MRV4SOC PROJECT

Preliminary considerations and results of the MRV4SOC project towards the definition of standardised baselines. Three case studies: Peatlands, agriculture, and agroforestry

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EEA-ESA conference EO for MRV
Data needs in support of baseline definition
10/10/2024

Objectives of MRV4SOC

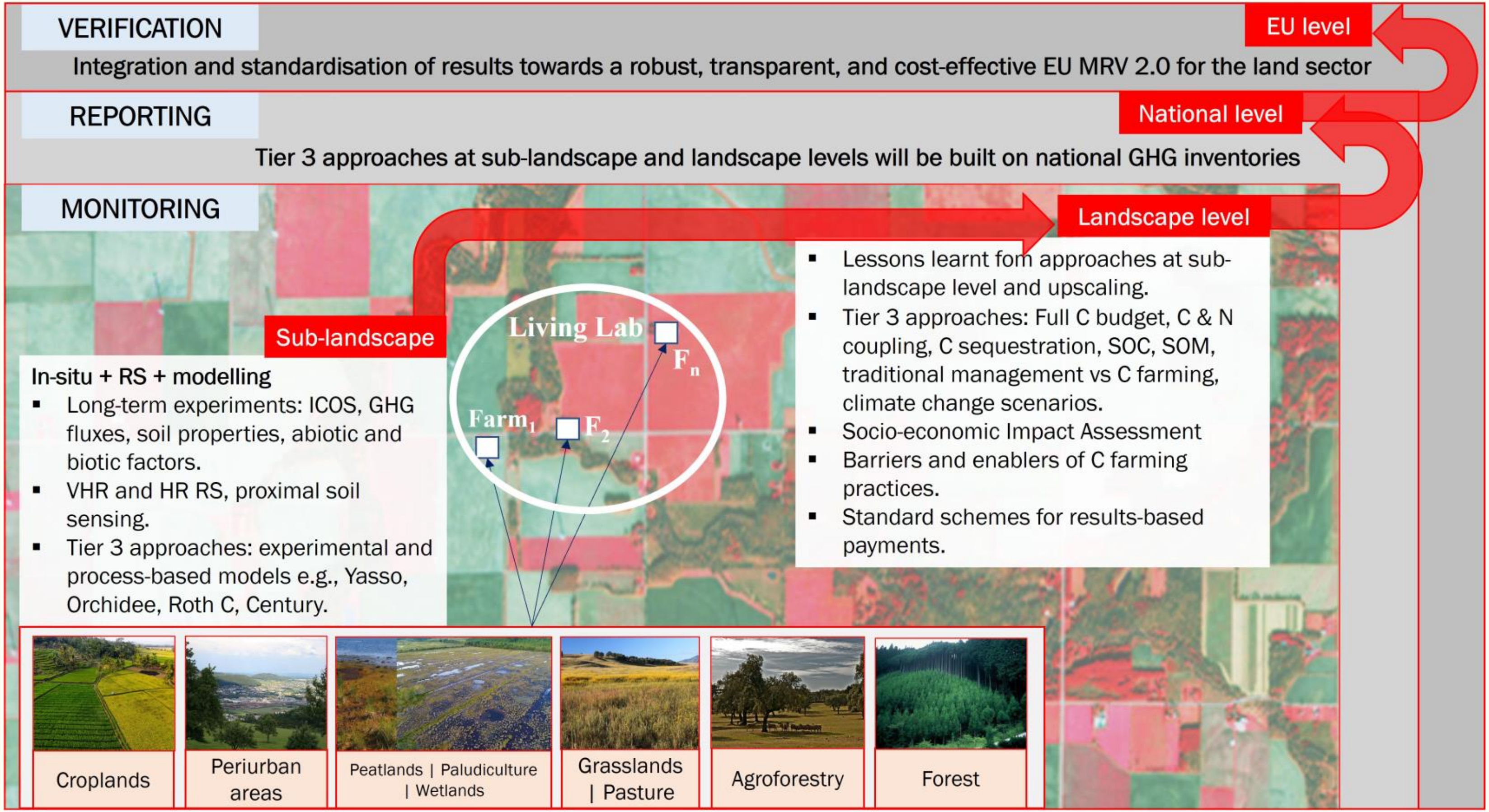
HORIZON-MISS-2022-SOIL-01-05
Monitoring, reporting and verification of soil carbon and greenhouse gases balance. GA. 101112754
21 partners
Duration: June 2023 – May 2026

General objective

Designing a **comprehensive* and robust Tier 3 approach*,** accounting for changes in **as many C pools** as possible, to estimate **GHG and full C budgets,** couple **C and N cycles, quantify C accumulation** (Soil Organic Carbon -SOC- and Soil Organic Matter -SOM-), and **assess the results of traditional management practices and C farming.**

- Scalable, accurate, transparent, standard, cost-effective, and reliable.
- assess the impact of **climate change on SOC accumulation** associated with **C farming practices.**
- 14 Demo Sites, 9 LULC classes in 5 EU countries (DE, CZE, IT, BE, SP) and 1 associated county (NOR)

Implementation and scales



Context

Demo Sites

- Agriculture / croplands
- Grassland / pasture
- Agroforestry
- Forest
- Peatland / Paludiculture / Wetlands
- Periurban

In-situ Boundary Conditions

Specific management conditions

1994 – SP	2014 – IT
1994 – IT	2019 – CZU
2004 – BE	2022 – BE

2010 - BE

1997 – SP	2010 – IT

1996 – NO
1997 – BE
2019 – CZU

2021 – NO
2028 – DE

1998 – SP

RS Boundary Conditions

RS indicators

Long-term datasets

Field campaign 2024

Tier 3

Process-based model

Assessment of in-situ and RS inputs
Uncertainty
Cost-effectiveness

Quantification of C removals or soil emission reduction

What do we quantify?

