Soil carbon modelling applied for nation-wide forest carbon inventory

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Outline

- Background
- Method to calculate C budget of forest vegetation and soil
- Carbon budget 1922-2004 in Finland’s forests
- Eligibility of the method for national GHG reporting (IPCC guidance)
- Summary and discussion

Background

- GHG reporting under the Climate Convention and Kyoto Protocol (KP)
- Forests included in the KP (Art. 3.3 and 3.4)
- Sinks can compensate emission reductions
- **GHG inventories of LULUCF sector need to be improved**
- **IPCC guidance** for GHG reporting
  - 1996 GL, 2003 GPG, and 2006 GL

Background

Current methods

- **Trees:** national C budget of trees can be derived from NFI data and drain (harvests) statistics with biomass equations or BEFs
- **Other vegetation**: in general excluded
- **Soil, litter and dead wood**: repeated nation-wide soil surveys are not available (except in Sweden and UK?), modelling can provide first estimates?

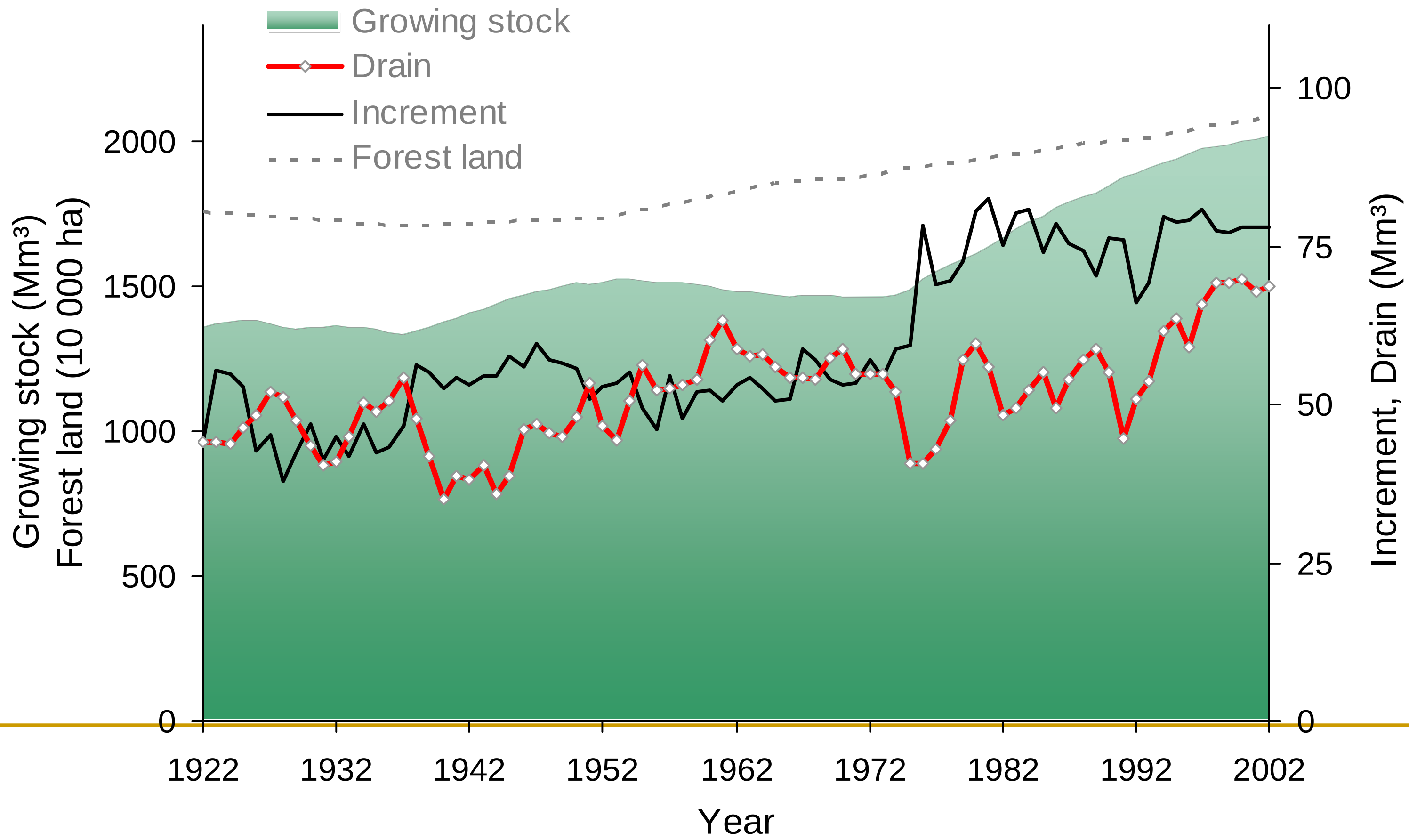
Need for applicable and consistent methods to assess changes in the all carbon pools at national scale

Dynamic soil C model integrated to NFI data on forest resources

We integrated:

- forest inventory data (aggregated) on
  - growing stock, area (forest land, no peat), growth indices, harvests, natural mortality
- biomass models / BEF(t)
- biomass turnover i.e. modelled litter input to soil
- soil decomposition model YASSO

