

# Synergies in Nordic landscape scale forest soil carbon research – can we use them better?

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## Background

Nordic countries share history, societal development and ideals and models for good governance. We also share landscape history and ecosystems heavily influenced by humans for thousands of years where climatic and soil gradients are unconstrained by national borders. Forests provide ecosystem services and when balancing future land use changes and sustainable food

and energy supplies – at the Nordic and regional scale - the understanding and prediction models need to be consistently informed by data and research in the whole region. Also for forests. For soil carbon in forests – most likely the largest carbon store in the region – such consistency is challenging. Likely not due to a lack of awareness nor willingness. This

poster shows a handful of **example** of national initiatives to understand landscape scale forest carbon development in response to human and climatic influences; initiatives that - with a higher level of coordination among research funding tools and countries - could support consistent Nordic models to a much larger extent than is currently the case.

## Examples

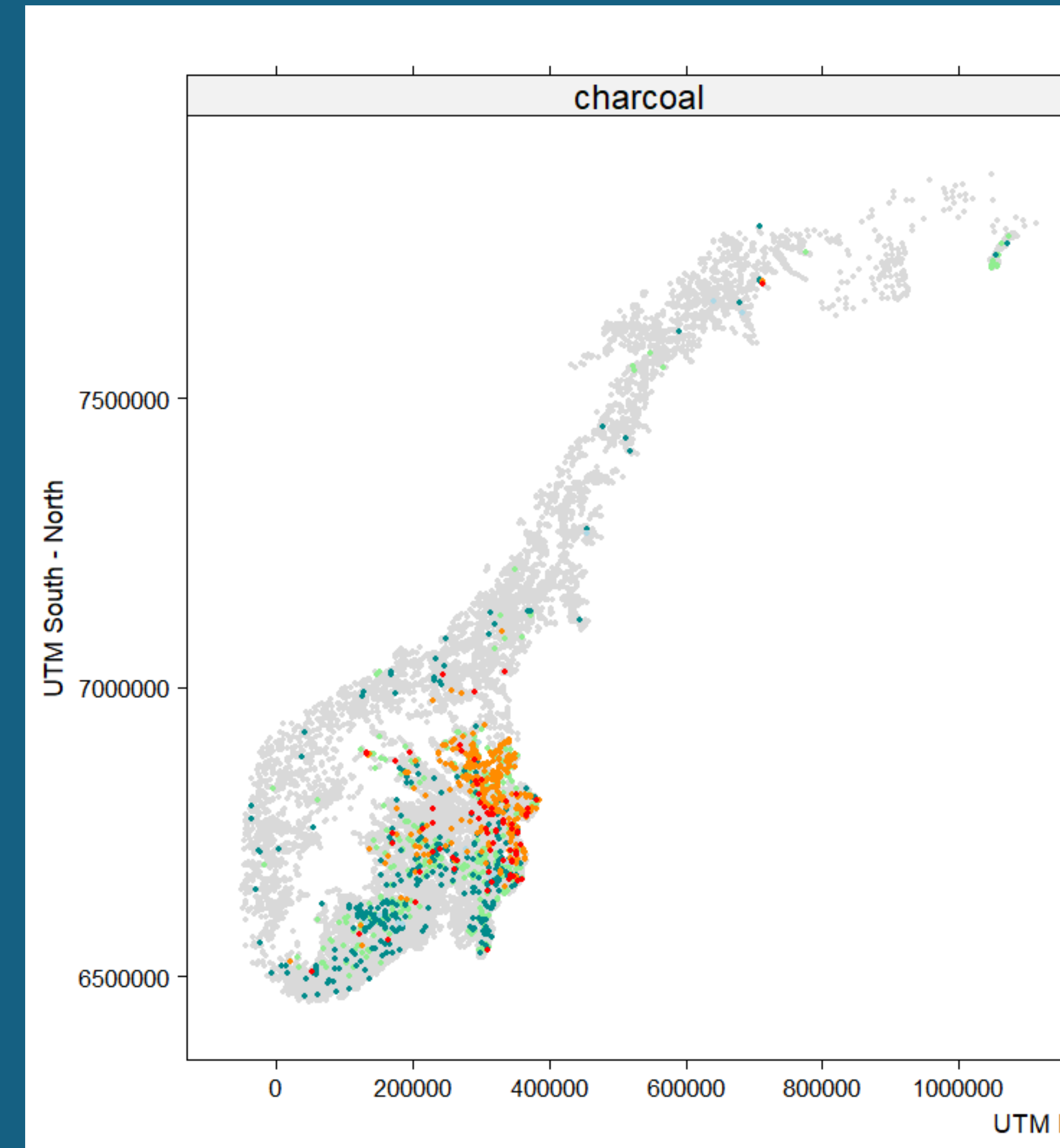
- Landscape history
- Mapping of forest soil carbon
- Effects of Land use change
- Effects of harvest
- Harmonization – data and model applications

## ➤ Landscape history

Slash and burn cultivation has influenced the Nordic region across boundaries. Data and research efforts to document both the cultural legacies of such migrations and the potential soil functional legacies of charcoal on soil ecology could be combined into more generic models for the Nordic region with links to national forest inventories – field based forest biomass and volume resource inventories carried out in very similar ways in all Nordic countries.



