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SCIENCE AND EDUCATION FOR SUSTAINABLE LIFE

Is it possible to reduce GHG emissions from cultivated peat soils while maintaining productivity?

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Background

- In the mid-19th century, people were starving and emigrated
- To increase food production, the government initiated large-scale drainage campaigns on peatlands and on lowering lakes
- Sweden had about 700.000 ha of drained cultivated peat soil in 1940, today about 250.000 ha.

What is peat soil?

- Formed when the degradation of organic material is hampered due to oxygen deficiency and cold climate
- Contains > 40% organic material
- Have very high porosity and can hold large amounts of water
- Usually low pH
- Needs drainage for crop production and trafficability
- The range in properties (porosity, bulk density etc) is very large, one peat soil is not comparable to another
- Behave differently than mineral soils

Benefits

- No stones
  - suitable for potato and carrot production
- Supply of nitrogen
  - Good in organic farming
- Can be very fertile if the pH is high
  - Island of Gotland
- Insurance during dry years to maintain fodder production

How to reduce emissions?

- Soil management (tillage, carbon availability, compaction)
- Manage water table (oxygen availability)
- Soil amendments (sand addition, carbon dilution)
- Crop management (different crops, effect on microbial structure)
- Fertilisation (Copper, P, K, effect on microbial structure)
- Liming (increase pH, reduce N2O)
- Nitrification inhibitor (reduce N availability)

Soil management - Tillage intensity

Long term field trial on fen peat on Gotland. Started 1976

Treatment	CO_2 emission (µmol m^{-2} s^{-1})	
	2012	**2013**
A Annual ploughing	2,14	3,74
B Ploughing every other year	2,59	3,24
C Shallow tillage	2,90	4,24
D Permanent ley	4,53	3,95

Ground water level

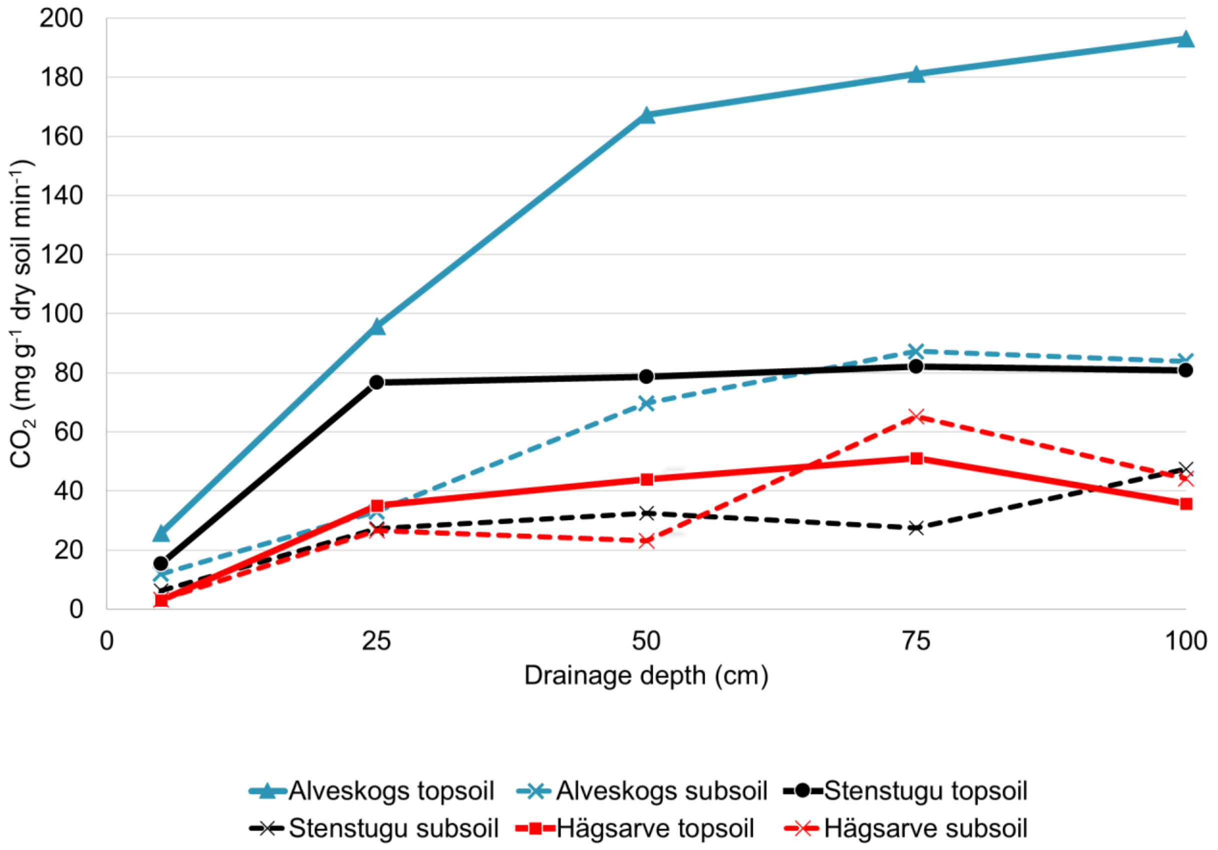
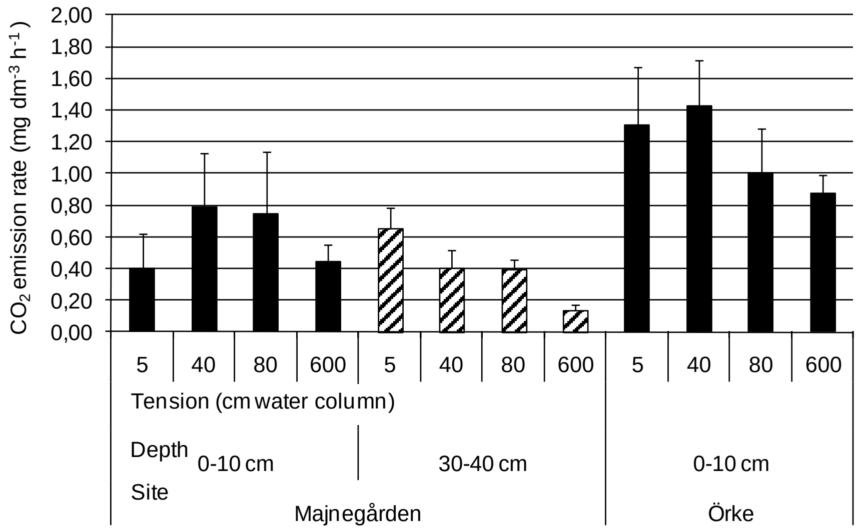
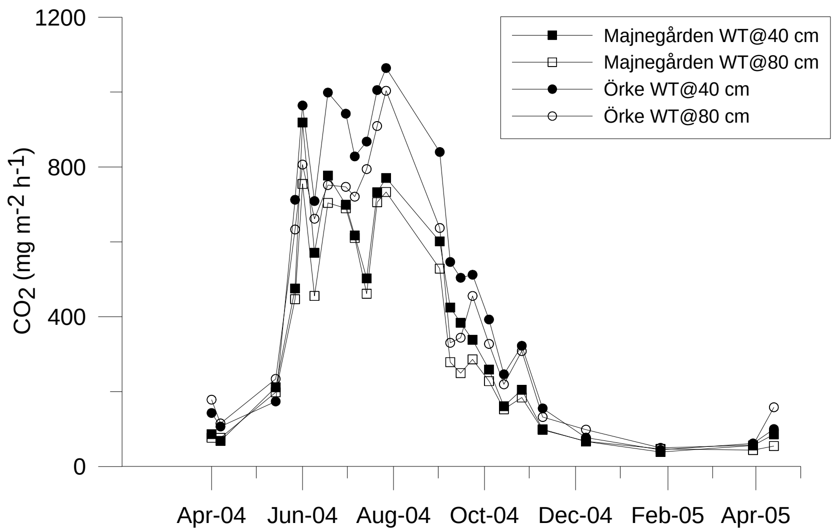
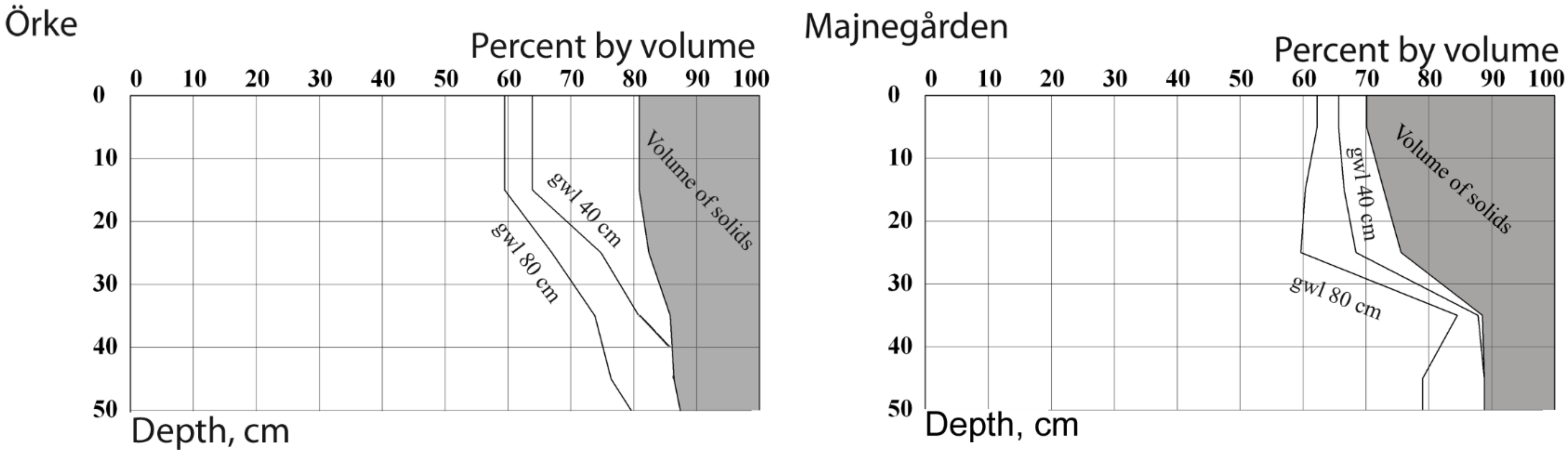


