Sveriges lantbruksuniversitet
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Time-dependent climate impact of bioenergy from logging residues

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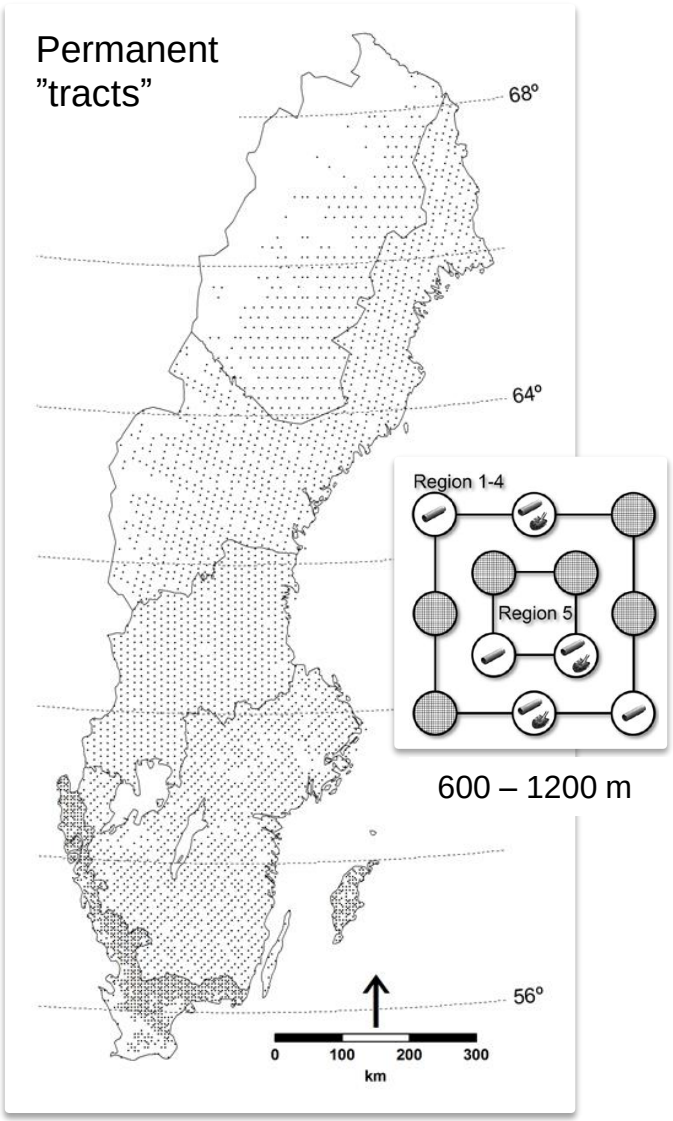
MARKINVENTERINGEN

The Swedish Forest Soil Inventory



Overview

- Long-term monitoring of soil conditions
- Forest land, wetlands and pasture
- Recurrent inventory with 10 year interval
- Co-ordinated with the Swedish NFI
- Since 1983

Data collection

- Field observations (20 000 plots)
- Humus soil sampling (10 000 plots)
- Mineral soil sampling (4 500 plots)
- 2 000 soil samples annually
- 12 000 chemical analyses annually

Applications

- Evaluations of environmental objectives
- International reporting
- Research

SLU

NATUR VÅRDS VERKET

NATIONAL ENVIRONMENTAL MONITORING
COMMISSIONED BY THE SWEDISH EPA

Research programme on stumps as fuel (SLU, Energy Agency)

Local effects on biodiversity

Can storage piles of stumps become traps for wood beetles? How many stumps can be harvested without effects on stump-dependent fauna?

Soil, water and green-house gases

What happens to soil nutrients, water quality and green-house gases after stump harvesting?

Input of results

Landscape effects on biodiversity

What happens with stump-inhabiting fungi, lichens and insects in landscapes with frequent stump harvesting?

Climate benefit and environmental effects

Analysis of the climatic gain of stump harvesting. How can the environmental problems be reduced? Are there compensation measures?