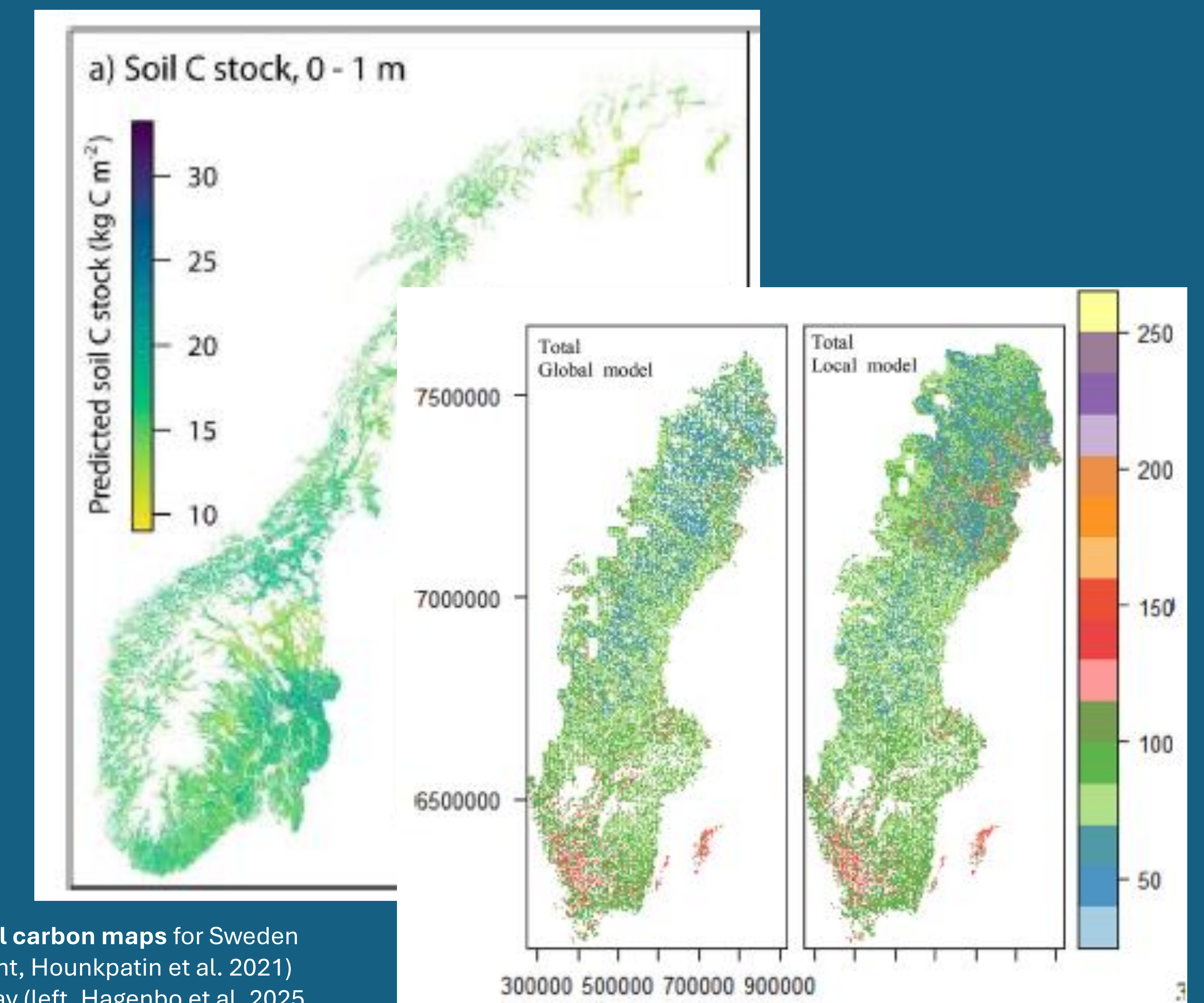
**Slash-burn-cultivation.** From ca. year 1630, people from Savolax in south-eastern Finland migrated to eastern Norway and to Sweden practicing their traditional «Huuhta» slash-burn cultivation by recurrently burning coniferous forest to grow rye. In spite of Norwegian laws in place already by 1648 to limit the burning of valuable timber resources, in some cases death penalty applied, this management regime spread to ca. 40 Norwegian municipalities in Hedmark, Akershus, Oppland, Østfold and Buskerud and continued through the 1800's. Up until the early 1900's, forest burning was still practiced locally in the «Finnskog» area near the Norwegian/Swedish border. **Right:** Extent of the «Huuhta» slash-burn cultivation spread, within the circle in 1500 AD, full line in 1600 AD, dashed line in 1700 AD. **Left:** photo by I.K. Inha from 1893 (Finland).



**Spatial distribution of charcoal in forest humus layers.** Charcoal was recorded in forest humus layers throughout the Norwegian NFI with a clear regional concentration in the southeast particularly toward the border to Sweden. Gray: all plots in the Norwegian NFI, other colors represent different types of forest humus (Dalsgaard et al. 2025).

