

SOIL ORGANIC CARBON AS A SOIL HEALTH INDICATOR

PLANTEKONGRESS

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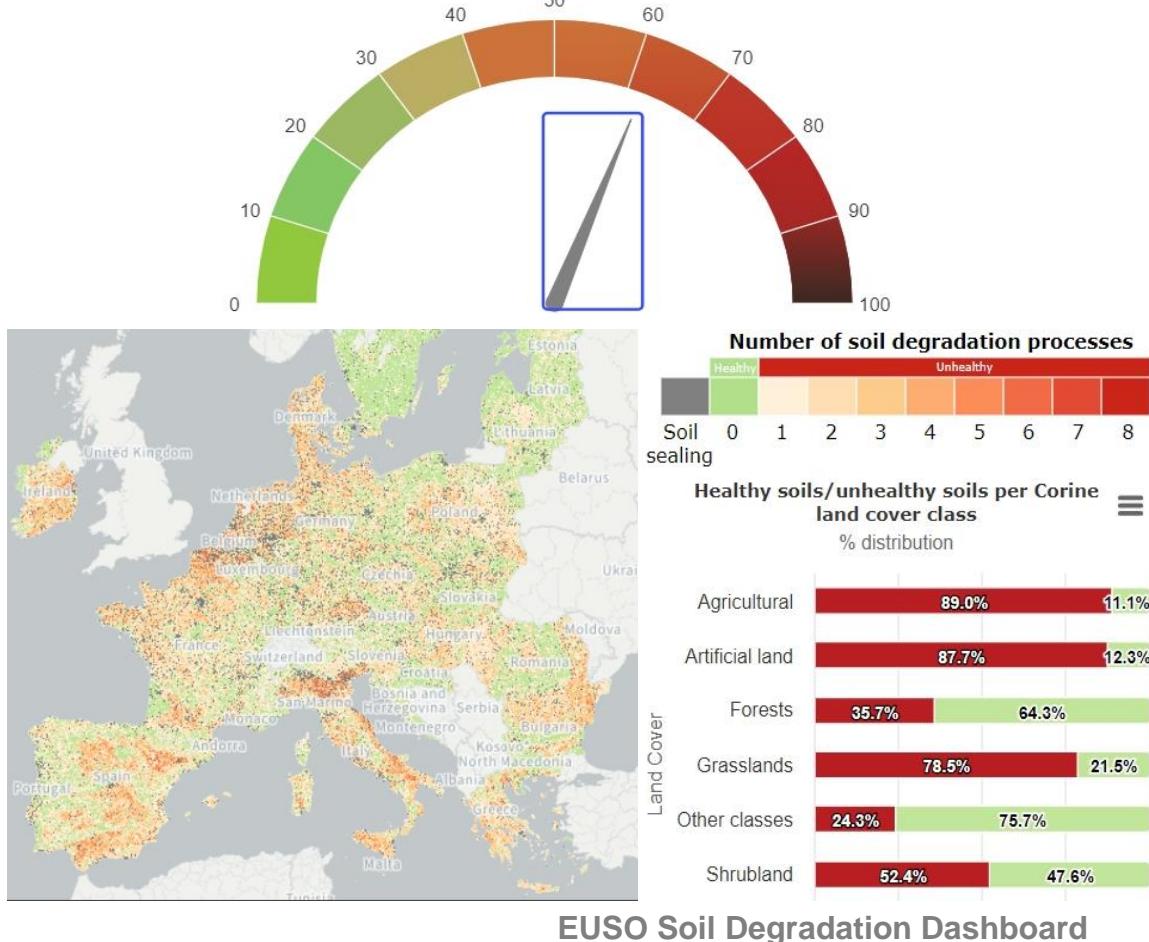
HEALTHY SOILS, DEFINITION

Soil health is defined as: "the physical, chemical and biological condition of the soil determining its capacity to function as a vital living system and to provide ecosystem services"

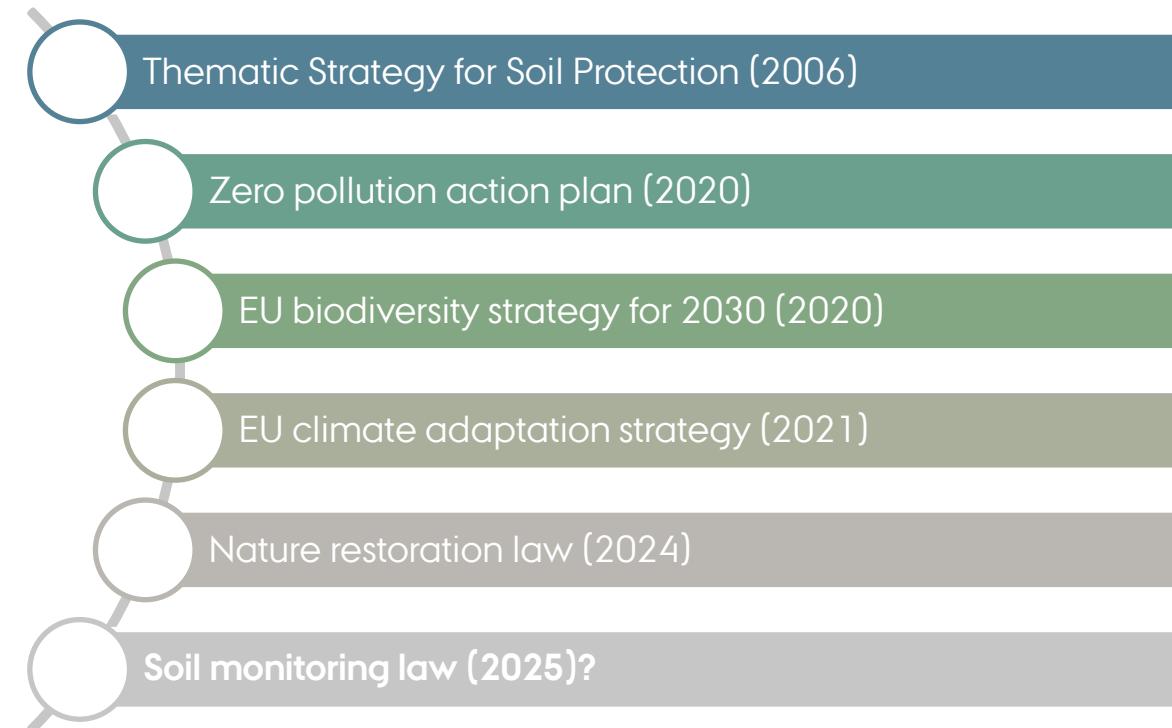
Jordens sundhed defineres som: Den fysiske, kemiske og biologiske tilstand i jorden, der sikre dens evne til at fungere som et levende system og leve op til økosystemtjenester

SOIL HEALTH ASSESSMENT

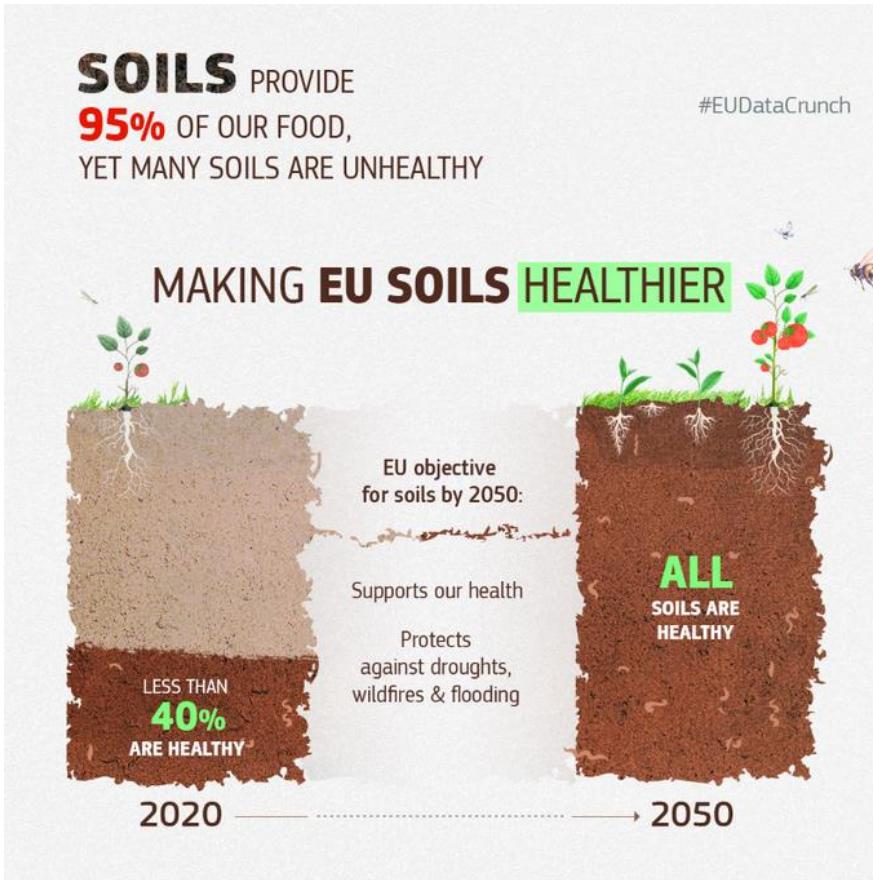
Soil degradation in the EU → 62% of the area



EU Soil Thematic Strategy → initiatives increasing the awareness of the need for soil protection (EU level)



SOIL HEALTH ASSESSMENT



Proposed list of indicators to assess soil health

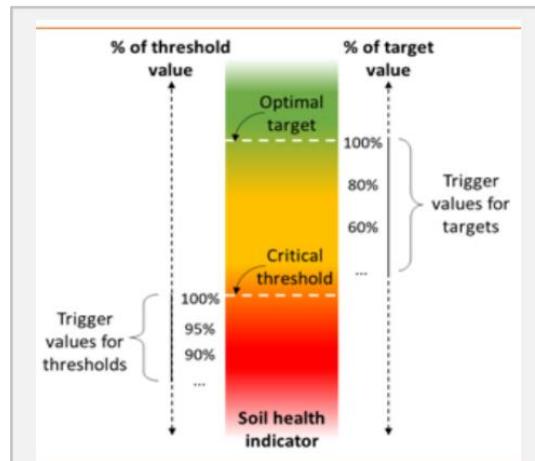
- Electrical conductivity
- Soil erosion
- SOC concentration
- Bulk density (top and subsoil)
- Concentration of pollutants
- Soil water holding capacity
- Soil biodiversity
- Land take and soil sealing

SOIL HEALTH ASSESSMENT

Soil health indicators are assessed using:

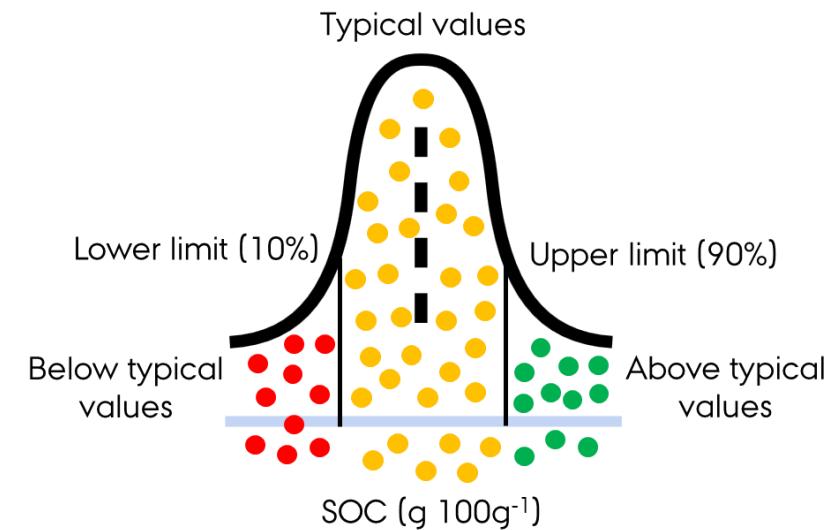
- **Targets** → desirable values to reach
- **Thresholds** → critical values not to overpass
- **Benchmarks** → when no thresholds are available

Targets and thresholds



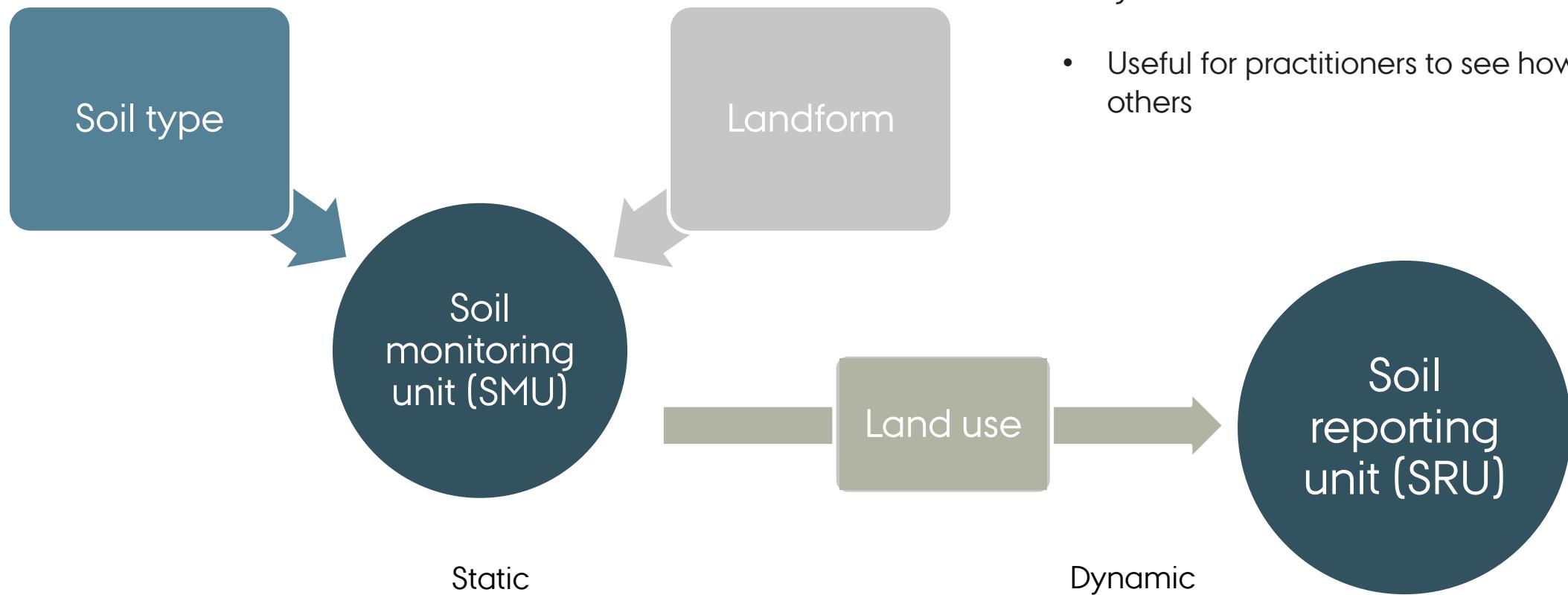
(Matson et al., 2024)