- *"The amount of **additional carbon removals or soil emission reductions** that an activity has generated in comparison to a **baseline.**"*

- *"Carbon removals and soil emission reductions, as well as the corresponding direct and indirect GHG emissions associated, should be quantified in a **relevant, conservative, accurate, complete, consistent, transparent, and comparable manner.**"*

2022/0394 (COD)

Definition of baseline

"Representative of the **standard performance** of **comparable practices** and processes in **similar social, economic, environmental and technological circumstances** and take into account the geographical context, including local pedoclimatic and **regulatory conditions.**"

Standard

- ***"Highly representative of the* standard** performance of comparable ***practices and processes*** in similar social, economic, environmental***, technological and regulatory*** circumstances and take into account the geographical context ***including local pedo-climatic and regulatory conditions ('standardised baselines')***."

Activity specific

- "Where duly justified *in the applicable certification methodology, including due to the **lack of data or the absence of sufficient comparable activities,*** *an operator shall use* ***a baseline that corresponds to the individual, performance of a specific* activity *('activity-specific baseline')***."

2022/0394 (COD)

Stratification of the analysis

Pedoclimatic conditions

At EU level

- Environmental zones (Metzger 2018) – EEA
- Pedoclimatic zone description ISQAPER EU (Interactive Soil Quality Assessment in Europe and China for Agricultural Productivity and Environmental Resilience)

At national and regional level

- Territorial units (NUTS)
- National pedoclimatic zone description
- Land use types (peatlands)

Regulatory conditions

- A minimum set of practices required by regulation.
- As practices widely adopted within a región with similar pedoclimatic and regulatory conditions.

MRV4SOC considerations

1) Standardised baseline should quantify a flux, i.e., a change of carbon stock in time

- Carbon removals and soil emission reduction (CO_2, N_2O, CH_4) → we need process-based models.

2) Performance of management practices: what should be considered as standard practices?

- A clear definition of Business as Usual is needed. We proposed considering the common management practices and the regulatory conditions.
  - Short-term: Nitrate directive + additional GAECs observed by farmers that choose to take CAP subsidies.
  - Mid-term: Common practices using digital maps + LUCAS + Copernicus

MRV4SOC considerations

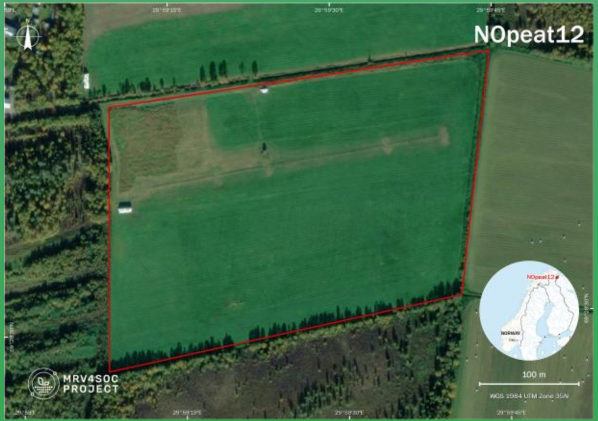
3) Similar circumstances.

- The standardised baseline should be fair for all farmers, i.e., conventional and early movers.

- There will be variability in initial SOC levels in the same region or under similar circumstances. A baseline should consider the same fixed range of key drivers of C removals to assess expected outcomes and the associated uncertainty.

- A range of baselines considering different initial conditions and not a unique number for all the region could account for regional variability and ensure fairness.

Peatlands



Peatland (drained with cultivated grass). Svanhovd Station

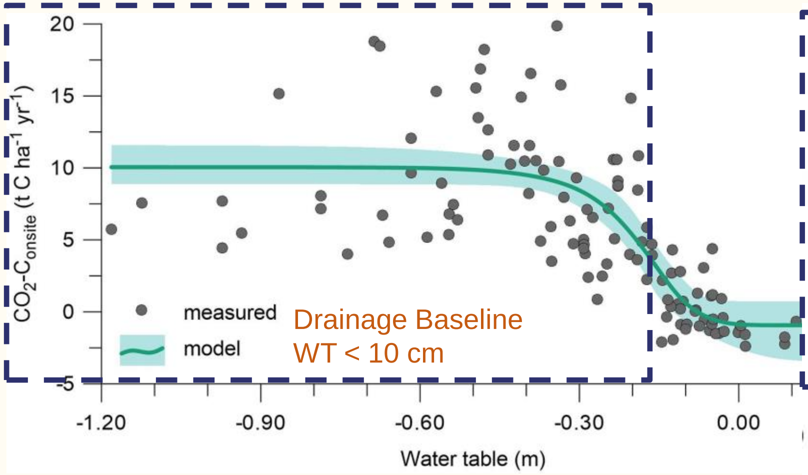
Peatland (drained for grassland) turned to Paludiculture. Bargischow

