Carbon stock change in Danish forest soils since 1990 as evidenced by two repeated soil inventory networks

Lars Vesterdal[a], Inge Stupak[a], Ingeborg Callesen[a], Lise Dalsgaard[b]
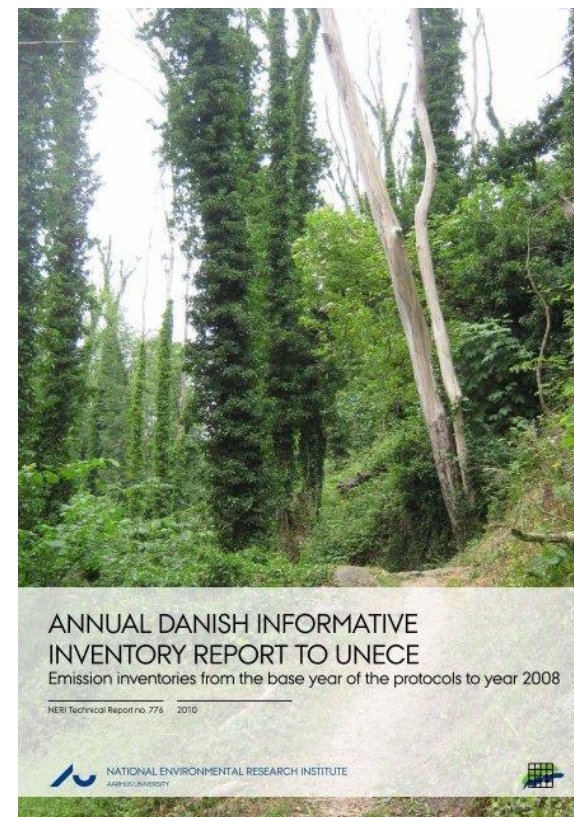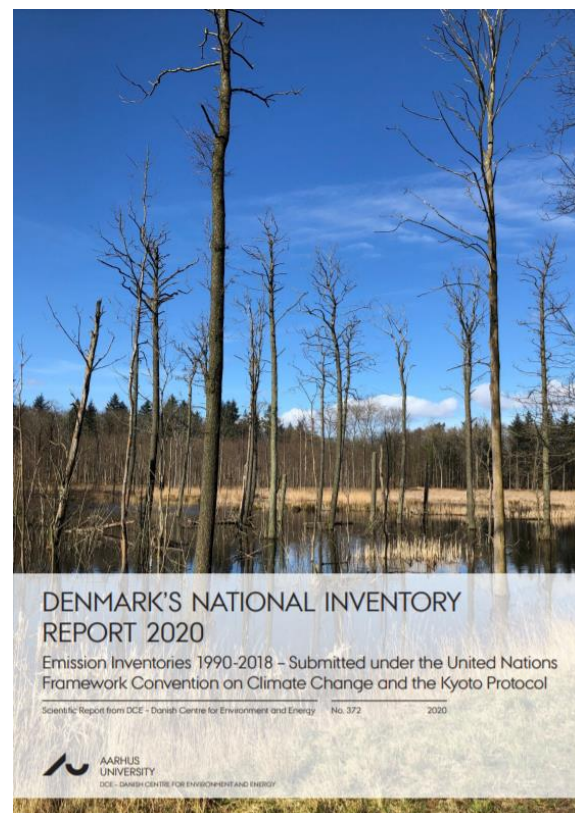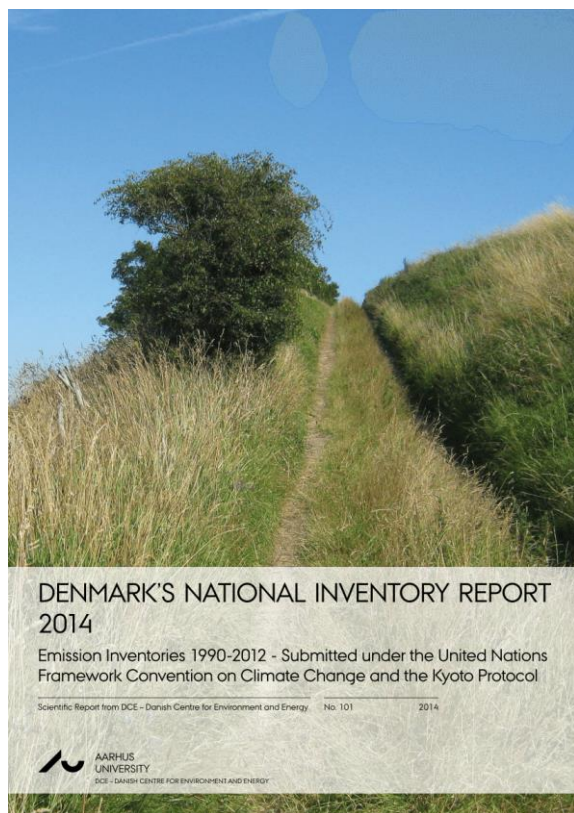
[a]University of Copenhagen
[b]Norwegian Institute of Bioeconomy (NIBIO)

The Danish forest soil inventory implemented through the SINKS projects to support reporting on national GHG emission reduction commitments

SINKS 2007-2011
SINKS2 2015-2021

DENMARK'S NATIONAL INVENTORY REPORT 2014

Emission Inventories 1990-2012 - Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol

Scientific Report from DCE – Danish Centre for Environment and Energy   No. 101   2014

AARHUS UNIVERSITY
DCE – DANISH CENTRE FOR ENVIRONMENT AND ENERGY

DENMARK'S NATIONAL INVENTORY REPORT 2020

Emission Inventories 1990-2018 – Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol

Scientific Report from DCE – Danish Centre for Environment and Energy   No. 372   2020

AARHUS UNIVERSITY
DCE – DANISH CENTRE FOR ENVIRONMENT AND ENERGY

ANNUAL DANISH INFORMATIVE INVENTORY REPORT TO UNECE

Emission inventories from the base year of the protocols to year 2008

NERI Technical Report no. 776   2010

NATIONAL ENVIRONMENTAL RESEARCH INSTITUTE
AARHUS UNIVERSITY

Aims - expected improvements

- *Forest soil SOC stock changes:* Evidence for stable or changing forest floor and mineral soil C pools?

- *Forest floor SOC stock:* New pedotransfer functions based on forest floor depth to improve upscaling to national level by Danish National Forest Inventory

- *(Bulk density:* Updated pedotransfer functions to improve estimates, especially for "organic"/ hydromorphic forest soils (> 6% C))

- *(Change in soil C after afforestation:* Country-wide estimates of soil C change after afforestation of agricultural land) – see presentation by Lise Dalsgaard!