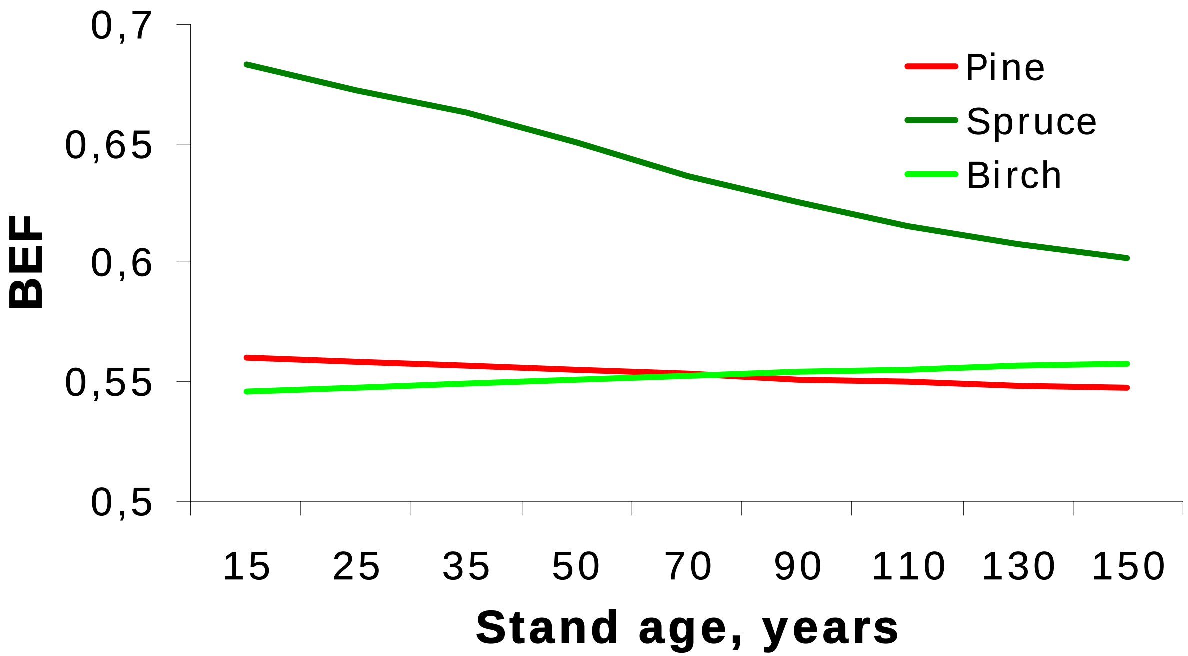
Input data from forest inventory



Methods - Biomass

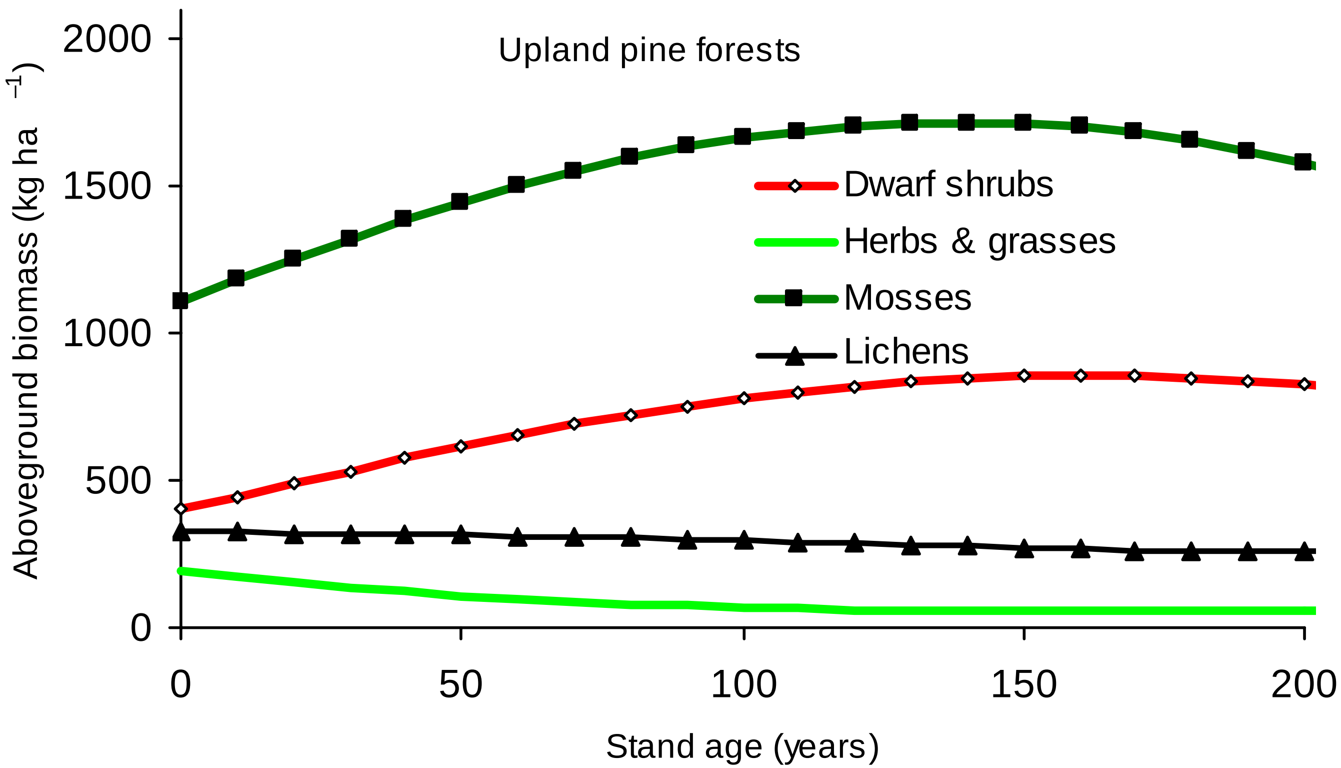
- Biomass of trees
  - tree species specific (Scots pine, Norway spruce, birch) age-dependent BEFs for different biomass compartments
- Biomass of understorey vegetation
  - biomass equations according to stand variables for groups of plant species
- Change in the biomass and carbon stock
  - rate of stock change of consecutive inventories
  - annual variation in growth accounted with the help of growth indices
  - annual variation in harvests accounted

