Estimating soil carbon sequestration from cover crops in Sweden using satellite images

Rong Lang, Martin Bolinder, Lena Engström, Mats Söderström, Thomas Kätterer

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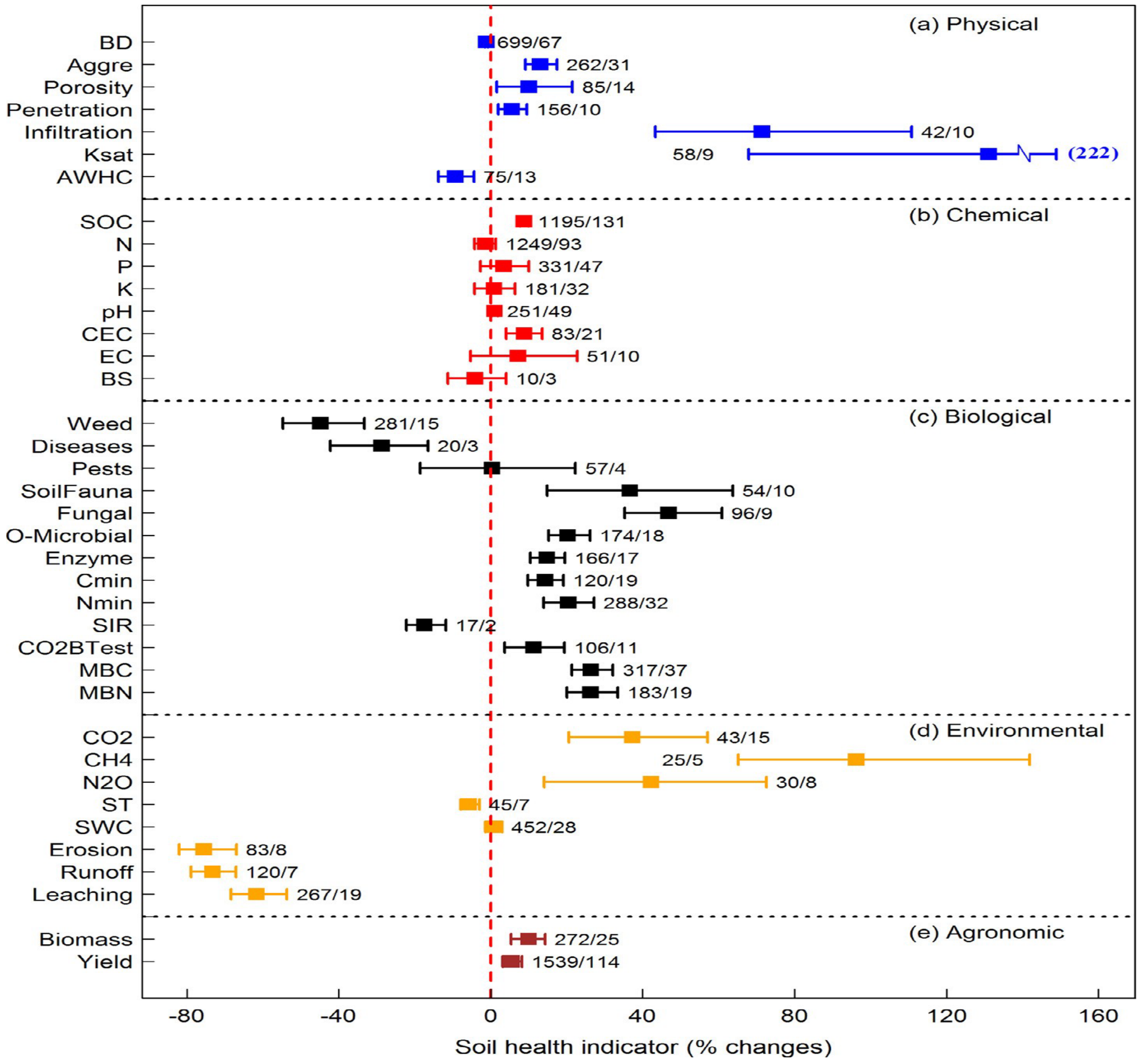
SCIENCE AND EDUCATION FOR SUSTAINABLE LIFE

Introduction

- **Nutrient leaching and soil degradation**: Intensive agricultural practices
- **Cover crop and catch crop (CC)**: multiple benefits to soil condition and health, agricultural productivity and mitigation of climate change (*Jian et al., 2020; Çerçioglu et al., 2025*)
- **Soil Carbon Sequestration (SCS):** above- and belowground biomass contribute to organic inputs to soil depending on biomass production, turnover rates, etc.