Fig. 4. CO_2 emission from top- and subsoil from three sites at different drainage depths (5, 25, 50, 75, 100 cm).

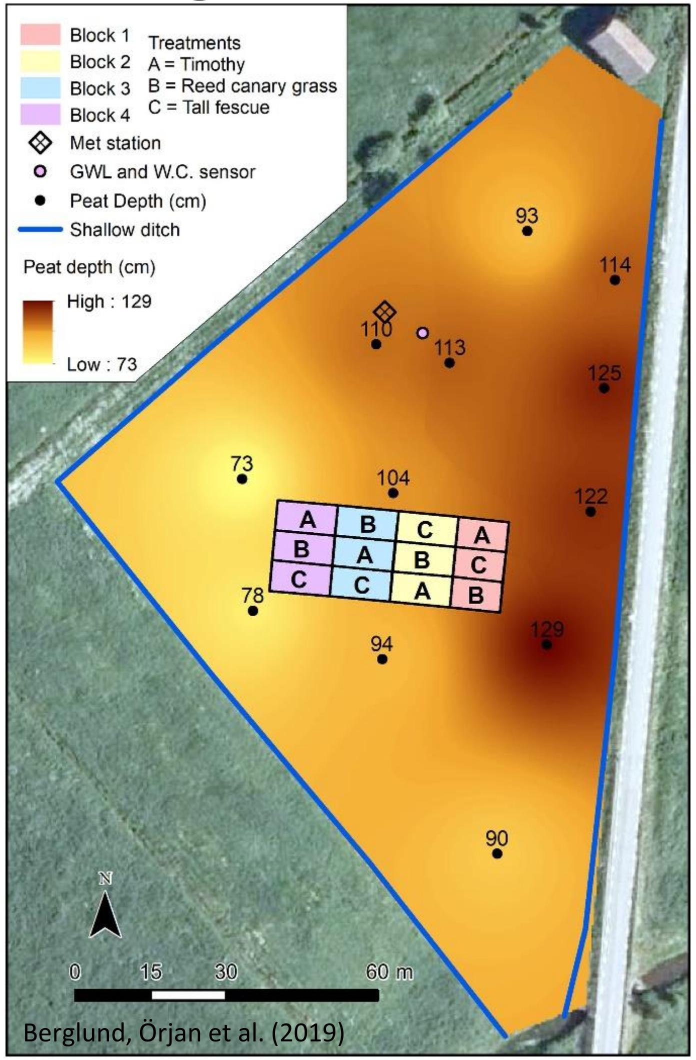




Drainage curve

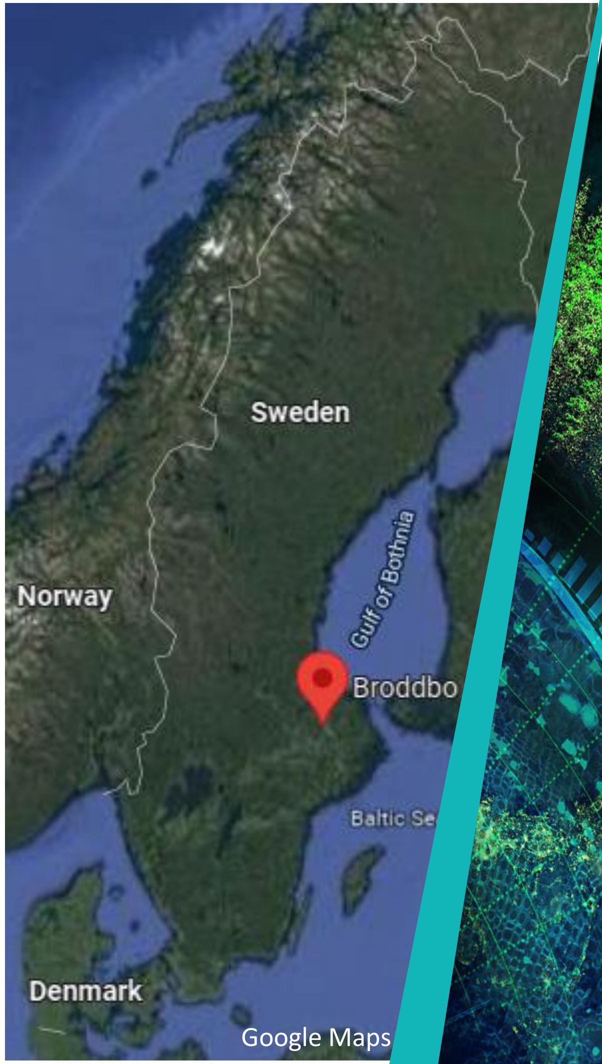


Long term field trial, Broddbo

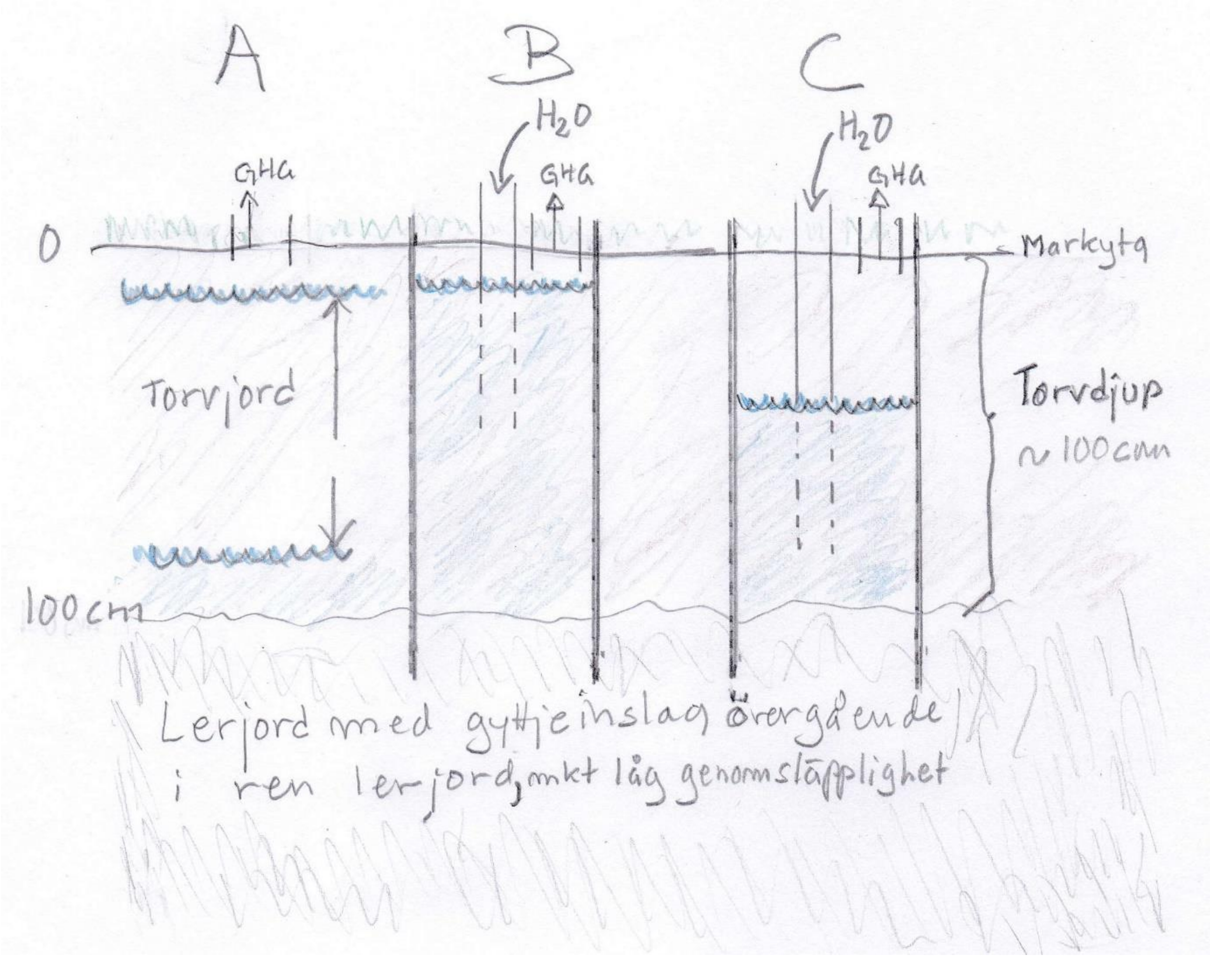


<u>Soil properties</u>

- Fen peat
- Humification degree von Post: H9-H10
- LOI: 86.2 %
- pH (H_2O): 5.55
- EC (µS/cm): 105
- Dry bulk density
    - Unpacked 0,29 g/cm3
    - Packed 0,33 g/cm3