Benchmark values

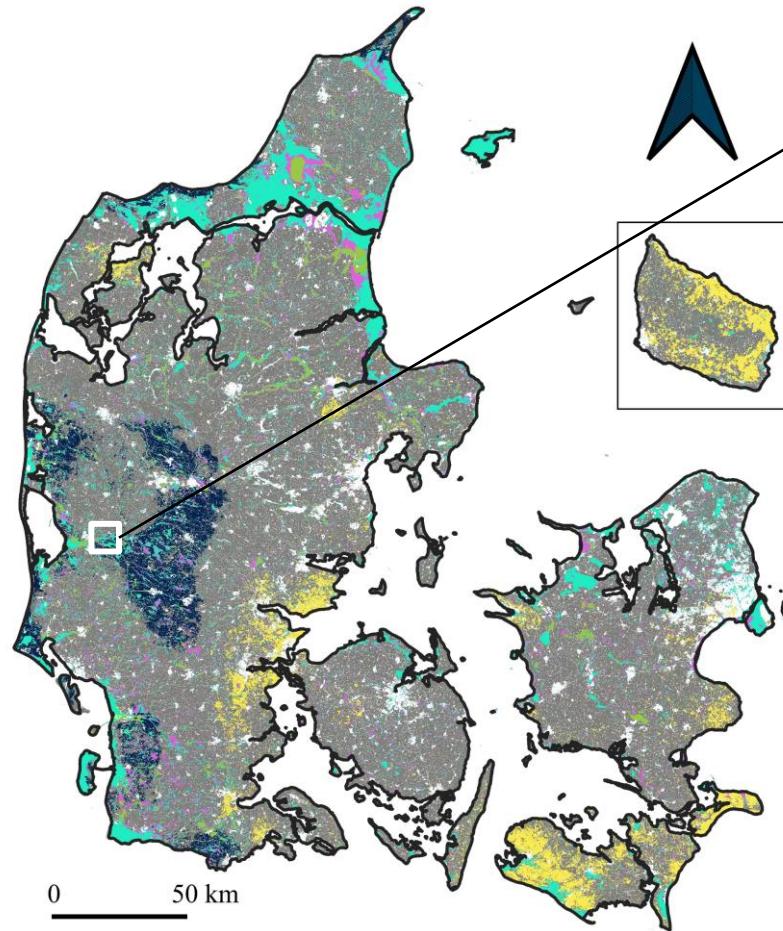


Land stratification to assess soil health

SOIL HEALTH ASSESSMENT



SOIL TYPE



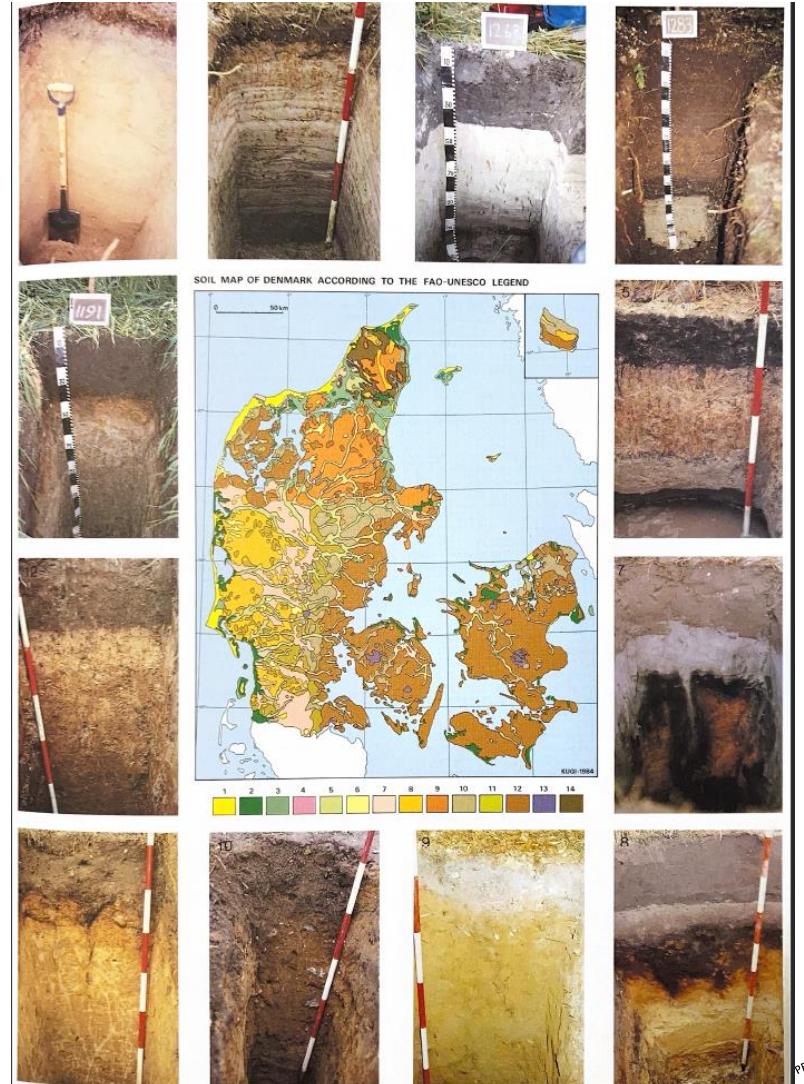
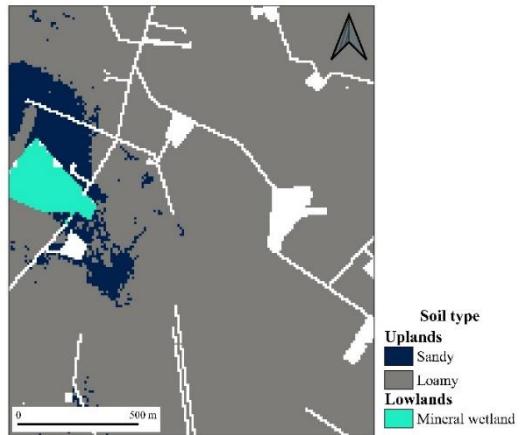
Soil type

Uplands

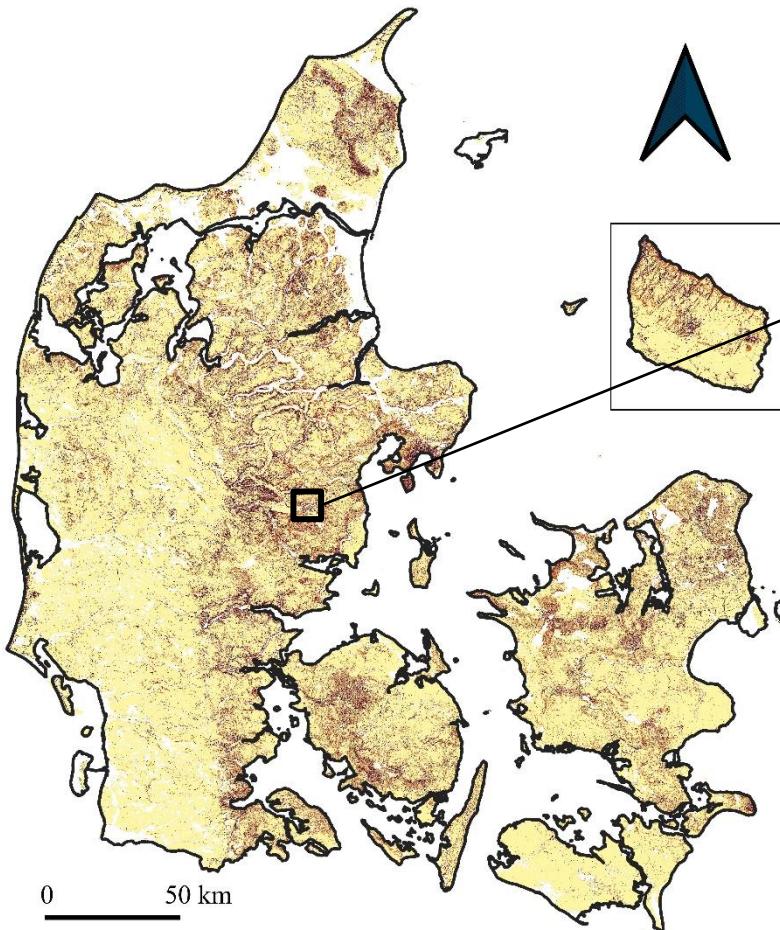
- Sandy
- Loamy
- Clayey

Lowlands

- Mineral wetland
- Historic peatland
- Present-day peatland

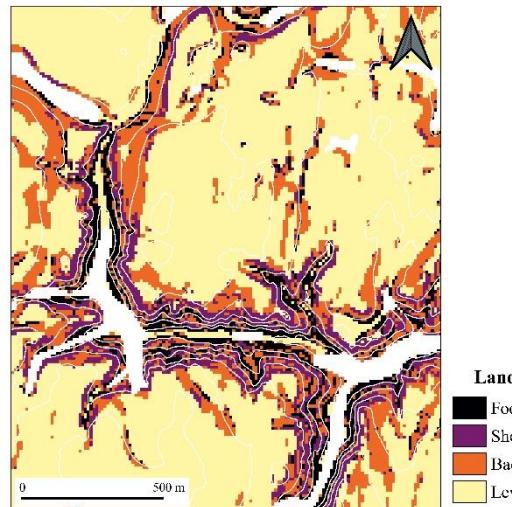


LANDFORM (UPLANDS)

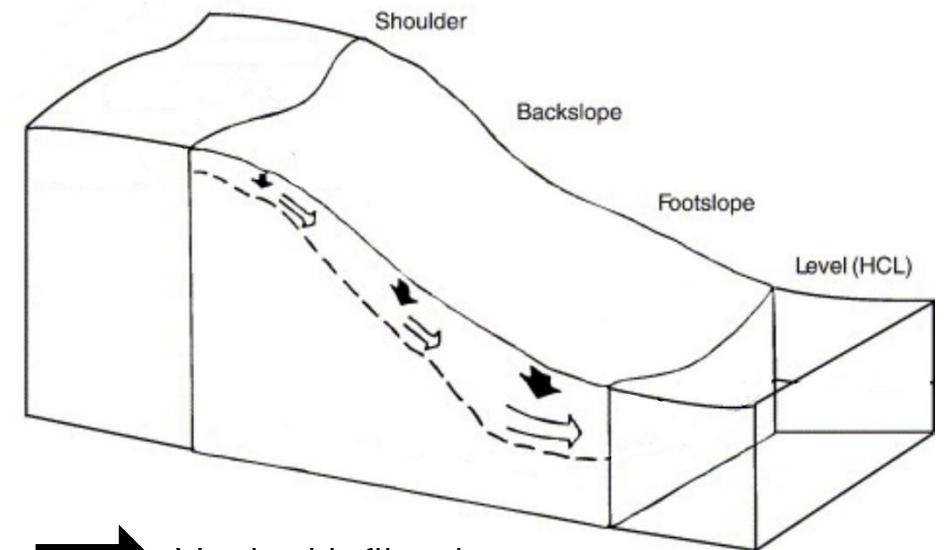


Landform

- Footslope
- Shoulder
- Backslope
- Level-flat



Water movement associated with different landform elements in a hillslope system



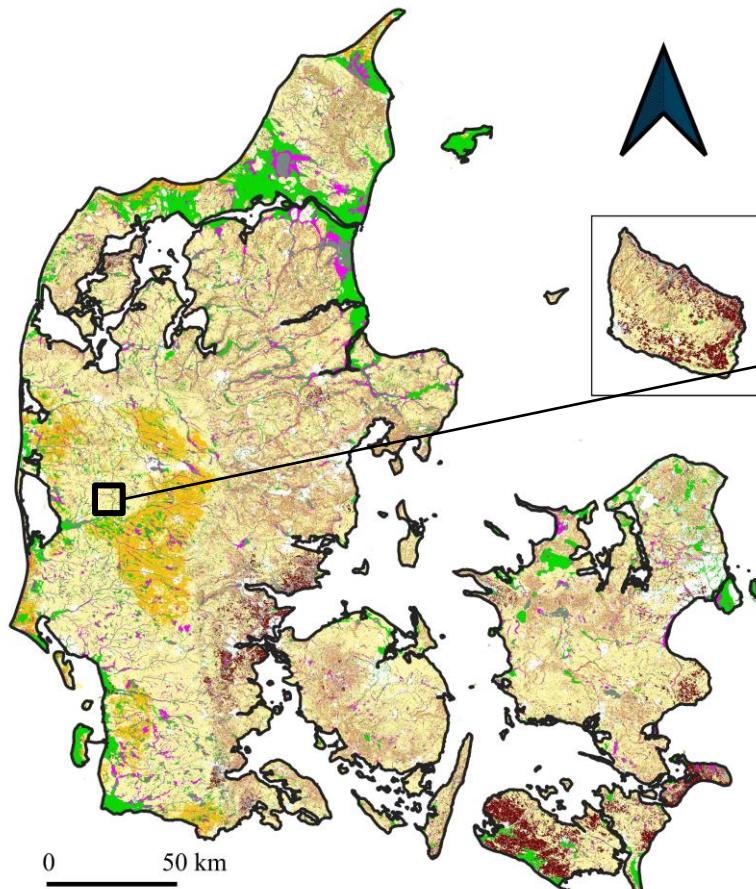
→ Vertical infiltration

Adapted from Pennock et al. (1987)