## ➤ Mapping of forest soil carbon

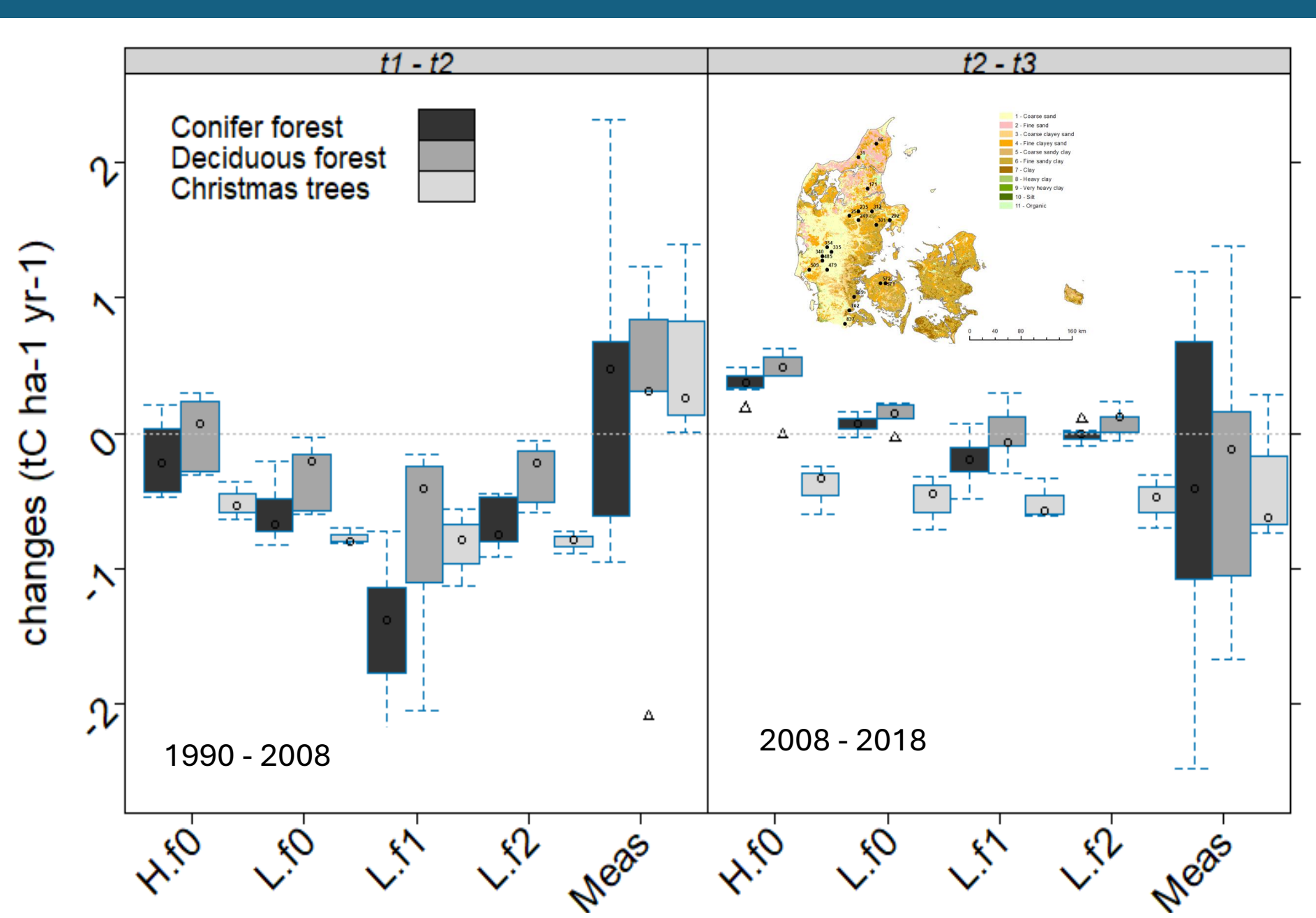
Mapping soil carbon stocks from old or current soil inventories have been done in several Nordic countries as separate national initiatives and may be coordinated for the whole region to create most likely more robust regional maps – challenges are related to differences in the field procedures; see below on “harmonization”