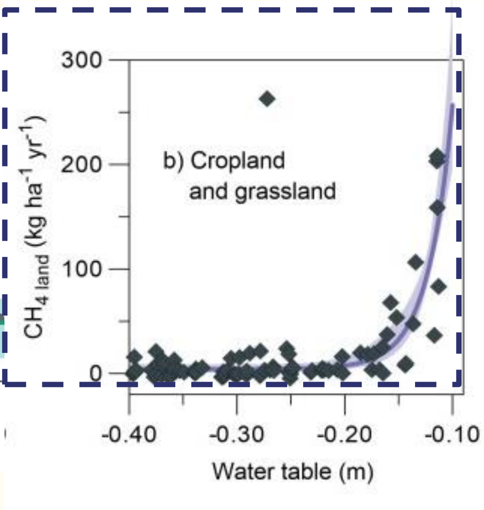
Peatland Heiligensee & Hutelmoor Nature Reserve, Rostock

"Ferne Wiesen", Natural peatland nearby Peene river

Peatland baselines from Nationally Determined Contributions (NDCs) in Germany

- 90% of peatlands have been drained for agricultural use
- Water level as main control for peatland emissions





Tiemeyer, B., Freibauer, A., Borraz, E. A., Augustin, J., Bechtold, M., Beetz, S., ... & Drösler, M. (2020). A new methodology for organic soils in national greenhouse gas inventories: Data synthesis, derivation and application. *Ecological Indicators*, *109*, 105838.

Peatland baselines from NDC in Germany

Simplified to Tier 2 approach due to **a lack of annual water level data**

Baseline EF for drained organic soils under different land use types

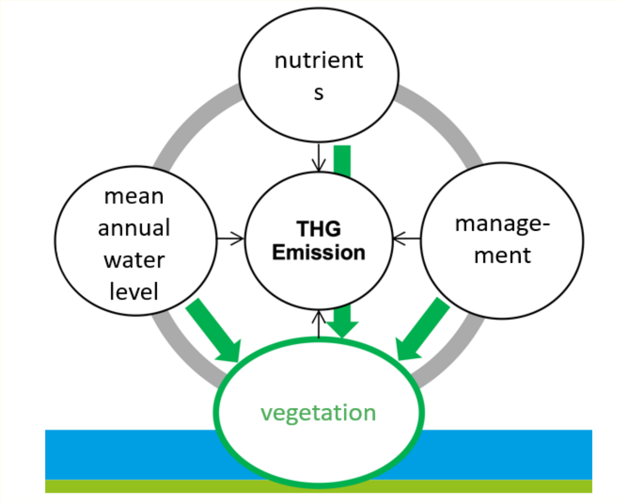
Land-use category	$CO_{2\ onsite}$ (t C ha^{-1} yr^{-1})		$CH_{4\ land}$ (kg CH_4 ha^{-1} yr^{-1})		direct N_2O (kg N_2O-N ha^{-1} yr^{-1})	
	German EF	Default EF (Tables 2.1 and 3.1)	German EF	Default EF (Tables 2.3 and 3.3)	German EF	Default EF (Table 2.5)
Forest land	7.7 (1.0–10.9)	2.6 (2.0–3.3)	4.0 (−12.4–45.7)	2.5 (−0.6–5.7)	2.0 (0.1–8.3)	2.8 (−0.57–6.1)
Cropland	9.2 (3.8–11.2)	7.9 (6.5–9.4)	5.5 (0.5–17.9)	0 (−2.8–2.8)	11.1 (1.8–40.5)	13 (8.2–18)
Grassland, settlement	8.3 (1.4–11.0)	3.6–6.1 (1.8–7.3)*	11.2 (0.6–86.4)	1.8–39 (−2.8–81)*	4.6 (0.3–22.2)	1.6–8.2 (0.56–11)*
Drained unutilized land	7.1 (0.7–10.8)	No EF	70.2 (1.3–184)	No EF	0.7 (−0.1–2.9)	No EF
Peat extraction**	1.3 (1.2–1.4)	2.8 (1.1–4.2)	4.2 (−0.4–13.1)	6.1 (1.6–11)	0.9 (0.3–1.4)	0.3 (0–0.6)
Rewetted organic soils	−0.4 (−2.4–1.3)	−0.23–2.5 (−0.71–1.71)**	279 (140–700)	123–288 (0–1141)***	0.1 (−0.5 to 1.0)	0

Tiemeyer, B., Freibauer, A., Borraz, E. A., Augustin, J., Bechtold, M., Beetz, S., ... & Drösler, M. (2020). A new methodology for organic soils in national greenhouse gas inventories: Data synthesis, derivation and application. *Ecological Indicators*, *109*, 105838.