Cover crops affecting soil health and productivity

Meta-analysis including 281 studies (mostly from North America)



- Improved soil structure and infiltration
- **Soil organic carbon (SOC) accrual**

  SOC increased by 7–74 % in 83 % of the 190 studies (*Çerçioglu et al., 2025*)

- Less weeds
- Less pests
- More soil animals and higher biological activity

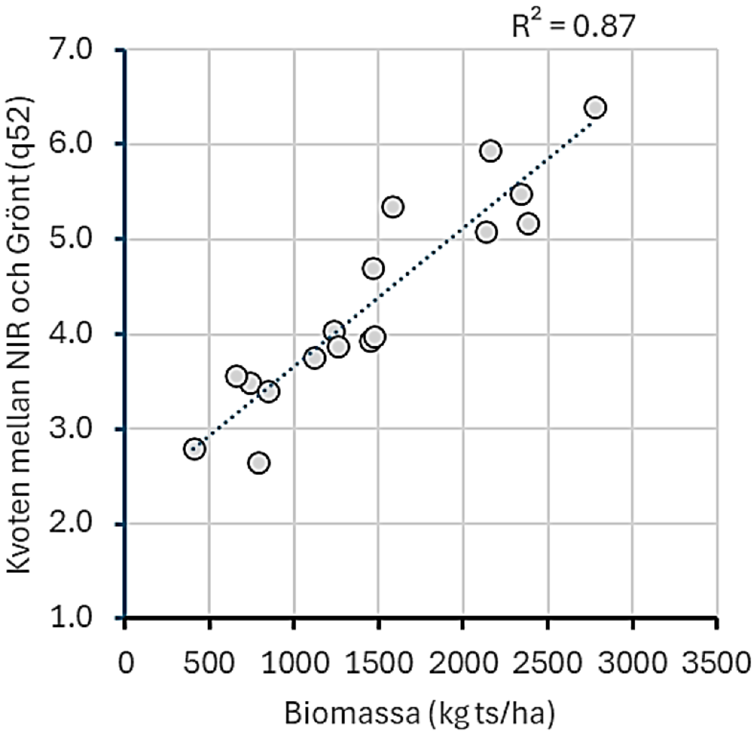
- Higer emissions of N_2O and CH_4
- Less erosion
- Less surface runoff
- Less leaching
- Higher yields of main crops

J. Jian, X. Du and R.D. Stewart / Data in Brief 29 (2020) 105376

Introduction

- **Satellite-derived vegetation indices:** cost-effective, monitor crop growth and estimate biomass

Introduction



Söderström & Engström (2025)

- **Satellite-derived vegetation indices:** cost-effective, monitor crop growth and estimate biomass
- **Estimating CC biomass & time-series analysis:** *Rosen et al (2024)*, *Swoish et al (2022), Söderström & Engström (2025),* etc.
- **Soil carbon sequestration**: ICBM model (national GHG reporting)

Method

Time series ClearSKY images (3 testing areas, 15 Sep – 31 Oct)

CC field parcels, 2024

Biomass=690.9 * NIR/G-1642.4

Söderström & Engström (2025)

Time series biomass, parcel scale

Maximum

Maximum biomass, parcel scale

Aggregate

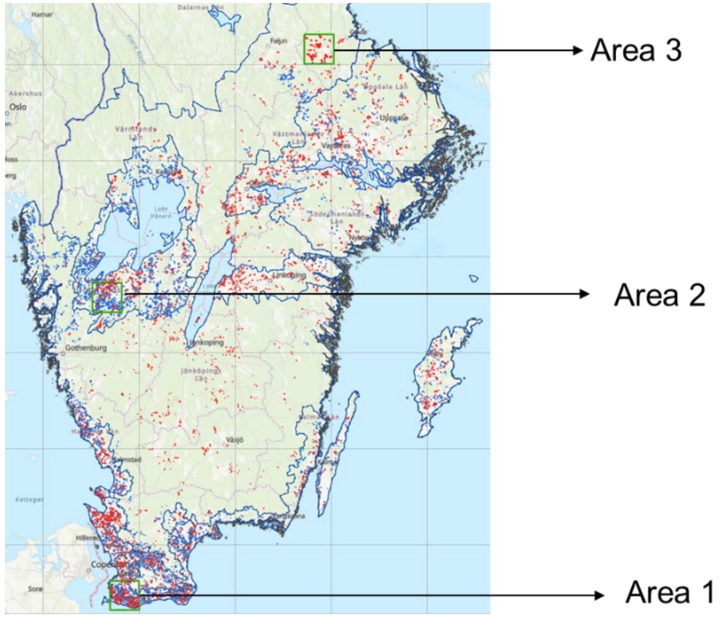
Grouped CC Species (report MI 30 SM 2303)