The inventory networks

"Nitrate Network"
- 7 x 7 km
- 126 forest plots, 50 x 50 m
- 10 subsampling points per plot

"National Forest Inventory"
- 200 x 200 m plot clusters in 2 x 2 km
- 140 clusters ~285 selected plots, r = 15 m
- 10 subsampling points per plot

Forest 2017
Non-forest 2017
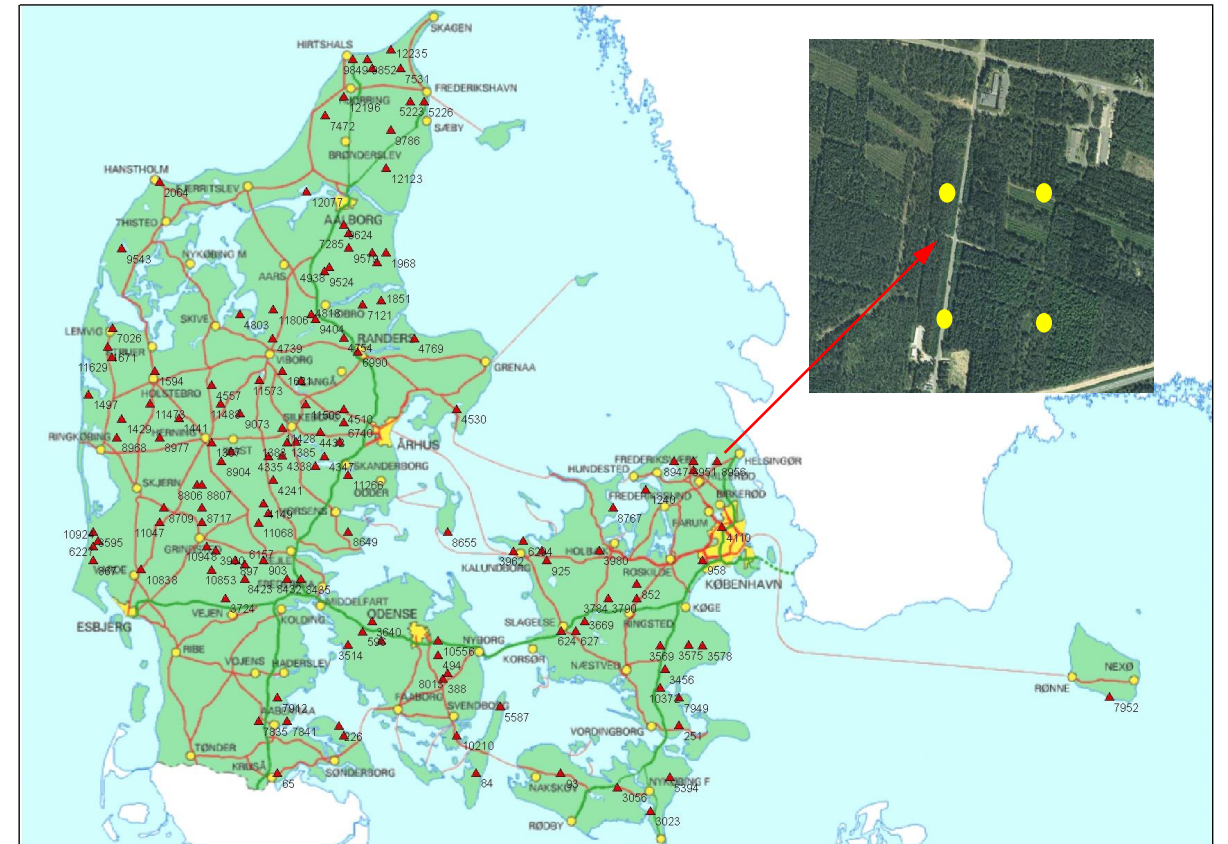
Plot design in Nitrate Grid