Tree species specific BEFs according to stand age for foliage,branches, etc.



Lehtonen et al. For Ecol Managem 188:211-224

Understorey Biomass



Muukkonen et al. Silva Fennica, accepted
Muukkonen & Mäkipää, submittted ms

Methods - Input to the soil

- Biomass turnover rates ($year^{-1}$) used to estimate the litter production of trees and understorey vegetation
- Litter input of harvest residues based on harvest statistics and BEFs
- Litter input resulting from natural mortality based on NFI estimate and BEFs

Lehtonen et al. 2004; Muukkonen & Lehtonen 2004; Muukkonen 2005; and other sources as reported in Liski et al. 2006

Methods - Input to the soil

Turnover rates of understorey vegetation

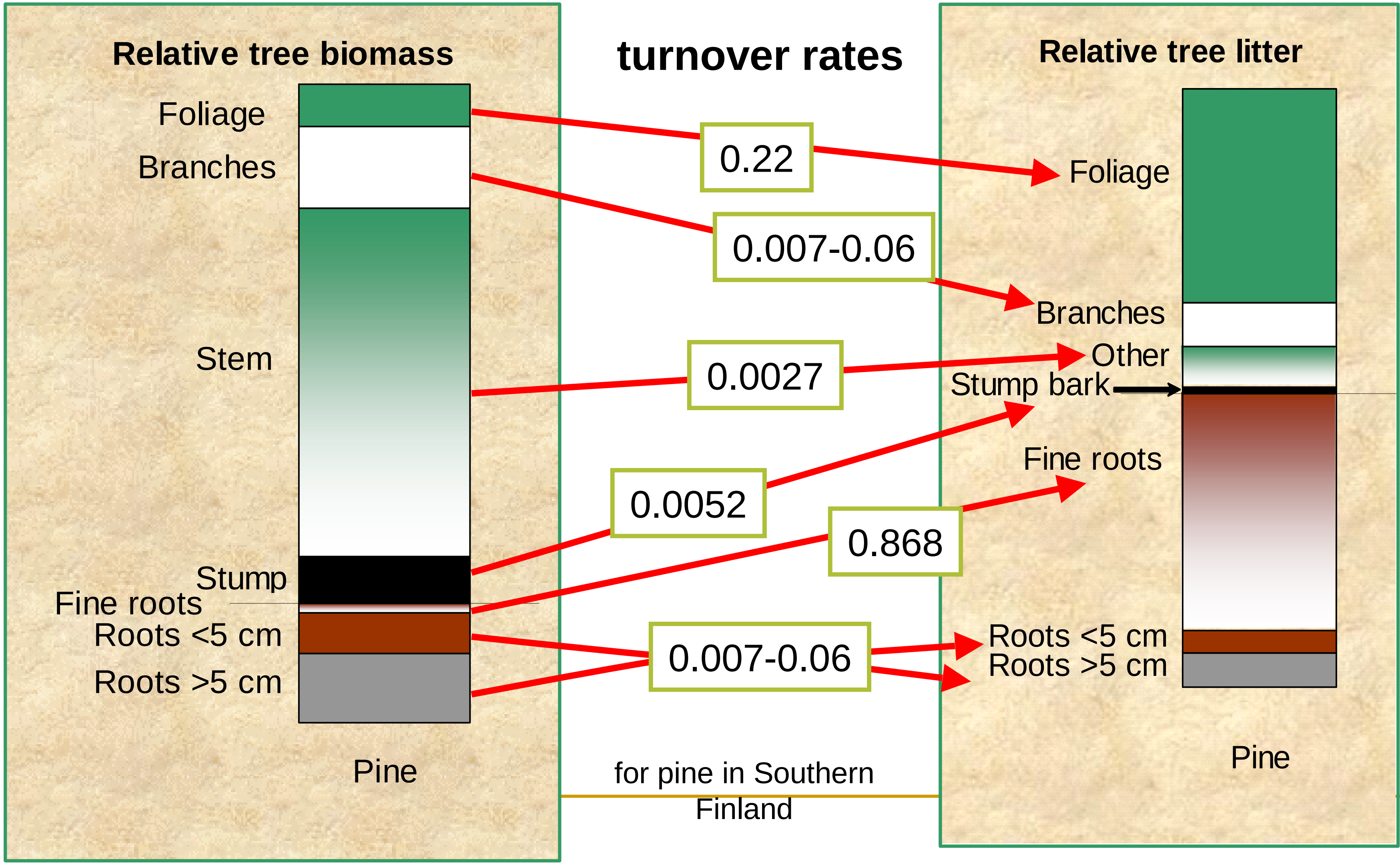
Bryophytes	0.33
Lichens	0.1
Dwarf shrubs, aboveground	0.25
Herbs & grasses, aboveground	1.0
Belowground (dwarf shrubs, herbs & grasses)	0.33

