GHG emissions from drained versus undrained organic soil:

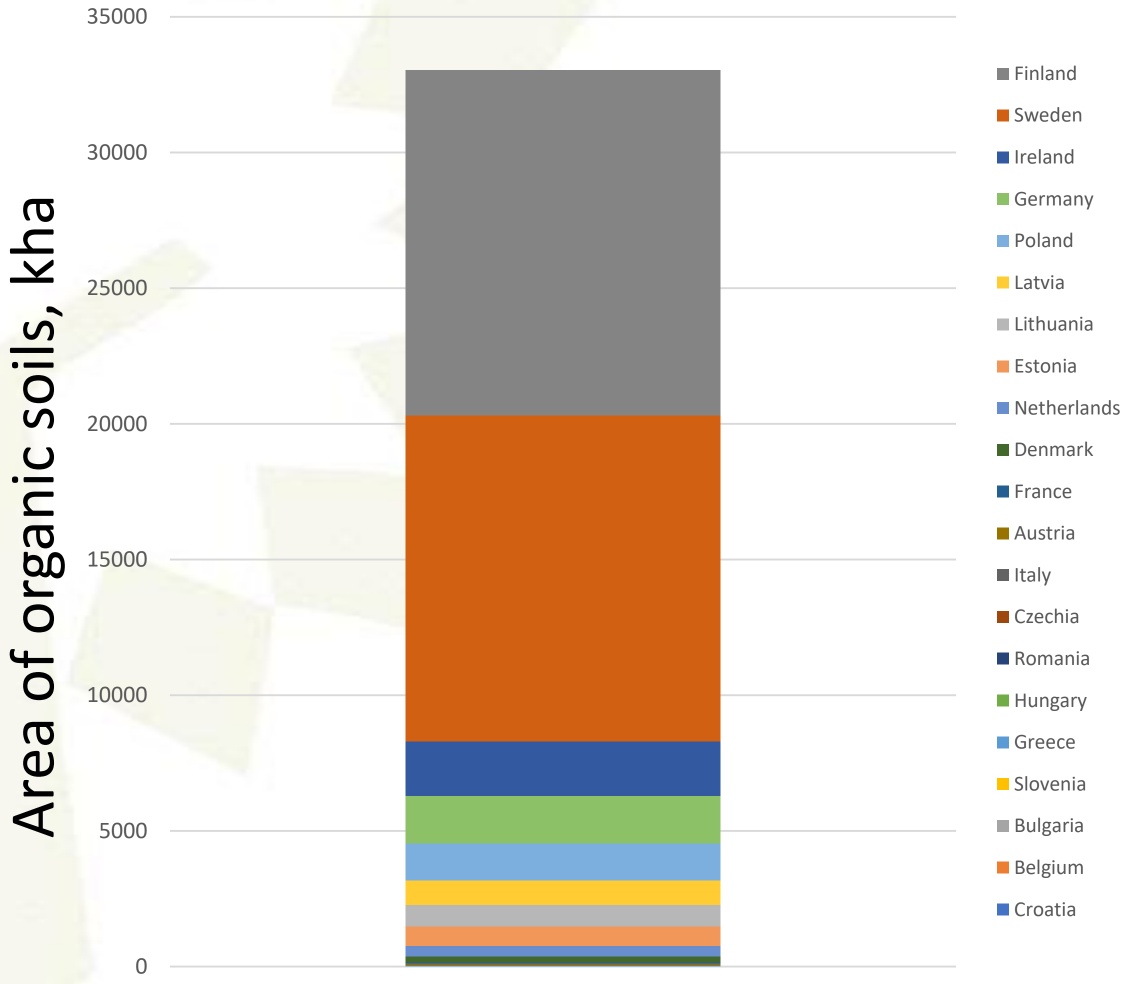
is it consistent with IPCC Guidelines to report GHG emissions from drained soil rather than the impact of drainage?

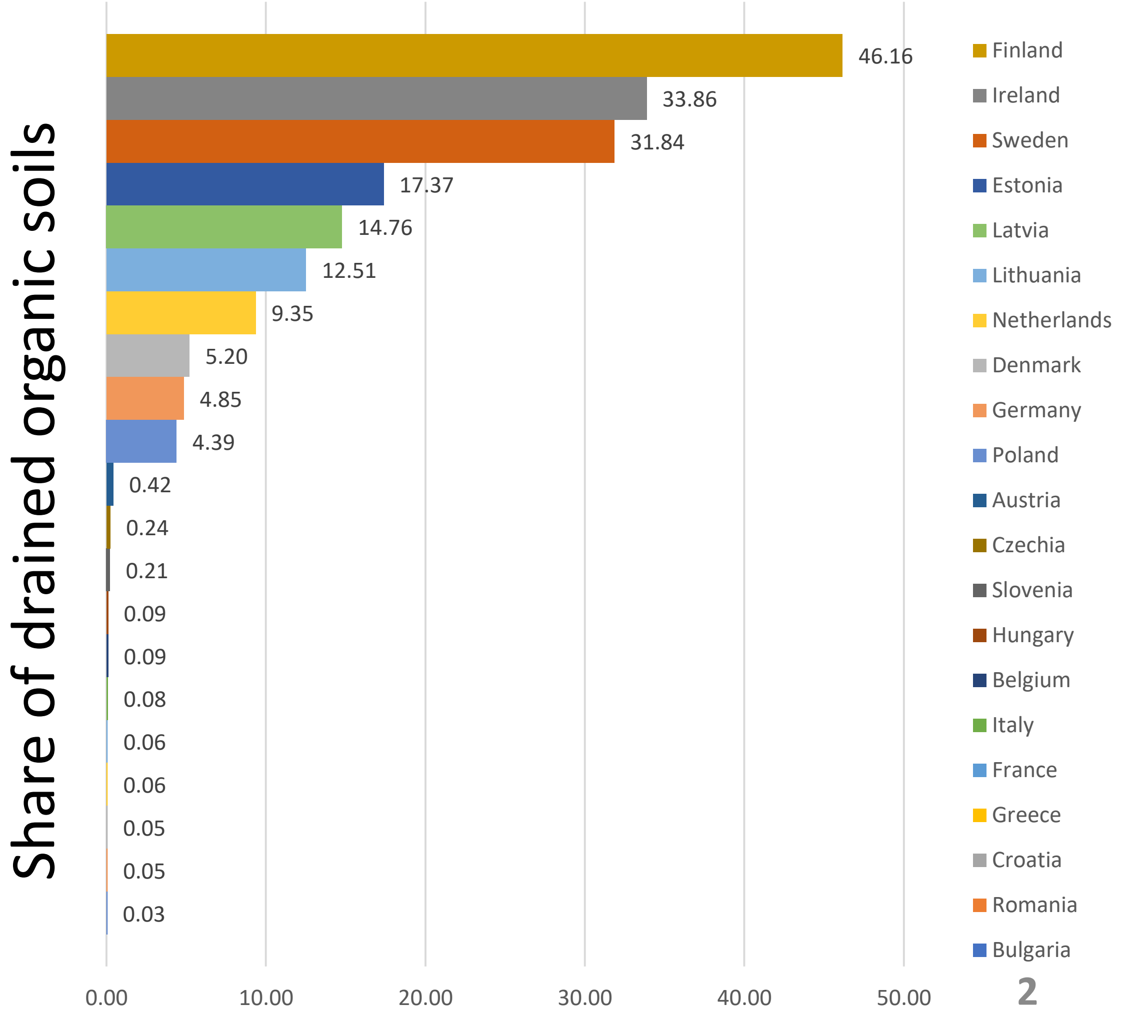
Aldis Butlers, Latvian State Forest Research Institute "Silava"