- 50 x 50 m plot
- 1990: 16 samples collected randomly
- 2007-08: 10 samples collected equidistantly along diagonal transect
- 2017-18: 10 samples collected in the same positions along transects
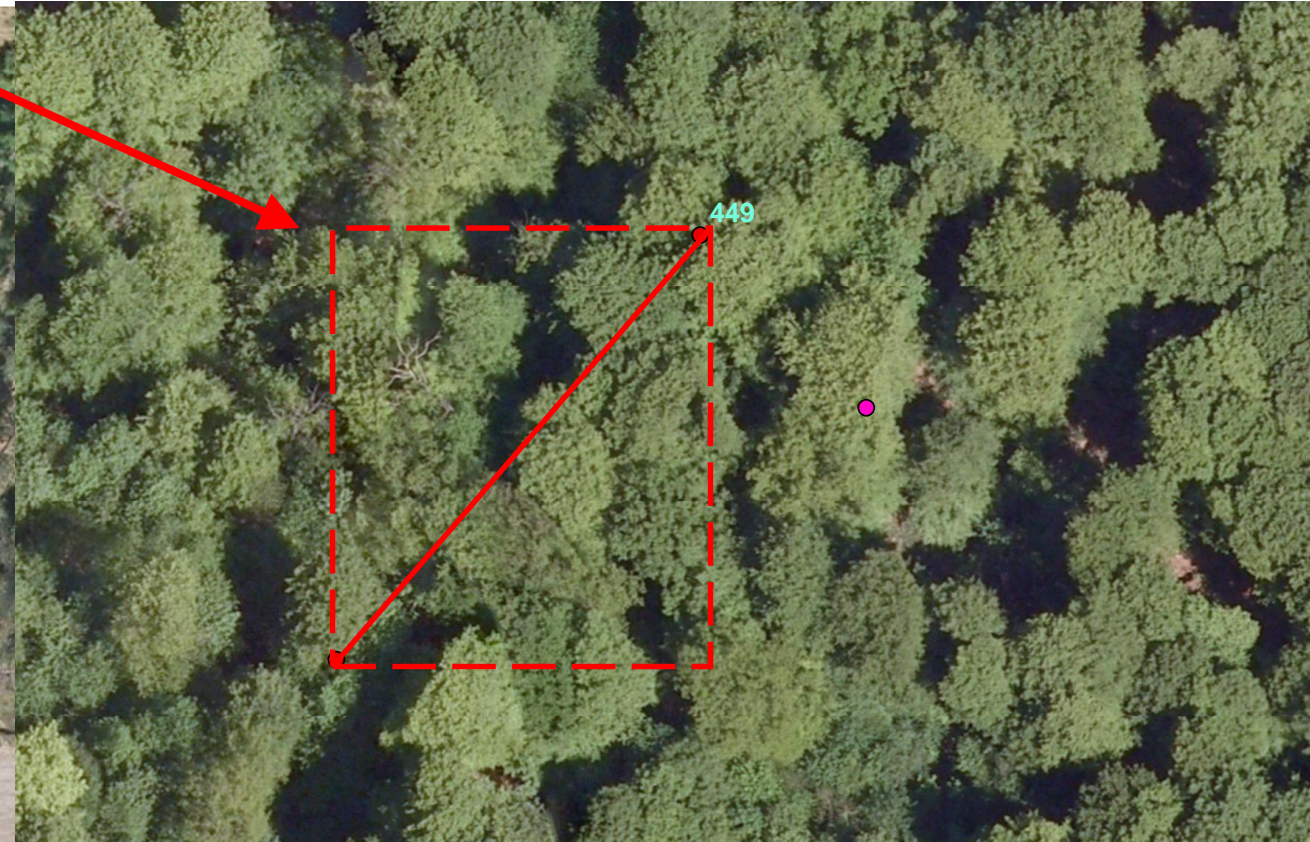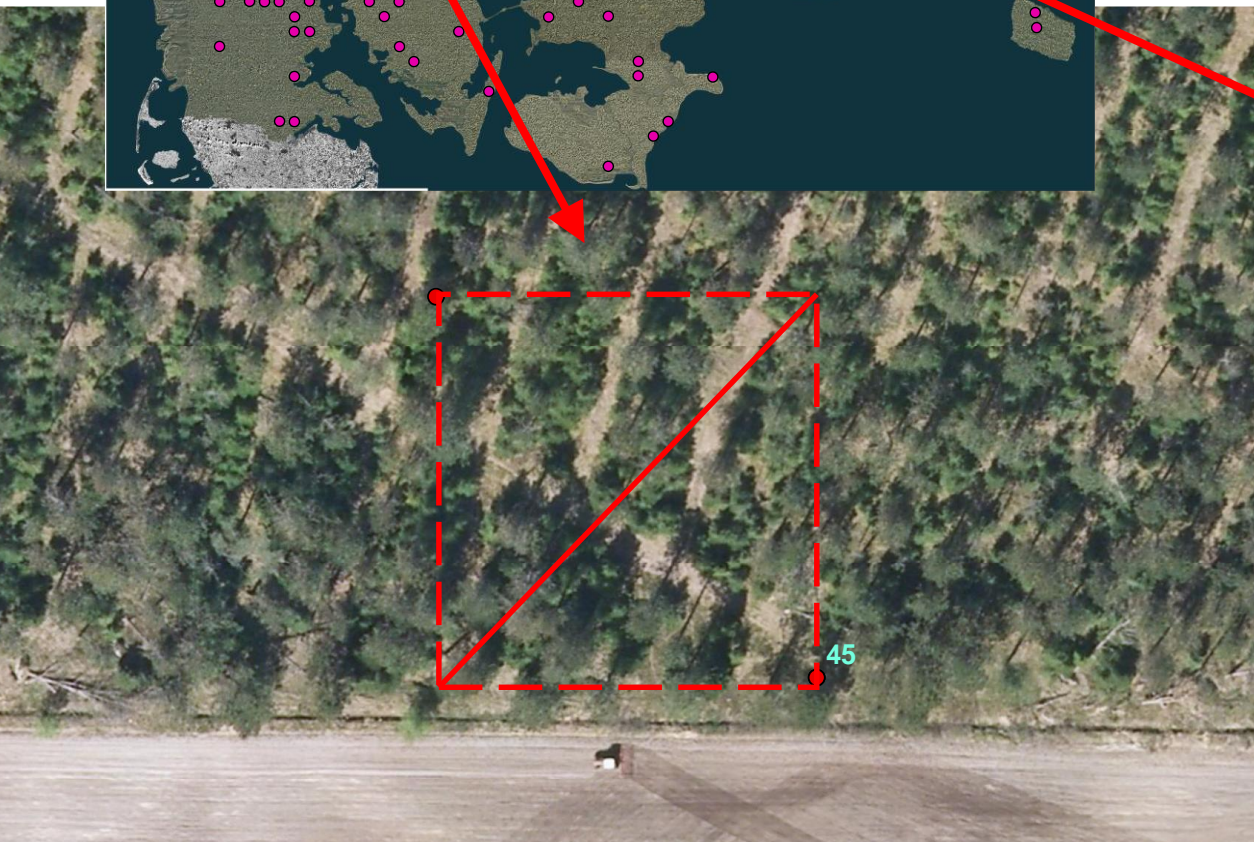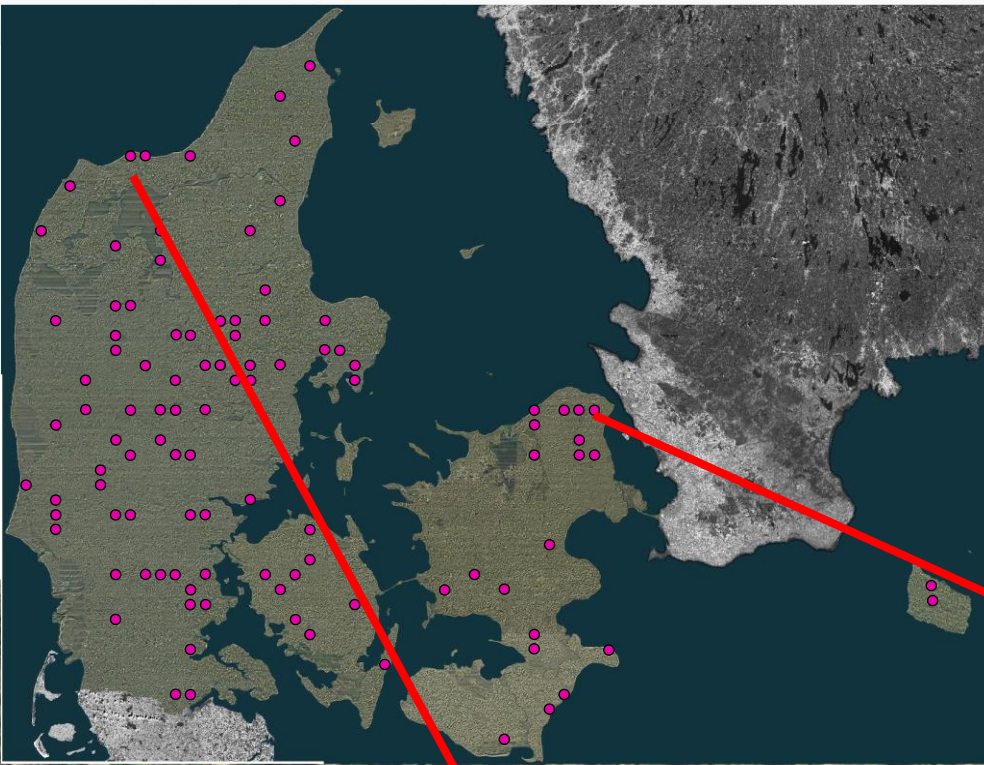
# Sampling of forest floor and mineral soil