Time-dependent climate impact of forest fuel

General approach

- Integrated analyses
- Ecosystem modeling
- Time dependent LCA
- Reference case
- Substitution of fossil fuel

Evaluated factors

- Forest fuel assortment
- Geography
- (Soil disturbance)
- Uncertainties in decomposition
- Fossil fuel type

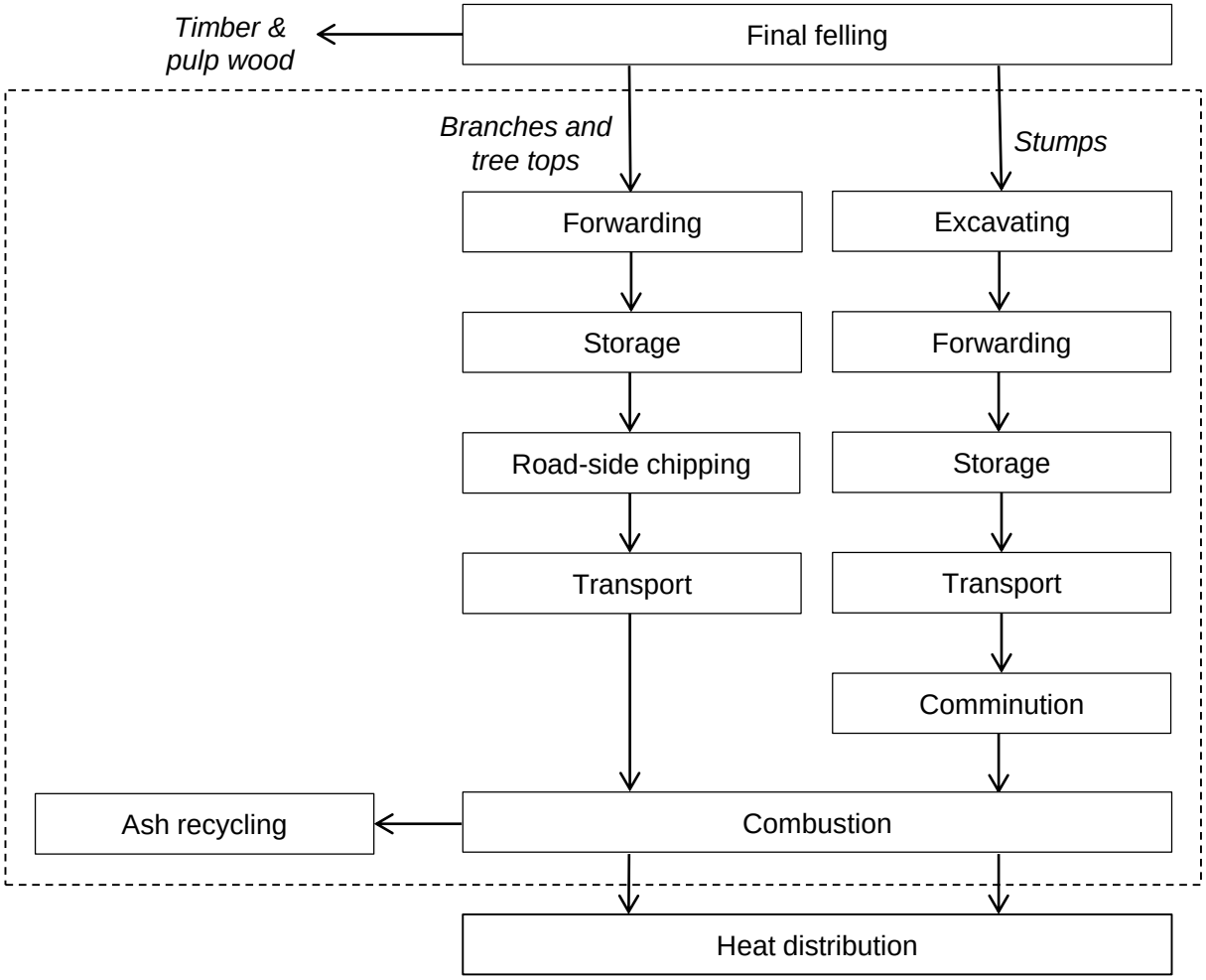
Ecosystem C balance and decomposition rates central