Methods - Input to the soil

Turnover rates of	Trees					
	Spruce forests		Pine forests		Broadleaved forests	
	S[1]	N[2]	S	N	S	N
Foliage	0.10[3]	0.05[3]	0.22[4]	0.10[4]	0.78[5]	
Branches & roots	0.0125[3]		f(t)[6]		0.0135[7]	
Stump bark	0.0[8]		0.0030[9]		0.0001[10]	
Reproductive origins & stem bark	0.0027[8]		0.0052[9]		0.0029[10]	
Fine roots	0.811[11]		0.868[12]		1.0[13]	

Lehtonen et al. 2004; Muukkonen & Lehtonen 2004; Muukkonen 2005; and other sources as reported in Liski et al. 2006

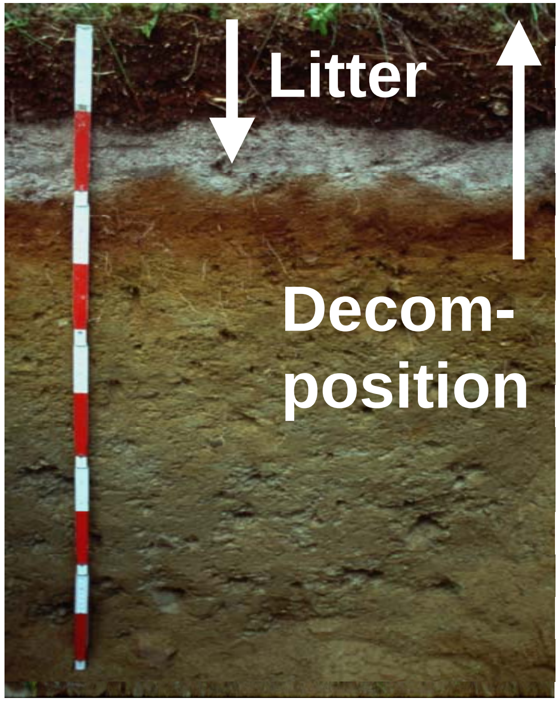
Litter production of standing trees



for pine in Southern Finland

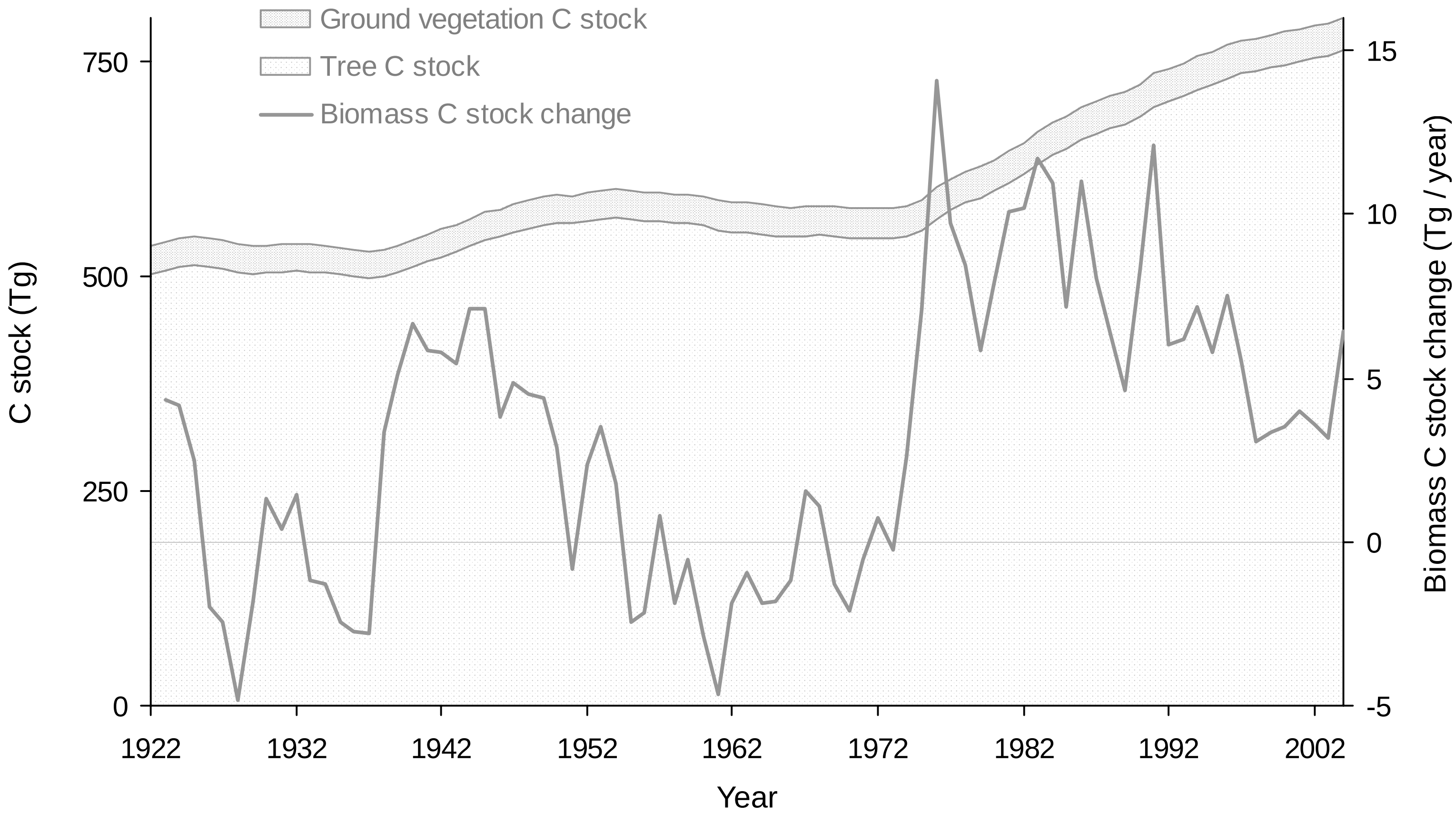
Soil carbon method

- Decomposition, soil carbon (mineral soils)
  - dynamic soil carbon model YASSO (Liski et al 2005)
  - input information
    - litter production
    - climate (temperature)



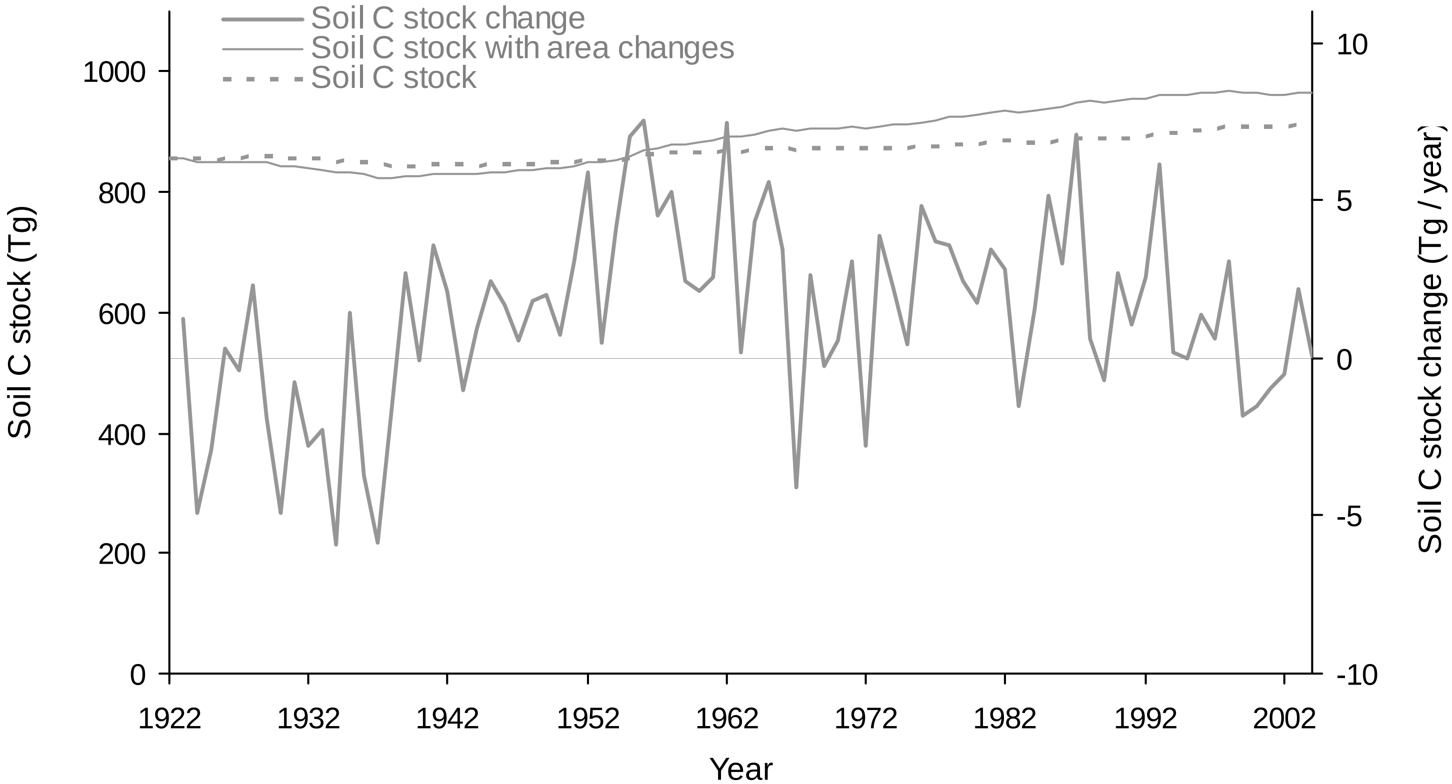
Liski J, Palosuo, T., Peltoniemi, M. and Sievänen, R. 2005. Ecological Modelling 189: 168-182