Soil archive
Mineral soil 1990

- Forest floor: 2008, 2018
- Mineral soil: 1990, 2008, 2018
- Forest floor sampled using frame
- Mineral soil sampled in 5 layers: 0-10, 10-25, 25-50, 50-75, 75-100 cm
- Bulk density by pedotransfer functions (further developed in subproject)
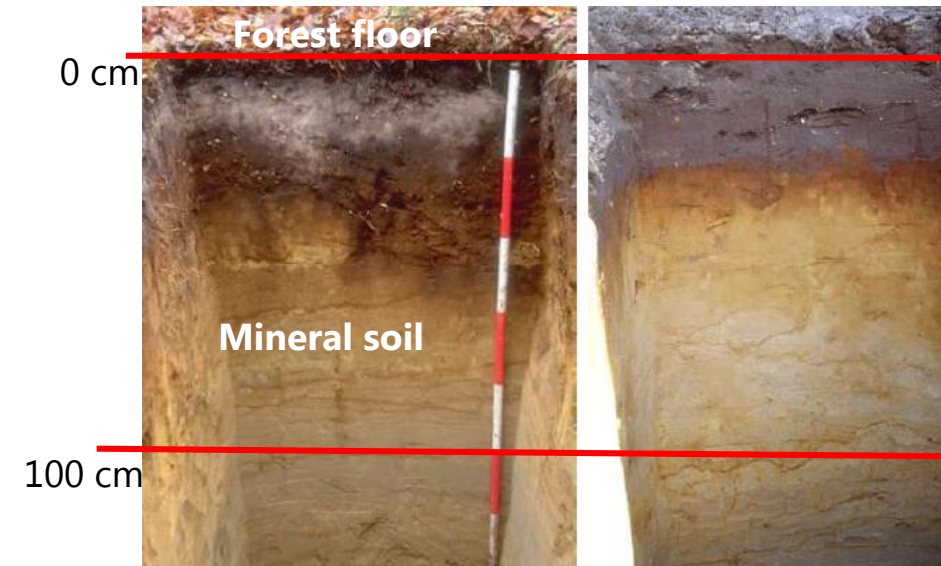