28th August

Organic soil topicality

Distribution of (managed/drained) organic soils (EU-27)

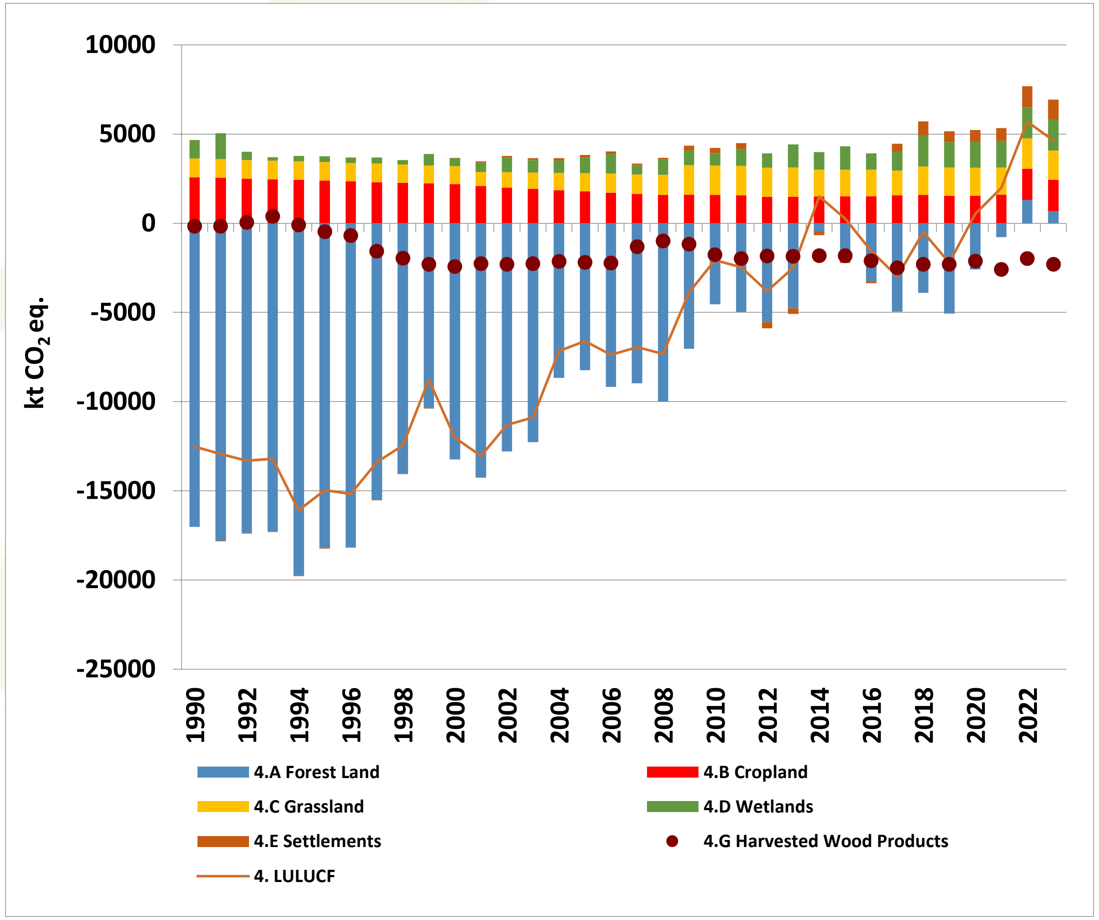


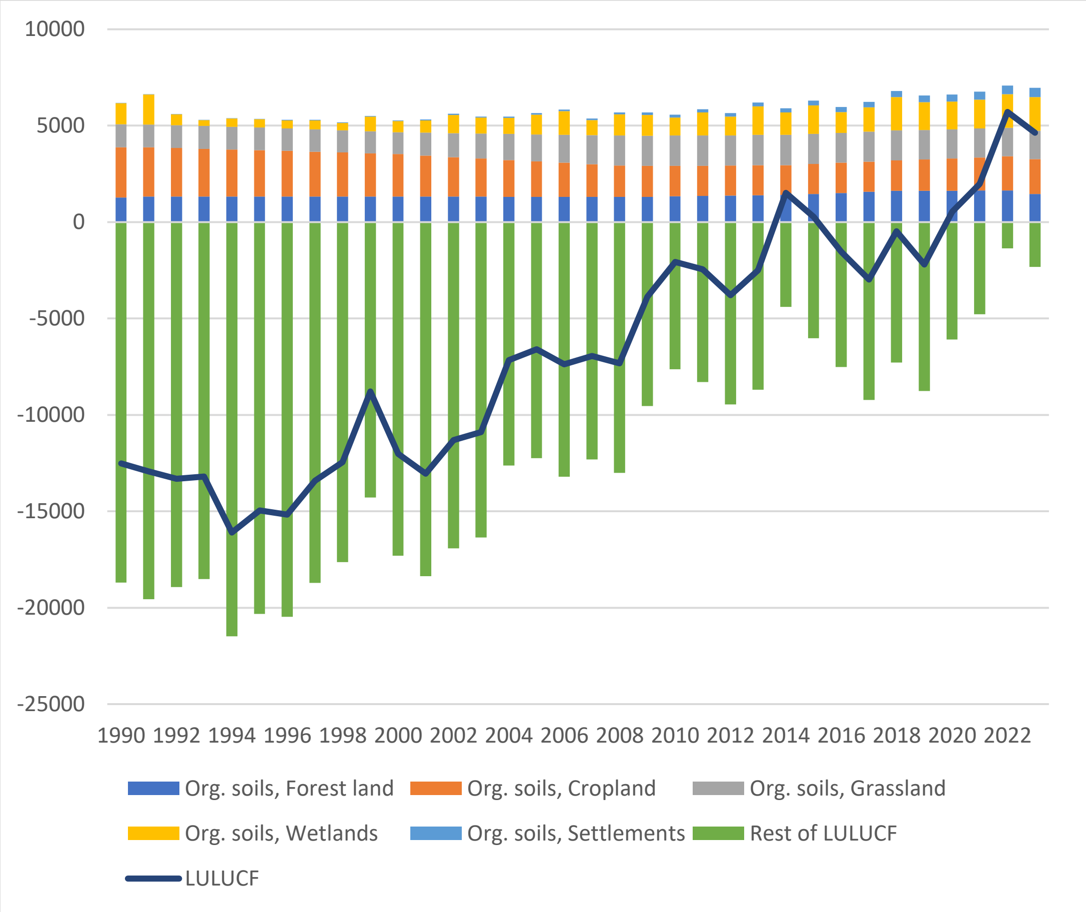


No organic soils reported for Cyprus, Luxembourg, Malta, Portugal, Slovakia, Spain