Peatland baselines from the GEST (GHG Emission Site Type) approach

A revised Tier 2 method for baseline scenarios under missing water level information

Baseline EF for drained organic soils under different land use types



- Vegetation is closely linked to water levels, nutrient ratios
- Vegetation itself has an influence on emissions
- Detection is comparatively quick, easy and cheap
- Detailed maps of vegetation types are available from local authorities

NEEDS AND OPPORTUNITIES

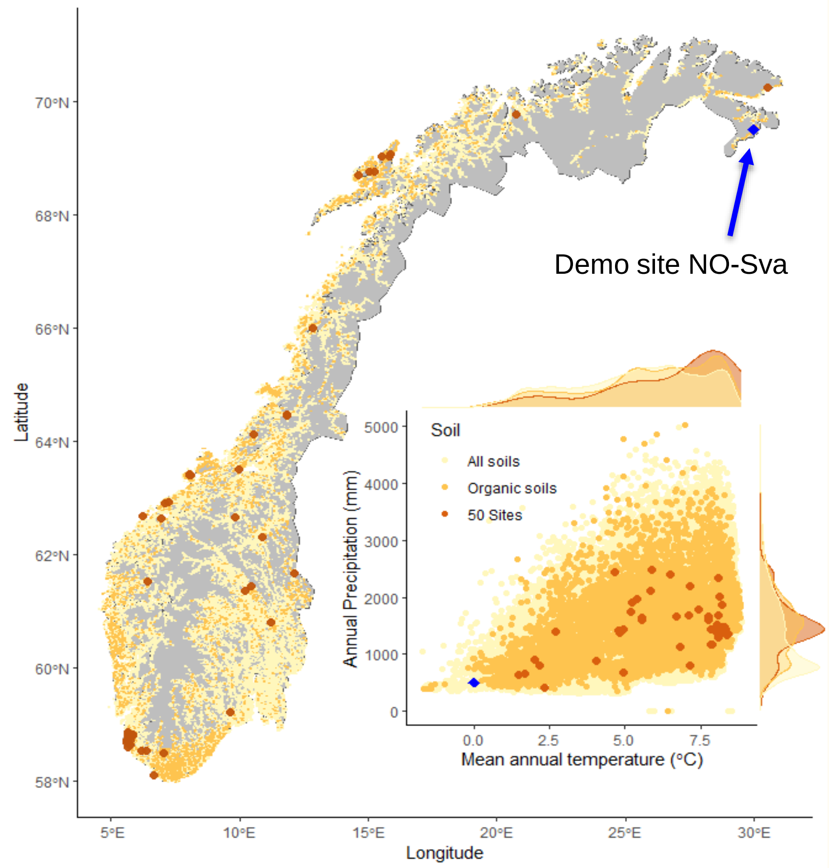
- **Accurate and updated maps of peatlands**
- **More granular** refinement of the National Greenhouse Gas Inventory, which is primarily focused on land use.
- Determining emission factors for **specific vegetation types**, GEST can provide **more precise** estimates of greenhouse gas emissions
- GEST approach is particularly beneficial for **baseline scenarios** involving **grassland on drained peatland**, where the approach can offer **greater differentiation** in emissions calculations