Installation of field lysimeters



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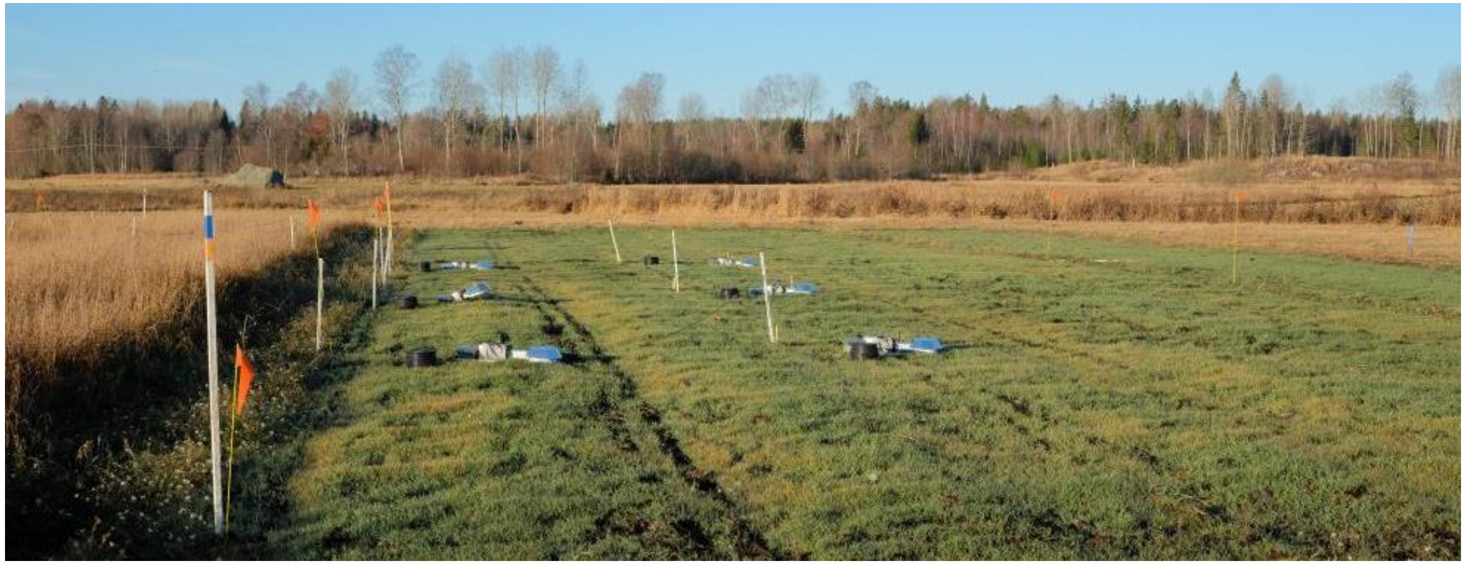
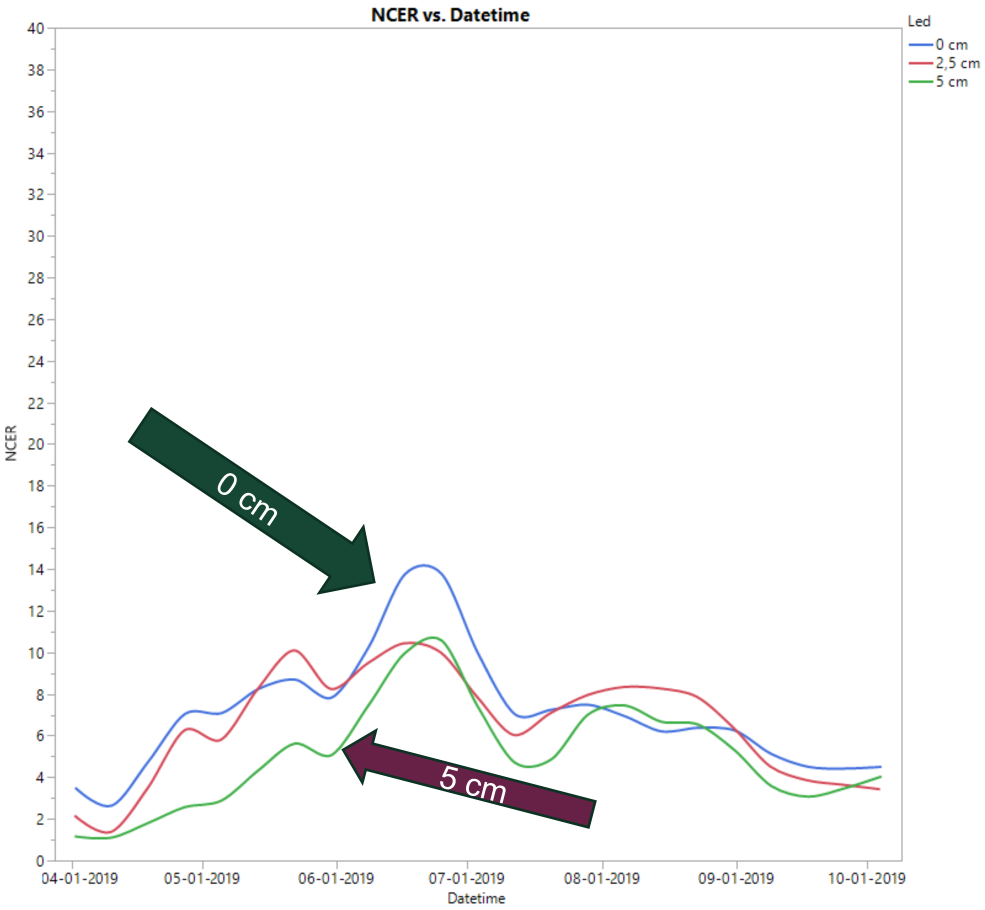
Soil amendments

Average CO_2 emission (µmol/m²/s)					
Treatment	2015*	2016	2017	2018	2019
0 cm	3.13	4.57	5.60	5.56	5.78
2.5 cm	1.58*	4.70	4.47*	7.16*	5.51
5 cm	1.05*	3.32*	3.64*	5.95	3.98*