Organic soil topicality

LULUCF inventory perspective





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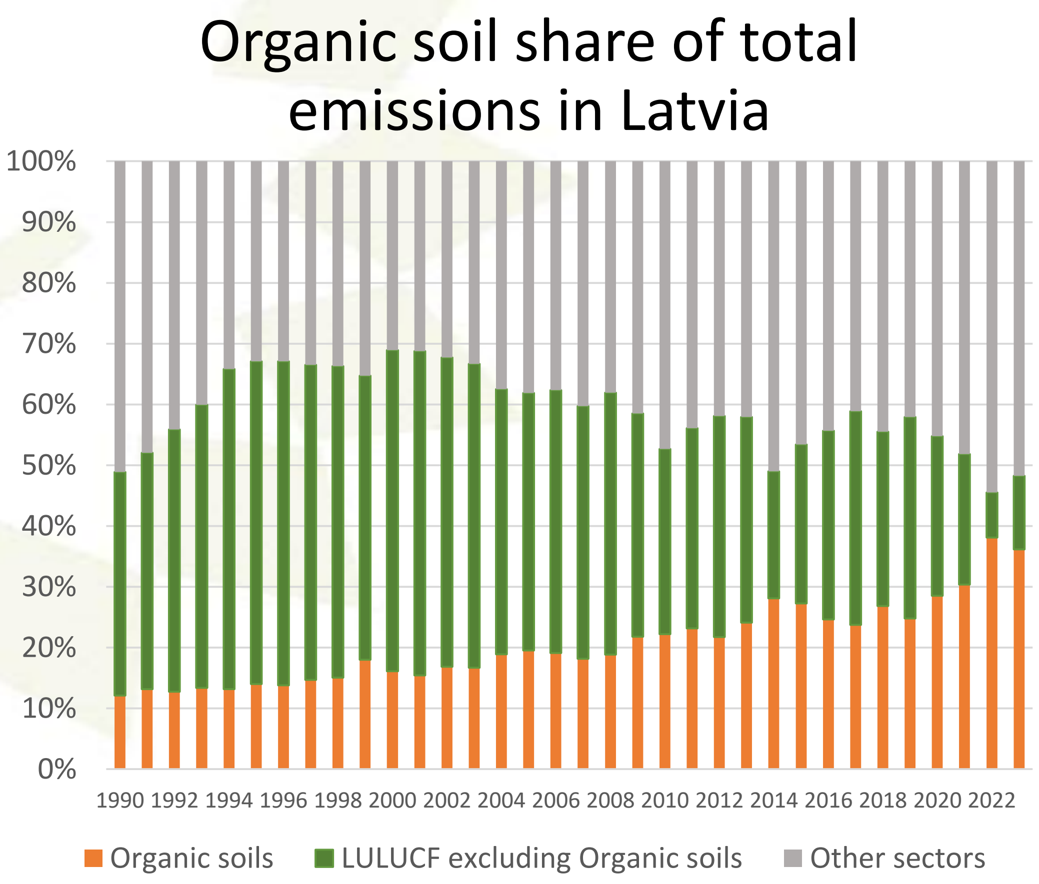
Organic soil topicality

Contribution of organic soils to total emissions in Latvia



Emissions from organic soils are associated with elevated uncertainty

x

Increasing contribution to total emissions

=

Growing uncertainty of the inventory

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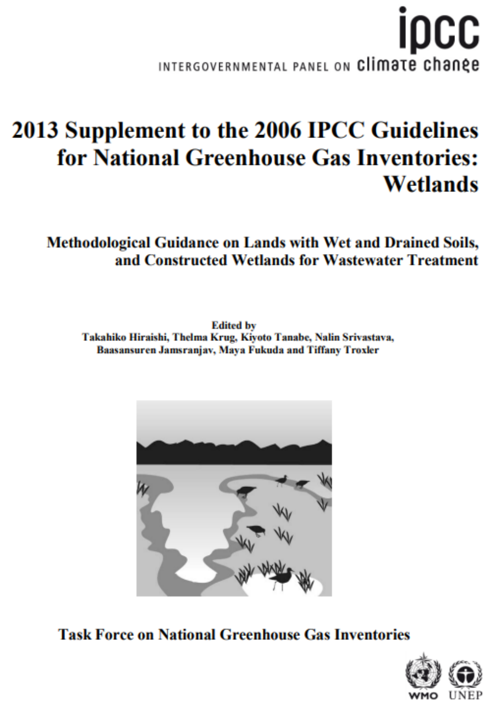
Climate target and policy implications

How can we reach climate targets if, according to emission factors, managed organic soils are basically a never-ending source of emissions?

We don't really know the GHG emissions from unmanaged organic soils or the outcome of rewetting — but rewetting fixes that!

Progress of soil GHG emission research

2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands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INTERGOVERNMENTAL PANEL ON climate change

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Edited by
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Task Force on National Greenhouse Gas Inventories

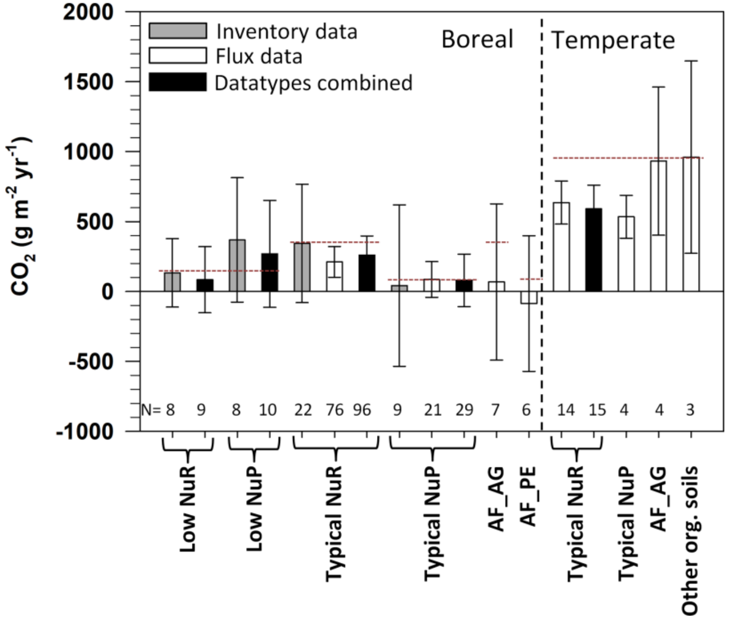
WMO UNEP

10 years →

Reviews and syntheses: Greenhouse gas emissions from drained organic forest soils – synthesizing data for site-specific emission factors for boreal and cool temperate regions

Jyrki Jauhiainen[1], Juha Heikkinen[1], Nicholas Clarke[2], Hongxing He[3], Lise Dalsgaard[2], Kari Minkkinen[4], Paavo Ojanen[1,4], Lars Vesterdal[5], Jukka Alm[1], Aldis Butlers[6], Ingeborg Callesen[5], Sabine Jordan[7], Annalea Lohila[8,9], Ülo Mander[10], Hlynur Óskarsson[11], Bjarni D. Sigurdsson[11], Gunnhild Søgaard[12], Kaido Soosaar[10], Åsa Kasimir[13], Brynhildur Bjarnadottir[14], Andis Lazdins[6], and Raija Laiho[1]

The added data caused only modest changes in the estimated EFs and their confidence intervals