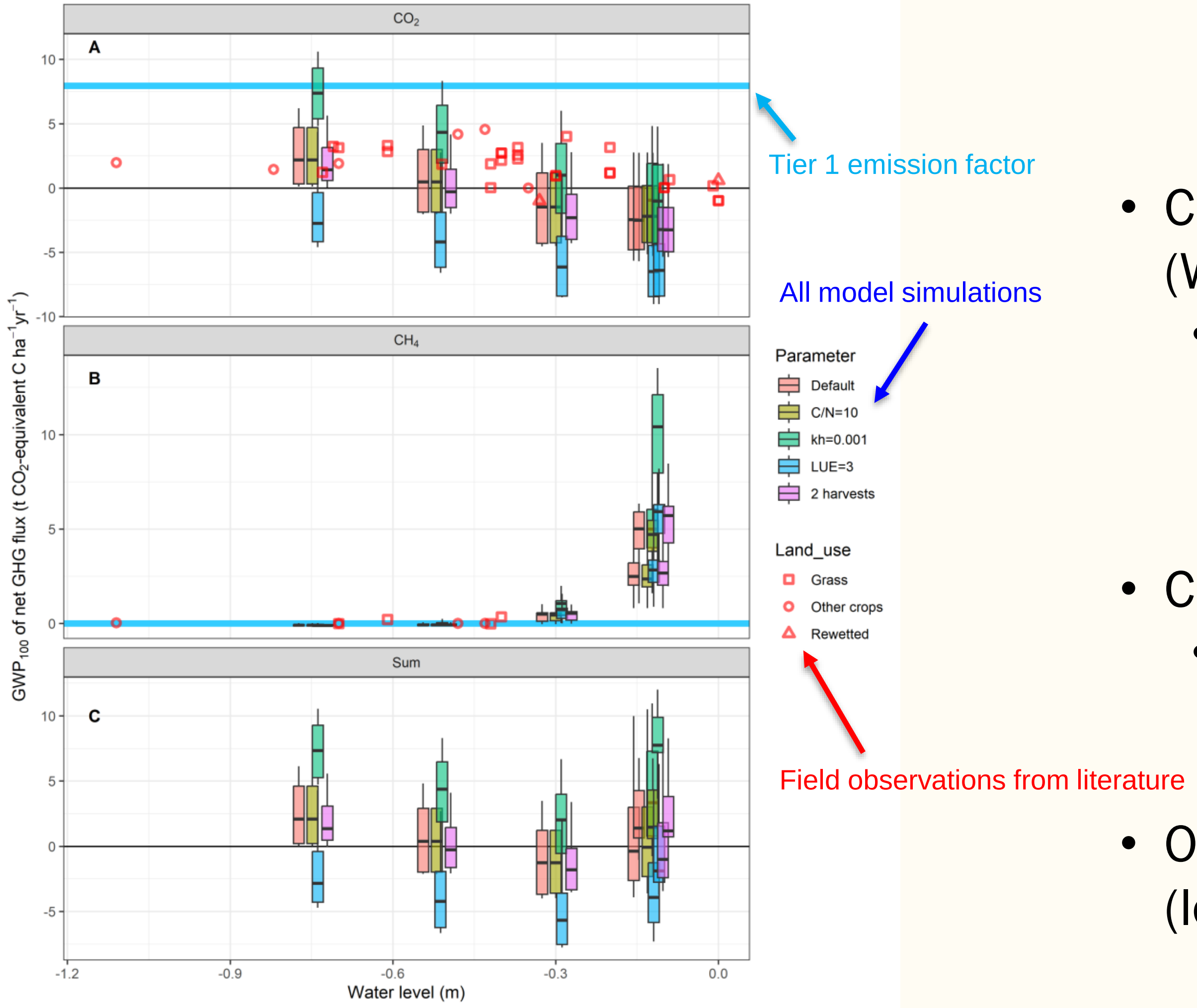
NEEDS AND OPPORTUNITIES

- **Meta-analysis of GHG measurement data for temperate Central Europe**
- Classification of **measurement data for different GHG emission site types** (GESTs)
- **Calculation of emission factors (EF) as average values for each GEST**
- Different versions:
  a. Couwenberg et al. 2008
  b. Couwenberg et al. 2011
  c. Reichelt 2015
  d. Couwenberg et al. unpublished (→ 2024?)
  e. GEST refined for MRV4SOC

Agriculture soil distribution in Norway

- ❑ Process-based **CoupModel** was trained using observed CO2 and CH4 fluxes from **NO-Sva.**
- ❑ Orange points are on organic soils (peatlands).
- ❑ Brown points are randomly selected sites for further model simulations.





- CO2 flux from drained sites (Water level< -0.6 m)
  - **Tier 1 EF higher** than simulations and observations

- CH4 flux from drained sites:
  - Similar among simulations, observations, and EF.

- Optimal water level: **-0.3 m** (lowest CO2 + CH4)

NEEDS AND OPPORTUNITIES

- Lack of data to develop a Tier 3 approach.
- Products that can provide information of water table levels at different locations will be a great breakthrough.
- For cultivated peatlands, field observations of CO_2 and CH_4 fluxes are extremely important but lacking, especially in Norway.
- Our field experiment includes a large water table gradient as a treatment: effect of rewetting.

NEEDS AND OPPORTUNITIES

- Our field experiment includes a large water table gradient as a treatment: effect of rewetting.
- Measurement networks provide high quality data with relatively standardised measurement protocol and open access such as ICOS.
- Since the coverage of the networks is quite limited, field measurements outside of the networks are also needed.

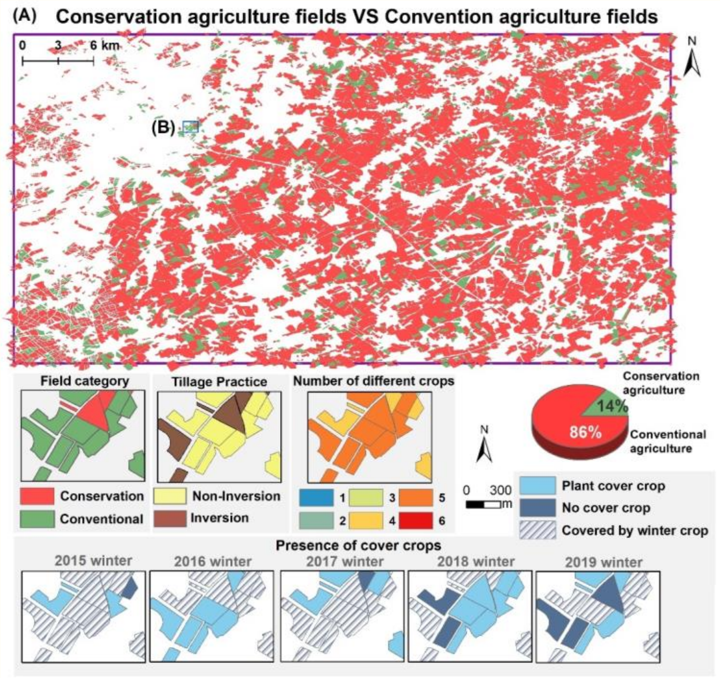
Agriculture

Agriculture. Lonzée, Namur, Belgium

Predict management practices for cropland using census data and remote sensing technologies

- Tillage practice (traditional/reduced)

Develop a tillage model using ground truth data and time-series satellite vegetation indices, also validated with independent dataset.