Biomass C stock & stock changes



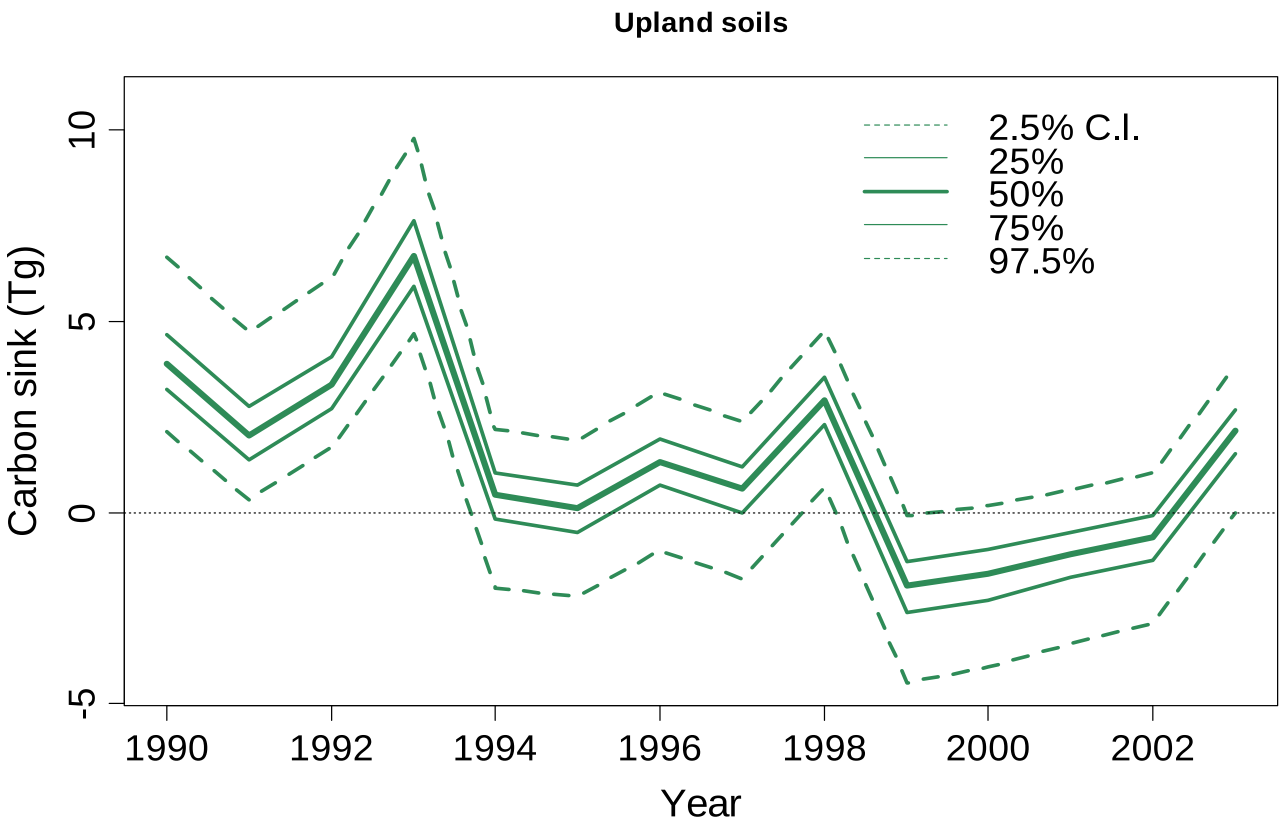
Liski et al. 2006. C accumulation in Finland's forests..Ann. For Sci. accepted.

Soil C stock and stock changes



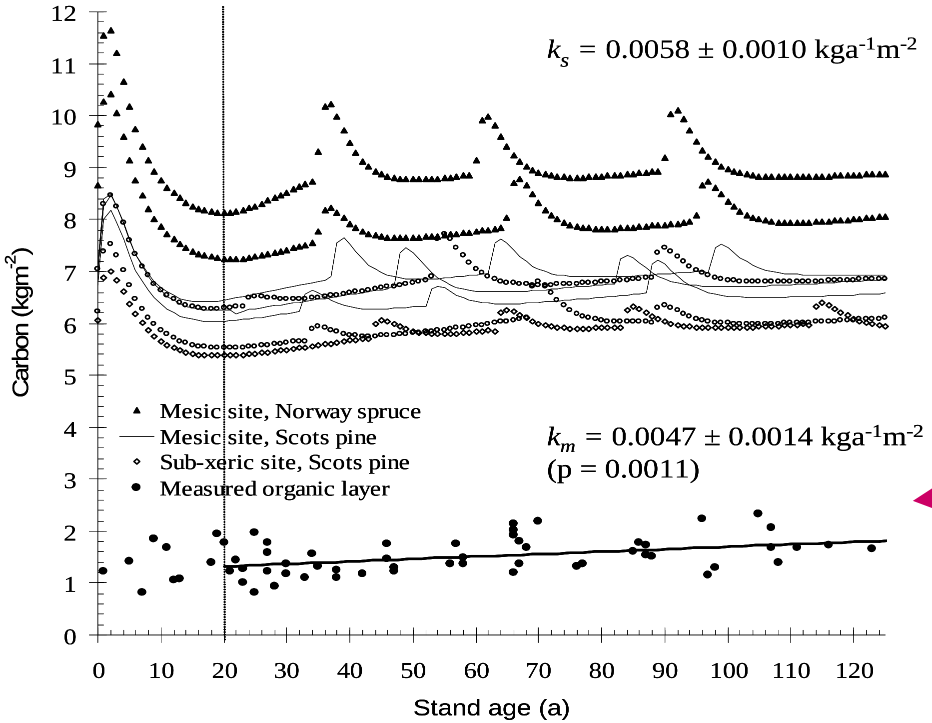
Liski et al. 2006. C accumulation in Finland's forests..Ann. For Sci. accepted.