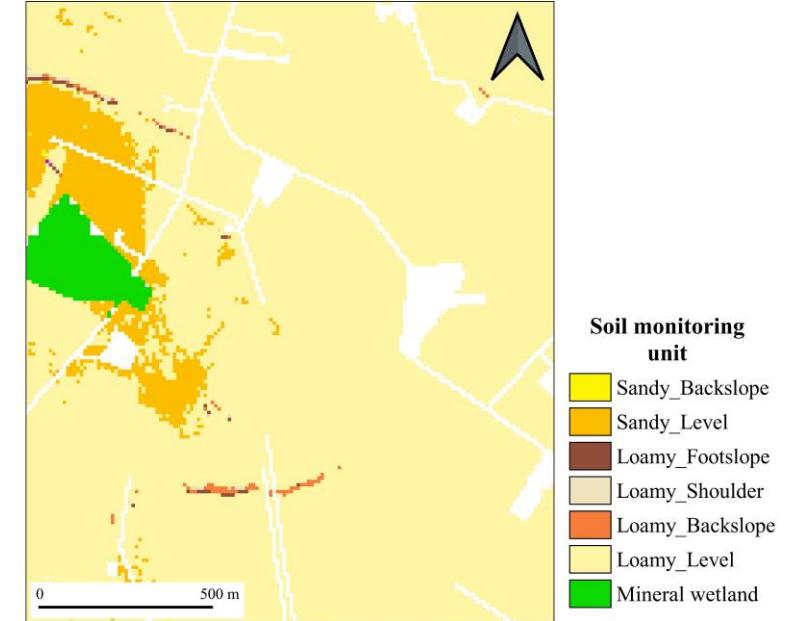
→ Subsurface flow

SOIL MONITORING UNITS

Soil type + Landform → Soil monitoring unit

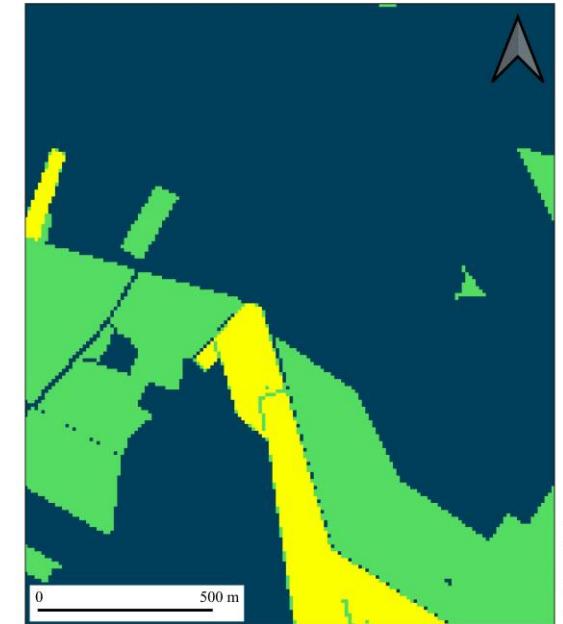
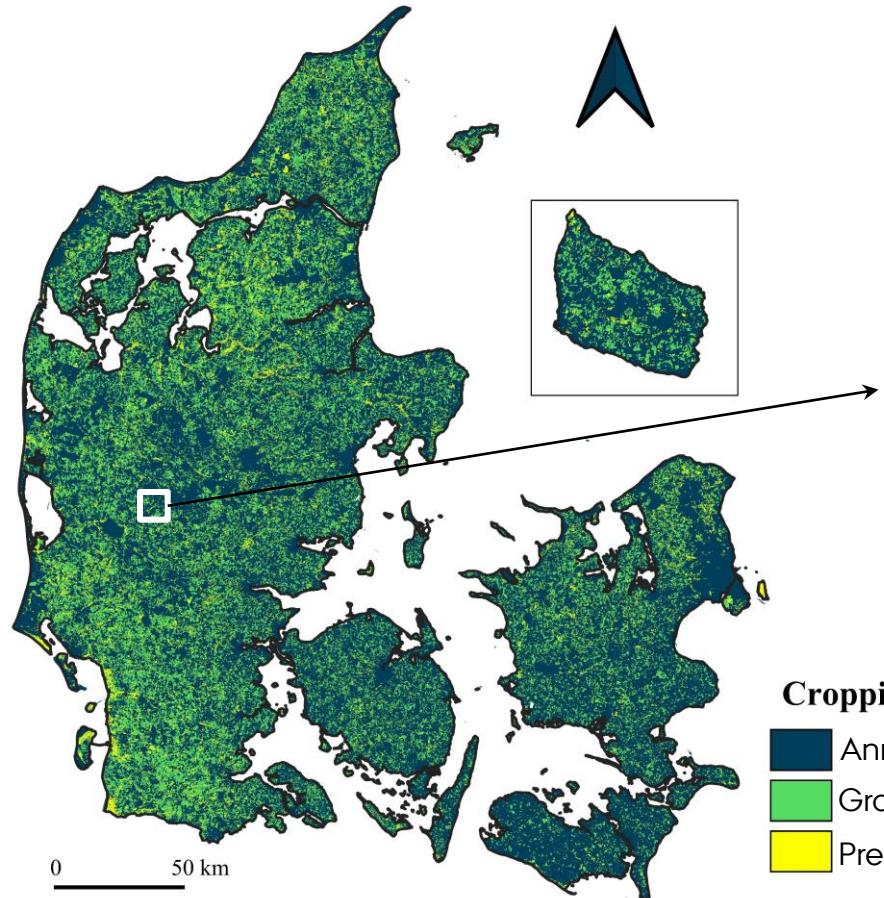


- Soil monitoring units**
- Sandy_Footslope
 - Sandy_Shoulder
 - Sandy_Backslope
 - Sandy_Level
 - Loamy_Footslope
 - Loamy_Shoulder
 - Loamy_Backslope
 - Loamy_Level
 - Clayey_Footslope
 - Clayey_Shoulder
 - Clayey_Backslope
 - Clayey_Level
 - Mineral wetland
 - Historical peatland
 - Present-day peatland



LAND USE (CROPPING SYSTEM)

Cropping systems classification based on the years cultivated with grass (2011-2020)



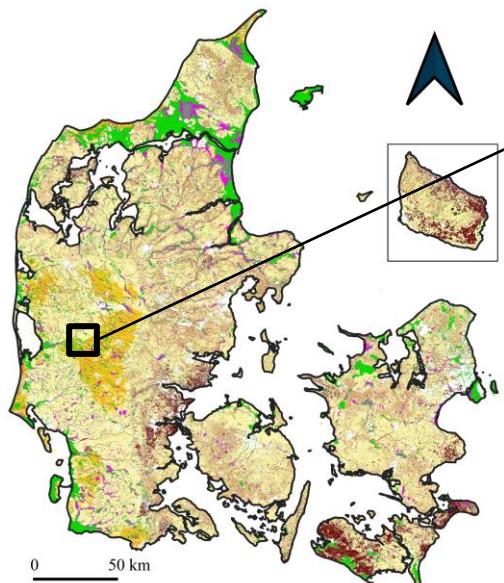
Cropping system

- Annual crop → 0 years with grass
- Grass in rotation → Less than 5 years
- Predominantly grass → More than 5 years



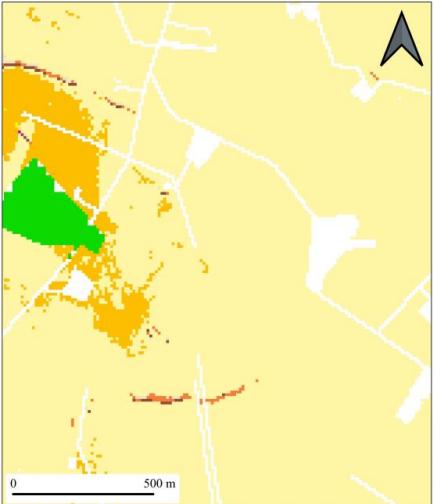
SOIL REPORTING UNITS

Soil monitoring units + Land use → Soil Reporting Unit



Soil monitoring units

- Sandy_Backslope
- Sandy_Level
- Loamy_Footslope
- Loamy_Shoulder
- Loamy_Backslope
- Loamy_Level
- Mineral wetland



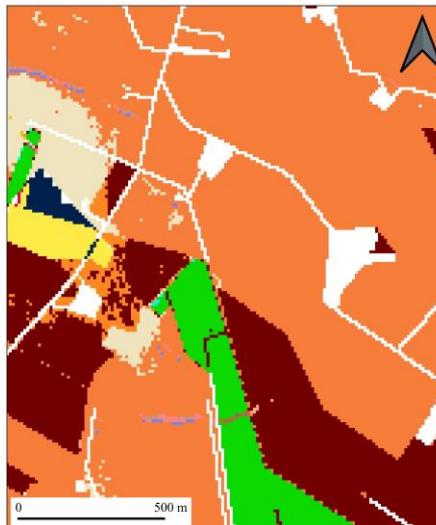
Soil monitoring unit

- Sandy_Backslope
- Sandy_Level
- Loamy_Footslope
- Loamy_Shoulder
- Loamy_Backslope
- Loamy_Level
- Mineral wetland



Cropping system

- Annual crops
- Grass in rotation
- Predominantly grass

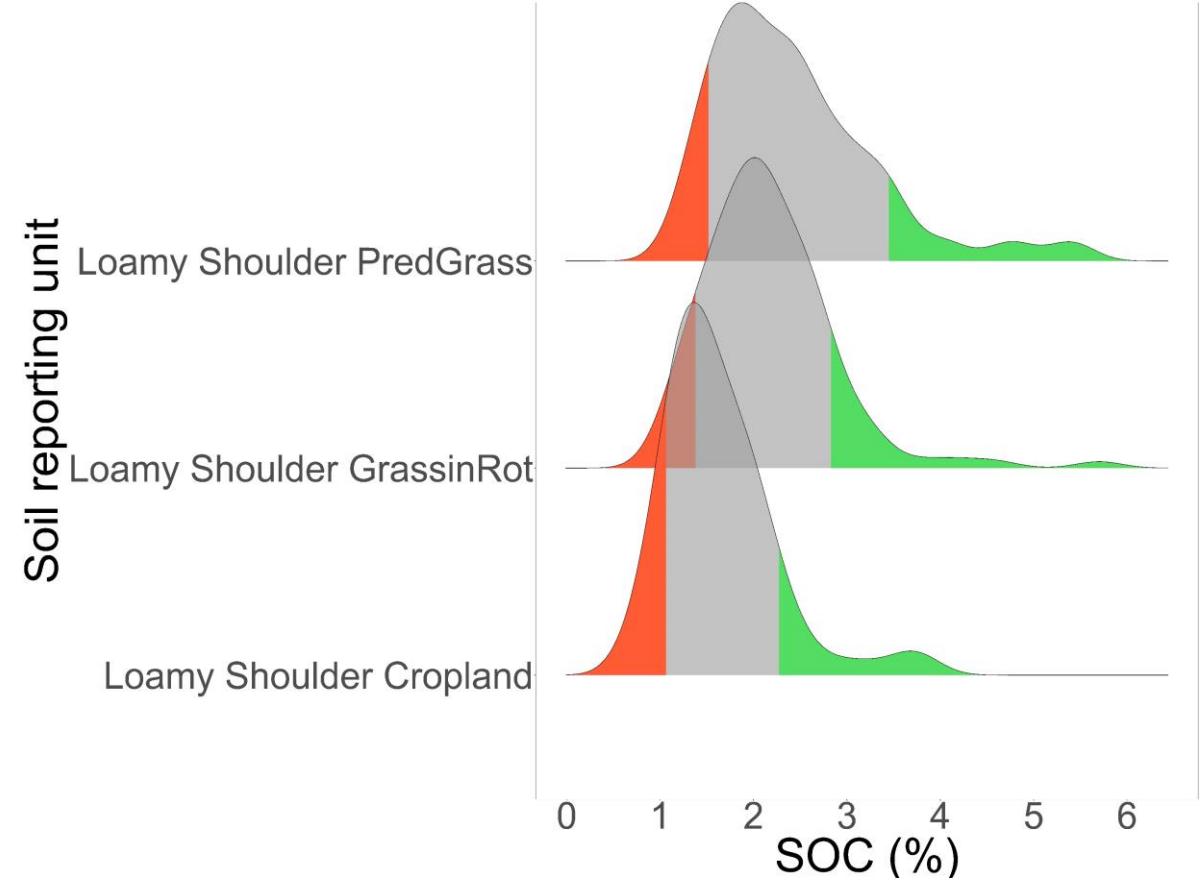
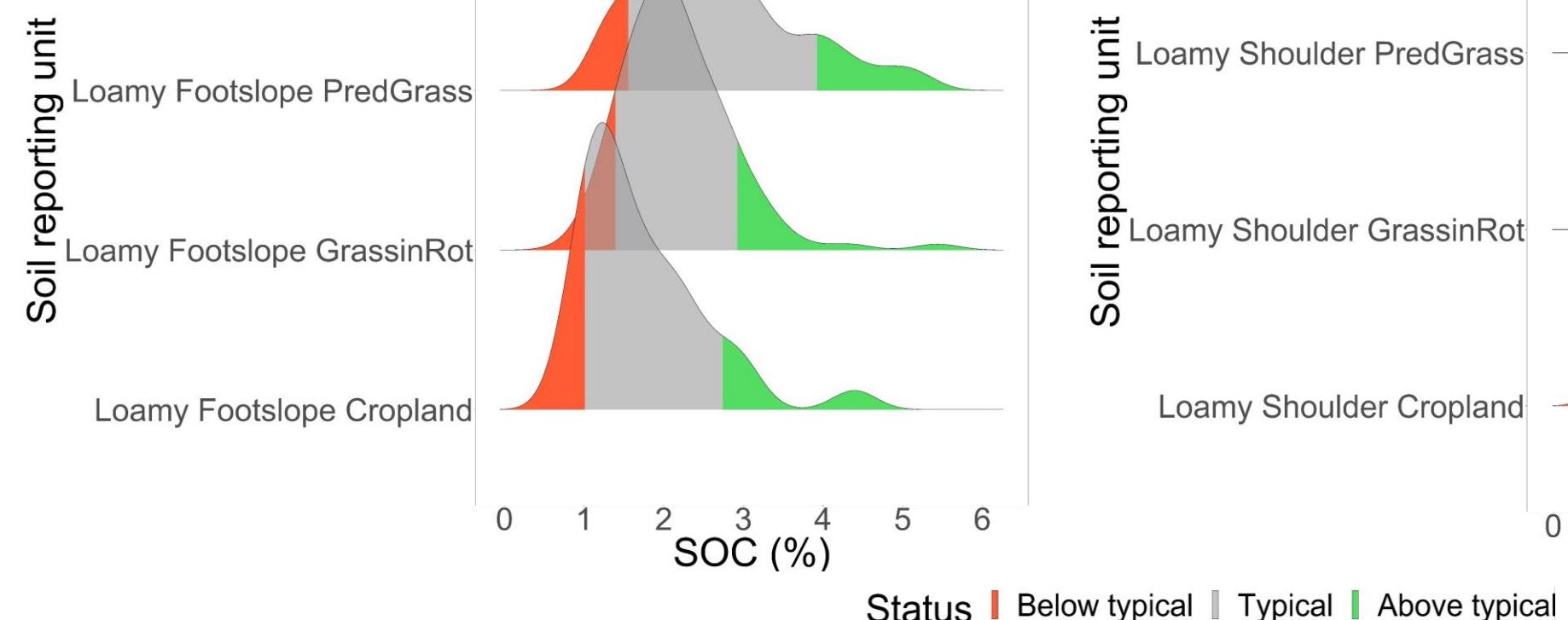