**Forest soil carbon maps** for Sweden (tC/ha, right, Hounkpatin et al. 2021) and Norway (left, Hagenbo et al. 2025).

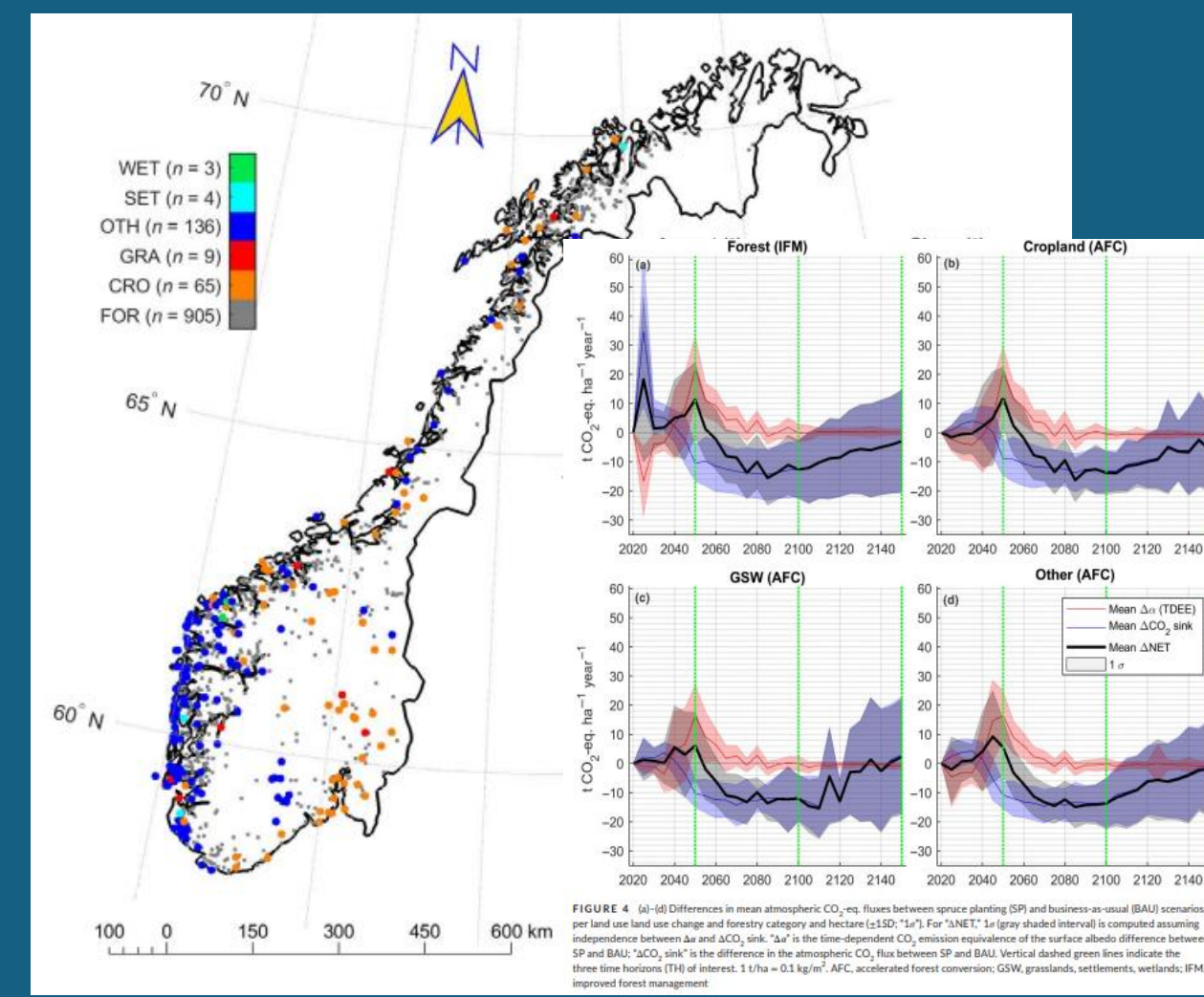
## ➤ Effects of land use change

Afforestation is a relevant option for GHG emissions mitigation. Currently specifically in Denmark, but throughout the region this is an option. A common Nordic experience in how to forecast and measure effects on soil carbon and in which regions data should be established could benefit land use change policies for the region as a whole.



H10, L10, L11 and L12 are different application routines using Yasso15 relating to the initialization of the model and input uncertainties.