H. v. Hofsten

Studied systems

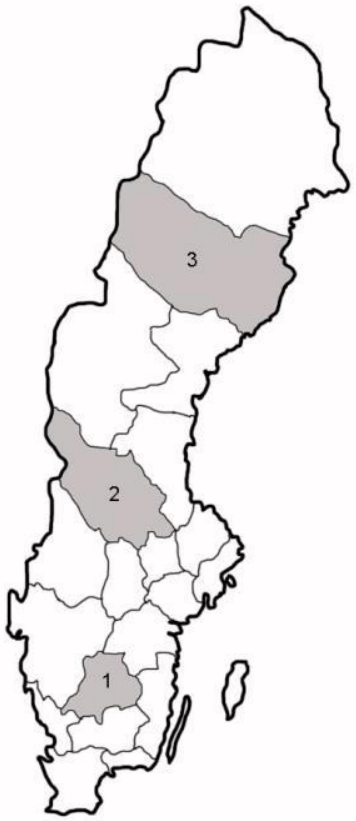
- **Bioenergy system**
  - Harvest of branches/tops at final felling (70%)
  - Harvest of branches/tops and stumps at final felling (70% and 80% resp.)
- **Reference system**
  - Equal amount of energy produced from fossil coal or natural gas, while the harvest residues are left to decompose in the forest
  - Same forest management as bioenergy case

System boundaries

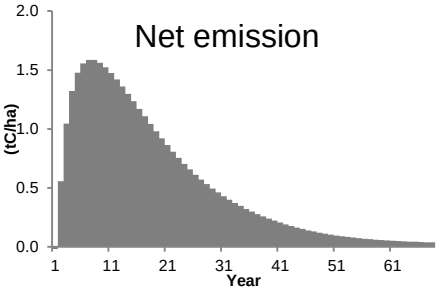


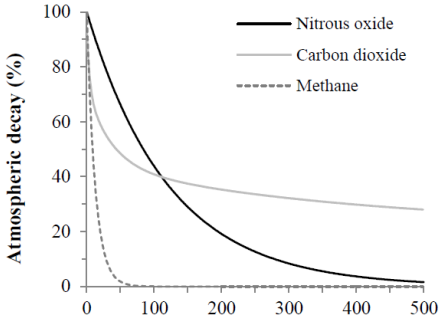
Studied systems

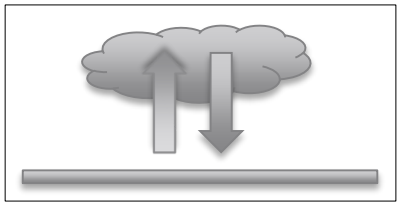
- **Forest simulation using Heureka and Q**
  - 3 regions: Jönköping, Dalarna, Västerbotten
  - ”Typical” Norway spruce stands
- **Realistic forest management**
- **Functional unit: MJ produced district heating**
- **Emissions of CO_2, CH_4 och N_2O from extraction, transportation, processing and energy usage**