Soil reporting unit

- Sandy_Backslope_Annual crops
- Sandy_Level_Annual crops
- Loamy_Footslope_Annual crops
- Loamy_Footslope_Predominantly grass
- Loamy_Shoulder_Annual crops
- Loamy_Shoulder_Predominantly grass
- Loamy_Backslope_Annual crops
- Loamy_Level_Annual crops
- Loamy_Level_Grass in rotation
- Loamy_Level_Predominantly grass
- Mineral wetland_Annual crops
- Mineral wetland_Grass in rotation

SOIL HEALTH ASSESSMENT → SOC

Soil Monitoring Unit + Land use → Soil reporting unit

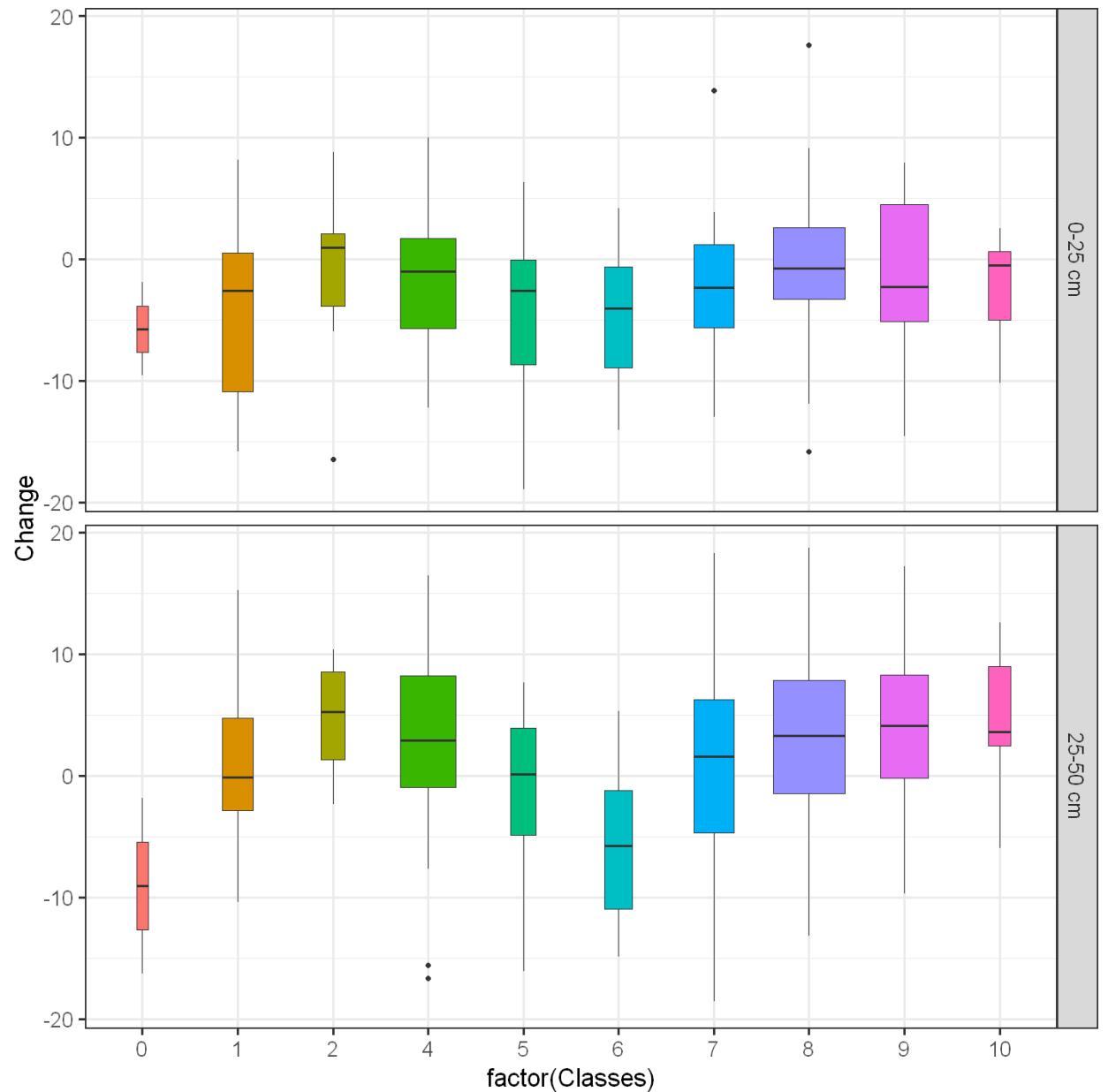
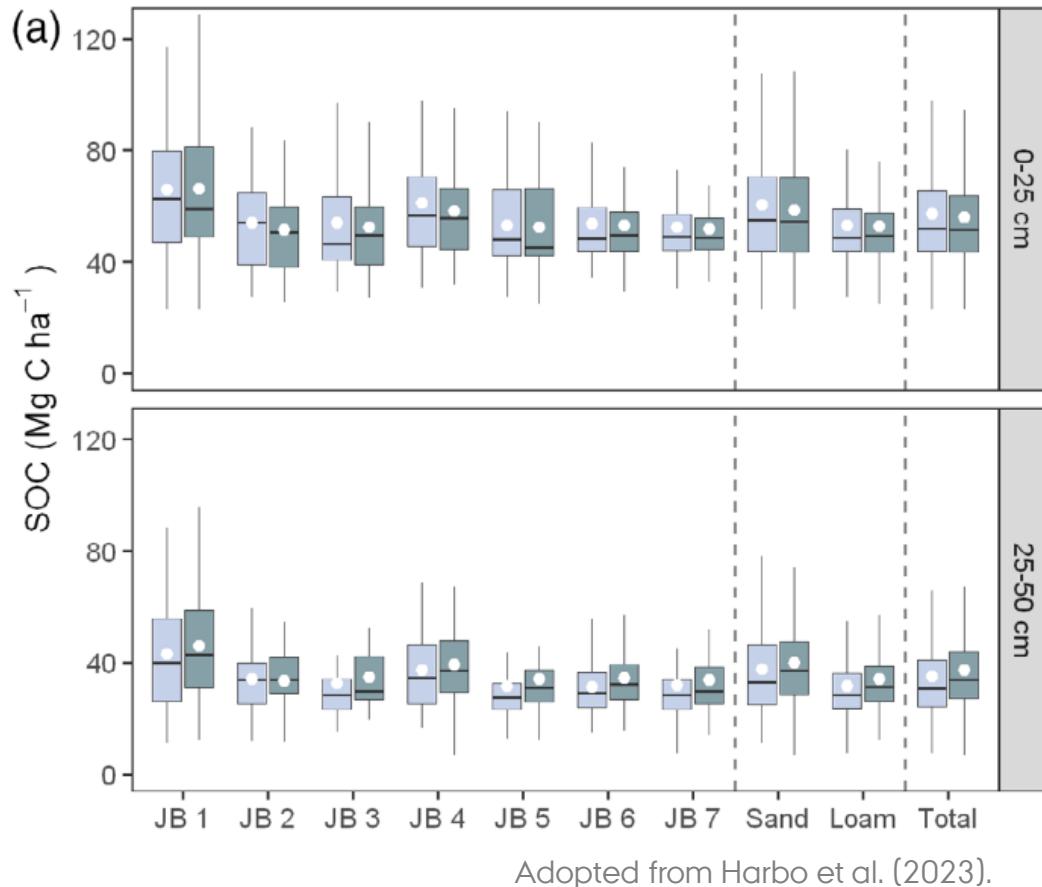


SOC CHANGE IN TIME

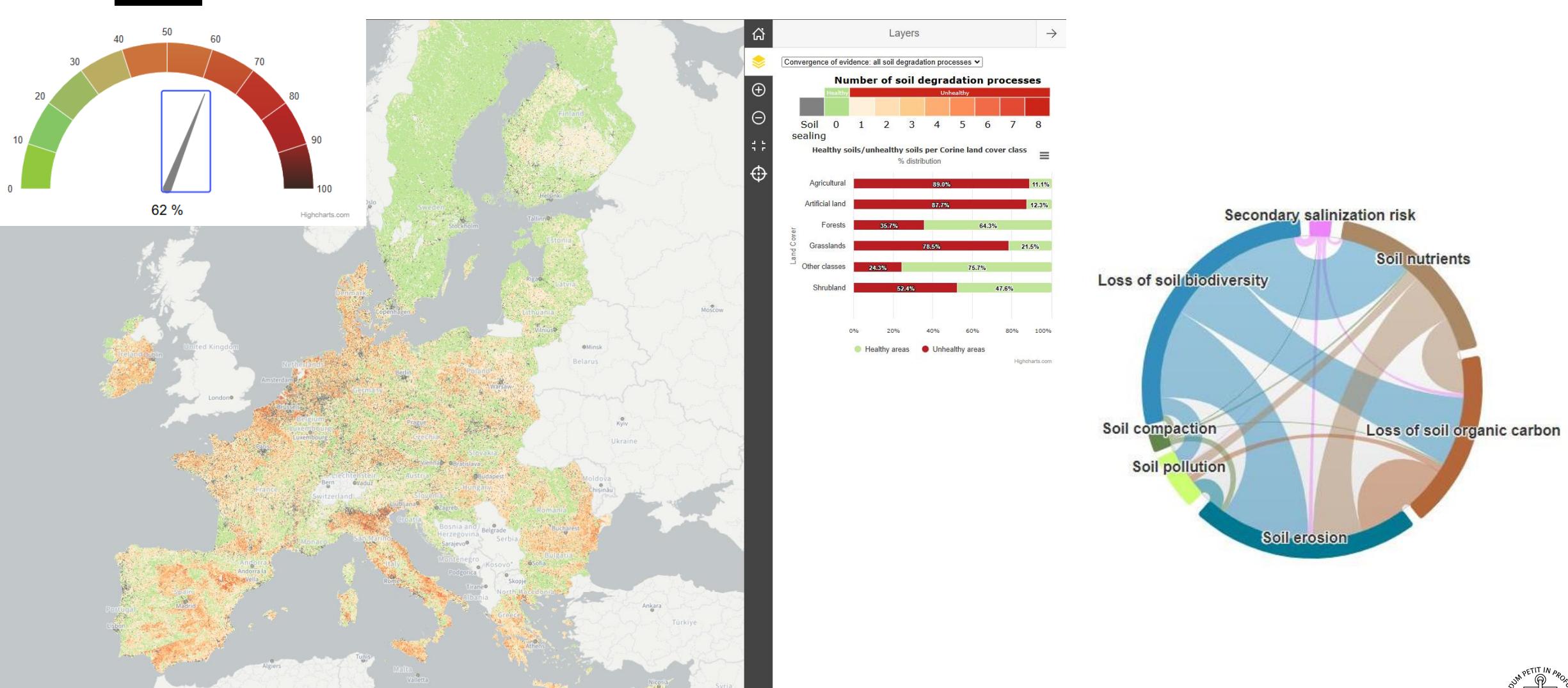
SOC stock estimates ($t C ha^{-1}$) for each JB category.