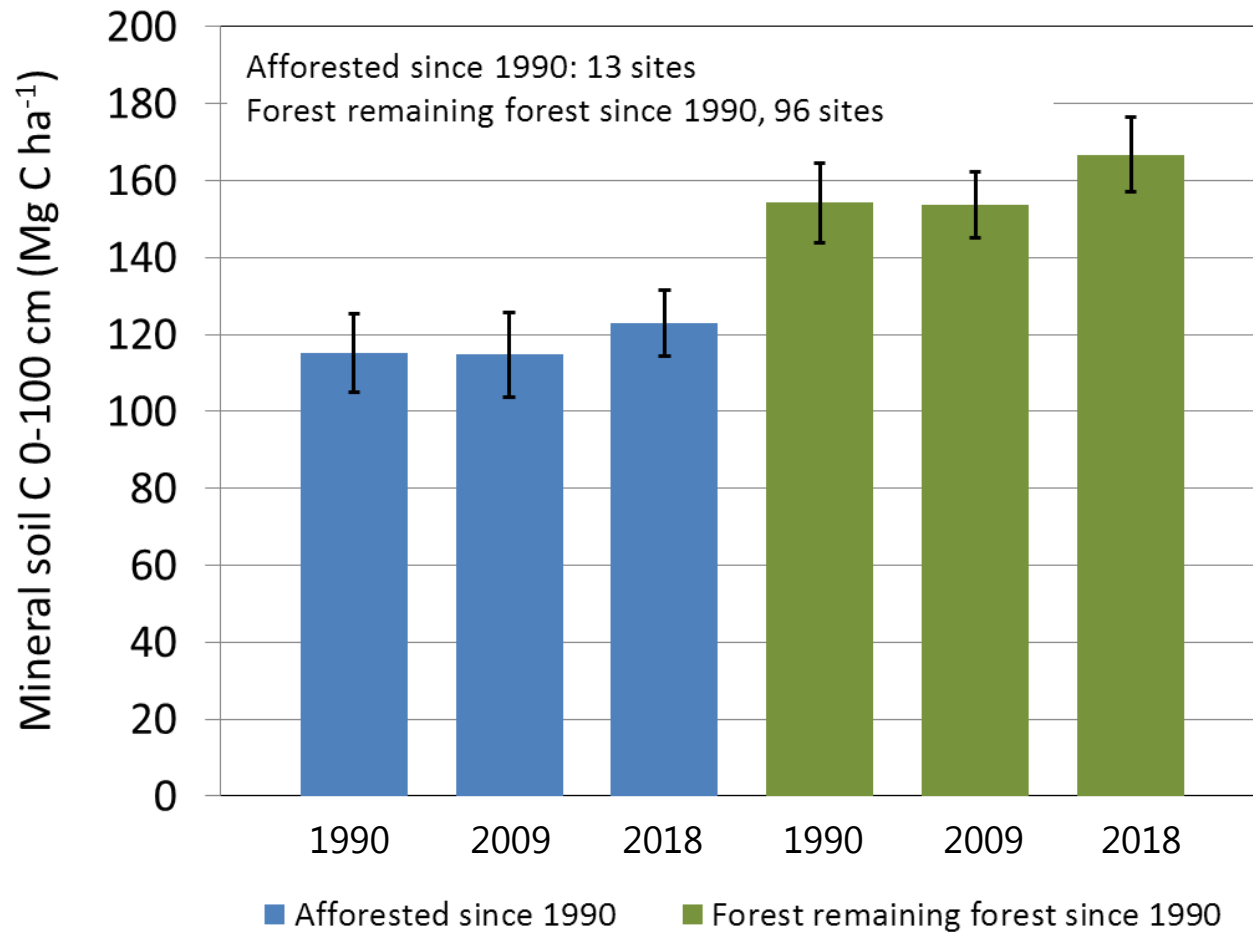# Mineral soil C stock – overall change 1990 – 2008 - 2018
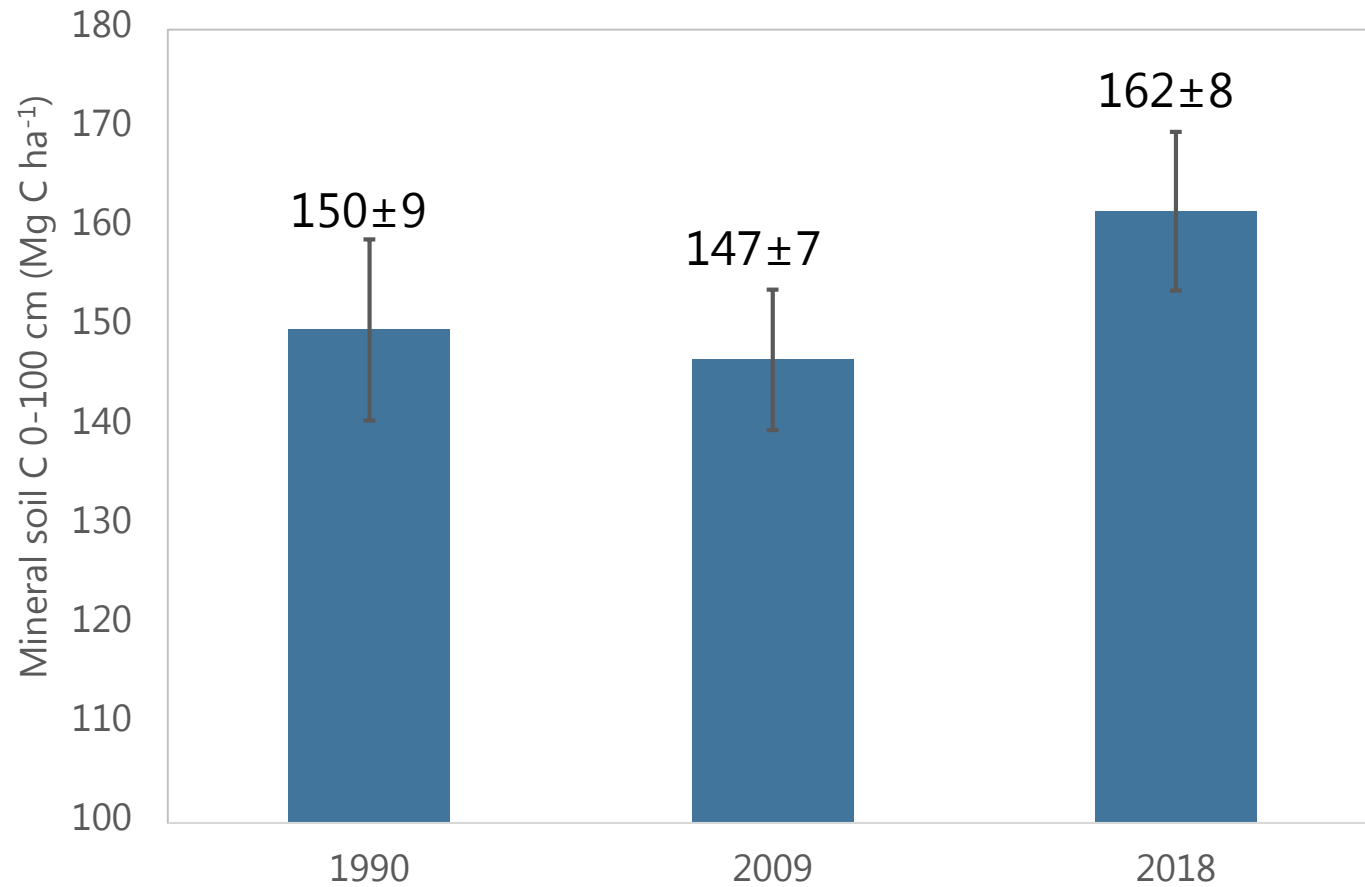
Mineral soil stock change by soil type 1990 - 2008 - 2018
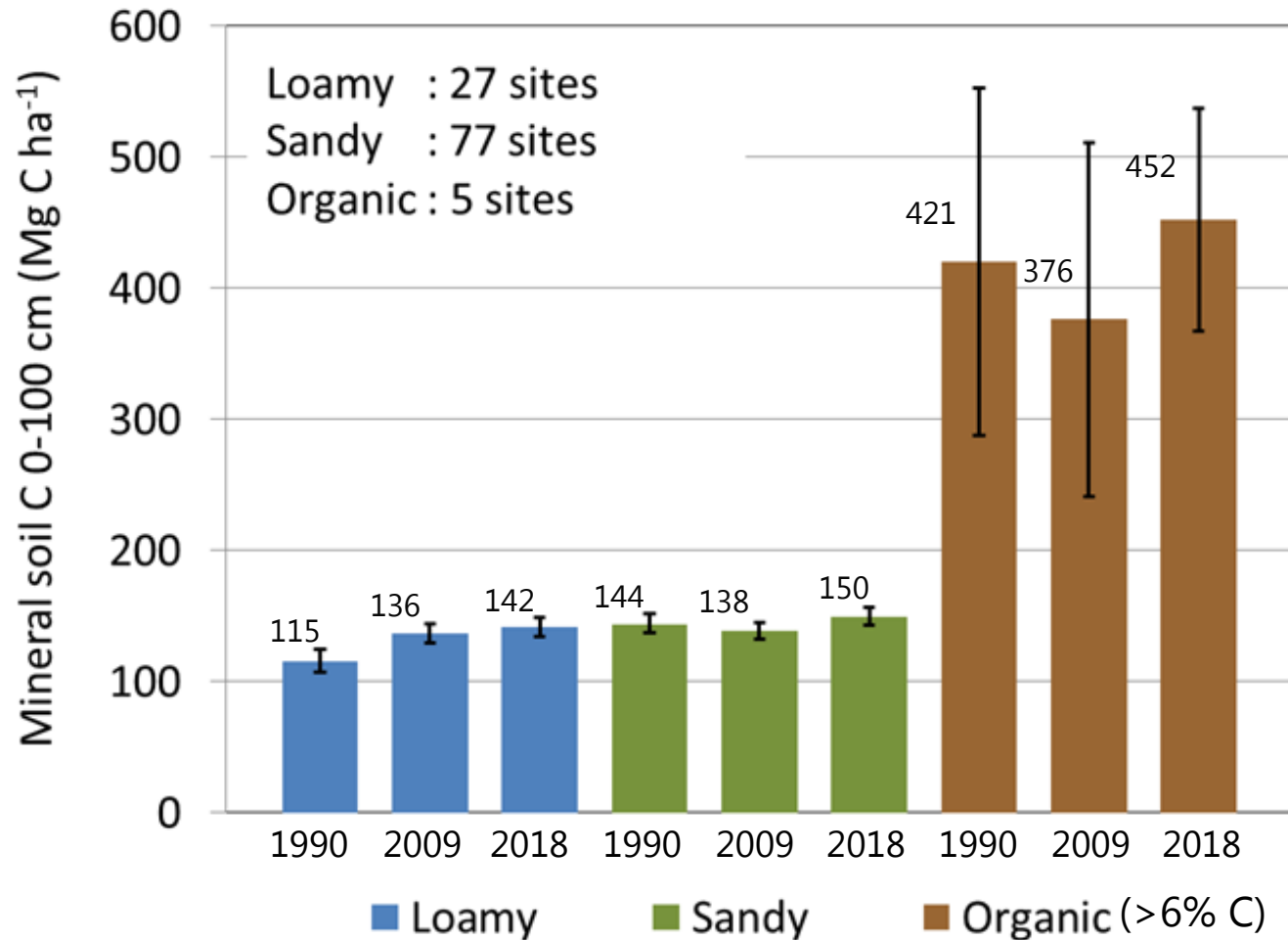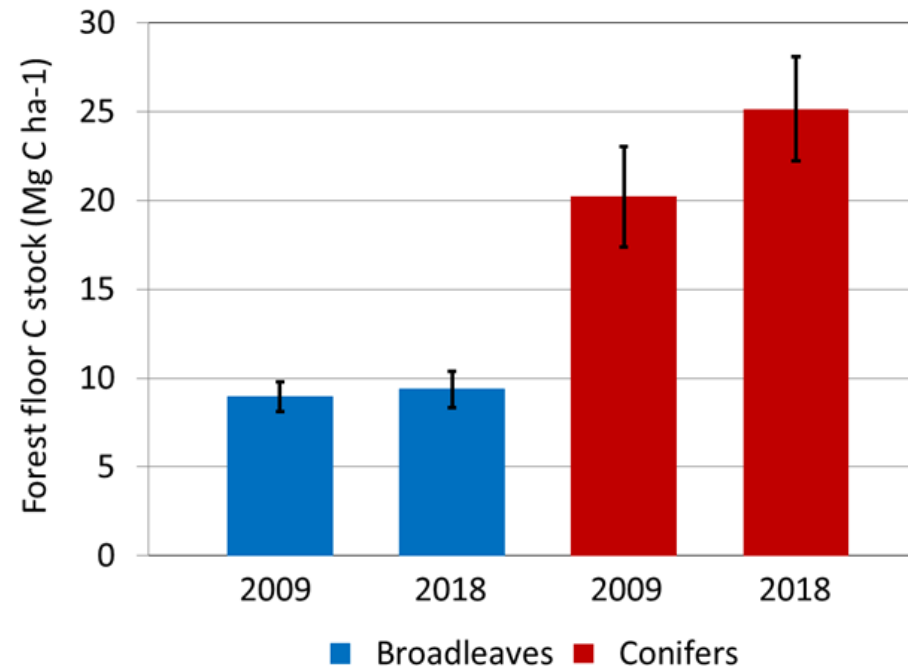