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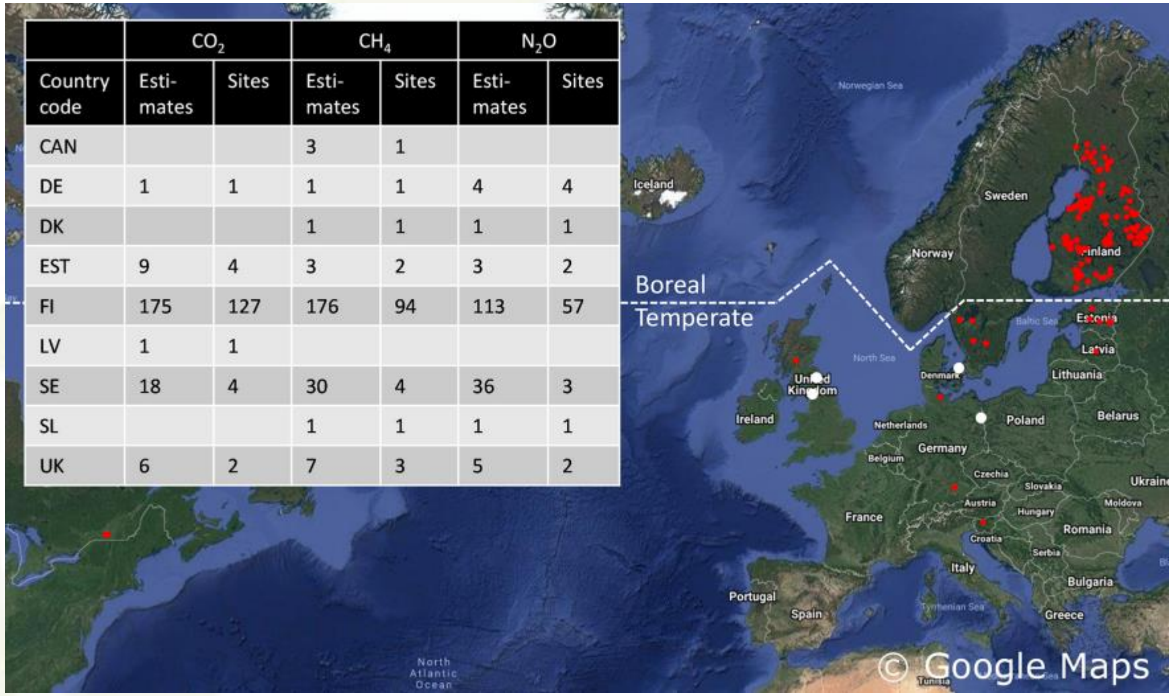
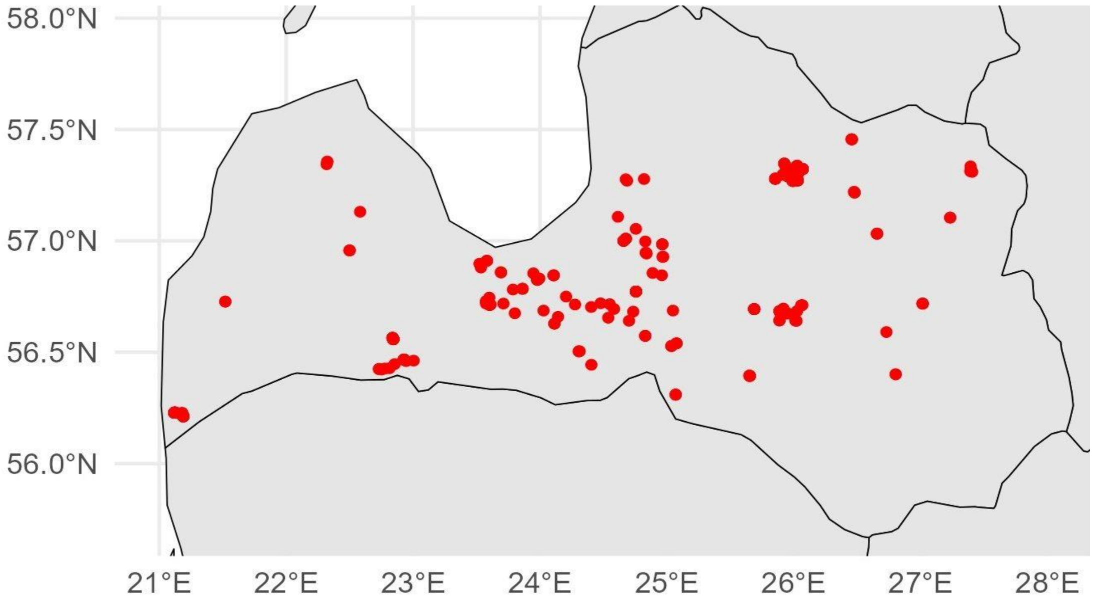
LOW PROGRESS

Progress of soil GHG emission research
Latvian case



	CO_2		CH_4		N_2O	
Country code	Esti-mates	Sites	Esti-mates	Sites	Esti-mates	Sites
CAN			3	1		
DE	1	1	1	1	4	4
DK			1	1	1	1
EST	9	4	3	2	3	2
FI	175	127	176	94	113	57
LV	1	1				
SE	18	4	30	4	36	3
SL			1	1	1	1
UK	6	2	7	3	5	2



By 2023, approximately 230 monitoring sites had provided annual soil greenhouse gas balance estimates for drained organic forest soils in the boreal and temperate zones (Jauhiainen et al., 2023).

Since 2015, more than 300 (and a growing number) soil carbon balance and greenhouse gas emission monitoring sites have been established, representing various land uses, management practices, and soil types

Progress of soil GHG emission research

Latvian case

DOI: 10.22616/ERDev.2024.23.TF157

DOI: 10.14214/sf.22017

DOI: 10.22616/ERDev.2020.19.TF492

DOI: 10.22616/ERDev.2024.23.TF131

DOI: 10.22616/ERDev.2024.23.TF158

DOI: 10.3390/agriculture14030387

DOI: 10.3390/atmos15091102

DOI: 10.3390/f13111790

DOI: 10.3390/f14071390

DOI: 10.3390/f15091500

DOI: 10.3390/land11122233

DOI: 10.3390/land13060790

DOI: 10.3390/w15101954

DOI: 10.46490/BF536

DOI: 10.5194/egusphere-2024-2523

DOI: 10.5194/egusphere-2025-1032

ISBN 978-9934-19-845-8

17 publications (2019-2025)

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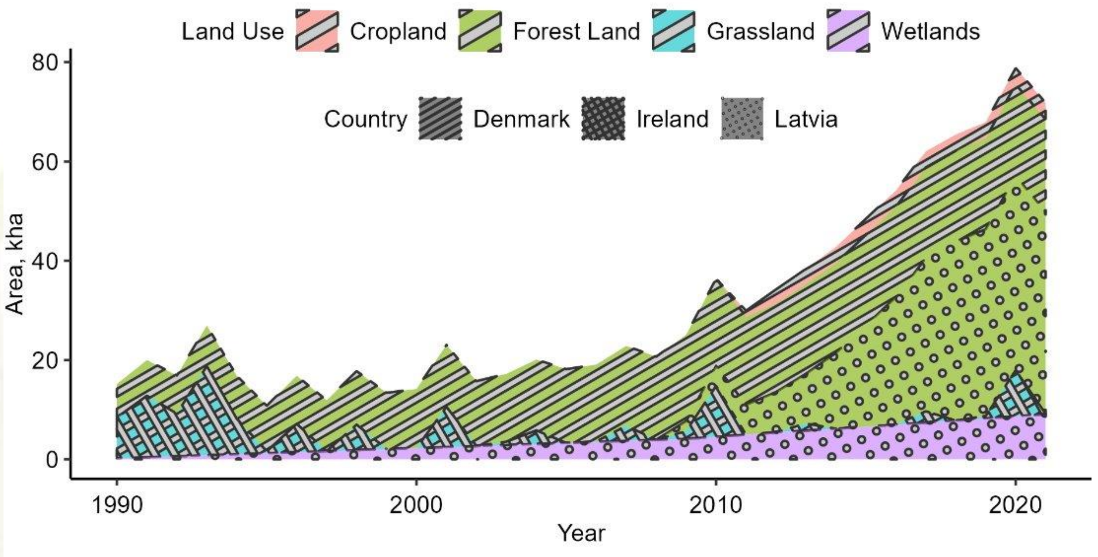
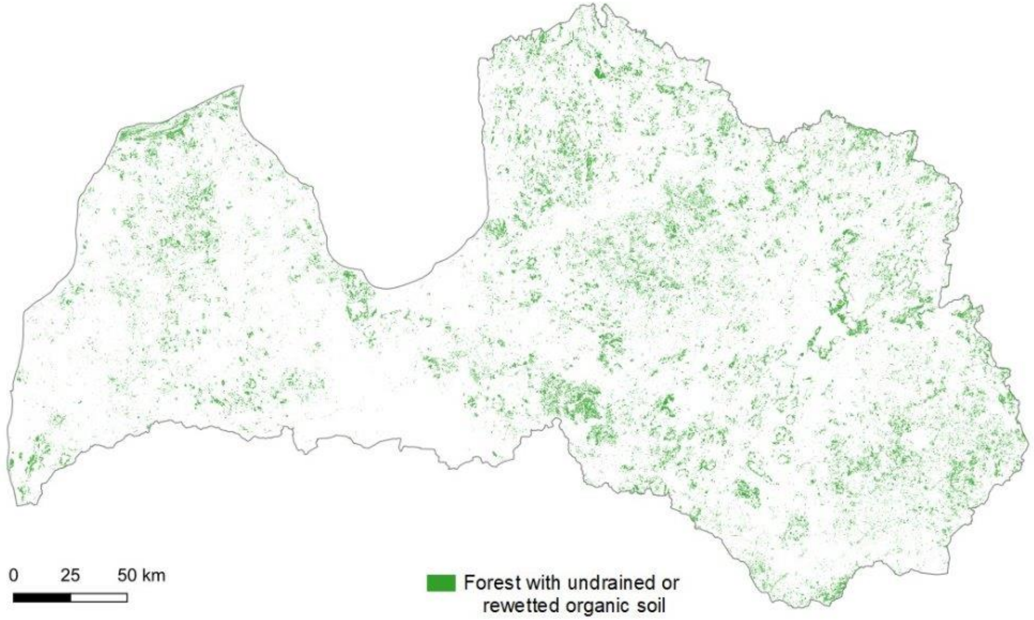
183 annualized soil C and GHG flux values