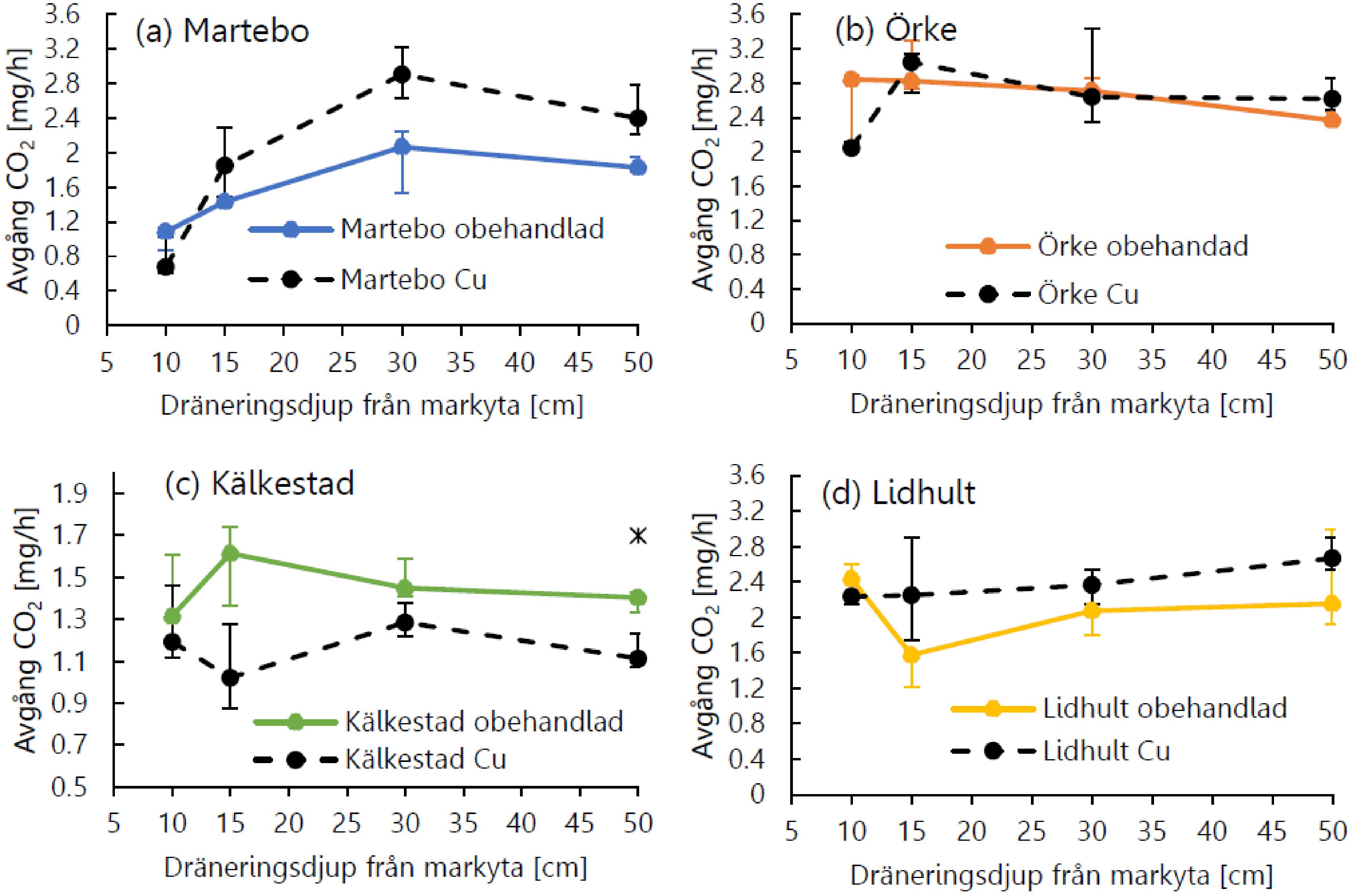
Automatic CO_2 chambers (ADC BioScientific, Herts, UK)

No significant differences between foundry sand and pure sand on CO_2 emission (Lab study).



CO_2 emission (µmol/m²/s) from April to October 2019. Lowest emission from the 5 cm treatment.

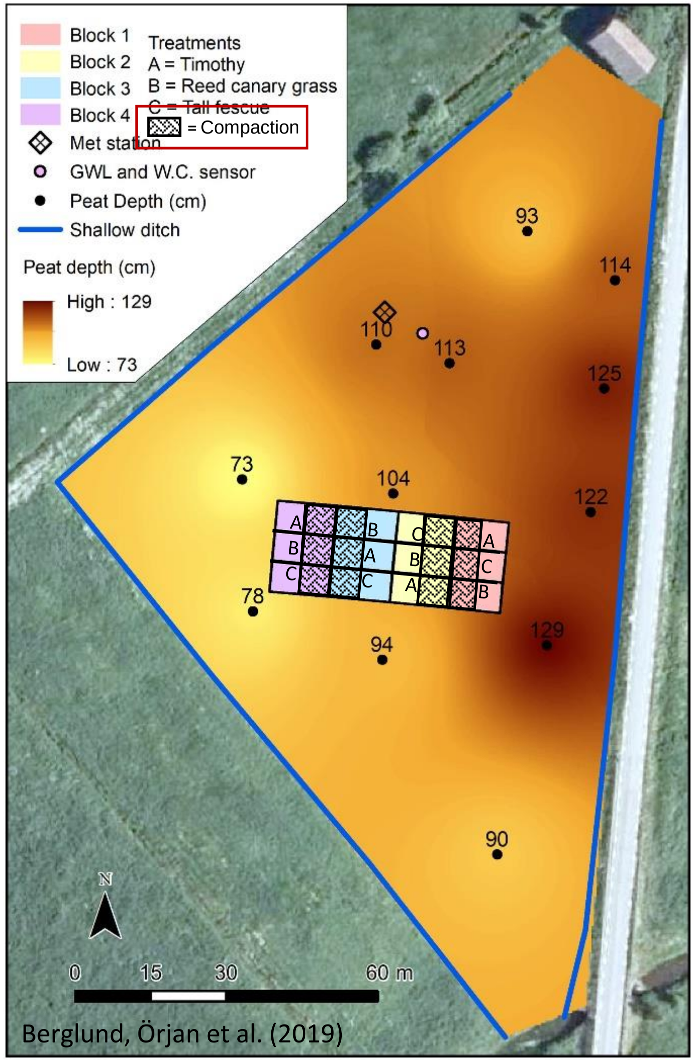
Fertilized to reach 100 ppm Cu in the soil