- Loamy soils increased in C stock
- Sandy soils were more stable

10/09/202

Mineral soil C stock change in "old forest" and "former cropland"

- Lower C stocks in former arable land
- Temporal pattern similar

Forest floor C stock change 2008 – 2018
- by soil type and tree species group
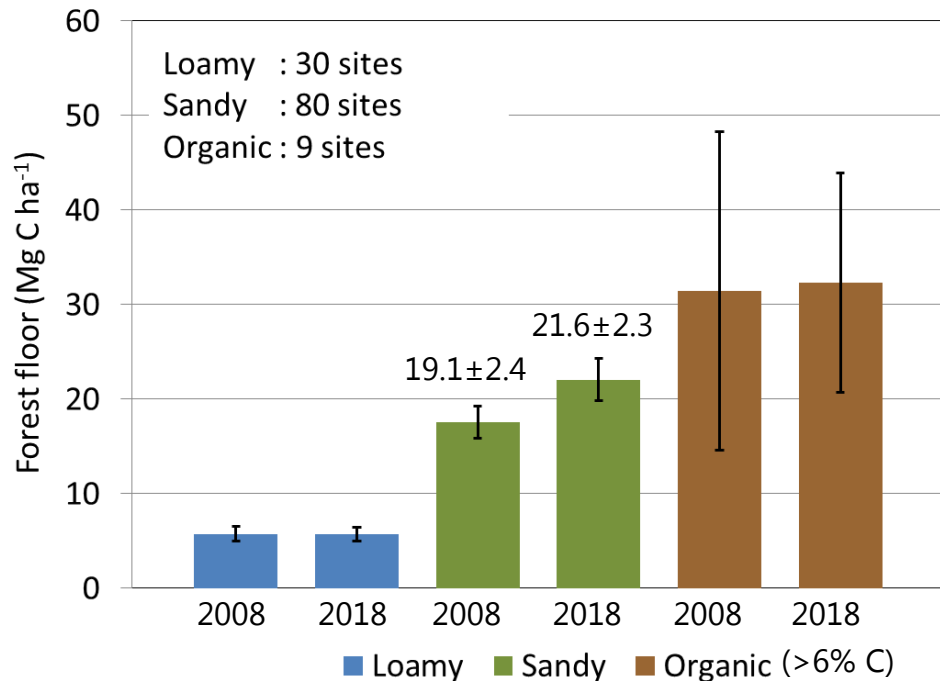
Forest floor

- Sandy soils and soils with conifers increased
- Loamy soils had stable forest floor C stocks at ca. 6 Mg C ha^{-1}.

10/09/2021

Extension of inventory to NFI plots

140 NFI clusters ~300 plots retrieved for soil sampling
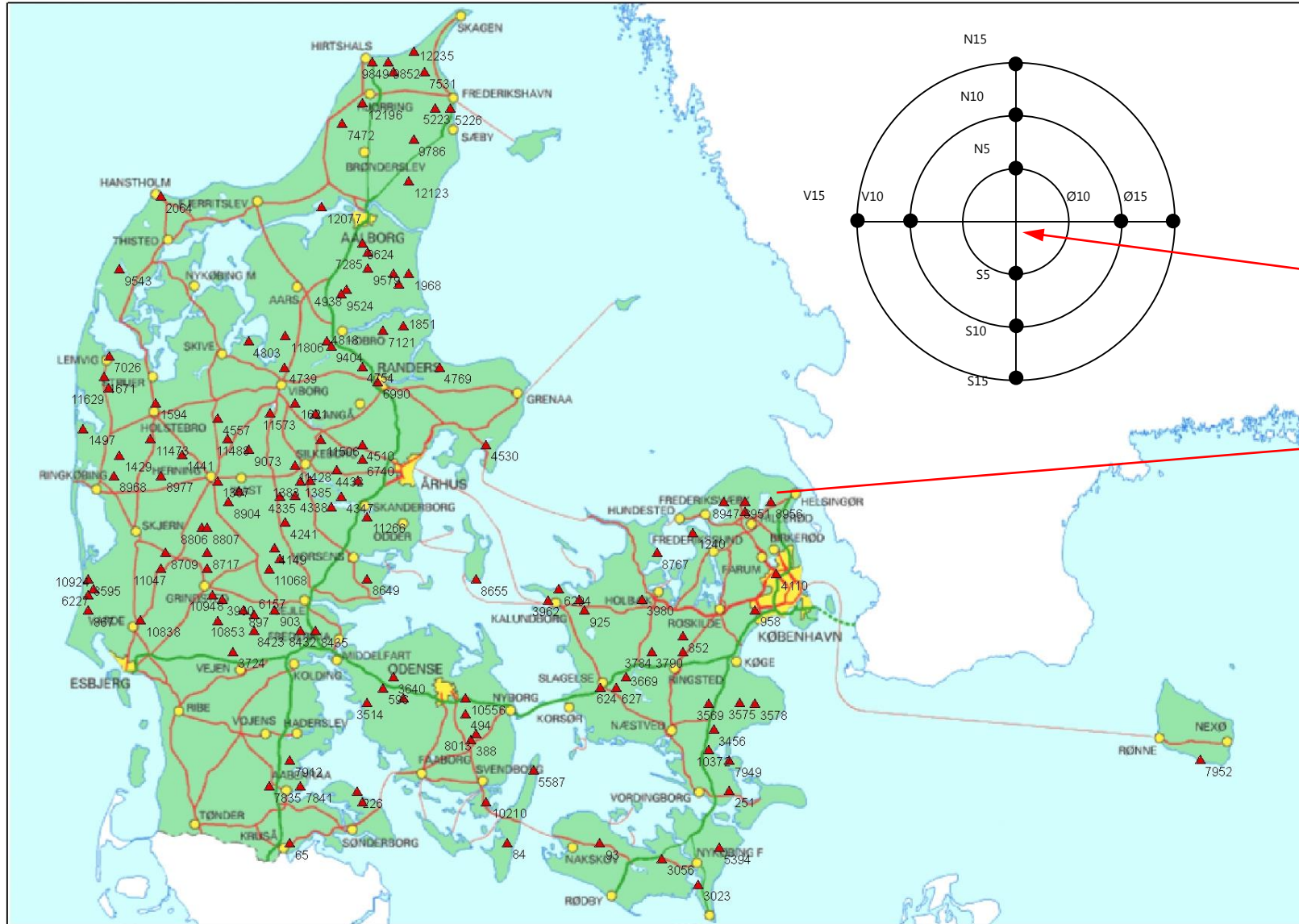
Forest floor C stock change in the two inventory networks – sneak peak...