1	Land use category	Sub-category	Source/Sink	GHG	Unit	Value	S.E.	Reference	DOI or ISBN of the reference
2	Forest land	Nutrient-rich (Kp)	Drained organic soil	CO2 (net)	t CO2-C/ha/yr	4.98	1.58	Lazdiņš et al., 2024	DOI: 10.14214/sf.22017
3	Forest land	Nutrient-rich (Ks)	Drained organic soil	CO2 (net)	t CO2-C/ha/yr	0.19	1.31	Lazdiņš et al., 2024	DOI: 10.14214/sf.22017
4	Forest land	Nutrient-rich (clear-cut)	Drained organic soil	CO2 (net)	t CO2-C/ha/yr	0.9	0.7	Butlers et al., 2022	DOI: 10.3390/f13111790
5	Forest land	Nutrient-rich (deciduous)	Drained organic soil	CO2 (net)	t CO2-C/ha/yr	-0.2	0.4	Butlers et al., 2022	DOI: 10.3390/f13111790
6	Forest land	Nutrient-rich (coniferous)	Drained organic soil	CO2 (net)	t CO2-C/ha/yr	0.0	0.3	Butlers et al., 2022	DOI: 10.3390/f13111790
7	Forest land	Nutrient-rich (clear-cut)	Wet organic soil	CO2 (net)	t CO2-C/ha/yr	0.4	0.4	Butlers et al., 2022	DOI: 10.3390/f13111790
8	Forest land	Nutrient-rich (deciduous)	Wet organic soil	CO2 (net)	t CO2-C/ha/yr	0.0	0.4	Butlers et al., 2022	DOI: 10.3390/f13111790
9	Forest land	Nutrient-rich (coniferous)	Wet organic soil	CO2 (net)	t CO2-C/ha/yr	-0.8	0.4	Butlers et al., 2022	DOI: 10.3390/f13111790
10	Forest land	Nutrient-rich (alder)	Drained organic soil	CO2 (net)	t CO2-C/ha/yr	-0.94	1.30	Butlers et al., 2025 (preprints)	DOI: 10.5194/egusphere-2025-1032
11	Forest land	Nutrient-rich (birch)	Drained organic soil	CO2 (net)	t CO2-C/ha/yr	-0.06	0.41	Butlers et al., 2025 (preprints)	DOI: 10.5194/egusphere-2025-1032
12	Forest land	Nutrient-rich (pine)	Drained organic soil	CO2 (net)	t CO2-C/ha/yr	-2.77	0.36	Butlers et al., 2025 (preprints)	DOI: 10.5194/egusphere-2025-1032
13	Forest land	Nutrient-rich (spruce)	Drained organic soil	CO2 (net)	t CO2-C/ha/yr	-0.59	0.95	Butlers et al., 2025 (preprints)	DOI: 10.5194/egusphere-2025-1032
14	Forest land	Nutrient-rich (mean)	Drained organic soil	CO2 (net)	t CO2-C/ha/yr	-1.06	0.45	Butlers et al., 2025 (preprints)	DOI: 10.5194/egusphere-2025-1032
15	Forest land	Nutrient-rich (alder)	Wet organic soil	CO2 (net)	t CO2-C/ha/yr	-1.12	2.47	Butlers et al., 2025 (preprints)	DOI: 10.5194/egusphere-2025-1032
16	Forest land	Nutrient-rich (birch)	Wet organic soil	CO2 (net)	t CO2-C/ha/yr	-2.11	1.69	Butlers et al., 2025 (preprints)	DOI: 10.5194/egusphere-2025-1032
17	Forest land	Nutrient-rich (spruce)	Wet organic soil	CO2 (net)	t CO2-C/ha/yr	-0.81	0.66	Butlers et al., 2025 (preprints)	DOI: 10.5194/egusphere-2025-1032
18	Forest land	Nutrient-rich (mean)	Wet organic soil	CO2 (net)	t CO2-C/ha/yr	-1.27	0.73	Butlers et al., 2025 (preprints)	DOI: 10.5194/egusphere-2025-1032
19	Forest land	Nutrient-rich (birch)	Drained organic soil	CH4	kg CH4-C/ha/yr	-1.73	2.03	Butlers et al., 2023	DOI: 10.3390/f14071390
20	Forest land	Nutrient-rich (birch)	Wet organic soil	CH4	kg CH4-C/ha/yr	-3.68	2.78	Butlers et al., 2023	DOI: 10.3390/f14071390
21	Forest land	Nutrient-rich (spruce)	Drained organic soil	CH4	kg CH4-C/ha/yr	-5.48	0.98	Butlers et al., 2023	DOI: 10.3390/f14071390
22	Forest land	Nutrient-rich (spruce)	Wet organic soil	CH4	kg CH4-C/ha/yr	-2.40	1.20	Butlers et al., 2023	DOI: 10.3390/f14071390
23	Forest land	Nutrient-rich (black alder)	Drained organic soil	CH4	kg CH4-C/ha/yr	6.83	16.58	Butlers et al., 2023	DOI: 10.3390/f14071390
24	Forest land	Nutrient-rich (black alder)	Wet organic soil	CH4	kg CH4-C/ha/yr	199.80	393.23	Butlers et al., 2023	DOI: 10.3390/f14071390
25	Forest land	Nutrient-rich (clearcut)	Drained organic soil	CH4	kg CH4-C/ha/yr	-4.73	0.98	Butlers et al., 2023	DOI: 10.3390/f14071390

Progress of soil GHG emission research
Latvian case – topicality of wet organic soils