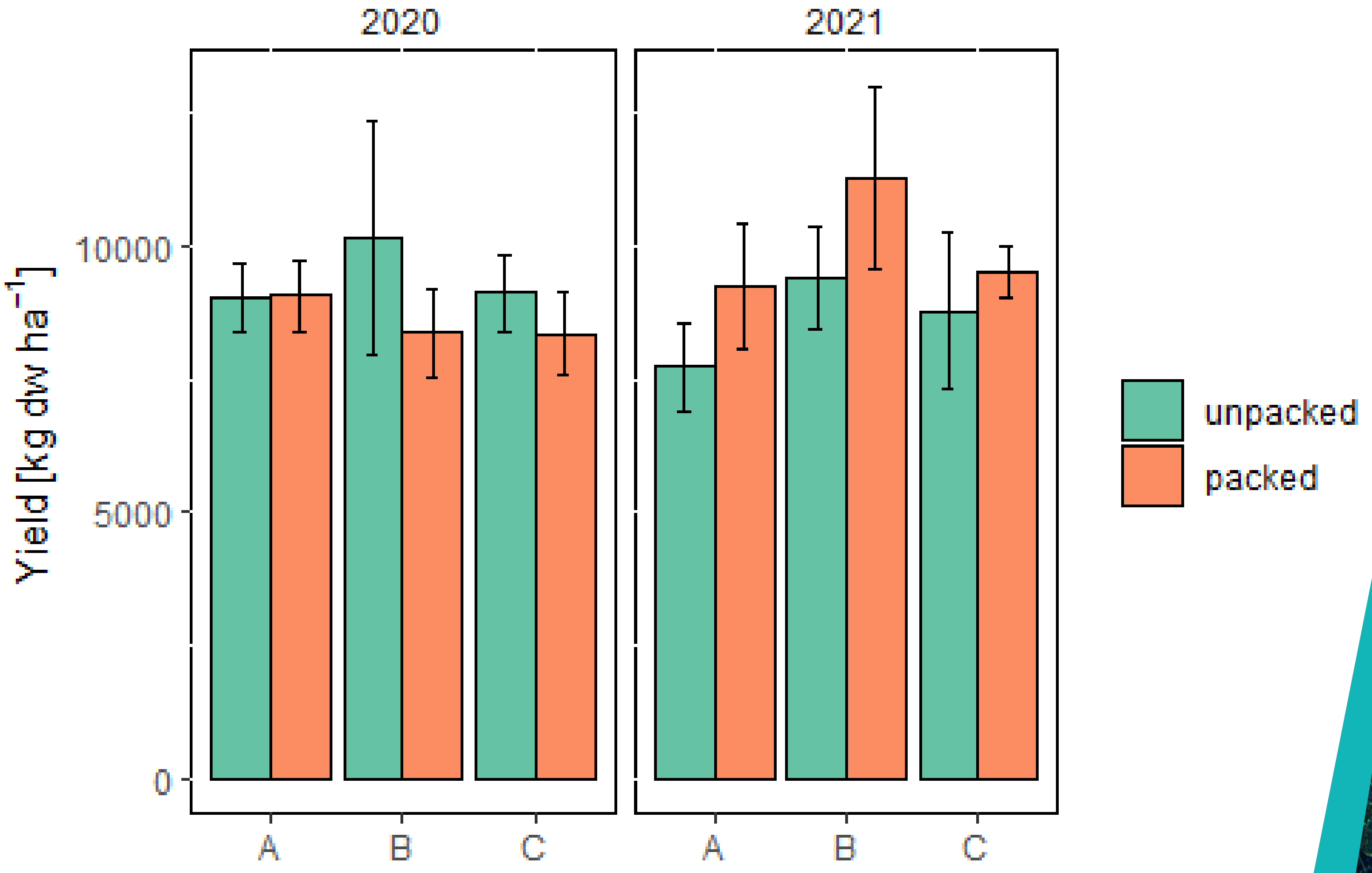
Markytesänkning, växthusgasavgång och utlakning från dikad torvjord (2021) Ros, S., Ahlvin M.

Compaction

May 2020 and October 2021 by 9640 kg tractor.



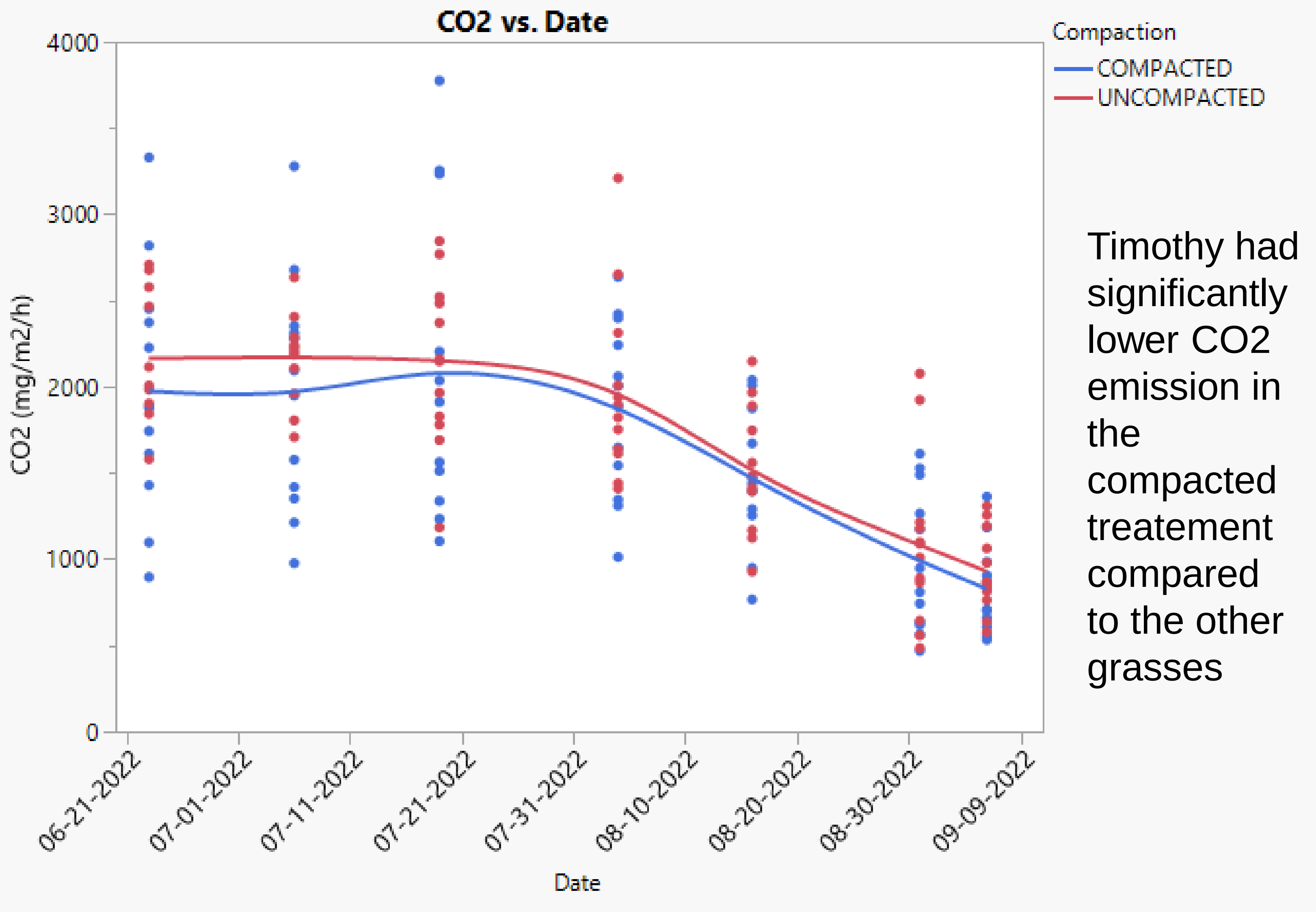
Yield



A = Timothy B = Reed canary grass C = Tall fescue

Compaction

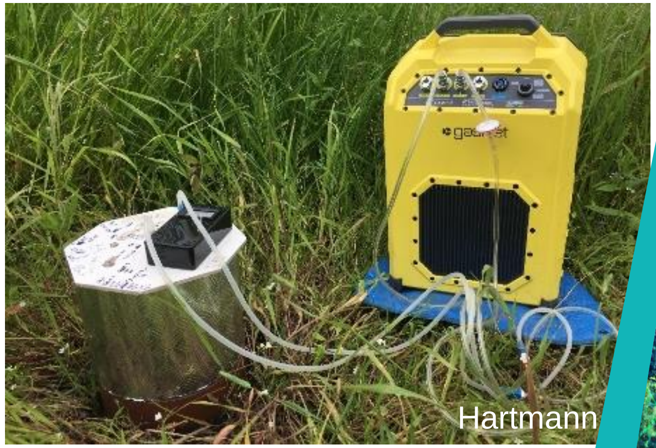
Effect of soil compaction on CO_2 fluxes