- KN: 108 plots
- NFI: 265 plots
- Similar stocks except organic soils
- No clear change

10/09/2021

Mineral soil C stock change in the two inventory networks – sneak peak…
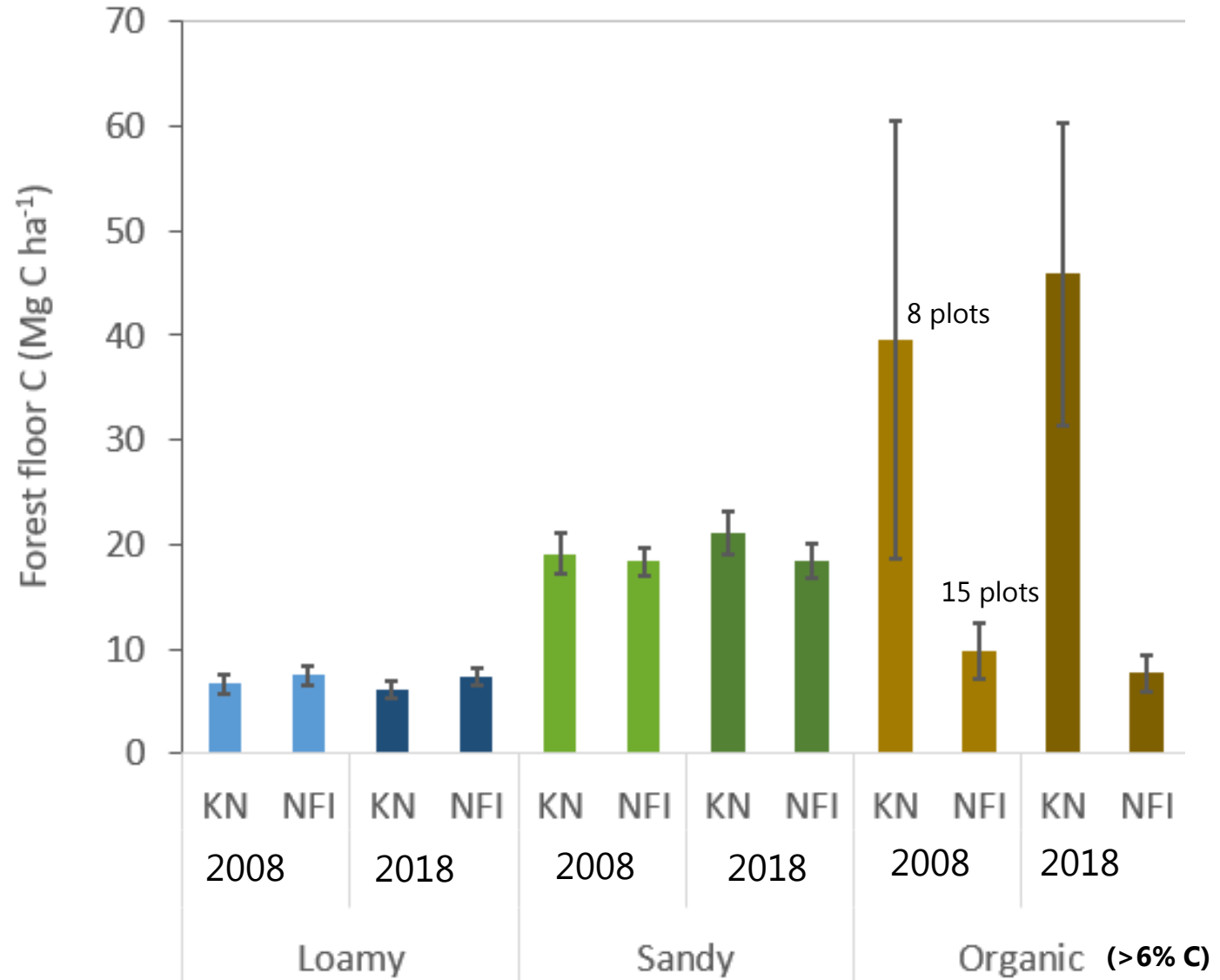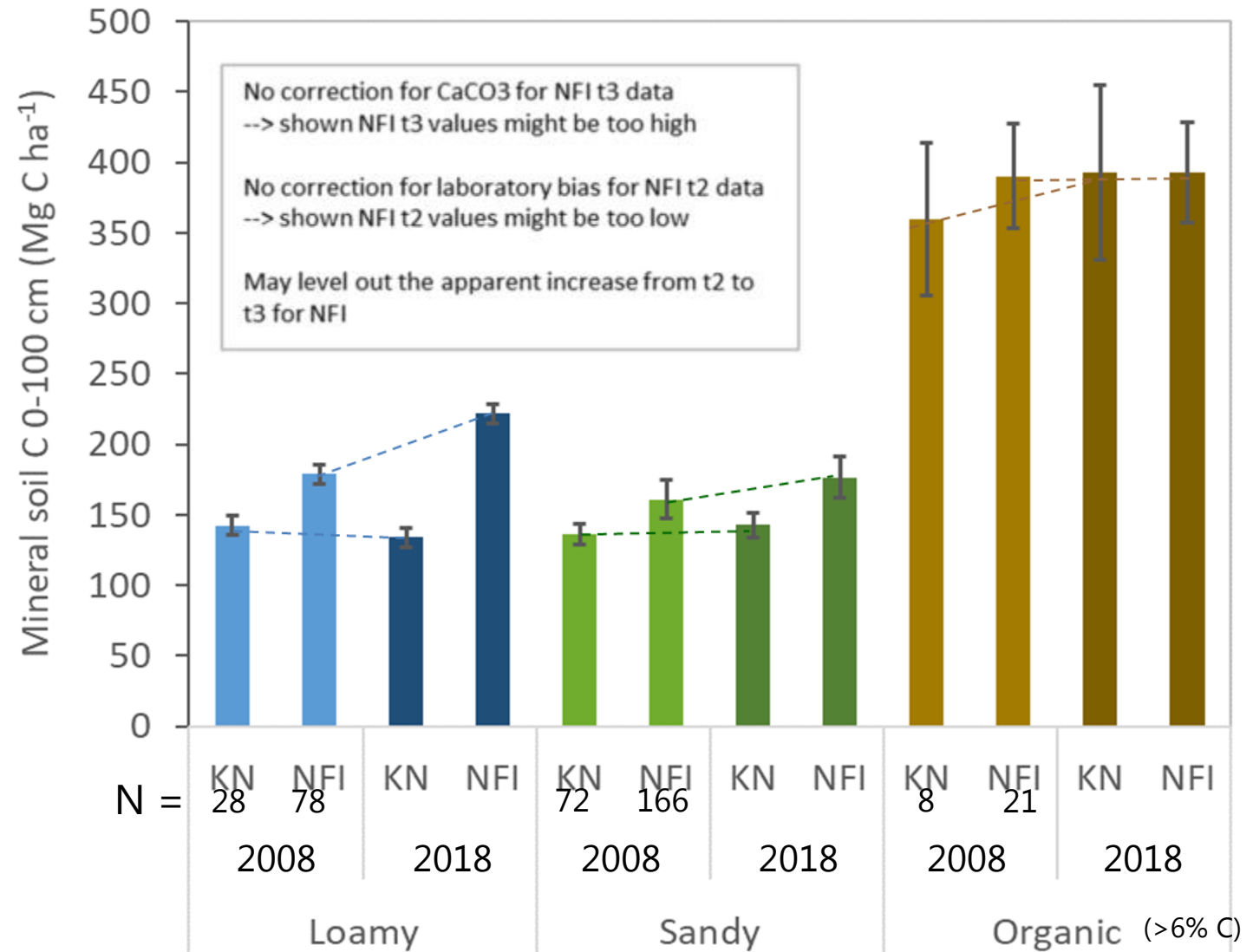
- KN: 108 plots
- NFI: 265 plots
- Higher stocks in NFI
- Increasing stocks in NFI
- Corrections to be implemented

pH (60 to 100 cm depth)
9,6
2,4

Roell et al. 2021

No correction for CaCO3 for NFI t3 data
--> shown NFI t3 values might be too high