Data for 2009 in light blue

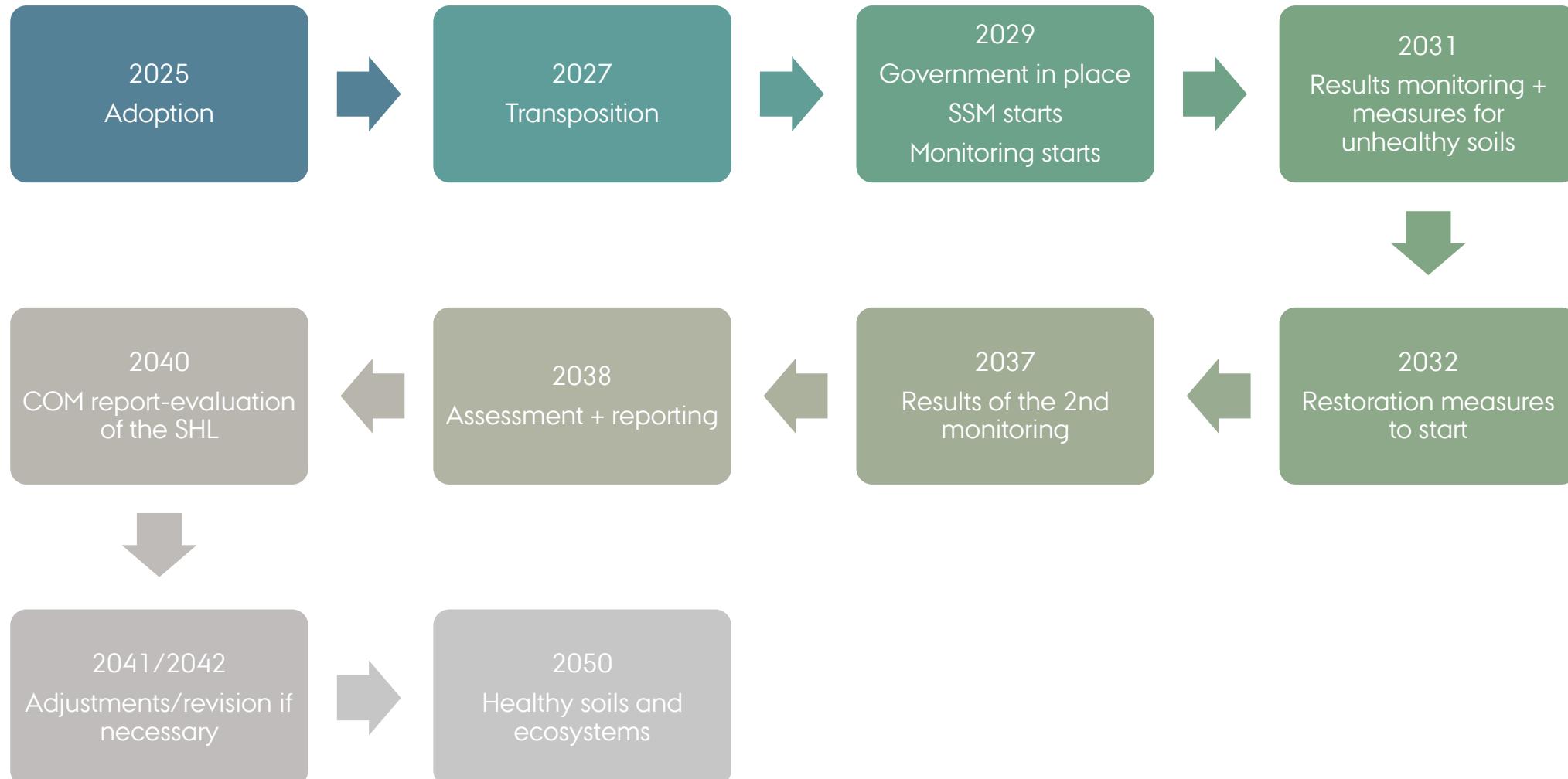
Data for 2019 in dark blue



FROM INDICATORS TO A SOIL HEALTH INDEX



TIMELINE FOR SOIL MONITORING LAW



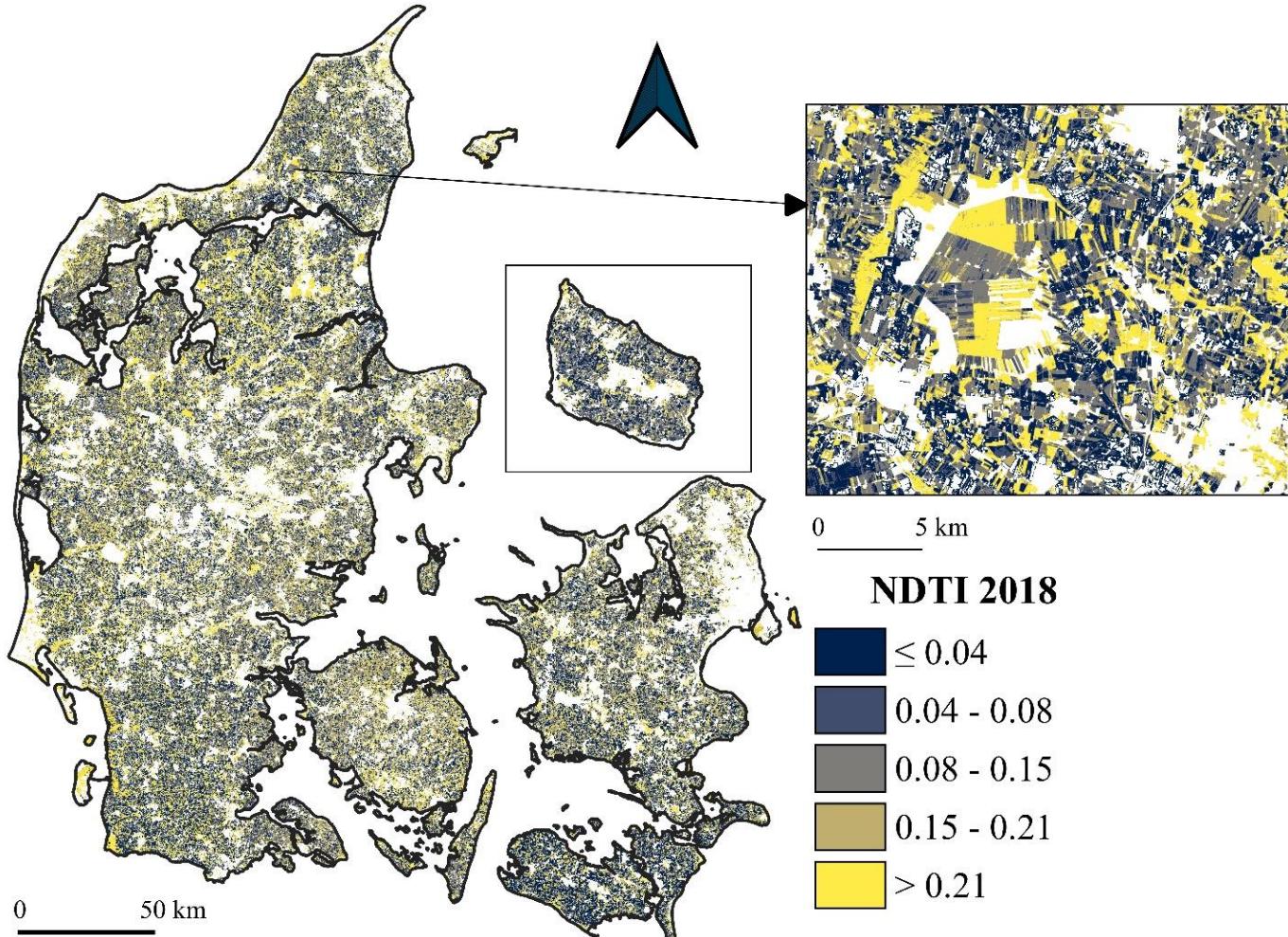
SOIL CARE INDEX

A soil care index could contain the following elements?

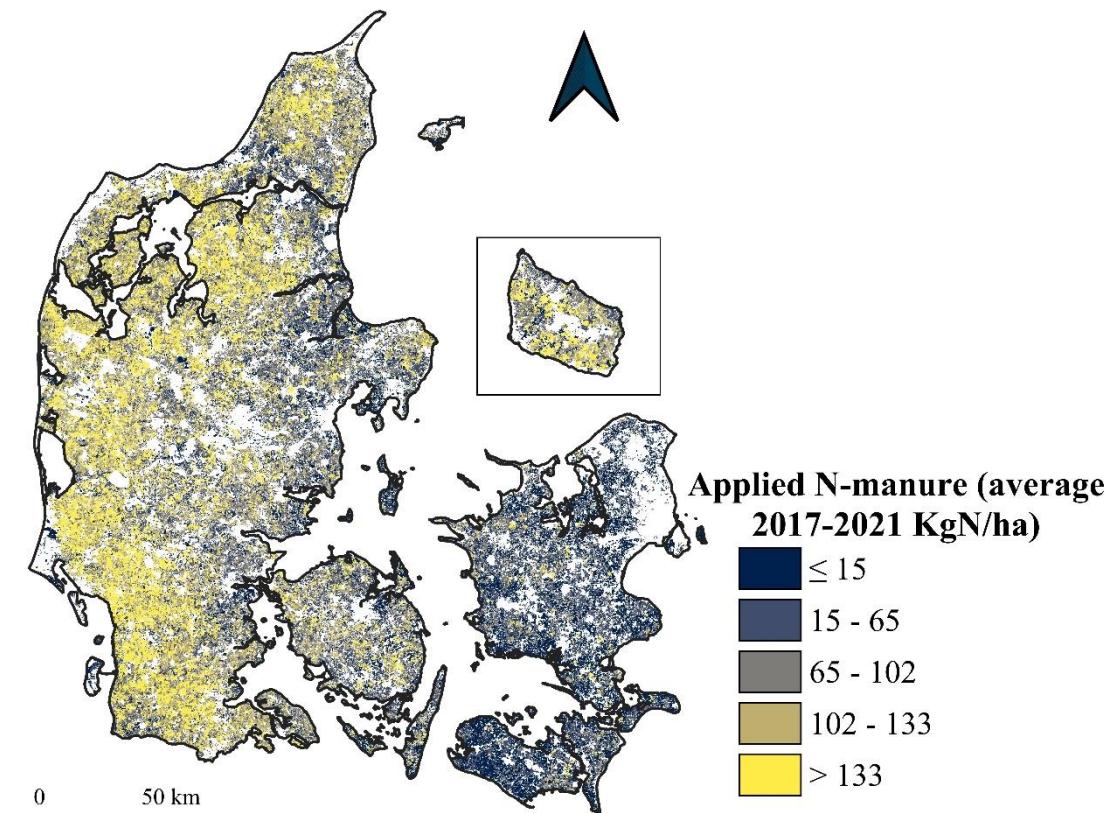
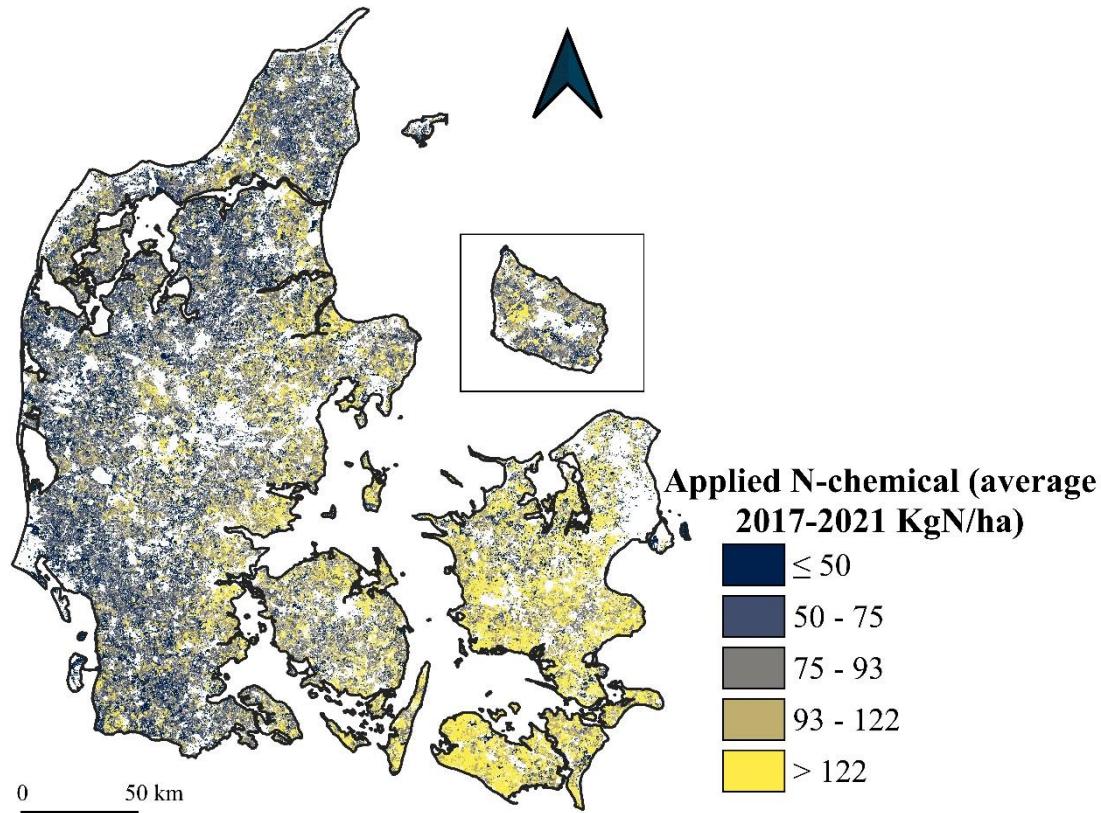
1. Conservation tillage (NDTI index)
2. Reduced and Intelligent traffic
3. No pesticides
4. Minimum chemical fertilizer
5. Grass in the rotation
6. Animal manure
7. Sustainable irrigation practices
8. Erosion control
9. No sludge
10. No Biochar?
11. Reduced export of organic matter

CONSERVATION TILLAGE

Normalized Difference Tillage Index (NDTI) for 2018 → conservation tillage practices