Median biomass & area by CC group, testing area

ICBM

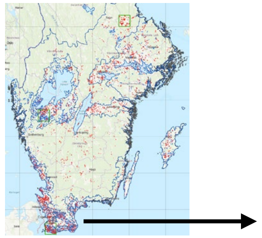
30-year simulation

SOC sequestration, testing area



Results- dynamics of NIR/G ratio and biomass

Area 1



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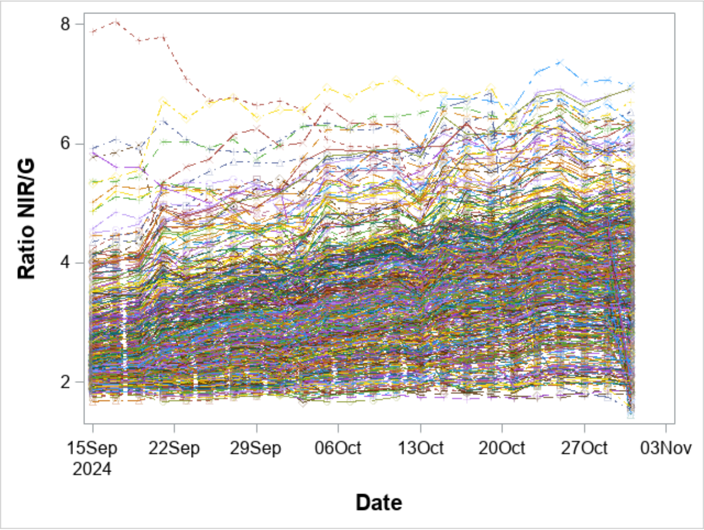
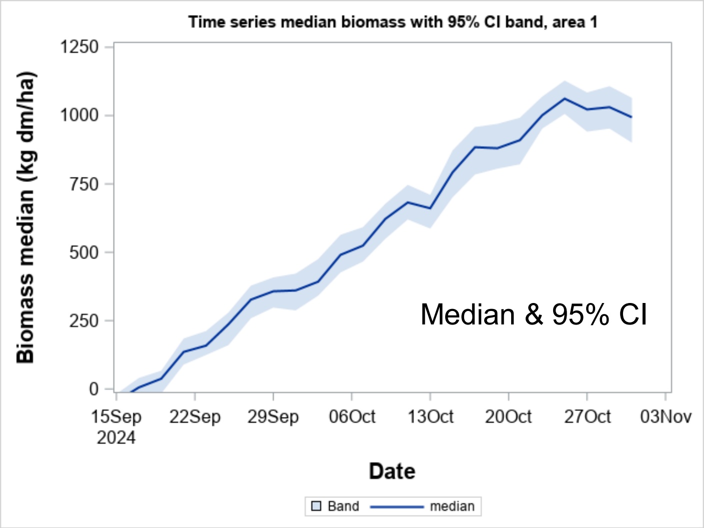
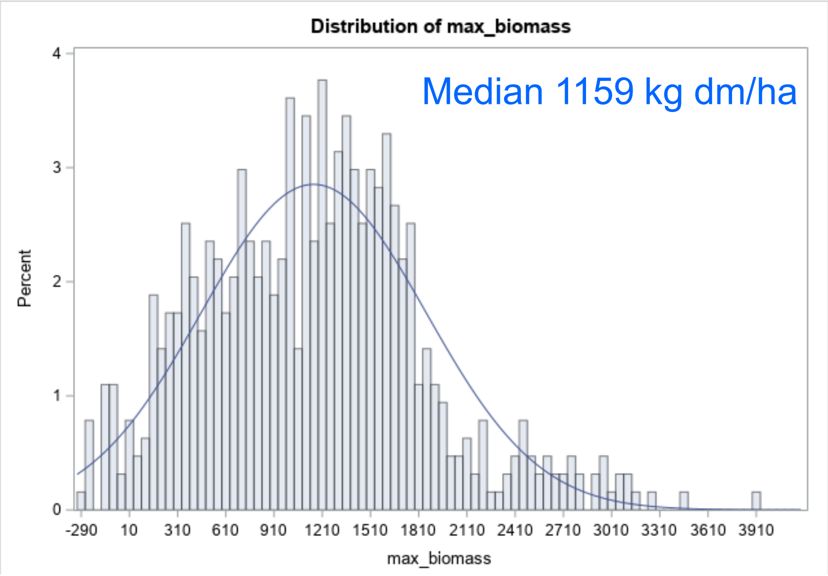
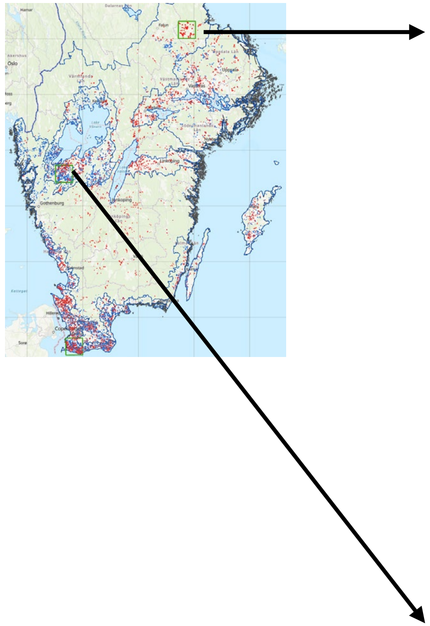