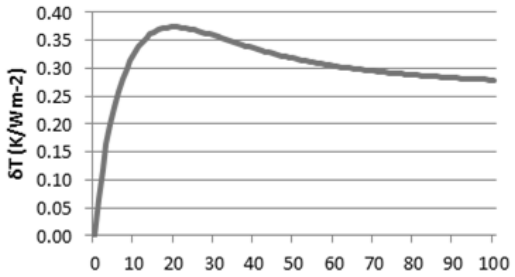


Global temperature change - methods





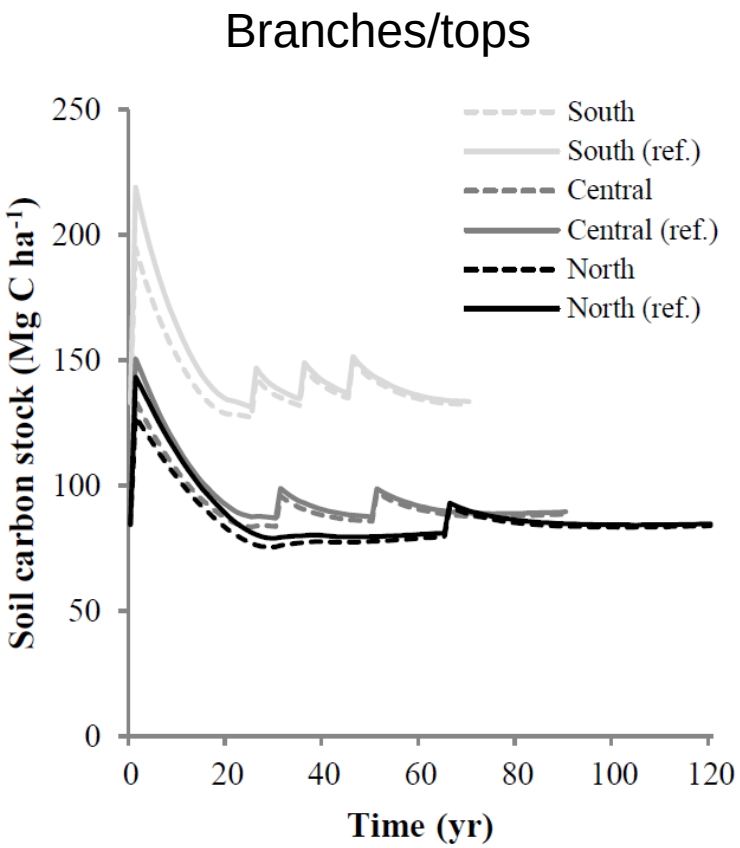


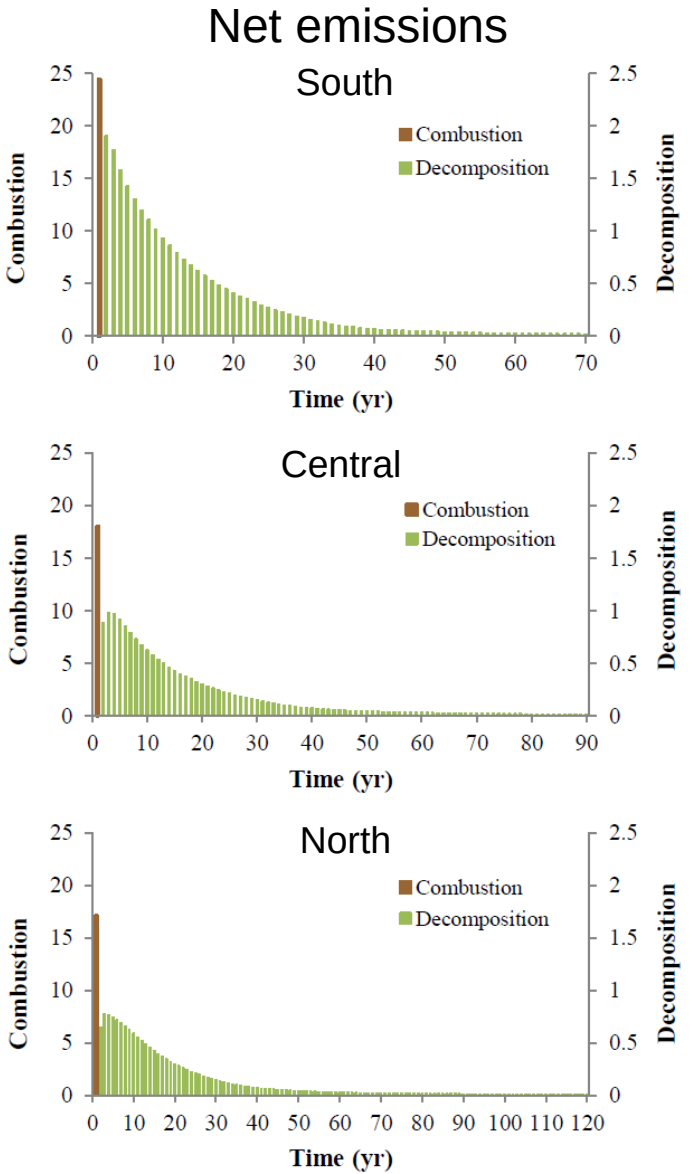


Climate process	Model steps
Impulse emission	1. Impulse emission E_{x_i} of GHG x at year i.
Change in atmospheric concentration	2. The atmospheric decay $f(t)$ of E_{x_i} during t years is calculated by an impulse response function (Bern CC model), which gives the change in atmospheric concentration $f_{x_i}(t)$.
Radiative forcing	3. The change in atmospheric concentration leads to a radiative forcing $RF_{x_i}(t)$ which perturbs the energy balance on Earth, and consequently the temperature. $RF_{x_i}(t)$ is calculated from the radiative efficiency of a GHG.
Temperature change	4. A convolution between the impulse temperature response δT and $RF_{x_i}(t)$ gives the individual temperature response $\Delta T_{x_i}(t)$. All $\Delta T_{x_i}(t)$ for every impulse emission, year and GHG is summed up to get the absolute surface temperature response ΔT_s.