Uncertainty of soil carbon sink



Monni et al. 2006. Climatic Change, accepted.

Validity of this integrated method



Simulated rate of change in soil C agreed with

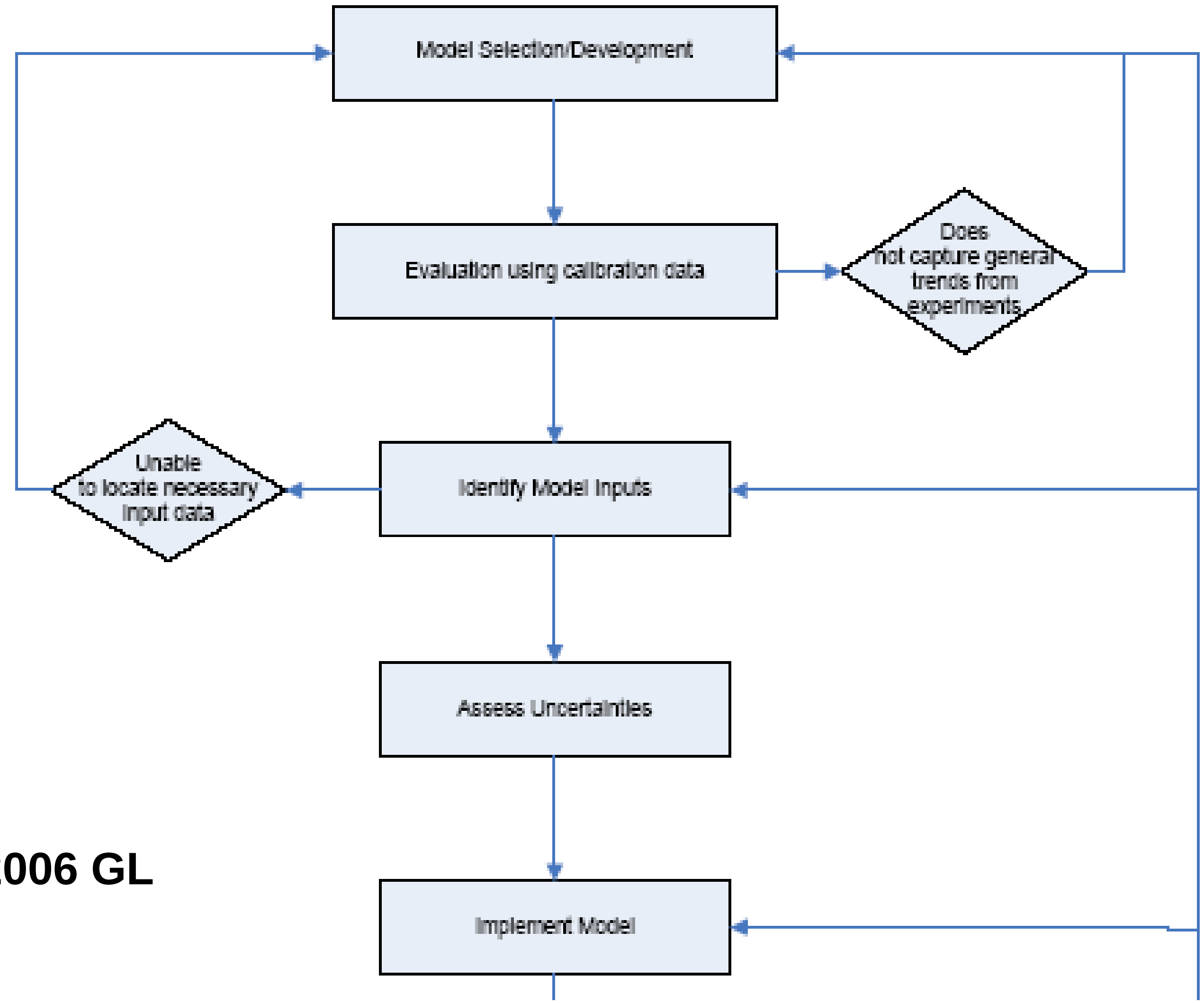
measured change in humus layer of a chronosequency

Peltoniemi et al. 2004. GCB 10:2078-2091.