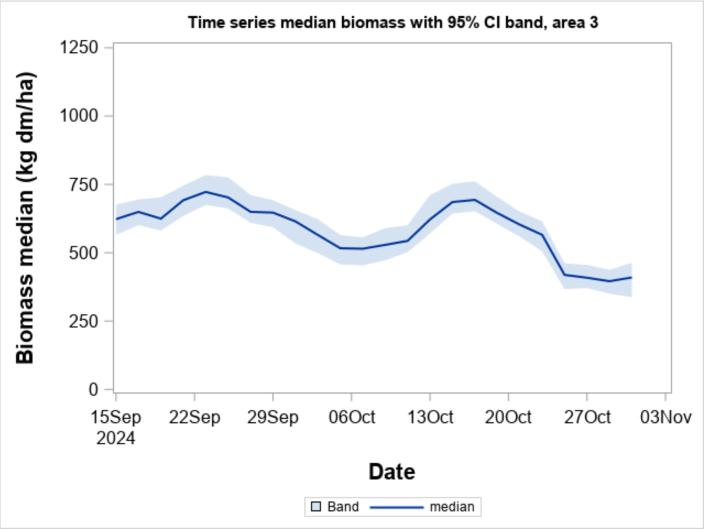


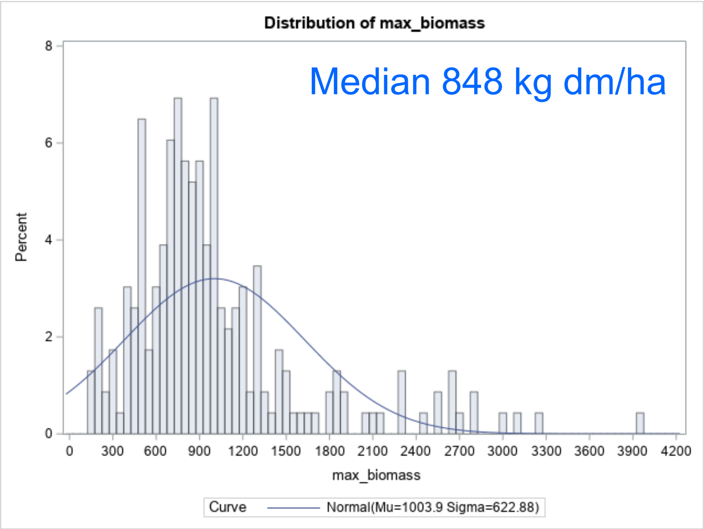


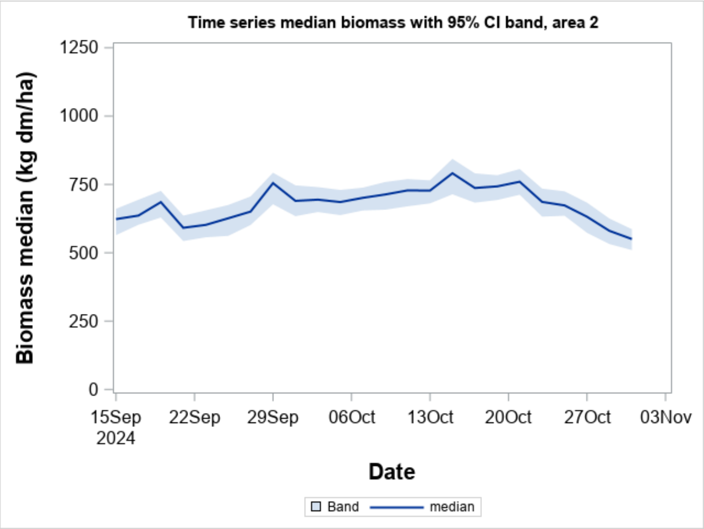
Results- dynamics of CC biomass

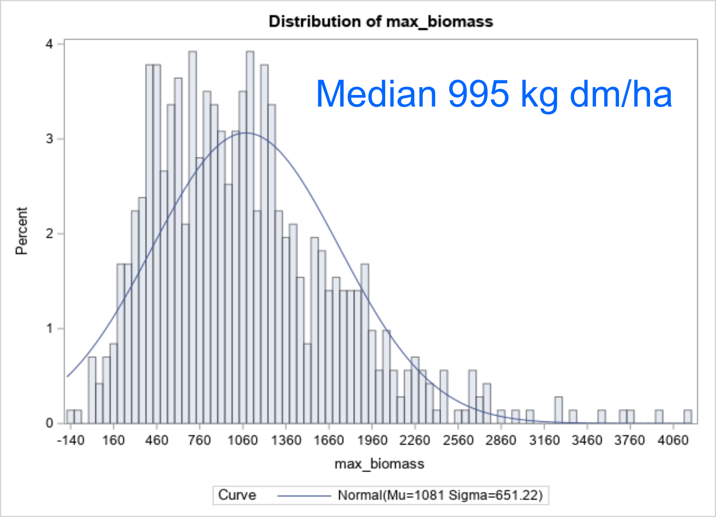