Timothy had significantly lower CO2 emission in the compacted treatement compared to the other grasses

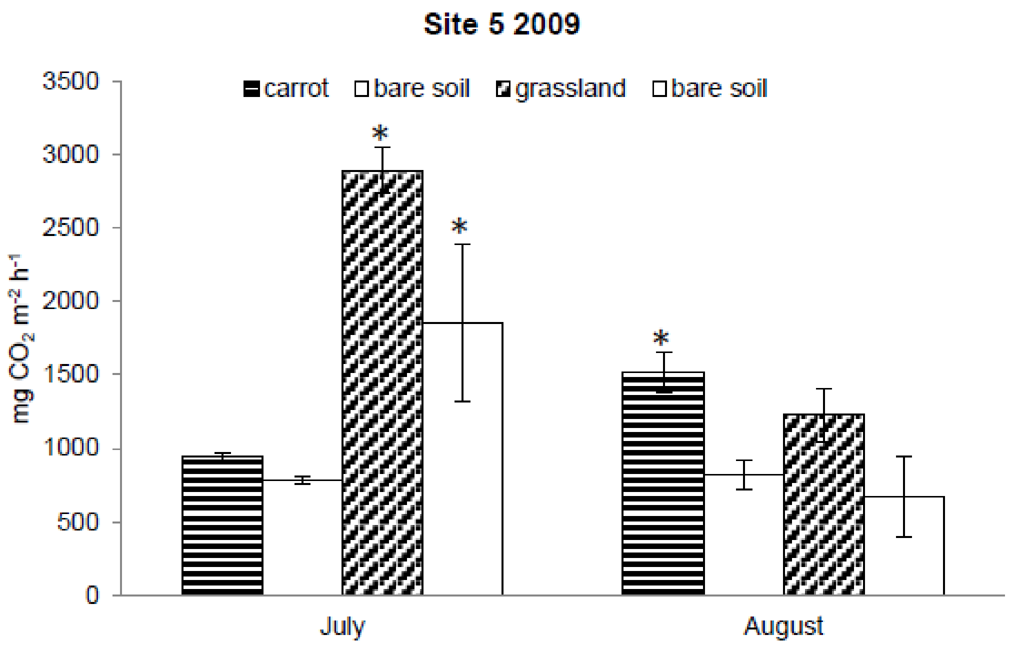
Significant lower CO_2 emissions from compacted plots 2021

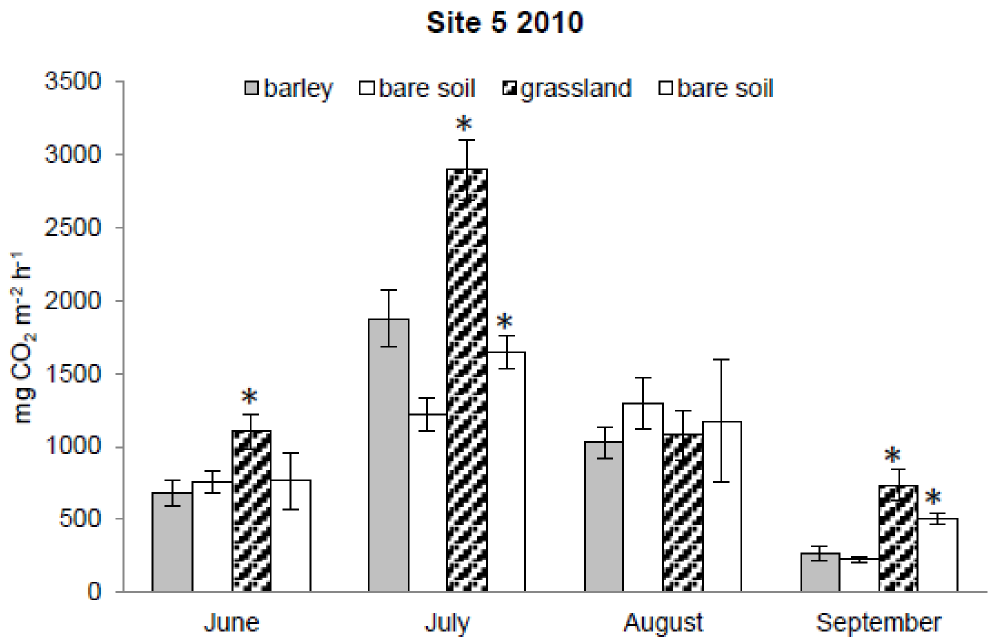
Peak N_2O emissions from compacted plots in autumn 2021!