Rewetted area reported by EU GHG inventories – Latvia contributes ~70 %

~10% of forest land or ~5% of Latvia is managed forest with undrained or rewetted organic soil:

paludiculture according to IPCC Wetlands supplement

Empirical basis for the presented view

Results of recent studies on drained and undrained hemiboreal forest organic soil C balance and GHG emissions:

- LIFE OrgBalt – Demonstration of climate change mitigation measures in nutrients rich drained organic soils in Baltic States and Finland:
    - Butlers A., Laiho R., Soosaar K., Jauhiainen J., Schindler T., Bārdule A., Kamil Sardar M., Haberl A., Samariks V., Vahter H., Lazdiņš A, Čiuldienė D, Armolaitis K., Līcīte I. Soil and forest floor carbon balance in drained and undrained hemiboreal peatland forests. **Manuscript submitted for publishing to Biogeosciences**
    - Kamil Sardar M., Schindler T., Vahter H., Butlers A., Vigricas E., Kull A., Līcīte I., Bārdule A., Čiuldienė D, Lazdiņš A., Jauhiainen J., Mander Ü., Laiho R., Soosaar K. Emission factors of soil CH4 and N2O from drained and undrained hemiboreal peatland forests. **Manuscript in preparation**
- LV MNKC - Elaboration of guidelines and modelling tool for greenhouse gas (GHG) emission reduction in forests on nutrient-rich organic soils
    - Butlers A., Lazdiņš A., Kalēja S., Bārdule A. (2022). Carbon Budget of Undrained and Drained Nutrient-Rich Organic Forest Soil. Forests, 13(11), 1790. **DOI: 10.3390/f13111790**
    - Butlers A., Lazdiņš A., Kalēja S., Purviņa D., Spalva G., Saule G., Bārdule A. (2023). CH4 and N2O Emissions of Undrained and Drained Nutrient-Rich Organic Forest Soil. Forests, 14(7), 1390. **DOI: 10.3390/f14071390**

Soil C balance and GHG emission monitoring sites

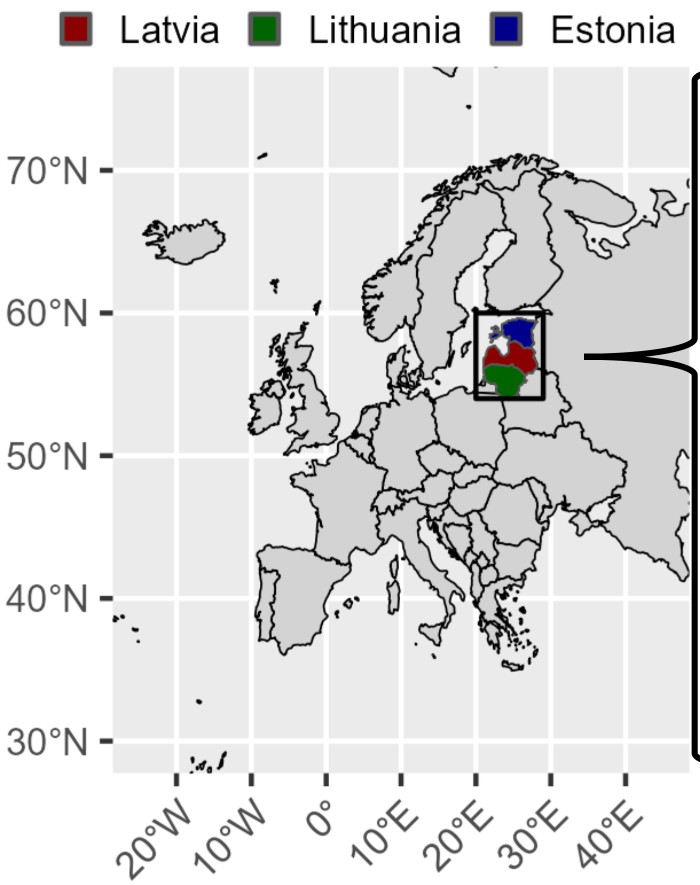
57 study sites in forest land

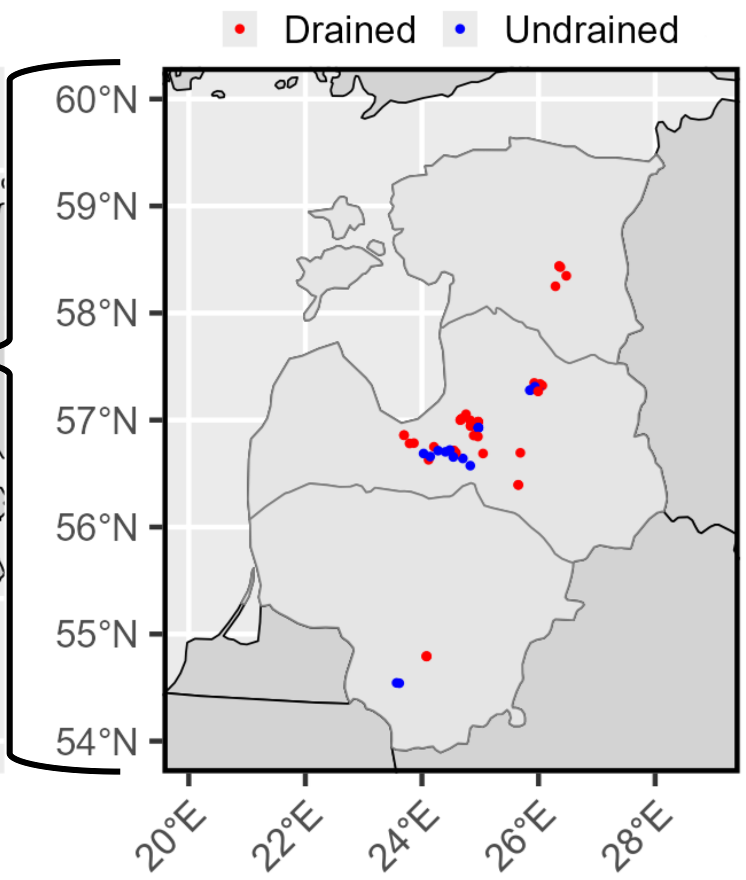
52 forest stands:
- Drained: 36
- Undrained: 16