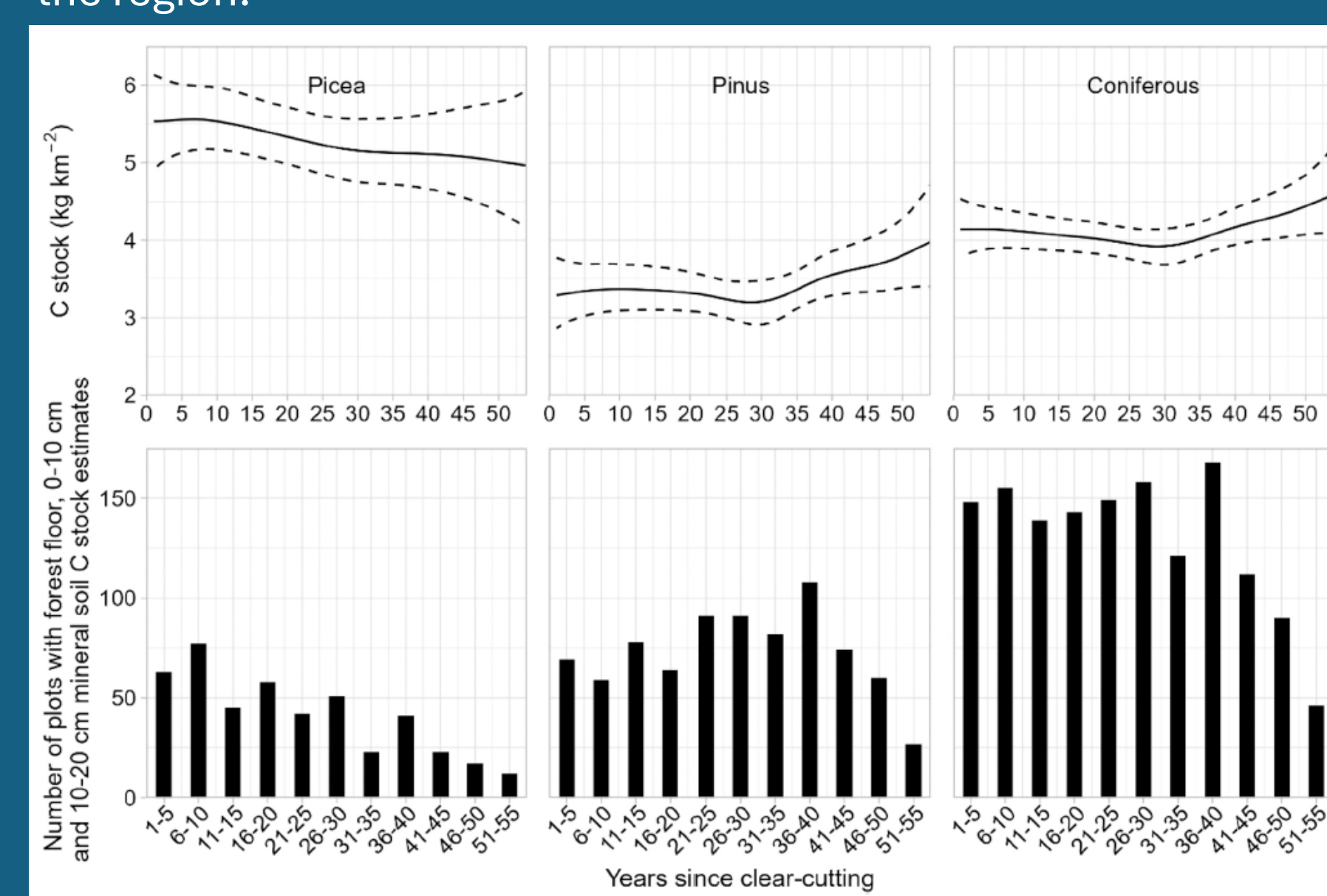
**Soil carbon changes after afforestation, Denmark.** Repeated soil carbon measurements and model simulations with Yasso15 are carried out to test our ability to predict soil carbon development upon afforestation. (Dalsgaard et al. in preparation).



**Forest carbon changes after afforestation and tree species conversion, Norway.** A simulation study based in forest inventory plots forecasting total carbon balance, albedo changes and carbon dioxide removal potential (Bright et al. 2020).