CHEMICAL VS. ORGANIC FERTILIZER APPLICATION

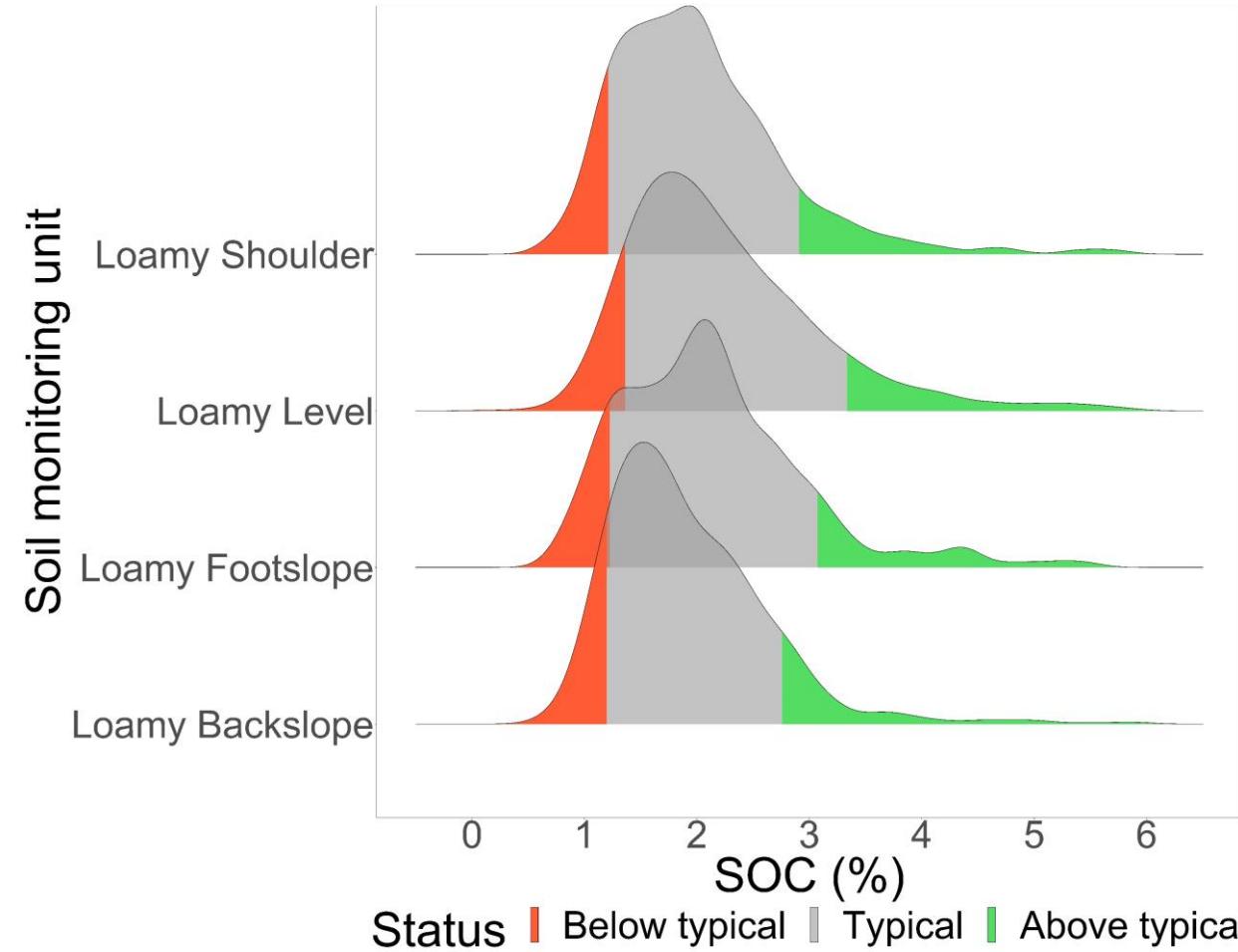
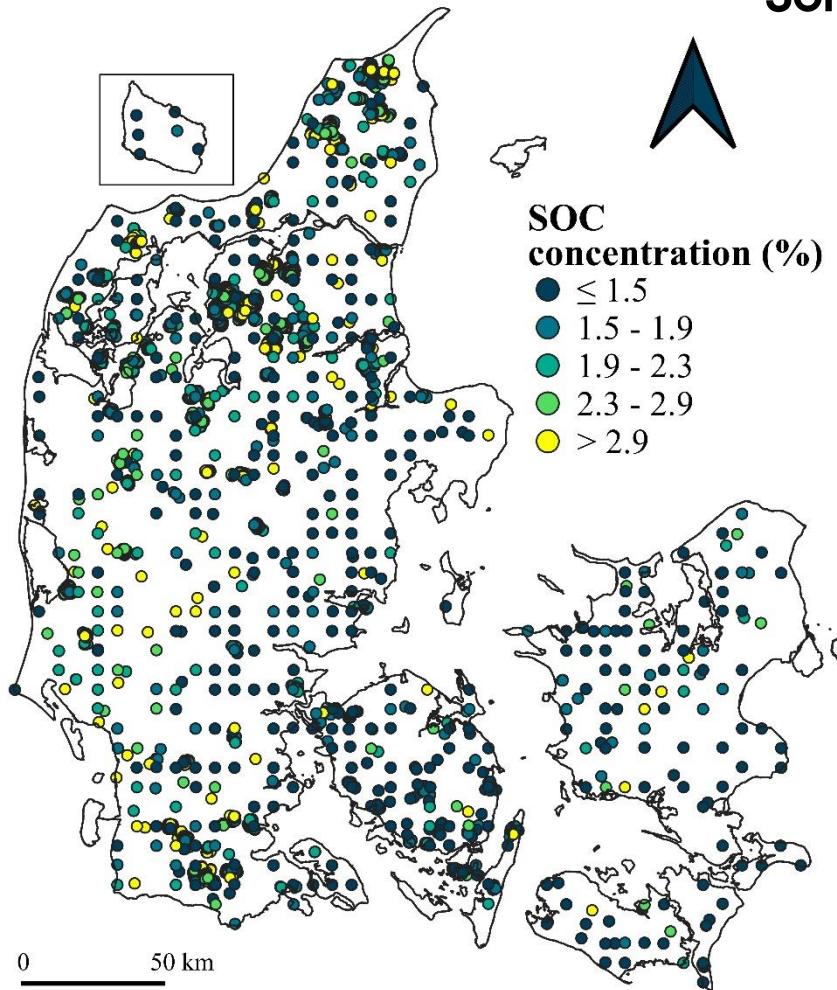




AARHUS
UNIVERSITY

SOIL HEALTH ASSESSMENT → SOC

Soil type + landform → Soil Monitoring Unit



Status | Below typical | Typical | Above typical



Kulstof & dyrkede jorde på Sydhavsoerne

v/ planteavlkskonsulent
Bent Buchwald
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Rundt om kulstof og jord

- ✓ Er et højt Dexter-indeks og dermed lavt kulstofindhold en udfordring på lerjorde?
- ✓ Er et lavt kulstofindhold = lavt udbytte?
- ✓ Er der ”sidegevinster” ved kulstof i jorden
- ✓ Hvem vil betale 300.000 kr. pr ha for lerjord med lavt kulstofindhold = under 2%

Definitioner

- ✓ **Organisk stof i jorden:** Samlet betegnelse for levende og døde organismer i jorden.
 - ✓ **Jordens kulstof-indhold:** Her tages resterende grundstoffer (O, H, N, osv.) i det organiske materiale ikke med i betragtning.
 - ✓ **Jordens humus-indhold:** Betegnelse for stabilt organisk materiale, som er svært nedbrydeligt. Humus udgør normalt 80-90 pct. af det organiske materiale i jorden. Humus indeholder ca. 58 pct. kulstof.
-
- *Alt humus er altså organisk materiale, men ikke alt organisk materiale er humus.*

Hvordan kvantificeres kulstof i jord?

$$\text{Dexter - indeks} = \frac{\text{lerindhold (\%)} }{\text{kulstofindhold (\%)}}$$

- ✓ Mætningsforholdet angiver mængden af ler i gram der kan binde 1 gram organisk stof.
- ✓ DVS. 10 gram ler kan binde 1 gram kulstof = Dexter-indeks = 10

Legend

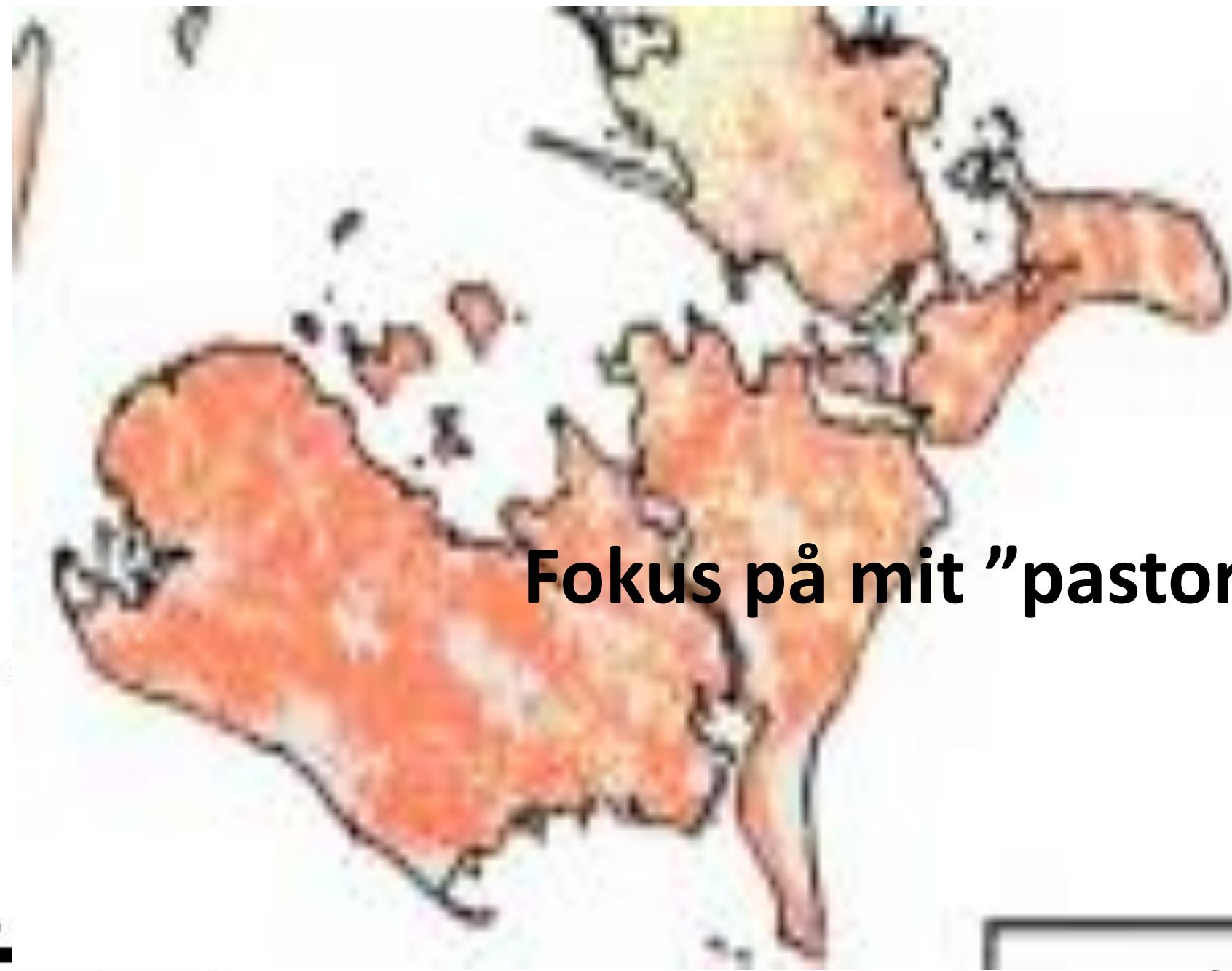
SOC content (%)

- Saturated soils
- Unsaturated soils



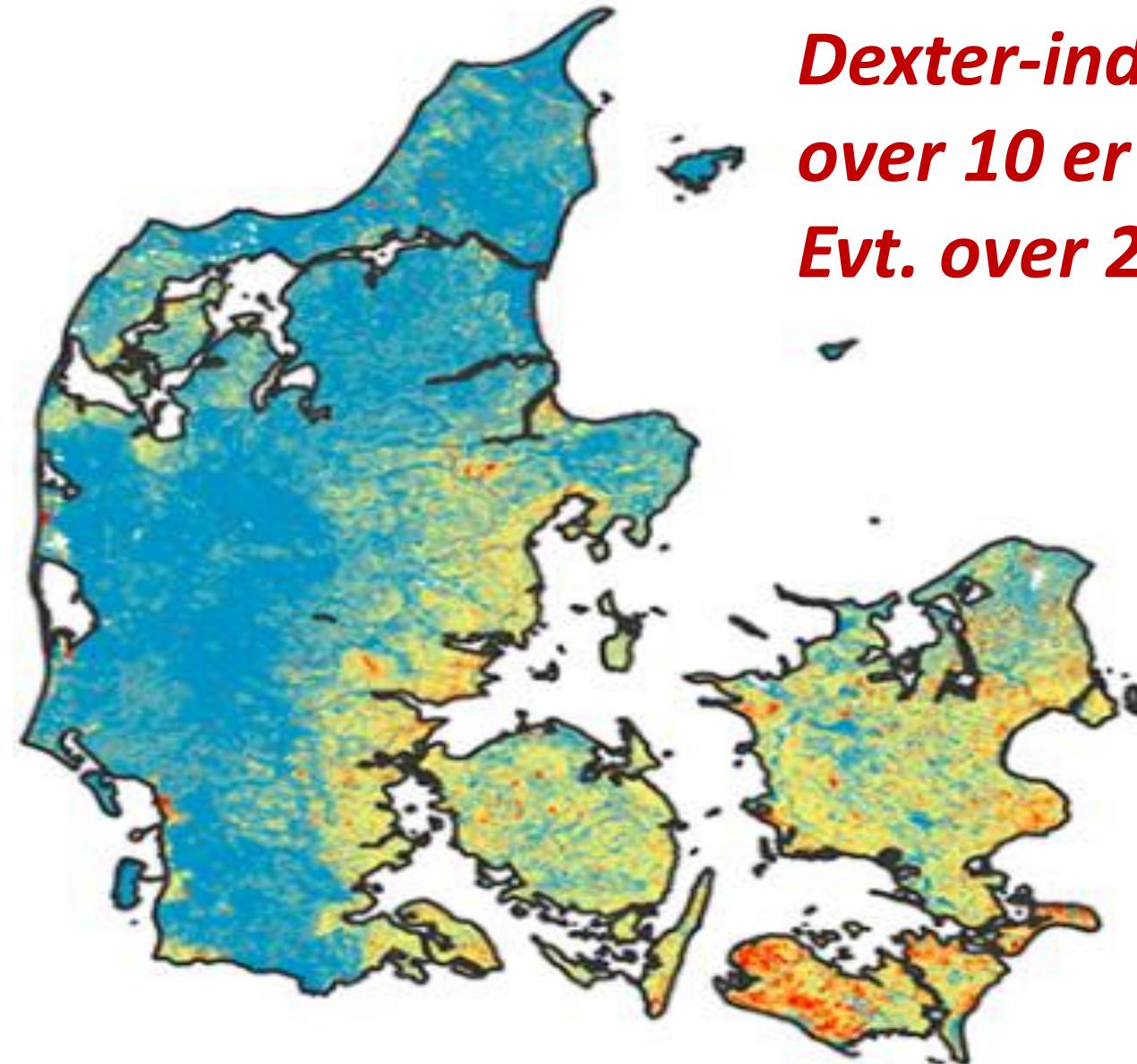
Rødt område =
Jorde der er umættede
med kulstof

(a)

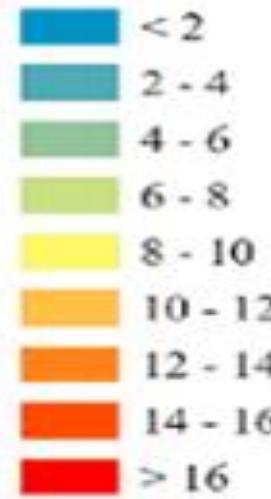


Fokus på mit "pastorat"

Dexter-indeks / I det røde felt!