5 Clearcuts:
- Drained: 4
- Undrained: 1

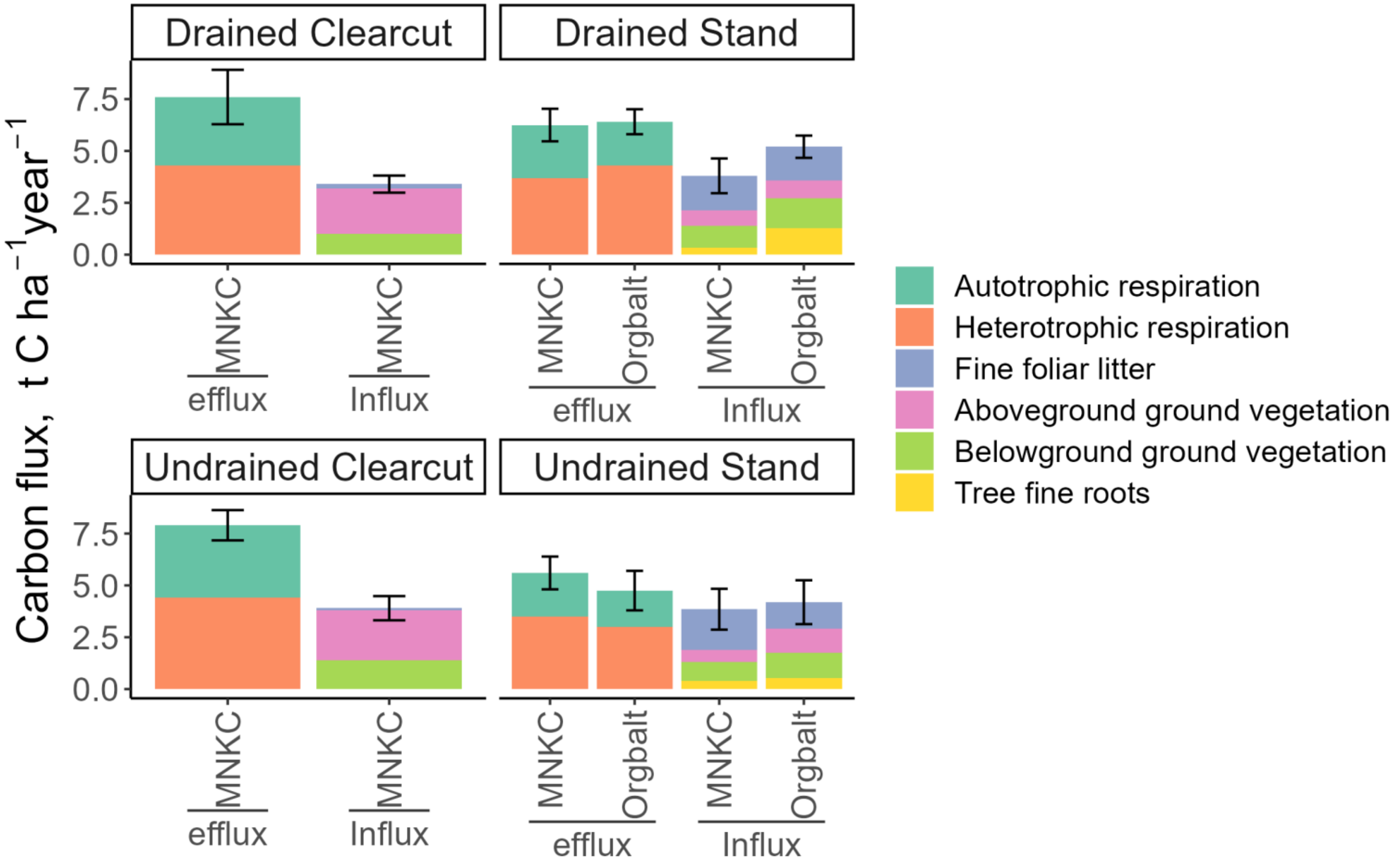
Peat layer depth, cm:
- Drained: >20
- Undrained: >30

Dominant tree species:
- Silver birch
- Black alder
- Norway spruce
- Scots pine





Soil and forest floor C balance

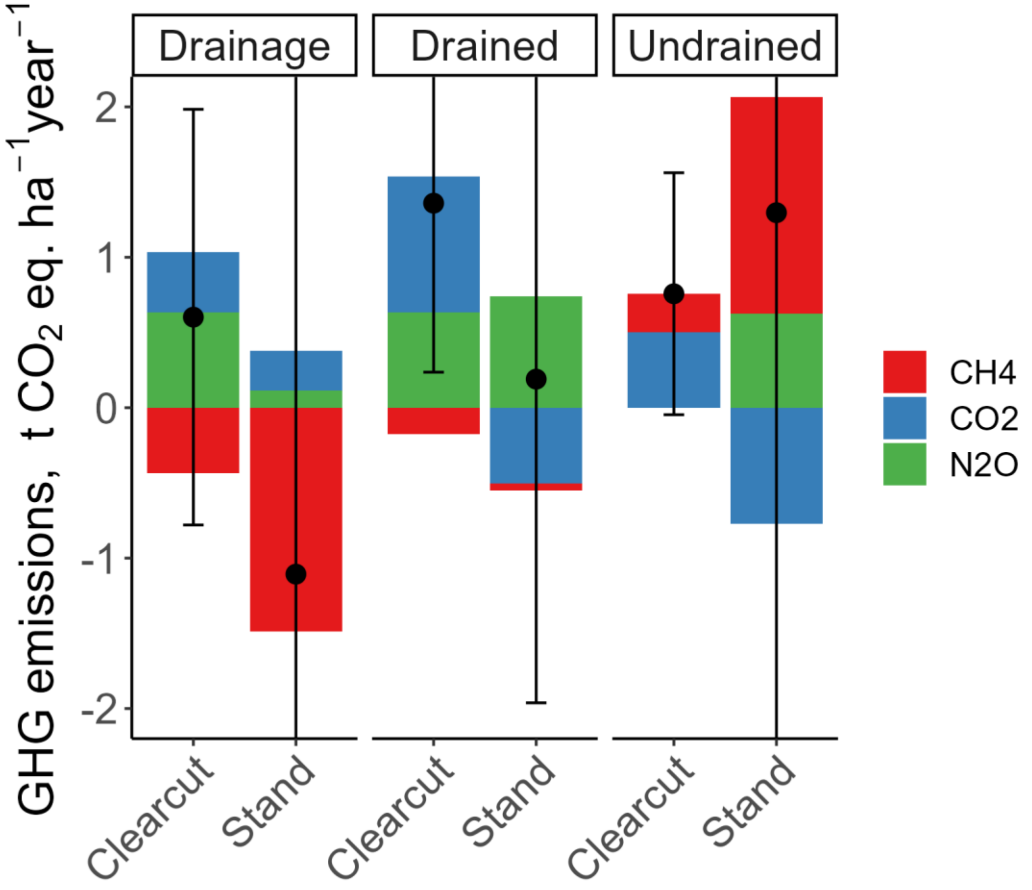


C balance in clearcut*	**Drained**	**Undrained**	**Drainage impact**
Forest floor	-4.2±2.2	-4.0±1.33	-0.2±2.61
Soil	-0.9±0.7	-0.4±0.4	-0.4±1.25

C balance in stand*	**Drained**	**Undrained**	**Drainage impact**
Forest floor	-1.75±1.83	-1.12±2.34	-0.64±2.97
Soil	0.51±1.82	0.77±1.87	-0.27±2.61

*Negative values indicate C loss, t C ha^{-1} $year^{-1}$

GHG emissions in CO_2 equivalents (AR5)



t CO_2 eq. ha^{-1} year^{-1}	Drained	Undrained	Drainage impact
Stand	0.19 ± 2.15	1.30 ± 14.97	-1.11 ± 15.12
Clearcut	1.36 ± 1.12	0.76 ± 0.80	0.60 ± 1.38

Pros and Cons of Estimating Relative Anthropogenic GHG Emission Impact

SILAVA

Advantages and Challenges:

- Comparing GHG emissions from drained and undrained sites offsets potential estimation biases
- More accurate estimate of drainage's human-induced climate impact, avoiding overestimation of emissions
- More empirical data needed, consequently requiring the combination of relevant uncertainties

Opportunities:

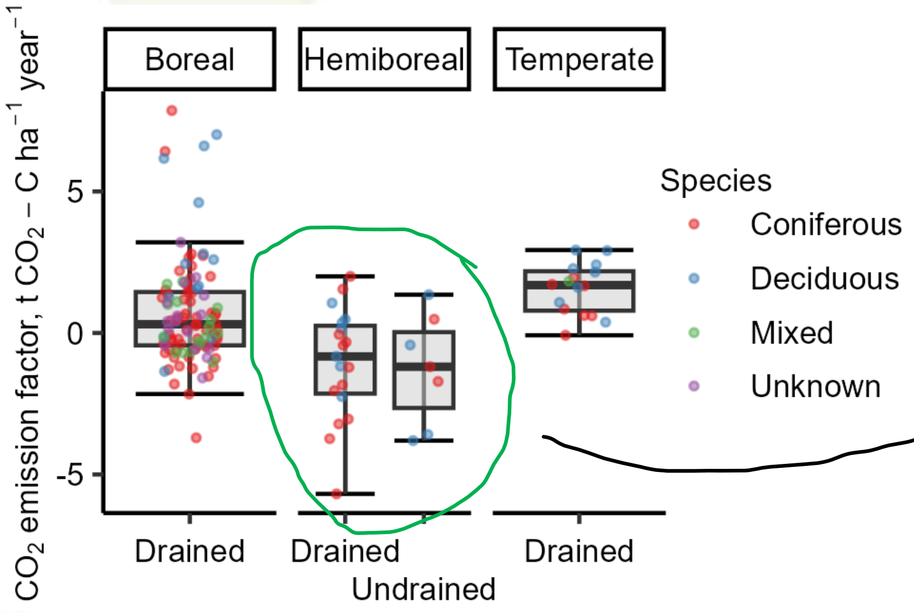
- Enables a more accurate comparison of projected impacts resulting from climate change mitigation measures
- Mitigates the risk of achieving the opposite effect when implementing climate change mitigation measures

Alternative?:

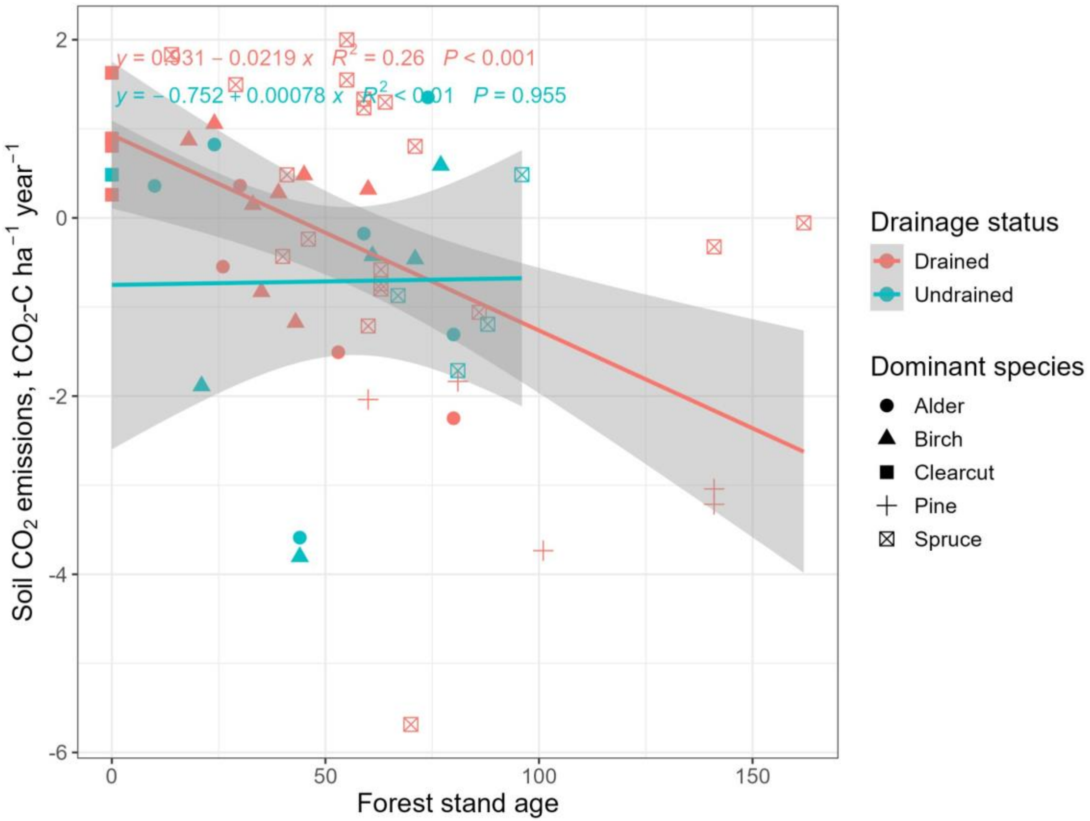
- Mandatory tier 3 or exclusion of organic soils from set climate policy targets

Emission factors are not suitable for accurate organic soil GHG emission inventory

(Jauhiainen et al., 2023; Butlers et al., 2022; Butlers et al., 2025 [preprint])



The “rule of thumb” that drained organic soils are a source of CO_2 emissions is not supported by the evidence.



The variability (uncertainty) in the results is not an error. Organic soil can be a C sink or source depending on site-specific conditions

Progress of soil GHG emission research

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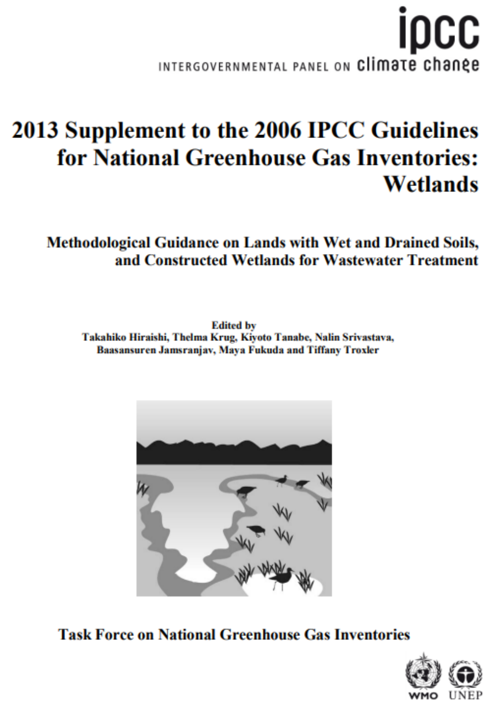
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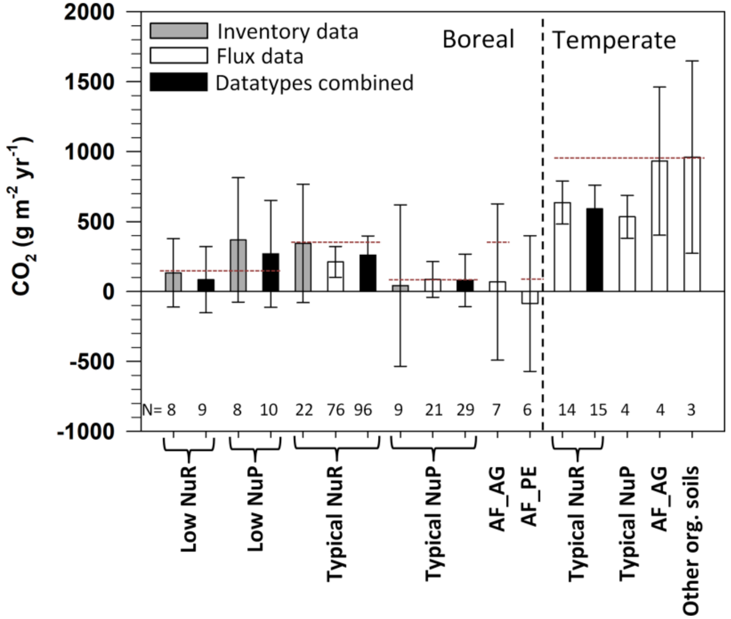

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Cross-institutional collaborations for the synthesis of raw soil GHG measurement data are needed to accelerate the development of advanced soil GHG emission and carbon balance prediction methods