Area 2 & 3



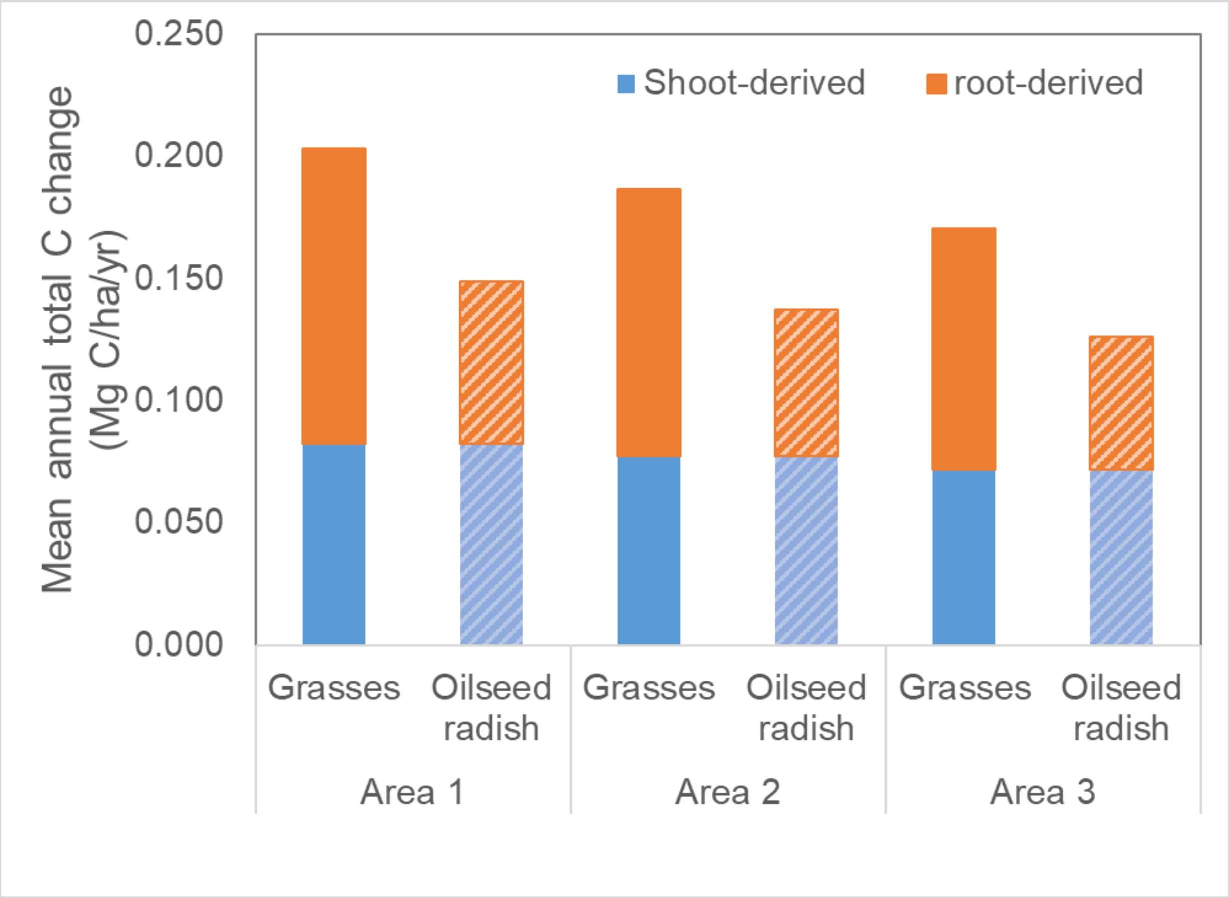








Results- Soil carbon change in 30 years



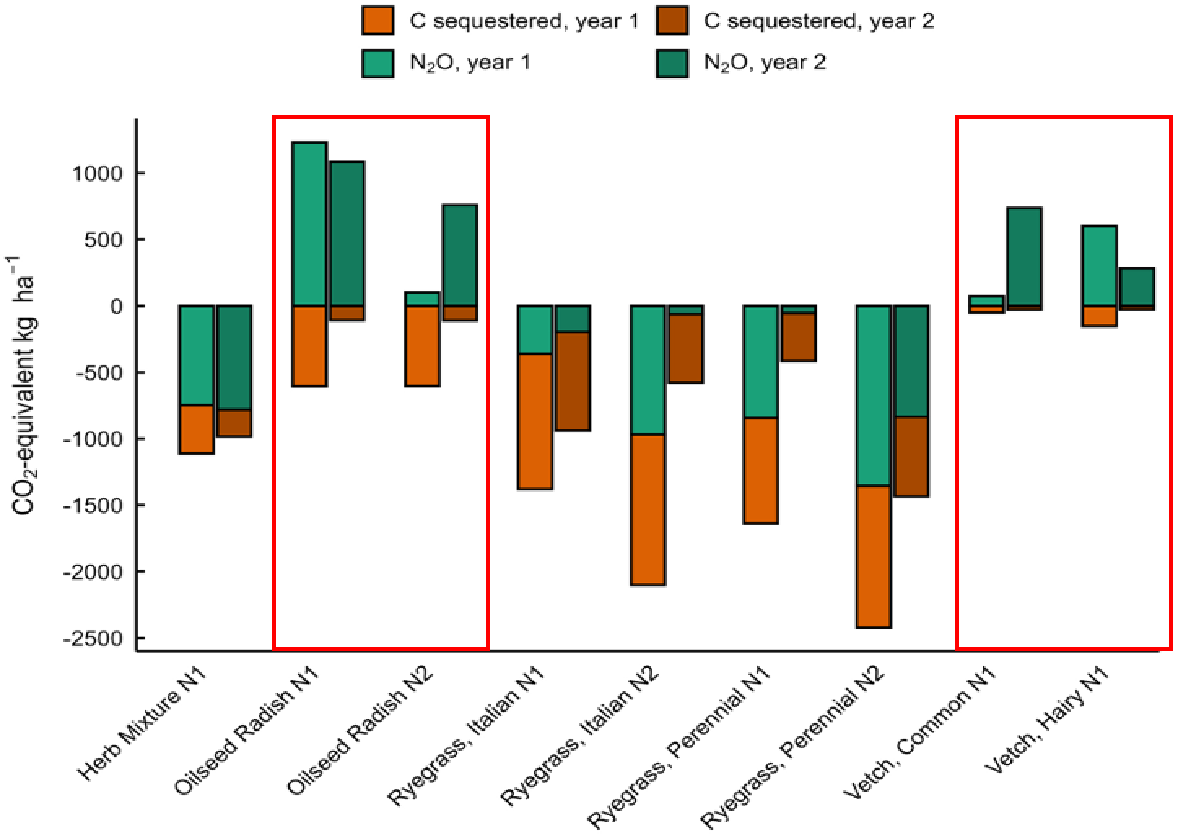
- **Grasses**: higher total carbon accrual; higher proportion of root-derived carbon in total C change
- **Oilseed radish**: same amount of shoot-derived carbon; lower proportion of root-derived carbon in total C change

