergrate C sequestration into optimization routines

- To include biodiversity measures into applied models

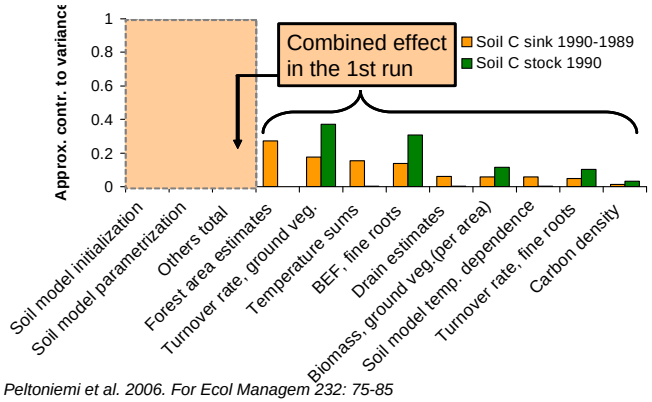
Thank you!

Further information

www.metla.fi/hanke/3422

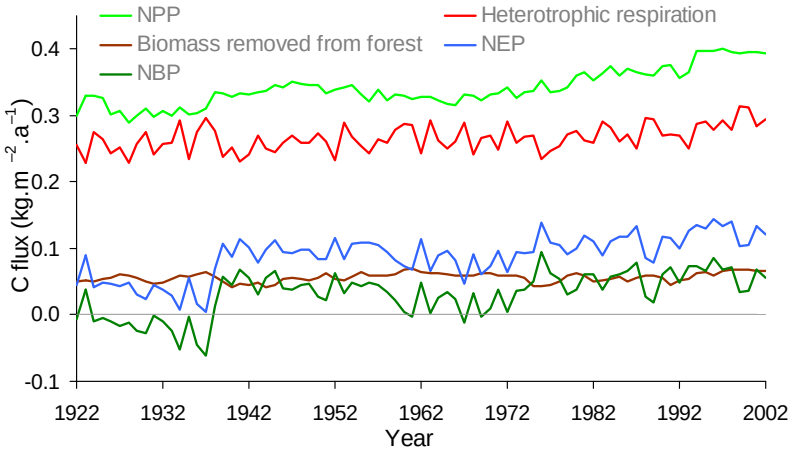


The key factors of uncertainty: **soil sink and stock**



Peltoniemi et al. 2006. For Ecol Managem 232: 75-85

Carbon fluxes in the upland forests of Finland



Liski et al. 2006 Ann. For. Sci. 63(7): 687-697