Summary

- Dynamic soil C model Yasso with litter input derived from NFI forest resource data -> Changes in the soil C stock can be estimated
- Soil model is applicable and NFI input data is available for the majority of the EU-countries
- Validity of the models tested independently as well as validity of the method as a whole (see references)
- This methodology is consistent with the IPCC 2006 draft - Model-Based Tier 3 Inventories (AFOLU 2.53)

Steps to develop a Tier 3 model-based inventory estimation system



IPCC 2006 GL

Steps to develop a Tier 3 model-based inventory estimation system

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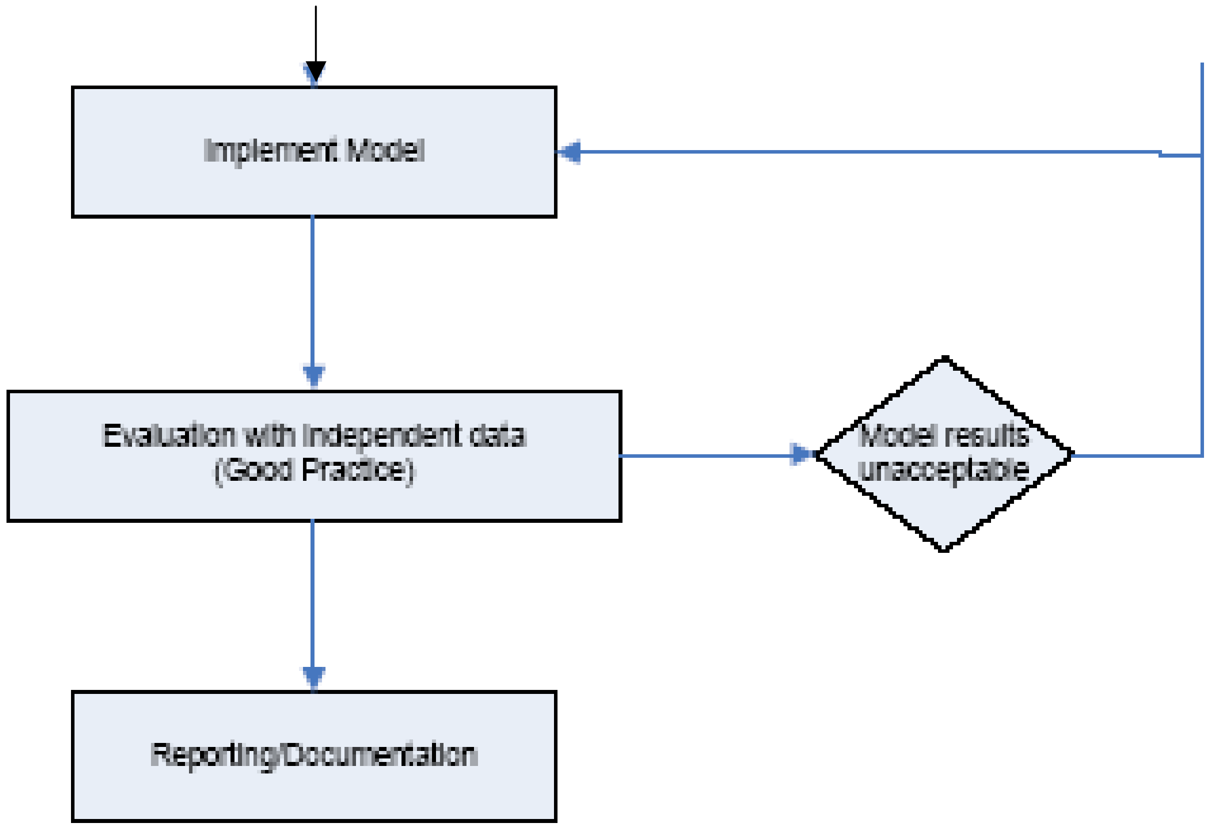

IPCC 2006 GL

Discussion

- Forests may sequestrate 1/3 of annual CO_2 emissions of forested country (such as Finland) and that C sink can be partly credited
- Changes in the soil C can be reported as requested by the Climate Convention, but uncertainties are large
- Only few countries will use C sinks under the Art 3.4. of KP

Election of activities under Article 3.4

	Forest management	Cropland management	Grazing land management	Revegetation
Austria	- not yet decided -			
Belgium	NO	NO	NO	NO
Denmark	YES	YES	YES	NO
Finland	NO	NO	NO	NO
France	YES	NO	NO	NO
Greece	- not yet decided -			
Ireland	YES	- not yet decided -		
Netherlands	NO	NO	NO	NO
Portugal	YES	YES	YES	NO
Sweden	YES	NO	NO	NO
UK	YES	NO	NO	NO

Discussion

- The current interest TO USE OR NOT TO USE forest C sinks influences on negotiations of the subsequent commitment periods
- Future challenges
  - Reliable forest GHG inventories
  - All habitat types and all GHGs to be included
  - Effects of LUC (especially transition period)
  - Direct human influence (management practices vs.climate change and other indirect factors)

References

- Lehtonen, A., Mäkipää, R., Heikkinen, J., Sievänen, R. & Liski, J. 2004. Biomass expansion factors (BEF) for Scots pine, Norway spruce and birch according to stand age for boreal forests. Forest Ecology and Management 188: 211-224.
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- ~~Peltoniemi, M., Palosuo, T., Monni, S. & Mäkipää, R. The factors affecting the uncertainty of sinks and~~ stocks of carbon in Finnish forest soil and vegetation. Submitted manuscript.

Thank you for your attention

Further information
www.metla.fi/hanke/843002/
Project on Monitoring changes
in the carbon stocks of forest soils

and earlier projects of this research team
www.metla.fi/hanke/3306/
www.efi.fi/projects/integrated
www.efi.fi/projects/uncertainty