Results- Soil carbon change in 30 years

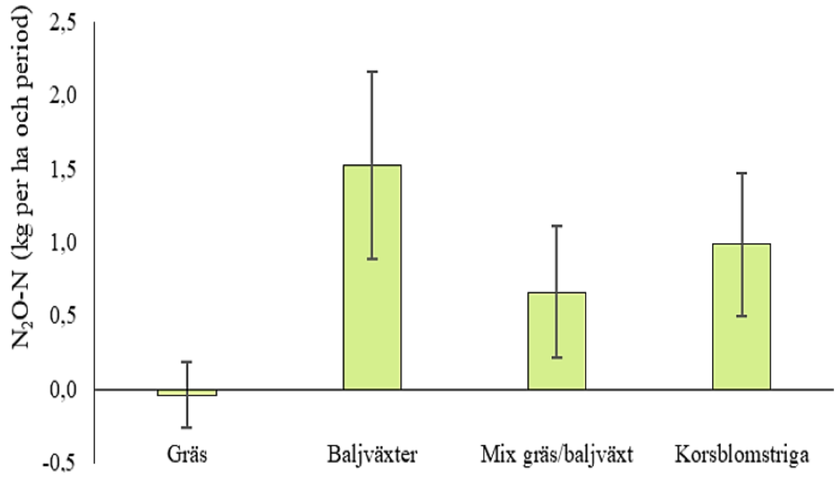
Testing area	Production region	CC group	Shoot-derived	root-derived	Mean annual total C change (Mg/ha)	Total C sequestration (30 year)	Relative area grasses vs. radish	Weighted SOC sequestration	C sequestration per region (Mg C /ha/yr)	C sequestration per region (kg CO_2-eq/ha/yr)
Area 1	Götalands södra slättbygder (GSS)	Grasses	0.082	0.121	**0.203**	**6.09**	0.47	0.095		
		Oilseed radish	0.082	0.066	**0.149**	**4.47**	0.53	0.079	**0.174**	**639**
Area 2	Götalands norra slättbygder (GNS)	Grasses	0.077	0.110	**0.187**	**5.60**	0.95	0.177		
		Oilseed radish	0.077	0.060	**0.137**	**4.12**	0.05	0.007	**0.184**	**676**
Area 3	Mellersta Sveriges skogsbygder (MSK)	Grasses	0.072	0.099	**0.171**	**5.12**	0.88	0.150		
		Oilseed radish	0.072	0.054	**0.126**	**3.79**	0.12	0.015	**0.165**	**606**

Discussion: risk of emitting more N_2O

Climate impact of nitrous oxide and estimated carbon sequestration in a two-year field experiment in Norway: **sequestered SOC was offset by N_2O emissions for oilseed radish and vetch** (*Kjær et al., 2026 AGEE 397*)

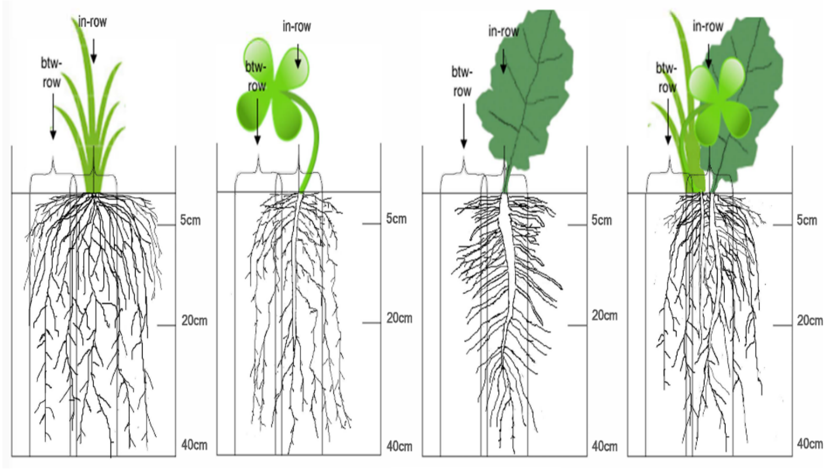


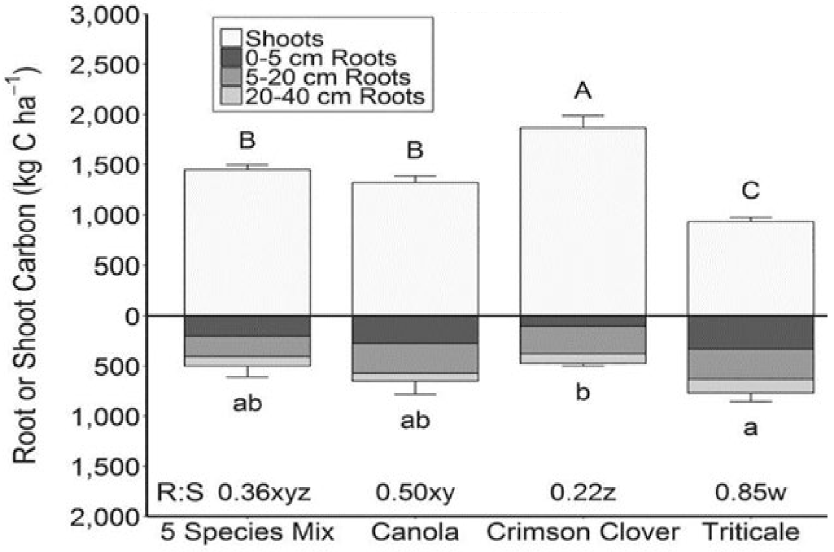
A global study based on 374 field trials
(*Abdalla et al. GCB 2019*)