Methodology from Ericsson et al. 2012, based on Boucher & Reddy (2008), Boucher et al. (2009) and Fuglestvedt et al. (2010)

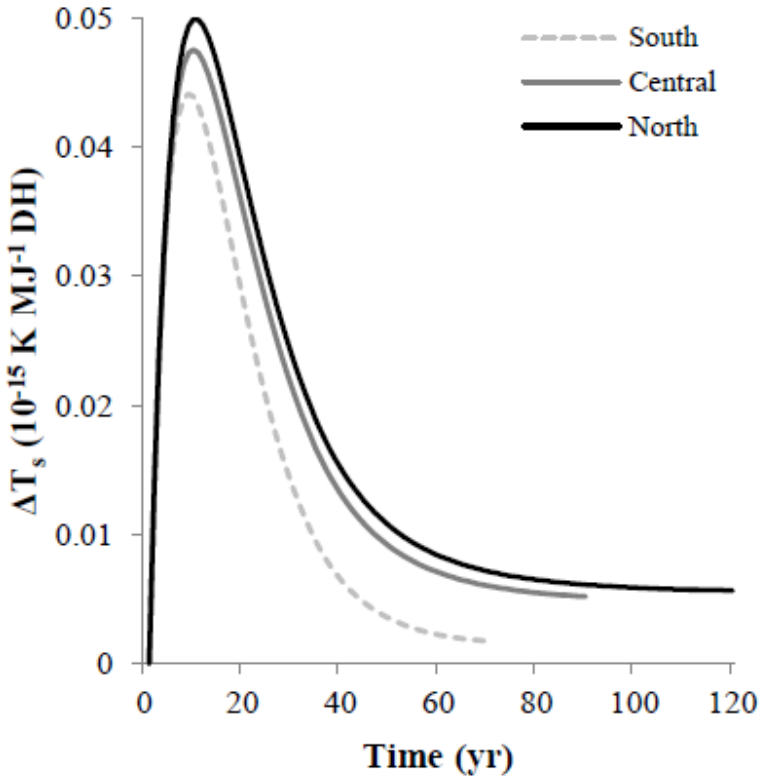
Simulation of SOC and litter



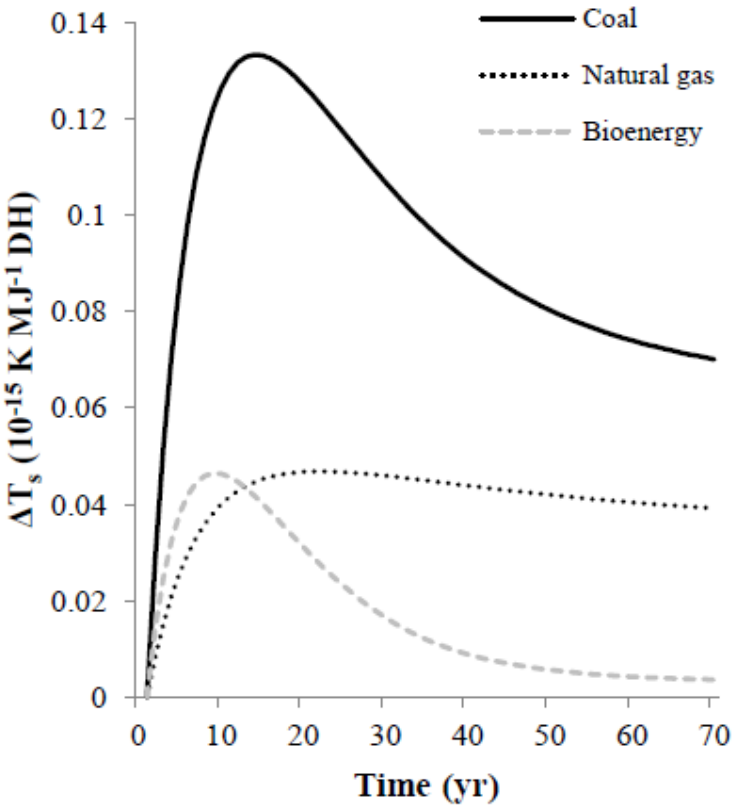