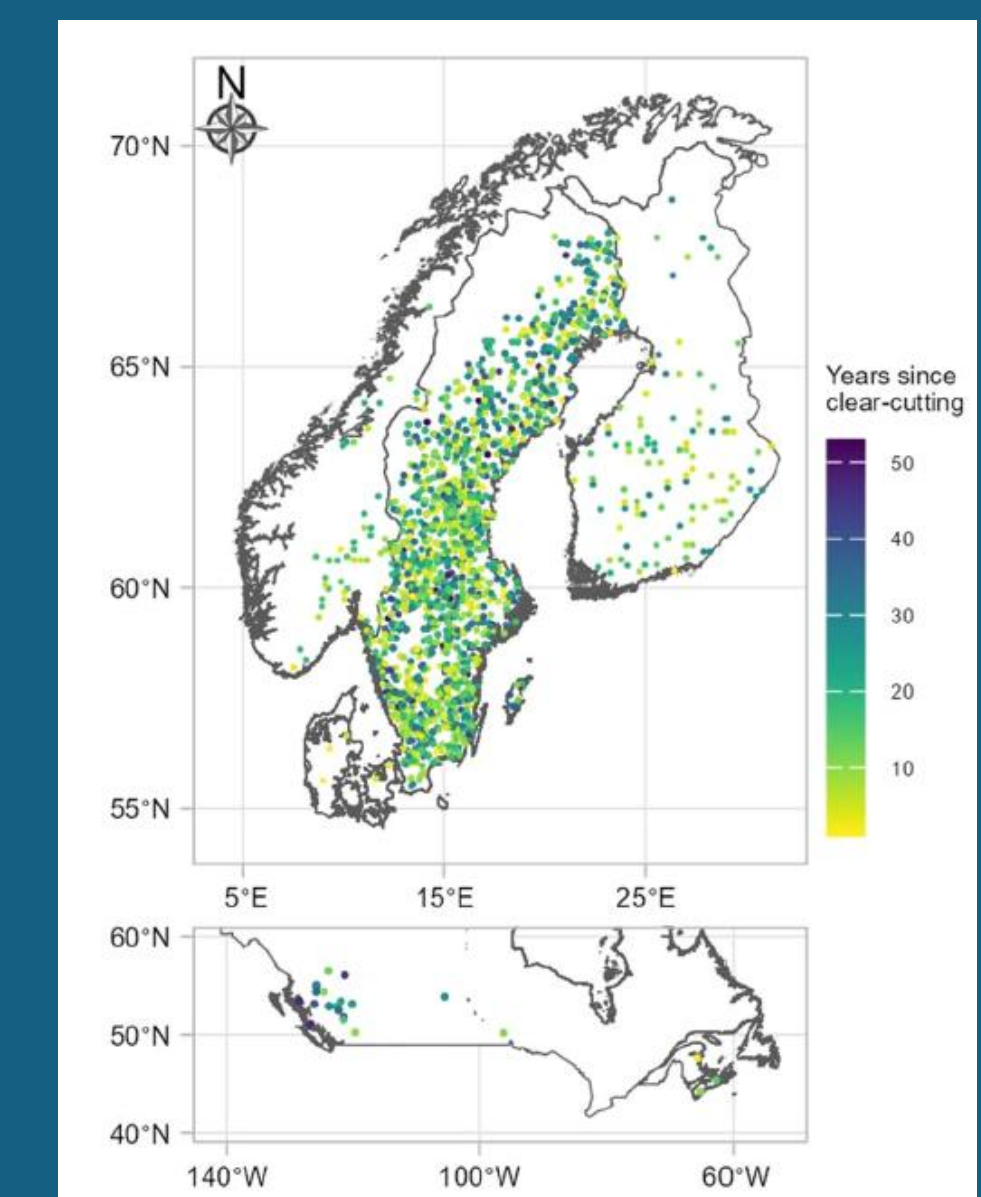
## ➤ Effects of harvest

Forests in the Nordic region are heavily influenced by management and the balance between the need to clear-cut harvest biomass and the need to harness forest carbon is difficult – due to many reasons but also due to a lack of knowledge on harvest effects on the soil. Nordic, Baltic and Canadian soil inventory data were harmonized by Johannesson et al. (2025). A study supported by the SNS network “NorForSoil”. Data density is not even throughout the region. Efforts are planned to connect Norwegian and Swedish data more closely to make interpretation of the study for Norwegian conditions more transparent (funding applied). Nationally scoped projects such as the recently started Norwegian project NorSink (Cicero) looking among other things at landscape scale forest carbon fluxes in the