- Similar findings from Swedish trials (*Olofsson & Ernfors 2022 STOTEN*)
- High N_2O emissions even from clover-rich meadows during winter (*Sturite et al. 2021 SBB 163*)
- Cruciferous species and legumes can be problematic

Discussion: root system & biomass

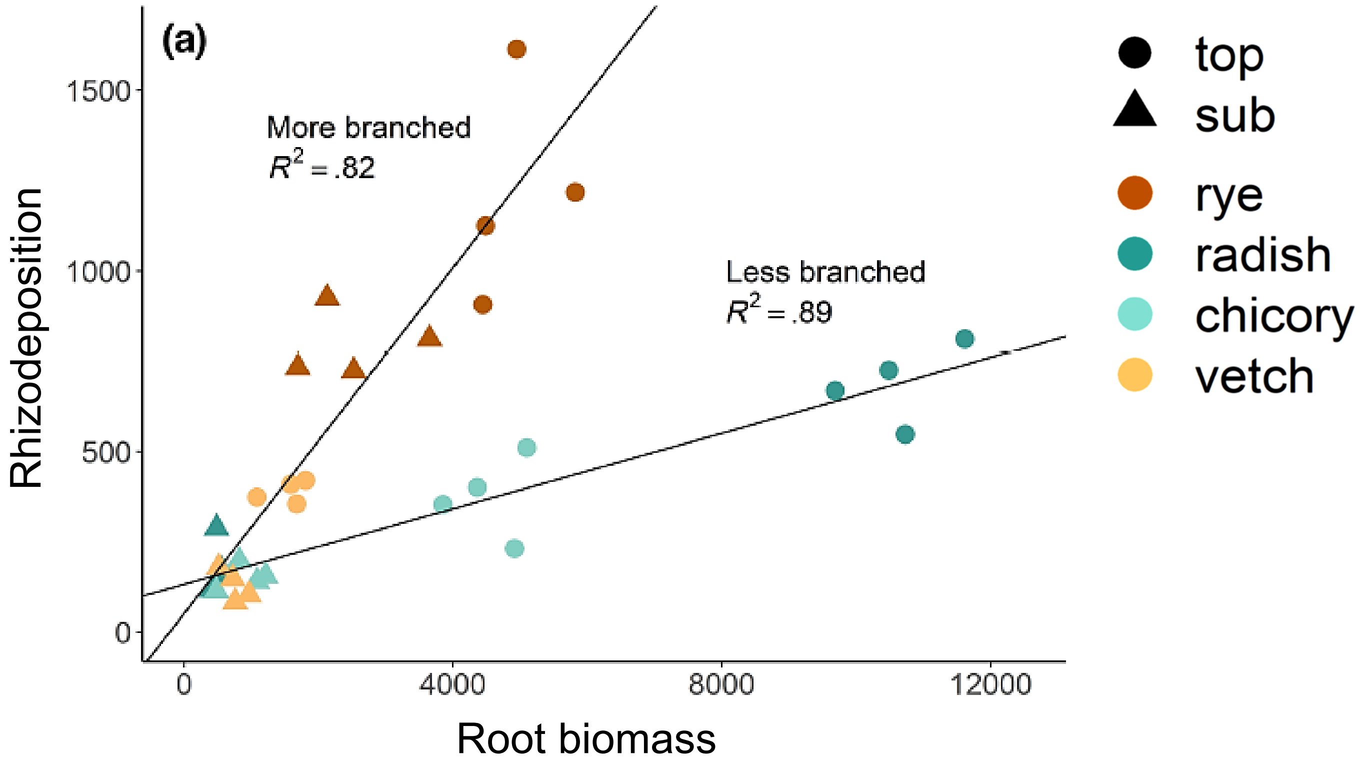




Amsili &Kaye (2020) Ren Agric Food Sys

Greater rhizodeposition from species with more branched root systems

Engedal et al. 2023 Glob Change Biol 29:5677–5690.



Take home message

- Estimating biomass for the fields with low biomass is challenging
- Cover crops and catch crops sequester carbon: higher root biomass and rhizodeposition from grasses contributed more to soil carbon than oilseed radish
- Species selection: frost-sensitive species may stimulate N_2O emissions, especially during freeze-thaw cycles, which can offset the benefit of soil carbon sequestration.

Acknowledgement

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