ΔT effects of branches and tops

Biogenic carbon



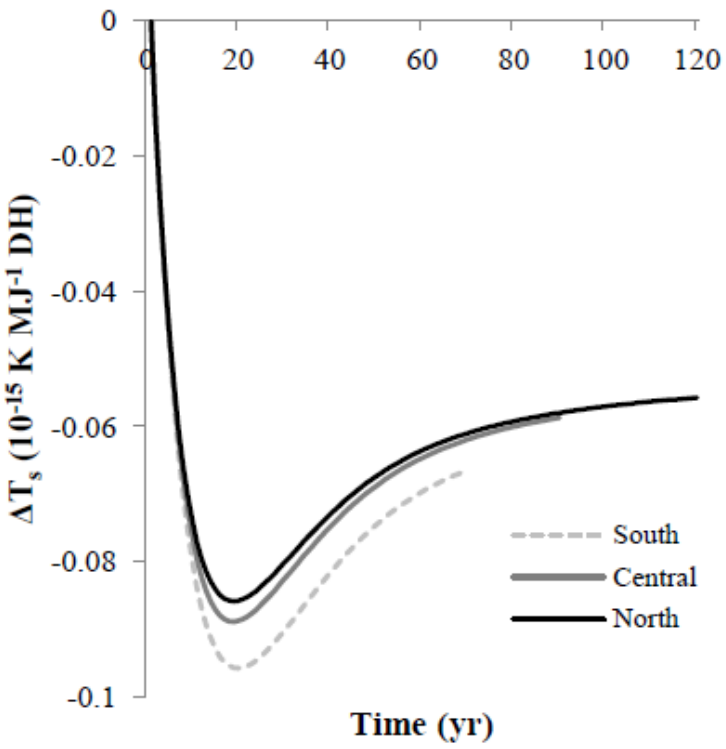
Bioenergy vs fossil systems (southern Sweden)



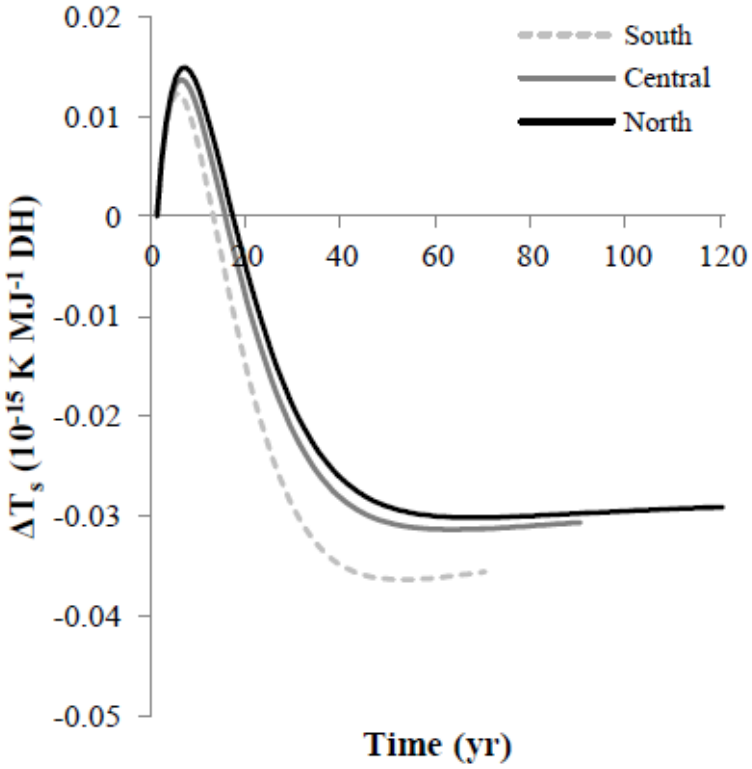
Bioenergy case: combustion, changes in SOC, decomposition of forest litter