context of disturbances could have included the Nordic spatial perspective. Forestry is an integral part of Nordic economy and it should be a goal to predict ecosystem effects consistently for the region.



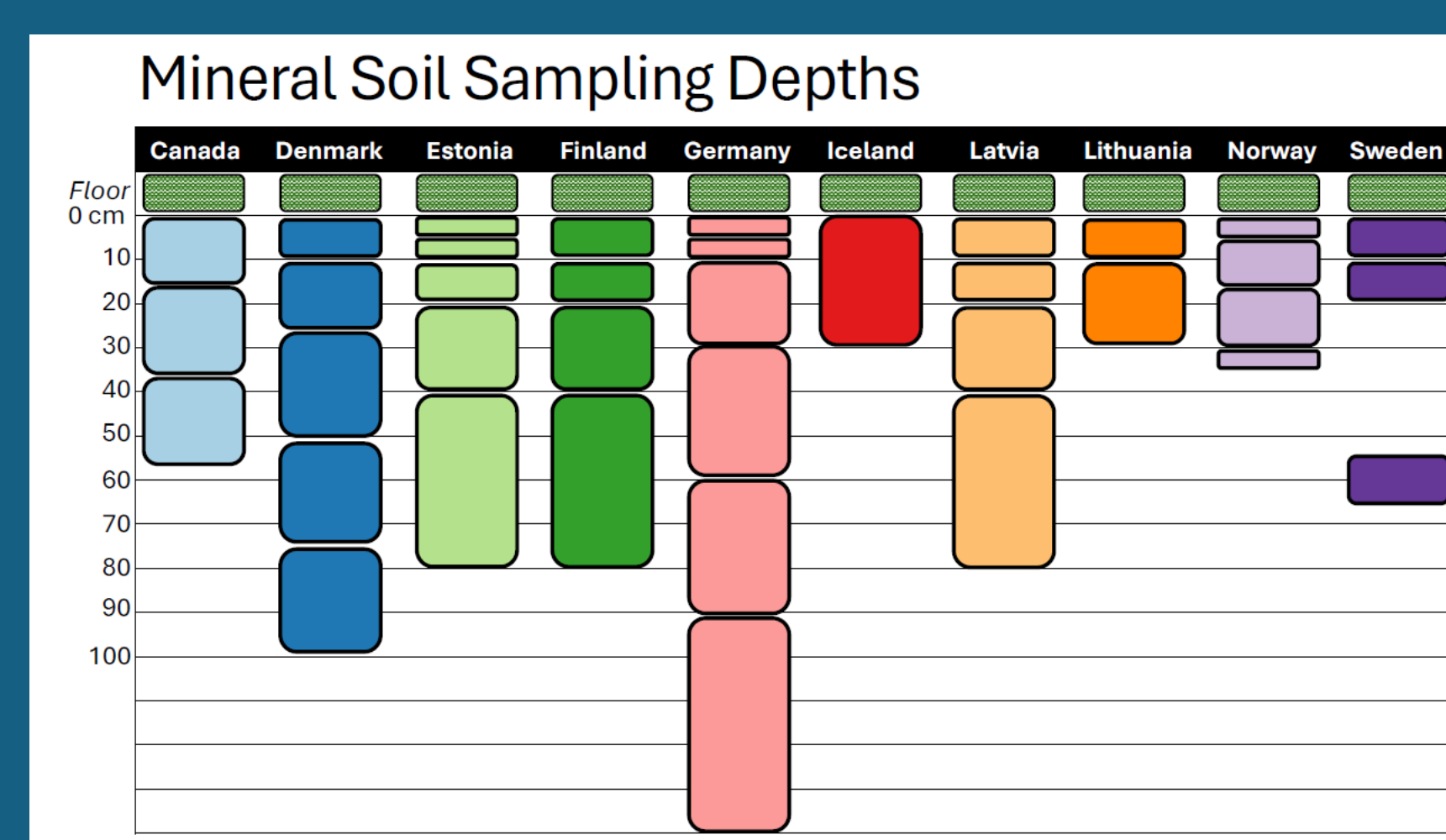
**Soil carbon after clear cut harvest.** Nordic, Baltic and Canadian soil inventory data were harmonized by Johannesson et al. (2025). The figure shows C stock development in topsoil (forest floor + 0–20 cm mineral soil; top panels) in *Picea* and *Pinus* dominated stands and pooled for all coniferous dominated stands. Solid lines are mean estimates, and dashed lines are 90 % credible intervals. Bottom panels show number of plots where C stock estimates were available from all three soil layers (forest floor, 0–10 cm and 10–20 cm mineral soil) along the clear-cutting gradient for each of the forest categories.