*Dexter-indeks
over 10 er kritisk
Evt. over 20!*





Legend

Soil organic carbon content (1975-1980)

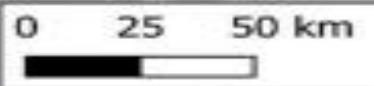
- 0.1 - 2.4
- 2.4 - 3.24
- 3.24 - 4.4
- 4.4 - 5.17

GNS af 38 analyser i 2023 fra Østlolland på 38 forsøgsarealer

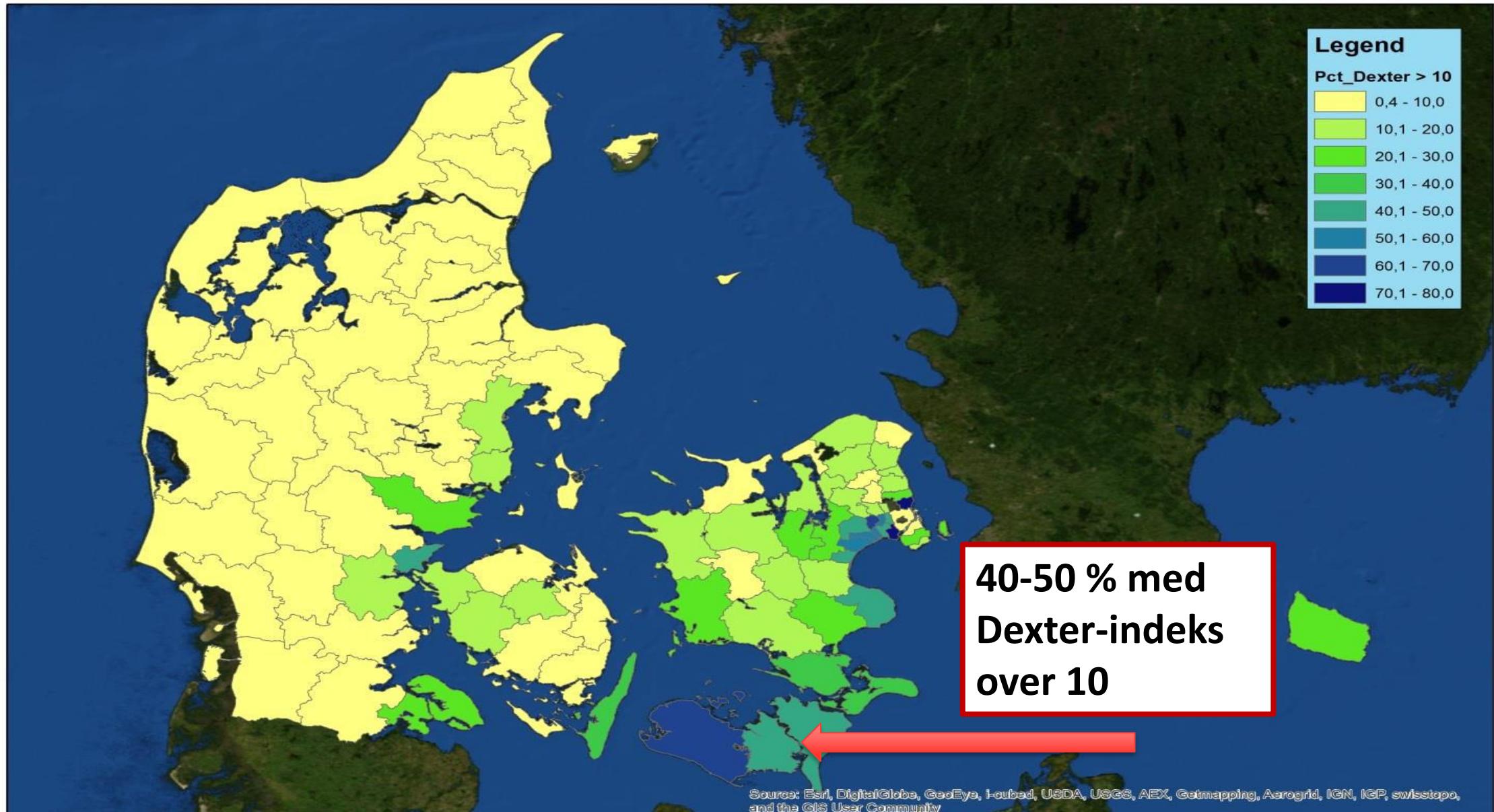
- ✓ Kulstofindhold = 2,37 pct. (variation = 1,33-7,83)
- ✓ Ler-indhold, gns. = 14,48 pct. (variation = 5,9-24,1)

Dexter-index = 6,11

Stor variation selv på "ensartede" forsøgsarealer



Procentdel med kritisk lavt kulstofindhold



Fokus på en planteavlsejendom på Nordfalster ca. 400 ha



Info om ejendommen

- ✓ Familieejendom hvor søn overtog ejendommen i 2015
- ✓ Planteavlsejendom med græsfrø de seneste 30 år.
- ✓ Halmen er indtil 2016 solgt – nedmuldet efter 2016.
- ✓ Drives delvis pløjefrit og ikke dyrket roer siden 2021
- ✓ Kulstofindhold = 2,41 pct.
- ✓ Ler-indhold, gns. = 13,23 pct.
- ✓ Dexter-indeks = $13,23/2,41 = 5,49$
- ✓ Kulstofindholdet steget fra 2015-2023?

Samme område med JB-kort fra 2024



Samme kort med kulstof-kort fra 2024



Dokumenterede udbytter fra 2014 til 2023

Uafhængige af nabo-effekten!

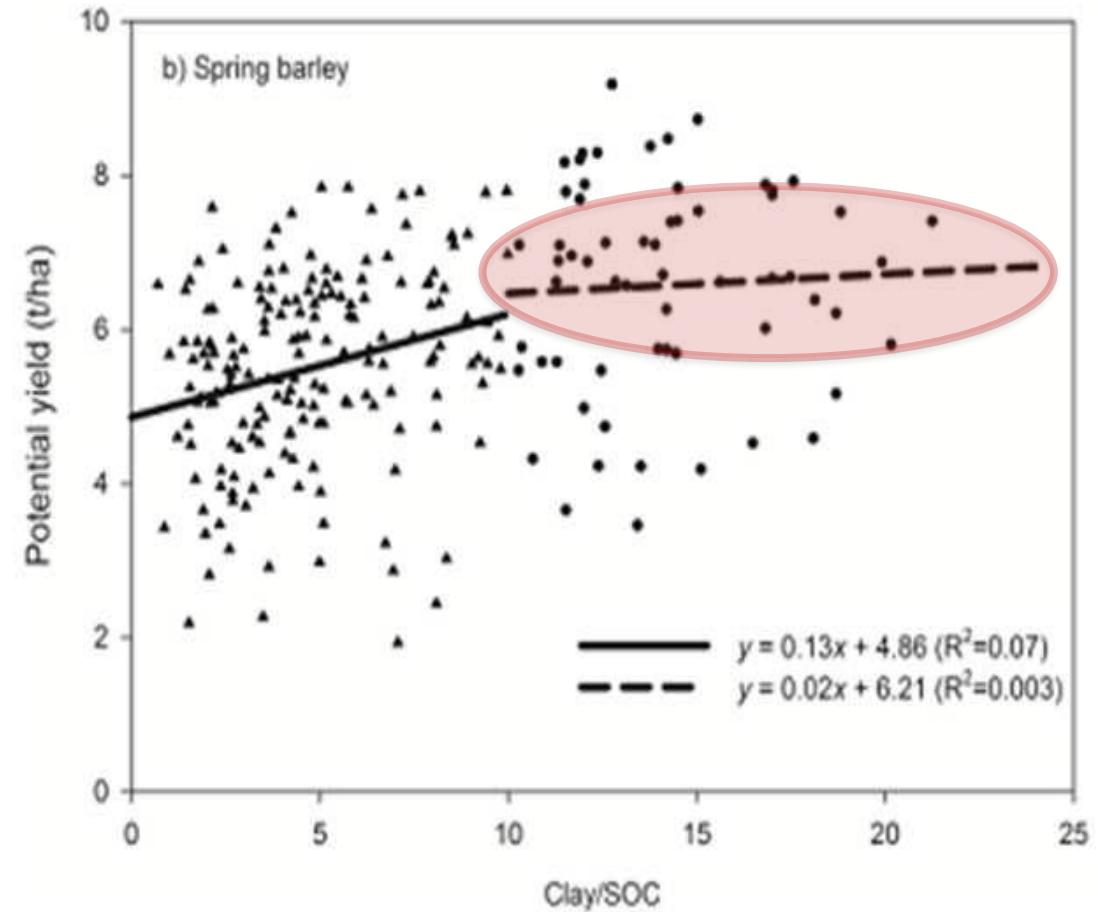
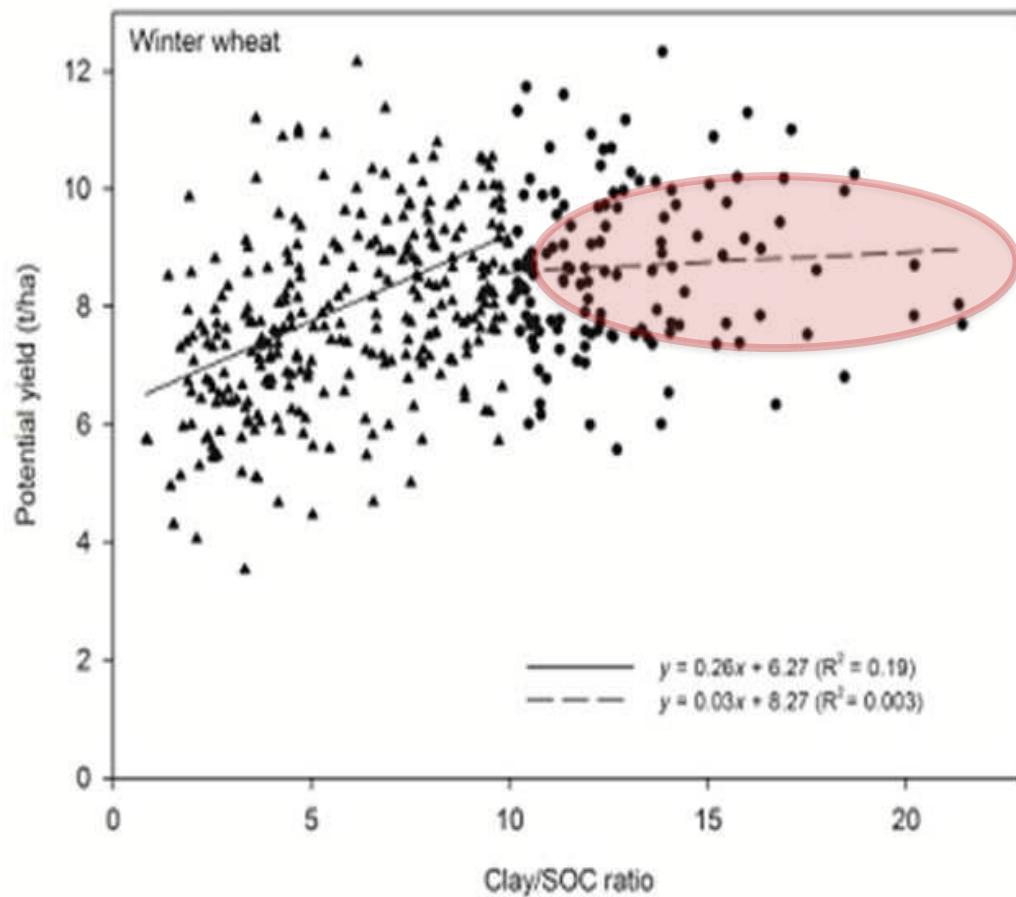
Afgrøde	2013		2014		2015		2016		2017		2018	
	Areal	Udbytte pr. ha	Areal	Udbytte pr. ha	Areal	Udbytte pr. ha	Areal	Udbytte pr. ha	Areal	Udbytte pr. ha	Forv. udbytte	Enhed
Sukkerroer til fabrik		100,43	763,03		72,26	788,83	72,12	794,99		782,28	hkg	
Vinterhvede		165,95	102,98	121,94	108,3	172,24	91,49	54,38	65,69	86,72	hkg	
Vårbyg		218	81,98	230,11	86,8	219,2	85,8	221,61	84,99	84,26	hkg	

Afgrøde	2018		2019		2020		2021		2022		2023	
	Areal	Udbytte pr. ha	Forv. udbytte	Enhed								
Vinterhvede	56,43	117,38	139,04	107,9	69,74	115,1	48,4	93,29	134,83	116,62	113,21	hkg
Vinterraps							81,3	46,4	59,72	50,6		hkg
Vårbyg	184,85	57	112,36	83,7	194,08	85	211,42	75,9	123,14	67	75,53	hkg

Hvede udbytte-stigning fra
2014-2023 = 26,49 hkg

Vårbyg udbytte-tab fra
2014-2023 = 8,73 hkg

Dexter-indeks og udbytte i hvede / vårbyg



Når Dexter-indeks er over 10, ses en meget lille udbyttestigning ved højere lerindhold (lavere kulstofindhold).