No correction for laboratory bias for NFI t2 data
--> shown NFI t2 values might be too low

May level out the apparent increase from t2 to t3 for NFI

	KN	NFI	KN	NFI	KN	NFI	KN	NFI	KN	NFI	KN	NFI
N =	28	78			72	166			8	21		
	2008		2018		2008		2018		2008		2018	

Loamy · Sandy · Organic (>6% C)
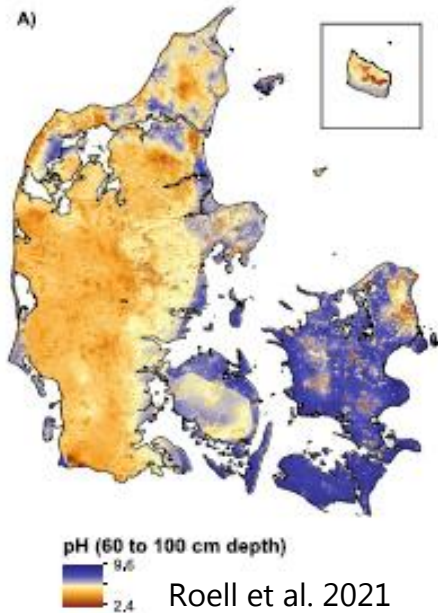
Modelling forest floor C stock from forest floor thickness – pedotransfer functions

10 cm ~ 40 t C/ha

Broadleaves: $\sqrt{y} = 0.4239 + 0.5653x$
Conifers : $\sqrt{y} = 1.2458 + 0.5653x$
$R^2 = 0.88, p < 0.0001$
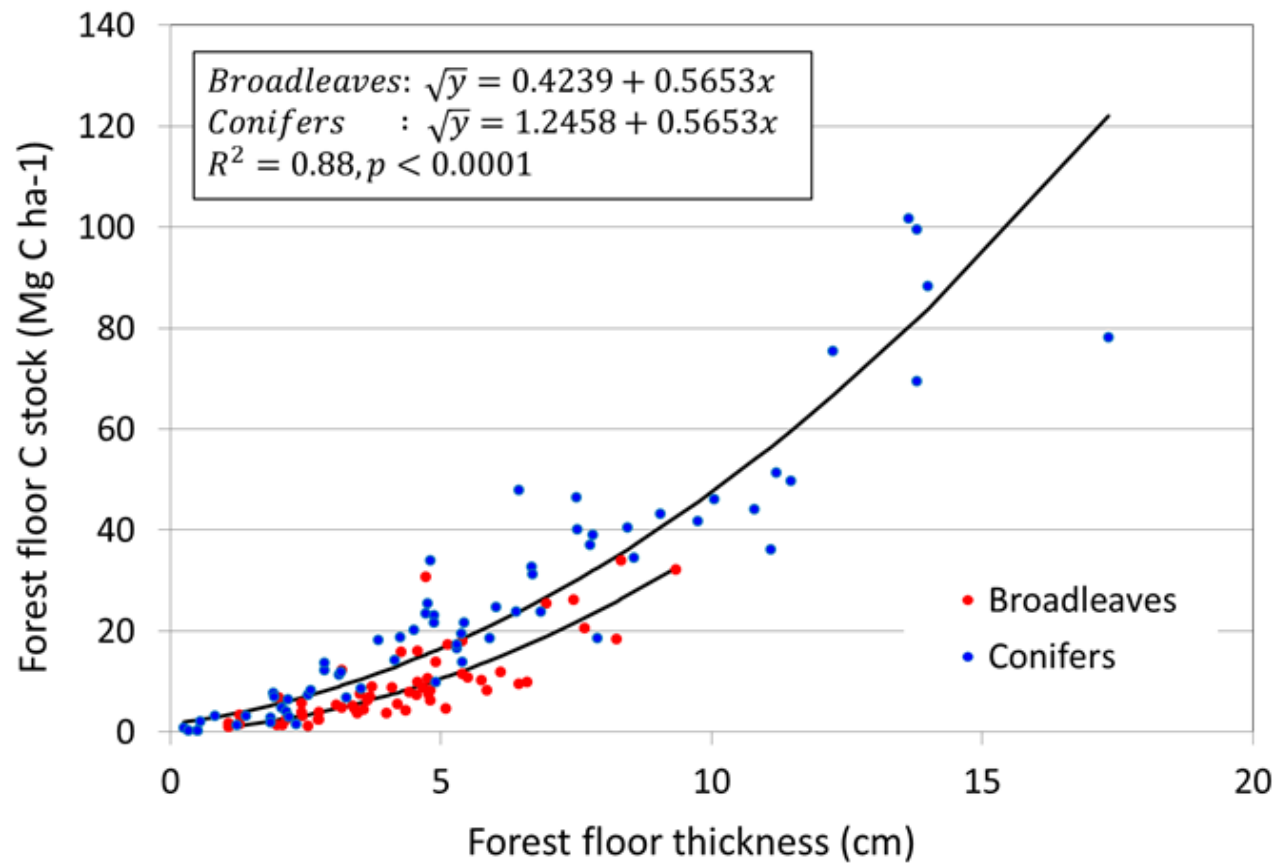
Conclusions, challenges and outlook

- Inventory networks established with other main aims, no forest floors sampled in 1990···more dynamic part of soil profile missing, corrections ongoing···

- Small temporal changes observed compared to variability

- Mineral soil C influenced by soil type (texture, drainage)

- Forest floor C influenced by tree species and soil type

- Forest floor C stocks can be predicted from NFI measurements of forest floor depth

- Merging of Nitrate Network (130 plots) with NFI (ca. 280 plots) expected to improve C stock change estimates

NFI plot 9849G   2010   2019

Thank you!

9849G
²/6-10
C -> N

Pedotransfer functions for bulk density – extension to soils >6% C - new measurements

$$\sqrt{y} = 1.3049 - 0.1202\sqrt{x}$$
$$R^2 = 0.90, \quad p < 0.0001$$

Legend:
- Measured bulk density
- Modelled
- Sandy soil, ABE horizons (Vejre et al. 2003)
- Sandy soil, C horizons (Vejre et al. 2003)
- Loamy soil, ABEC horizons (Vejre et al. 2003)
- Organic soil > 10% C (2009 equation)

Axis labels: Bulk density (g cm-3) vs C concentration (%)