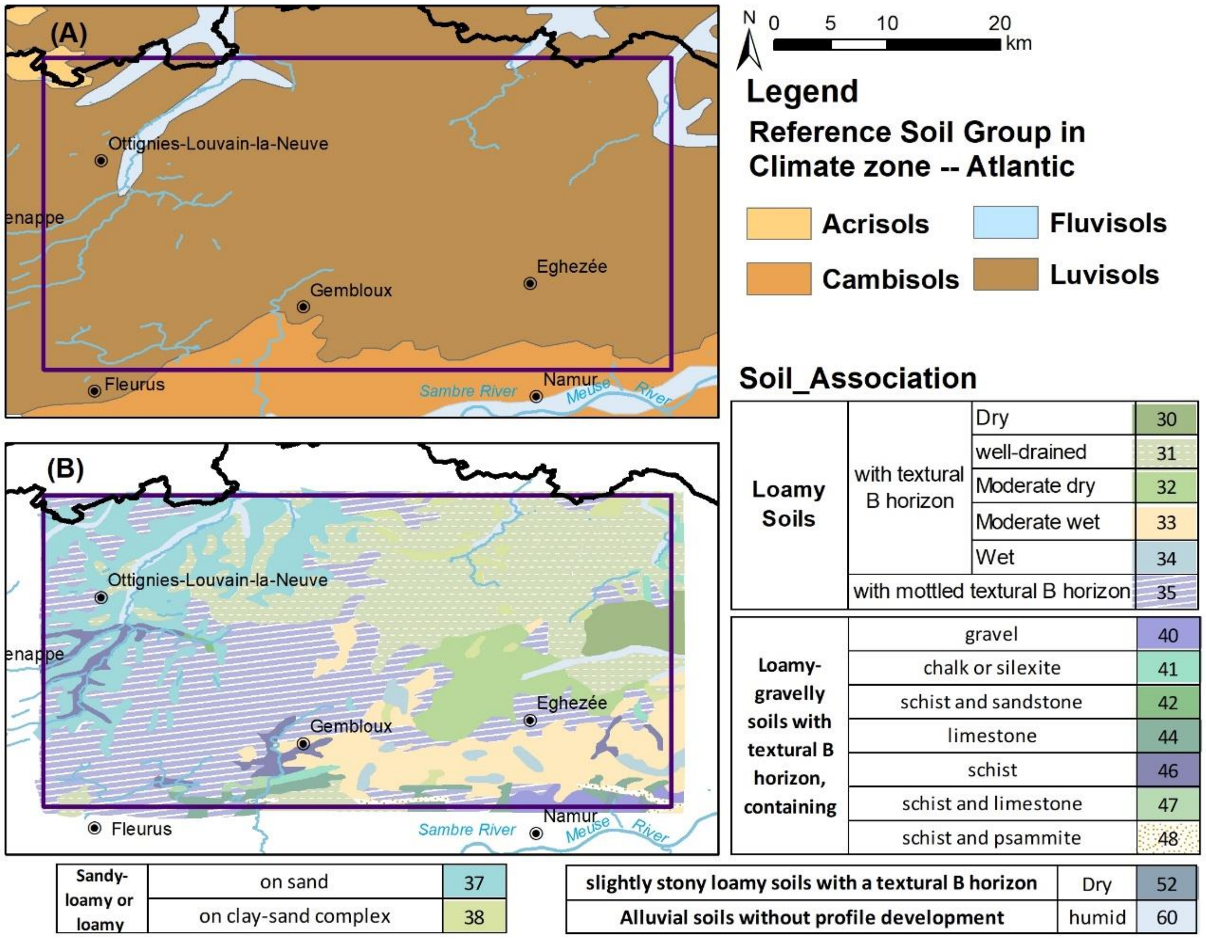


Overall statistics

Reduced tillage: 9.6%

Traditional tillage: 90.4%

- And, In our study area, there are **90.4% of fields use Traditional tillage**



Option for EU Scale

ISQAPER - pedoclimatic zones
Task 2.2

Option for national Scale

Soil Associations Map for Belgium
JRC, European Soil Data Centre (ESDAC)

Boundary conditions for each subregion

Business As Usual **Reduced tillage** **Long Cover Crop**

Data type	Source
Climate	Average climate products
Manure (original: Per province)	Based on area proportions of different provinces within the subregion
C input from main crops (original yield: Per province) & CC (per field)	For main crops: Based on the proportion of different main crops For cover crops: adoption rate from prediction map (digital technologies) statistics value regulation value
Tillage	Set as traditional tillage

SOC stock changes (BAU) Different pedoclimate zone

	Reference Soil Group (RSG) in Climate zone Atlantic	Area(ha)	Clay (%)	SOC stock 2015 ($t{\cdot}ha^{-1}$)	SOC stock 2024 ($t{\cdot}ha^{-1}$)	Delta ($t{\cdot}ha^{-1}$)
201	Acrisols	0.05%	13.26	40.43	41.64	1.21
207	Cambisols	6.74%	15.76	51.72	51.33	-0.39
209	Fluvisols	2.09%	13.068	46.13	45.93	-0.20
215	Luvisols	91.13%	13.33	46.17	46.37	0.19