ΔT effects of branches and tops

Substitution of fossil coal

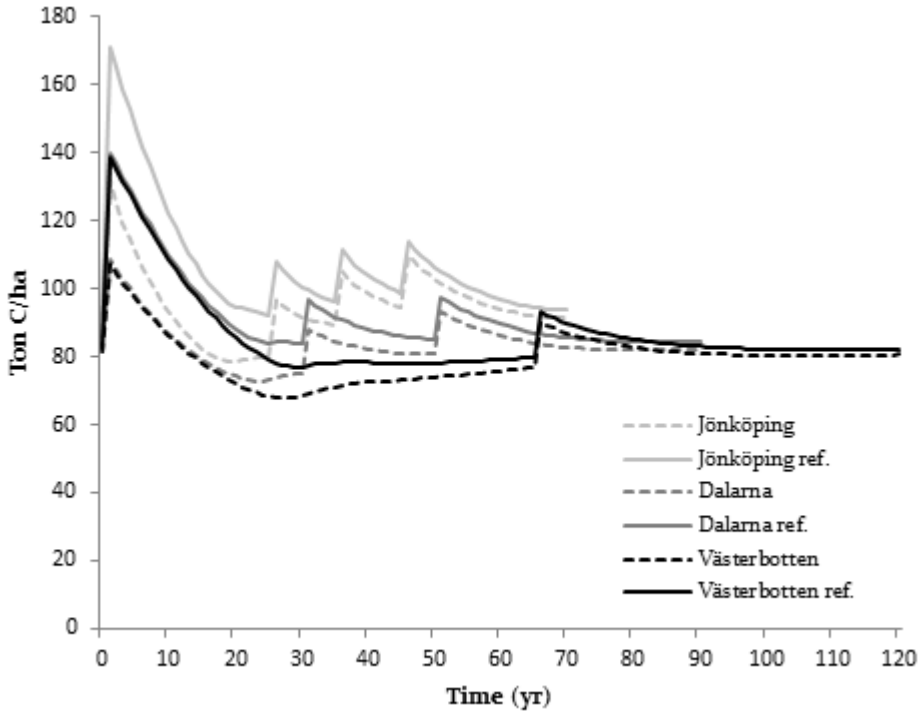


Substitution of natural gas

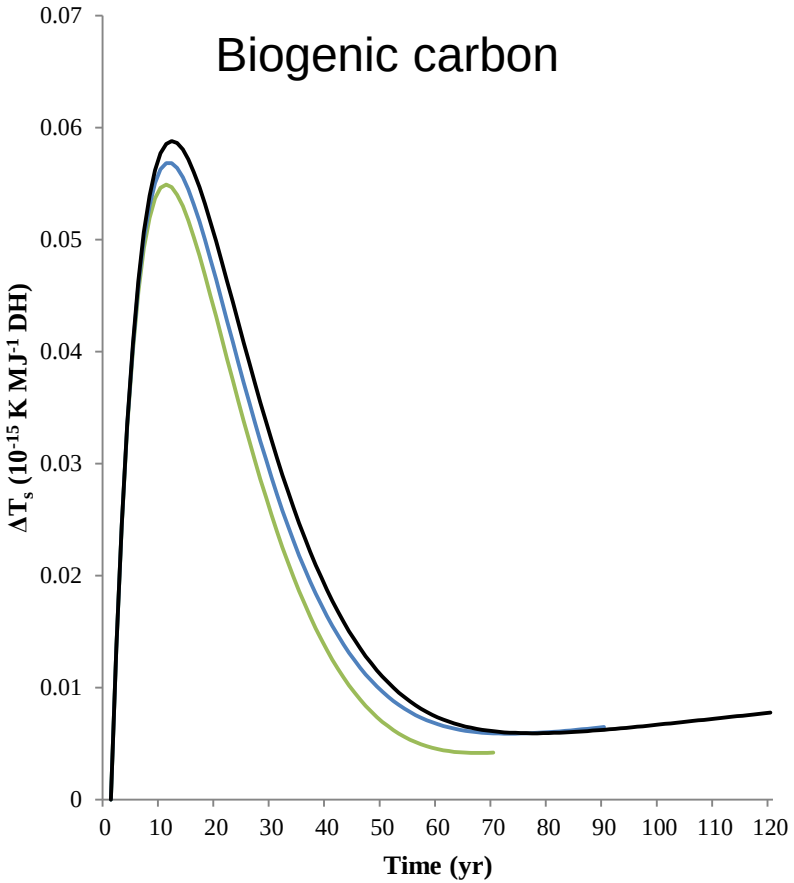


Simulation of SOC and litter

Branches/tops+Stumps

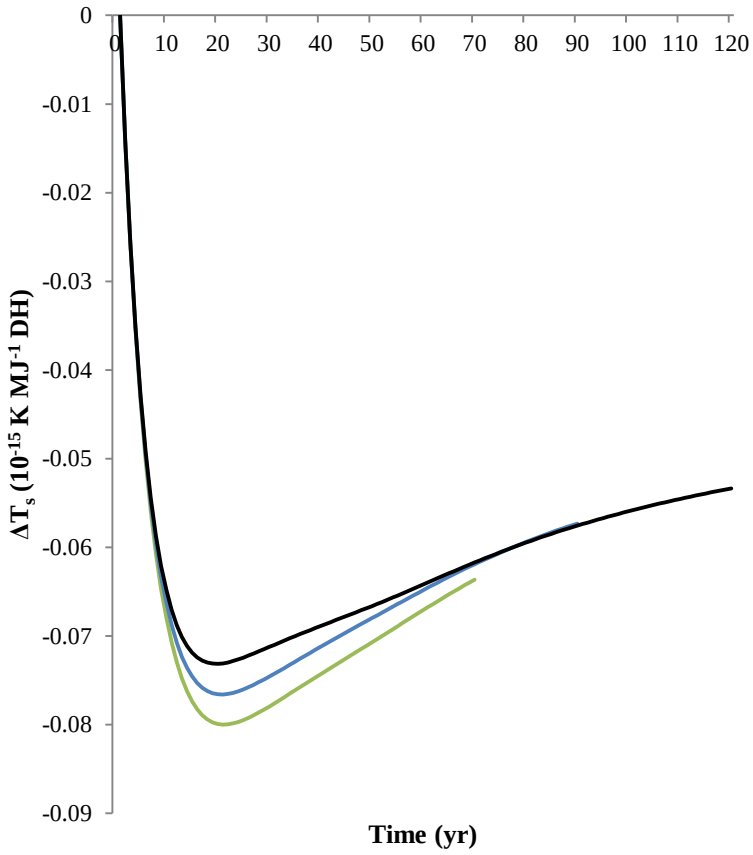


ΔT effects of stumps (only)

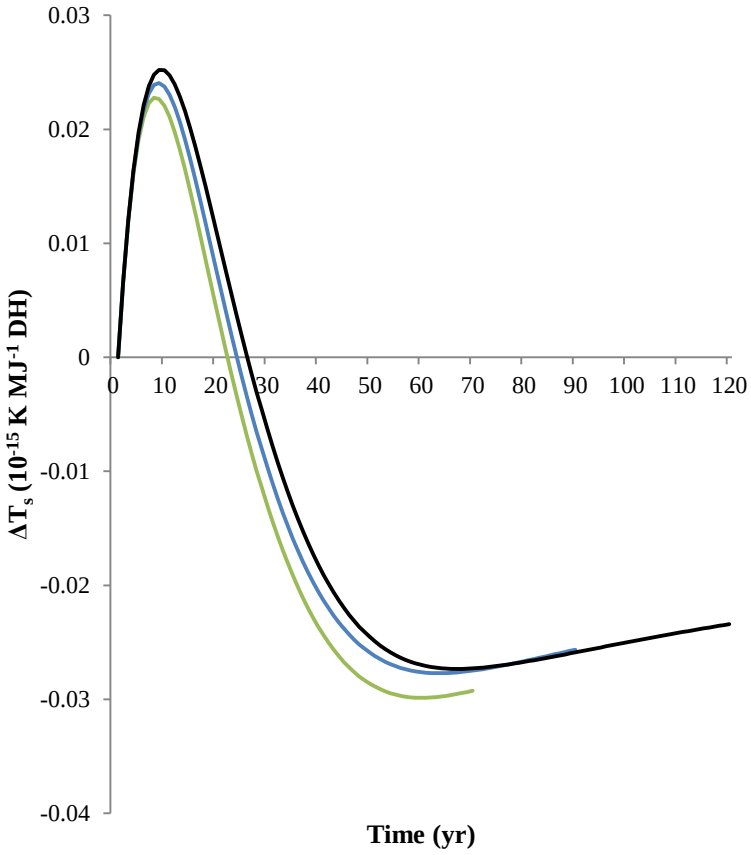


ΔT effects of stumps (only)

Substitution of fossil coal



Substitution of natural gas



Main conclusions

- Immidiate climate benefit from forest fuel when substituting fossil coal
- Climate benefit when substituting natural gas with branches/tops after ca 15 years and stumps after ca 25 years
- Net effect from forest fuel decline to small levels
- Small regional differences in climate efficiancy
- Soil disturbance effect remains uncertain