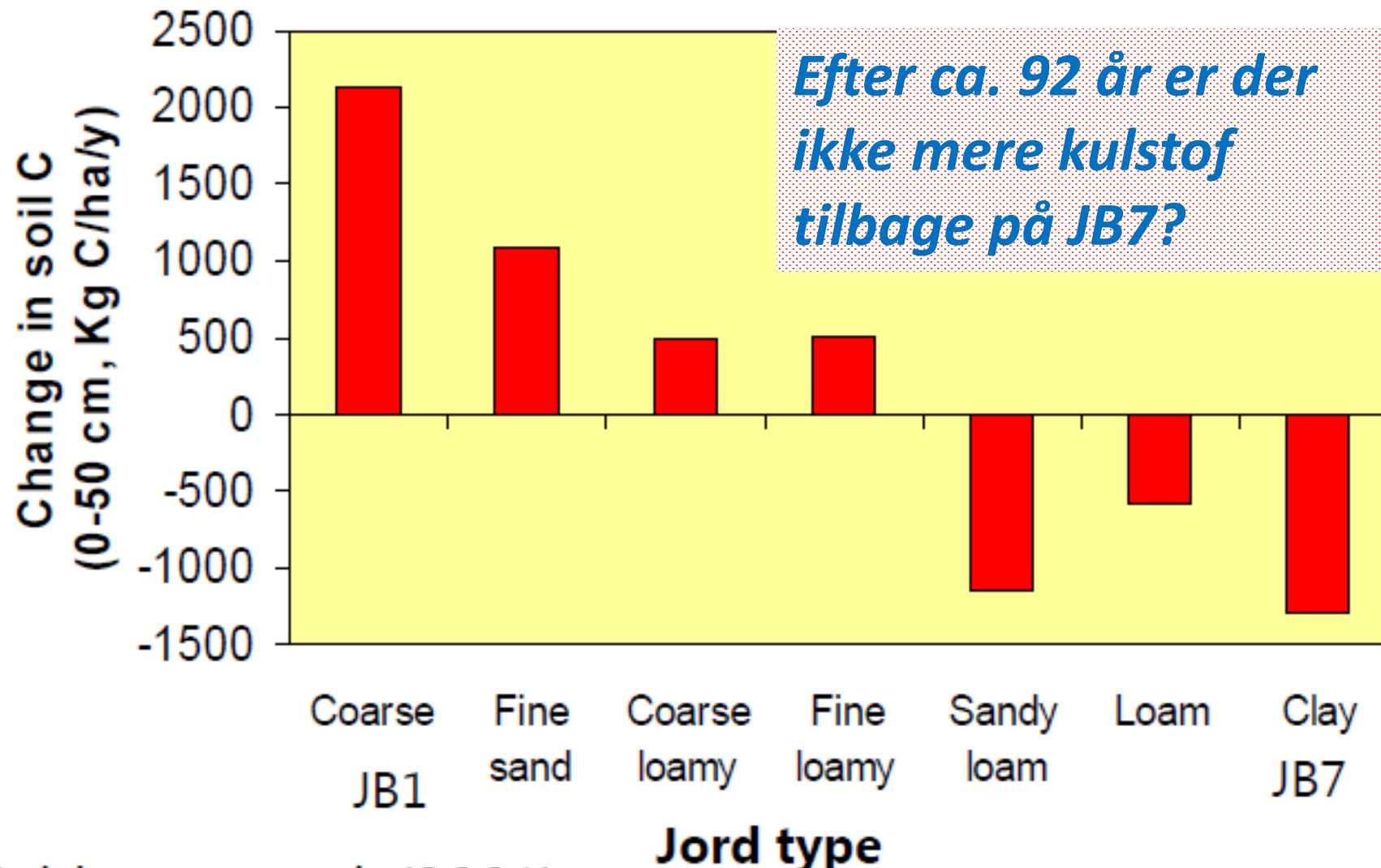
Praksis & teori!

- ✓ Iflg. kvadratnettet er kulstofindholdet i området mellem 2,4 og 4,4 - målt værdi = 2,37 pct.
- ✓ Dexter-indekset er iflg. officielt kort = 11-14. Gns. af analyser = 6,11.
- ✓ Udbyttet i hvede og byg bør falde når Dexter-indekset stiger, men dette ses sjældent – evt. pga. højt lerindhold.
- ✓ Markstyring/teksturanalyse: Meget ofte er der ikke analyse for kulstofindhold og lerindhold på en ejendom.

Praksis & teori!

- ✓ Fordelen ved halmnedmuldning er mindre behov for jordbehandling = 1-2 gange harvning ifht 2-3 gange
- ✓ Dyrkningssikkerheden øges ved rel. højt kulstofindhold i jorden. De dårlige år bliver tydeligere.
- ✓ For hver pct. jordens humusindhold øges med, øges rodzonekapaciteten med 4 mm vand, pr. jordlag (25 cm) = 37 tons humus pr. ha i 25 cm dybde = 22 tons kulstof.
- ✓ CO₂ binding = 1 pct. humus svarer ca. til 50 tons CO₂-ækvivalenter pr ha.
- ✓ Der er fortsat et marked for at købe jord til 300.000 kr. pr ha.

Ændring af kulstof indhold i danske jorde



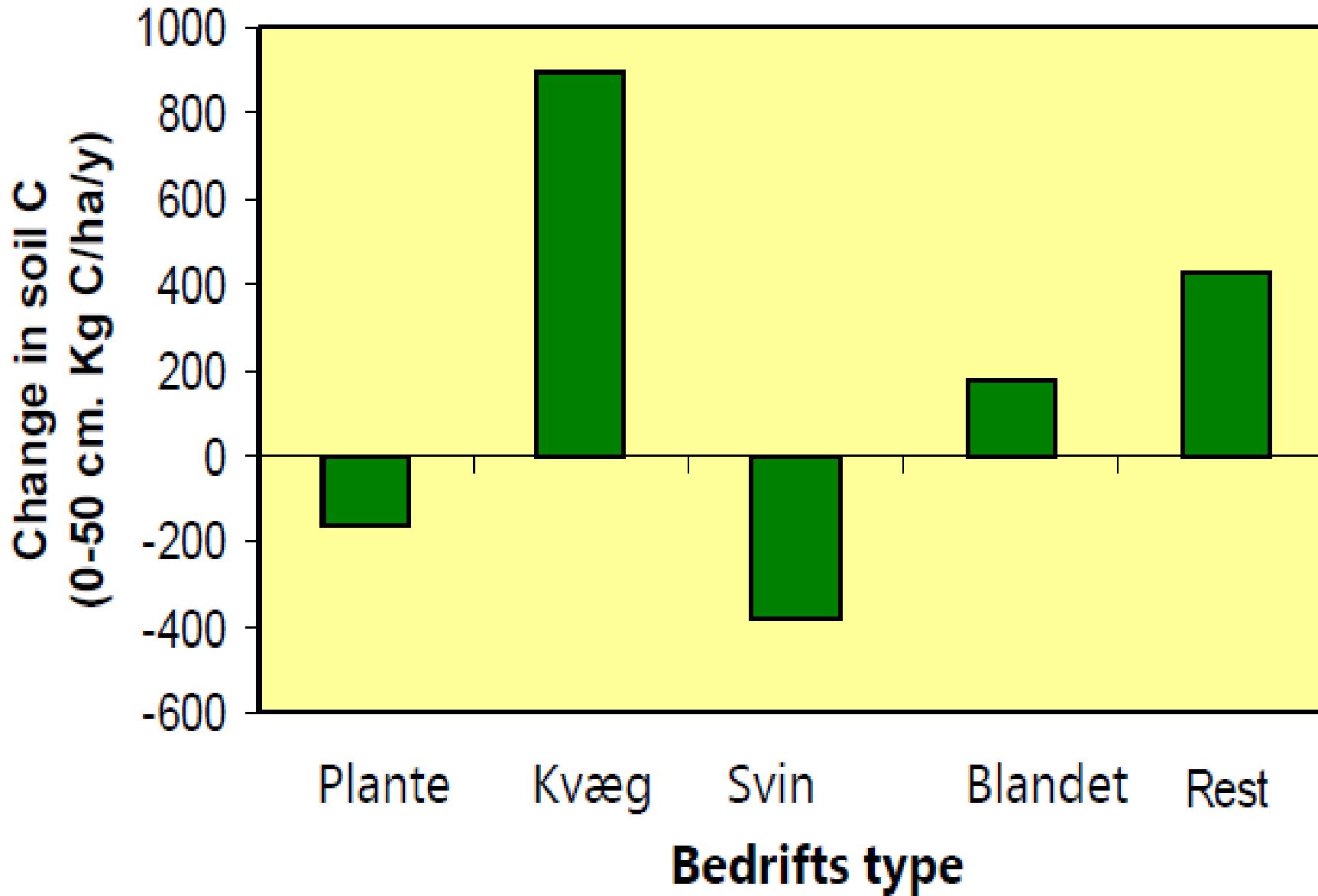
Heidmann et al. (2001)

Kulstofindhold og udbytte i sukkerroer iflg NBR

Måling	Gødningsdosis	Lerindhold	Effekt af...	Vekselvirkninger
			Humusindhold	
NDVI 14. juli <i>Skala fra 0-1</i>	Signifikant effekt.	NDVI påvirkes signifikant negativt af lerindhold	NDVI påvirkes signifikant positivt af humusindhold	Der er signifikant vekselvirkning mellem humus og dosis. Positiv for lav dosis og negativ for mellem og høj dosis
NDVI 9. august <i>Skala fra 0-1</i>	Signifikant effekt	Ingen signifikant effekt	NDVI påvirkes signifikant positivt af humusindhold	Ingen vekselvirkninger
Rodudbytte t/ha	Ingen signifikant effekt	Ingen signifikant effekt	Ingen signifikant effekt	Ingen signifikante vekselvirkninger
Sukkerprocent %	Ingen signifikant effekt	Ingen signifikant effekt	Ingen signifikant effekt	Ingen signifikante vekselvirkninger
Sukkerudbytte t/ha	Ingen signifikant effekt	Ingen signifikant effekt	Ingen signifikant effekt	Ingen signifikante vekselvirkninger
Topudbytte Friskvægt, t/ha	Signifikant effekt	Ingen signifikant effekt	Ingen signifikant effekt	Signifikant vekselvirkning både med ler- og humusindhold

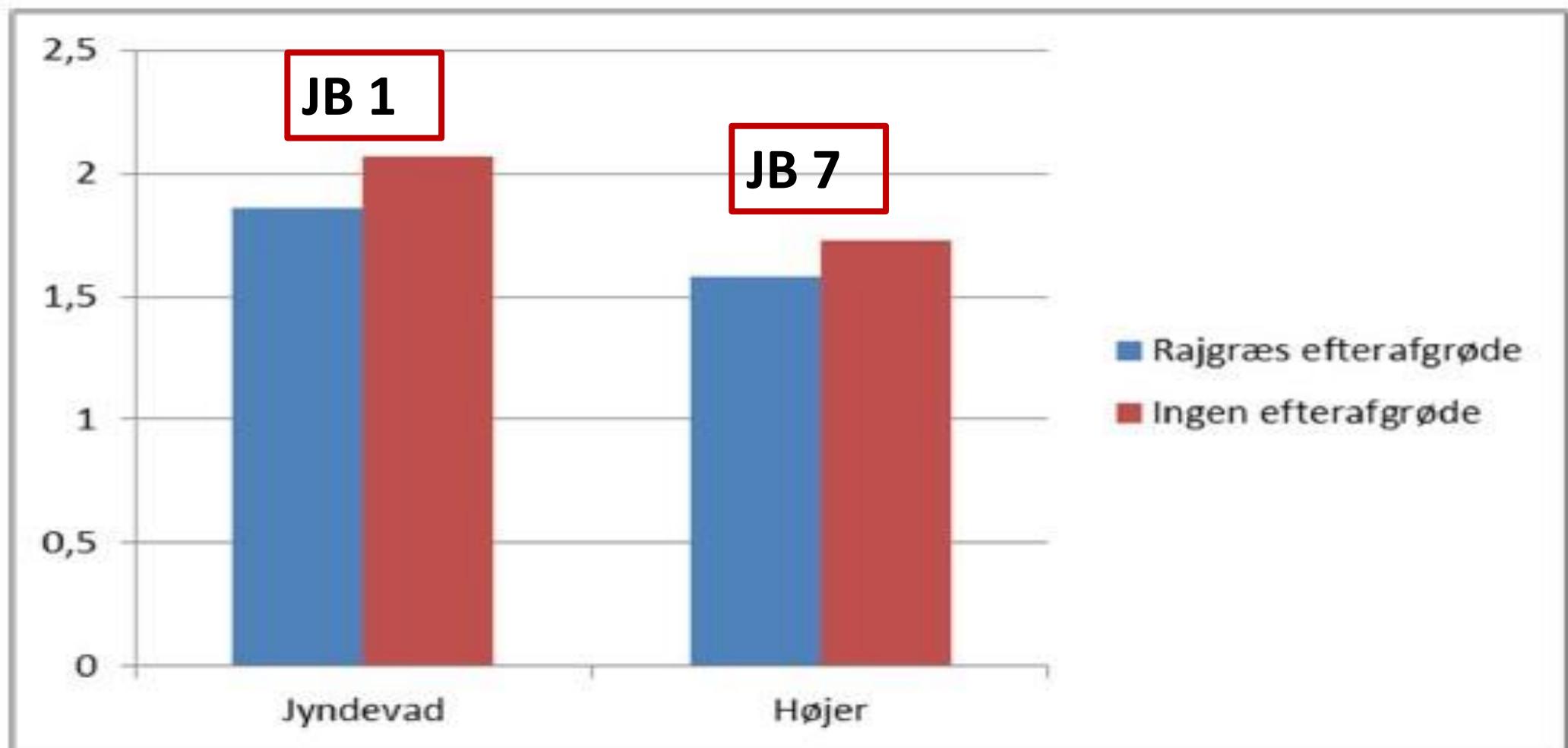
vkst

Bedriftstype & ændring af kulstofindhold



% C i jorden

Efterafgrøder og effekt på kulstofindhold



Effekt af efterafgrøder på kulstofindholdet i jorden (0-10 cm) efter
10 år med kontinuert korn (Rasmussen et al. 1991)

vkst



Tak for opmærksomheden ☺