SOC stock changes (BAU) –Different soil association group

Id	Area (ha)	Clay (%)	SOC stock 2015 ($t{\cdot}ha^{-1}$)	SOC stock 2024 ($t{\cdot}ha^{-1}$)	Delta ($t{\cdot}ha^{-1}$)
31	15,279.85	13.05	44.84	44.95	0.11
35	19,762.52	13.40	46.39	46.94	0.56
38	1,410.35	12.80	44.62	44.73	0.12
33	4,516.03	14.56	51.12	51.05	-0.07
32	3,326.47	13.74	45.97	46.46	0.49
37	1,618.72	11.89	46.92	47.41	0.49
40	421.78	16.10	56.40	55.99	-0.41
60	530.00	13.71	47.24	47.49	0.24
30	1,496.31	15.61	44.02	44.53	0.51
34	921.93	14.67	51.30	51.08	-0.22
44	444.58	16.06	52.33	52.79	0.46
46	324.85	14.70	50.55	50.76	0.21
48	300.34	15.62	53.55	53.43	-0.13
41	184.45	14.66	51.24	50.21	-1.03
47	55.50	16.36	48.70	49.51	0.81
52	55.58	16.15	58.88	57.42	-1.46
42	6.27	11.71	48.31	46.92	-1.38

NEEDS AND OPPORTUNITIES

- ❑ Bulk density
- ❑ SOC ranges for NUTS 2/3.
- ❑ Leverage on remote sensing and other networks: NFI, ICOS, ICP Forest, LPIS, LUCAS
- ❑ Resampling dates after a couple of years/decades and monitoring C inputs is key to calibrate the model.

Agroforestry

Agriculture. Lonzée, Namur, Belgium

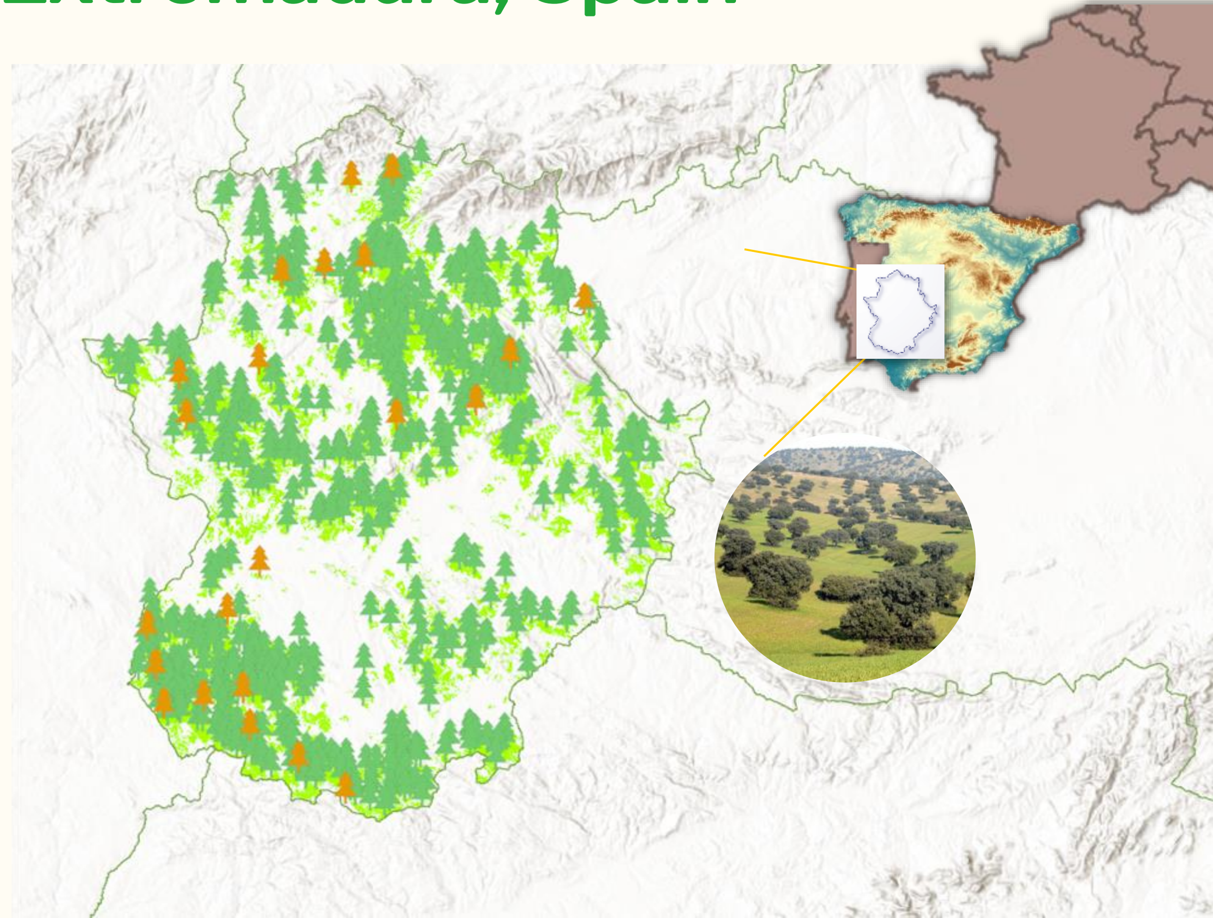
NFI dehesas in Extremadura, Spain

- Extremadura Autonomous Community (NUTS-2)
  25% of dehesas

- *Quercus ilex L.*

- 499 NFI plots dehesas (remeasured plots between NFI 2, 3 y 4)