Geographical distribution of available clear-cut plots in the National Forest Soil Inventories in the Nordics (top) and southern Canada (bottom).

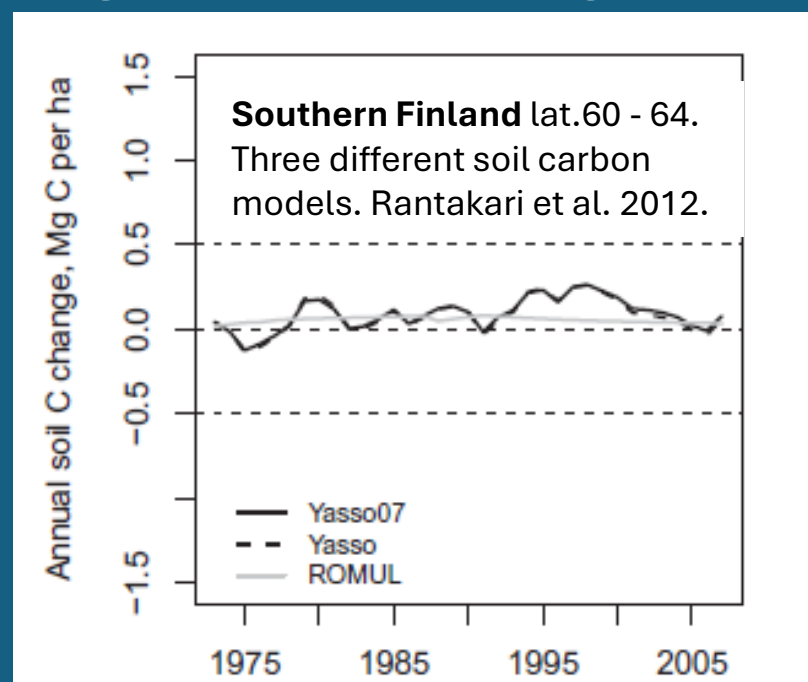


## ➤ Harmonization – data and model applications

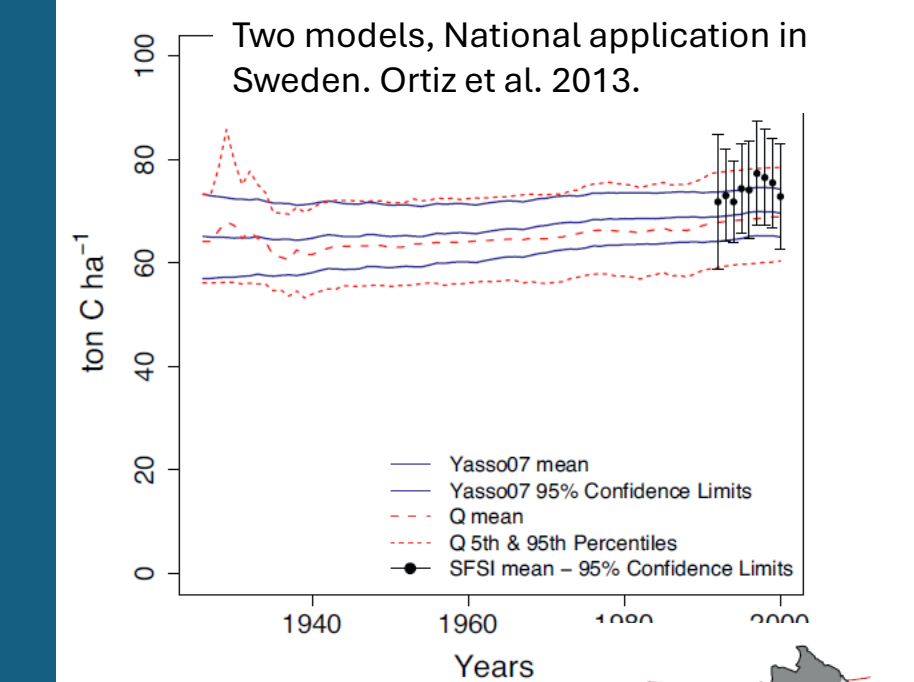
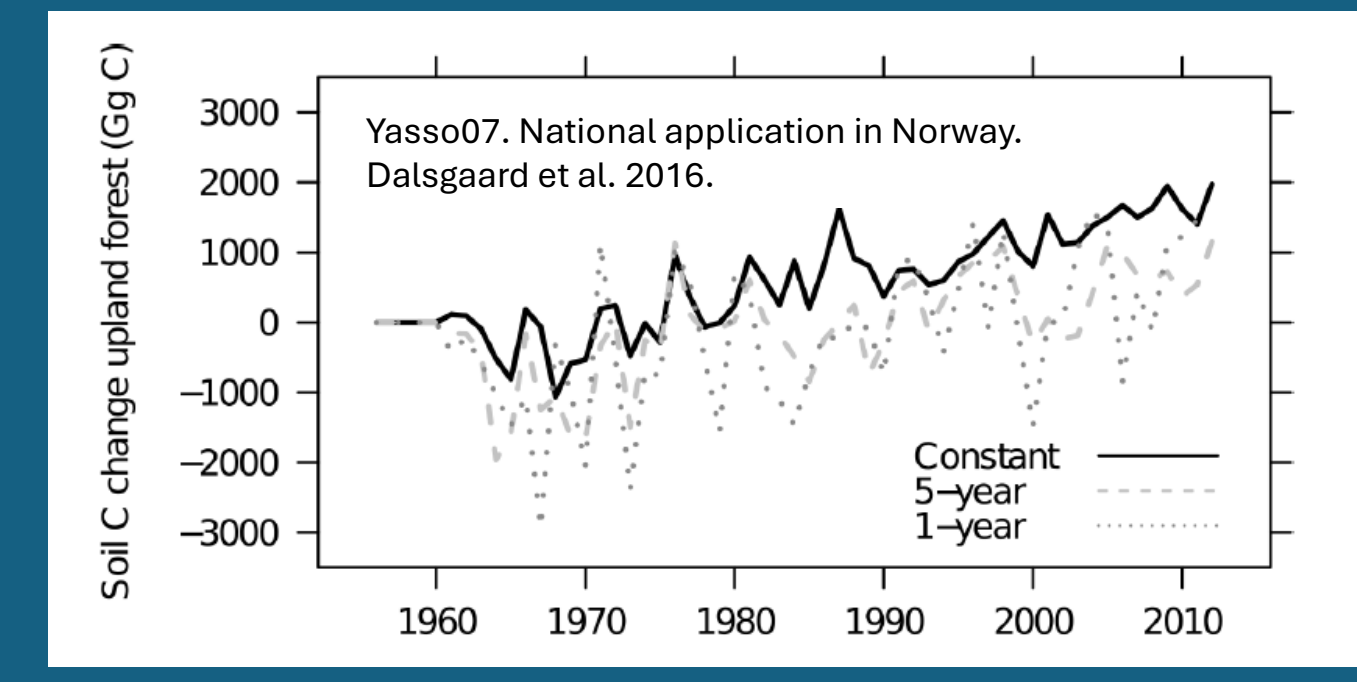
The way that **soil sampling** is performed in the field and subsequently analyzed differ among countries in the Nordic region (Hasegawa et al., in press). SNS network initiatives NorForSoil and the follow-up MoniForSoil work to improve our ability to use Nordic data together. **Models** are used to forecast forest soil carbon development in several Nordic countries. Yasso, century, MIMICS+ (Aas et al. 2024) and Q-models are examples. National applications may differ in essential assumptions on input generation and model initialization procedures. Coordination in ways to generate input data and initialize and calibrate models in the Nordic region will increase transparency and consistency among studies and facilitate regional applications. Informal cooperation ongoing but lacks funding and focus.



**Soil sampling depths** differ among countries in the Nordic and Baltic region presenting a challenge for their use in common studies. To some extent data can be adjusted and gaps can be filled (harmonization) for studies to be done. Johannesson et al. (2025) on harvest effects presents an example. Figure from Hasegawa and Dalsgaard 2025 (presented at MoniForSoil meeting, Iceland).



**National scale model applications for estimating forest soil carbon changes Yasso, Q, measurements.....working toward simulation protocols (applications) that are comparable as much as possible and may be used to do consistent carbon balance studies at the Nordic scale. Involving long-term cooperation among data holders, GHG inventory teams and nationally funded projects.**



## Conclusions

- Relevant projects to understand human and environmental drivers of forest soil carbon are being conducted.
- Often these are at national scales, supported by national funding and without linking to the Nordic scale.
- Research agendas at the Nordic scale could help to align national efforts.
- Parallel efforts – also those ongoing in all Nordic countries for fulfilling UNFCCC and EU reporting schemes – could be linked more efficiently in the Nordic region to increase both efficiency and quality of models.

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