Field measurements with Gasmet GT5000

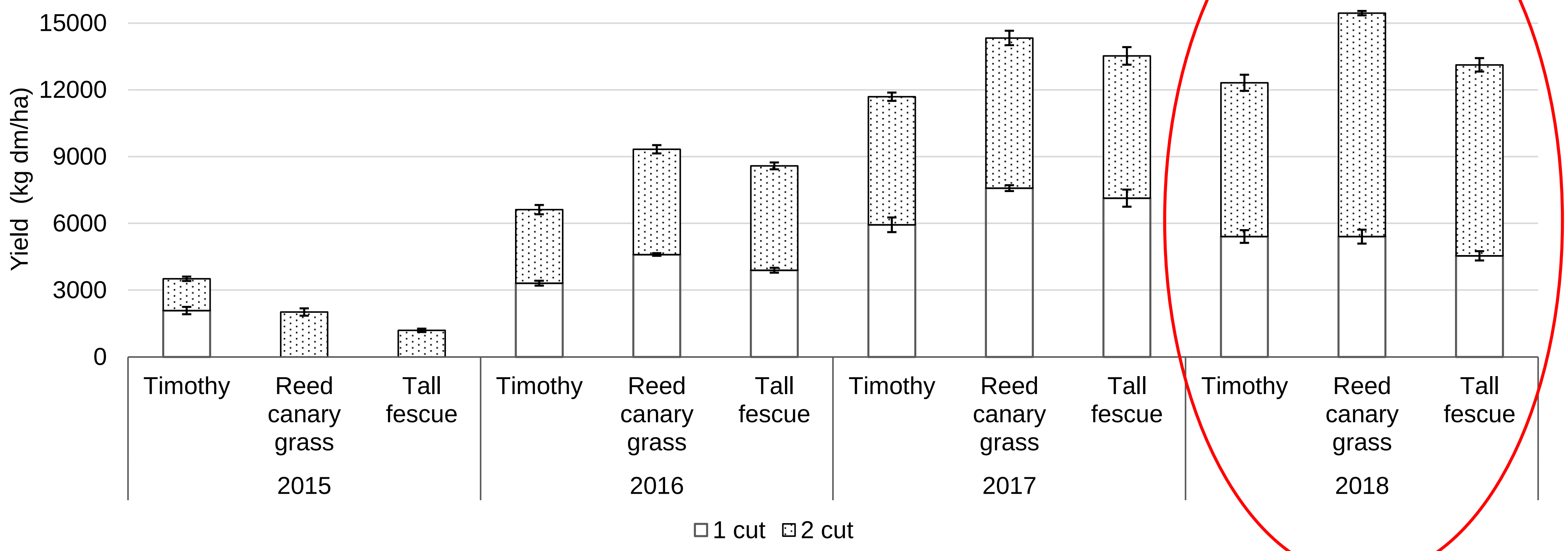
Cropping systems





Lisbet Norberg, Örjan Berglund, Kerstin Berglund,
Seasonal CO2 emission under different cropping systems on Histosols in southern Sweden,
Geoderma Regional, Volume 7, Issue 3, 2016

Grass trial



Örjan Berglund, Kerstin Berglund, Sabine Jordan, Lisbet Norberg,
Carbon capture efficiency, yield, nutrient uptake and trafficability of different grass species on a cultivated peat soil,
CATENA, Volume 173, 2019

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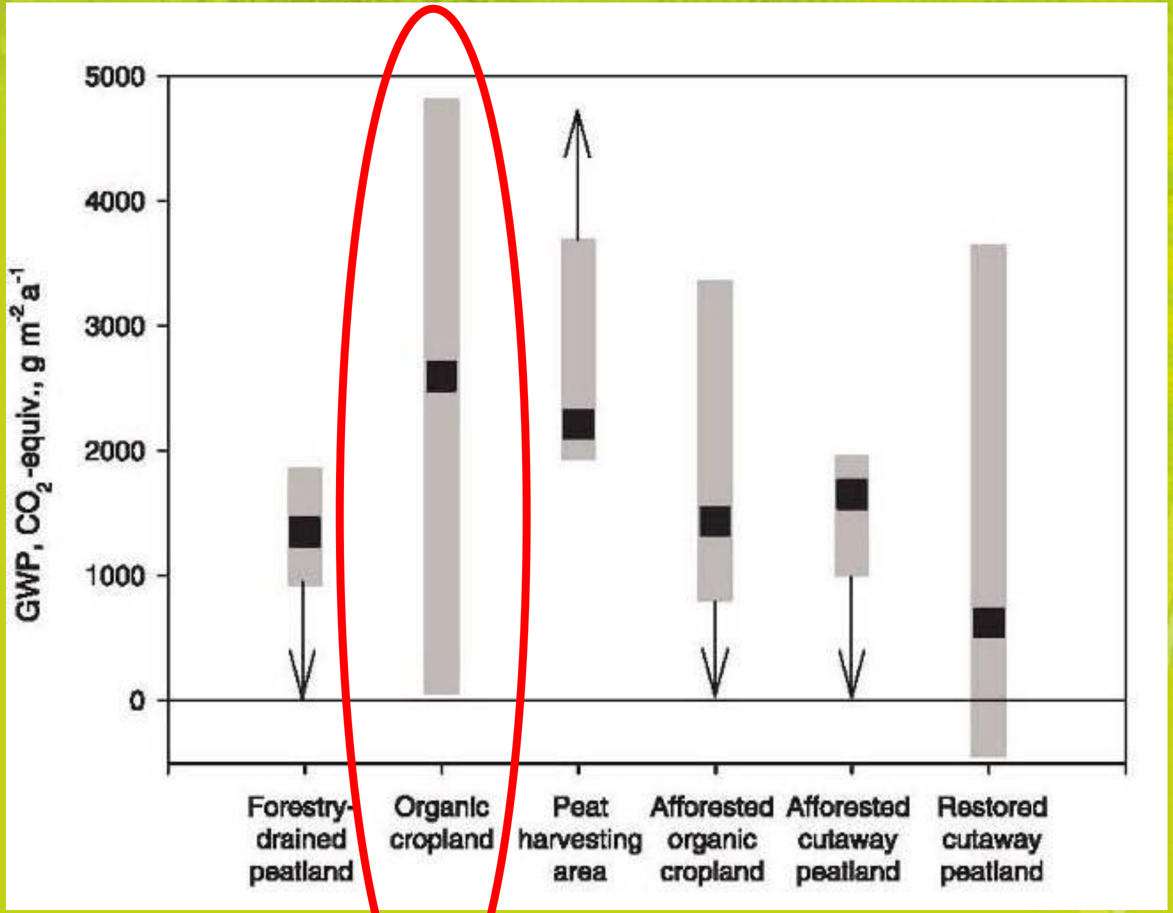
GHG emissions at different land use?

GHG emissions

At different land use



Finnish trials

Greenhouse Impacts of the Use of Peat and Peatlands in Finland
Research Programme Final Report, 2008, Sarkkola (ed.)
Ministry of Agriculture and Forestry 11a/2007

Results from field trials

- Manage water table (oxygen availability)
  - Often high emissions even with a quite shallow water table (30 cm)
  - Hard to manage the wt, need water
  - Risk of all GHG (CO_2, N_2O, CH_4)
  - Different responses due to high variability in physical properties (porosity)
  - Legal difficulties in changing water table level in streams
- Soil management (tillage, carbon availability)
  - No effect on emission between ploughing och shallow tillage
- Soil amendments (sand addition, carbon dilution)
  - Lower emissions (20%) from plots treated foundry sand (5 cm)
- Crop management (effect on microbial structure)
  - No impact on GHG emission of different crops
  - High yield increases carbon capture efficiency
- Fertilisation (Copper, P, K, effect on microbial structure)
  - Effect of Cu in Canada, not with reasonable rates in our trials
- Liming (increase pH, reduce N_2O)
  - Did not work
- Nitrification inhibitor (reduce N availability)
  - It might work if N-release can be delayed until crops are growing

Conclusions

- It is possible to reduce emissions, but it is not easy, and every site is unique
- Sand addition reduced emissions
- High yield improve carbon capture efficiency
- Vegetated surface counteracts erosion and might reduce N_2O emissions
- The peat soils are important to ensure fodder production in dry years
- It is hard to regulate the water table

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