- Years: 1991 – 2017 (26)
  NFI2: 1991
  NFI3: 2002
  NFI4: 2017



Management practices

From Rolo and Moreno, 2019

PLOTS	% sCCF	CLASS DESCRIPTION
77		Shrub cover increases
76	NFI2 NFI3 NFI4	Shrub cover decreases
235		No changes with low shrub cover
103		Variable

LAND USE TREND

- Scenario 1 → Abandonment traditional management
- Scenario 2 → Returning to traditional management
- BAU → Tradicional management
- Var → No pattern defined

Preliminary results

GLMM: SOC_balance ~ Scenario * ns(Year, df=4) + (1|Plot)

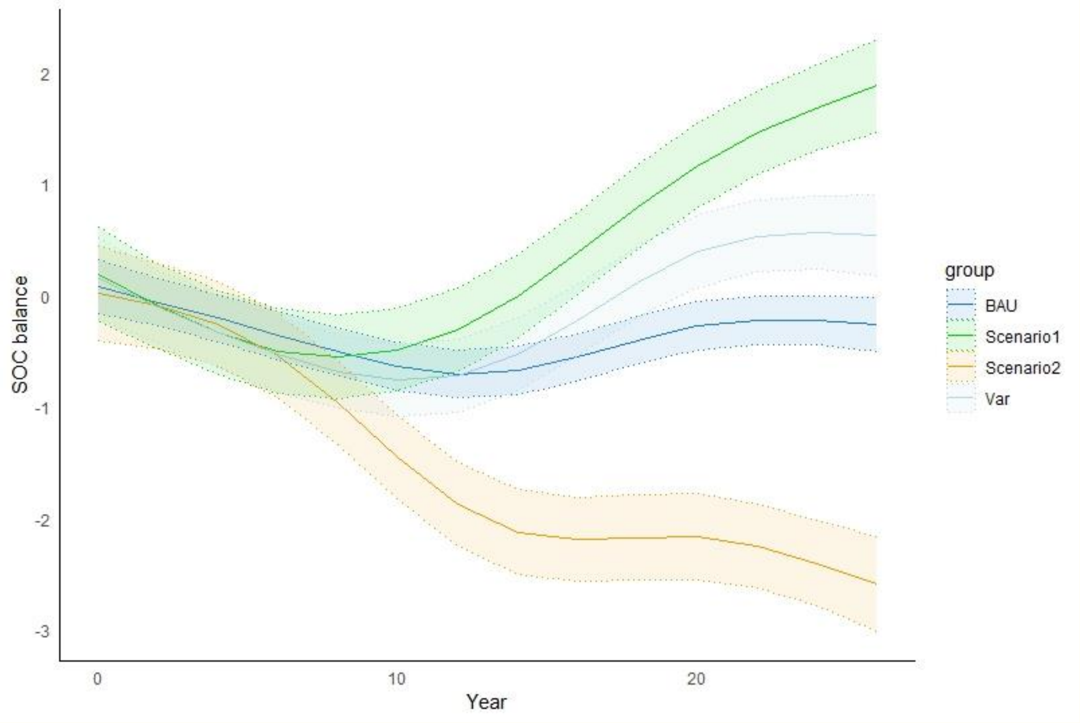


Table. Test POST-HOC; pairs significance

Contrast	Estimate	SE	p. value
BAU – Scenario1	**-0.530**	**0.223**	**0.026 ***
BAU – Scenario2	**1.323**	**0.224**	**<.001 ***
BAU – Var	-0.055	0.201	0.784
Scenario1 – Scenario2	**1.854**	**0.275**	**<.001 ***
Scenario1 – Var	0.475	0.256	0.076
Scenario2 – Var	**-1.378**	**0.257**	**<.001 ***

* Significant differences between factor levels (p<0.05)

NEEDS AND OPPORTUNITIES

- Oaks are long –living trees and agroforestry dynamics are slow. **SOC is stable in dehesas,** requiring long periods of time to reflect important changes (at least > 26 years). However, **C balances show significant variations** between scenarios

- In dehesas where there is an **abandonment of traditional management** there is a **tendency to gain soil carbon**, whereas in dehesas where the traditional **management is recovering,** we see the opposite tendency, which is a **loss of SOC** (more research needed).

- Account for other C inputs, detect good practices, and assimilate RS products

Final conclusions

- The standardised baseline should be fair for all farmers, i.e., conventional and early movers.
- A process-based model Tier 3 method is a comprehensive and cost-effective approach.
- RS data provides key information about vegetation, soil, and land management practices to parametrise process-based models.
- Additional in-situ data is needed to reduce uncertainties.

Thank you!

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