International Conference
"Climate Change Mitigation in Organic Soils in Agricultural and Forest lands"
University of Latvia Academic Center in Riga
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OrgBalt LIFE project

Soil CH_4 and N_2O balance from forest and agriculture lands

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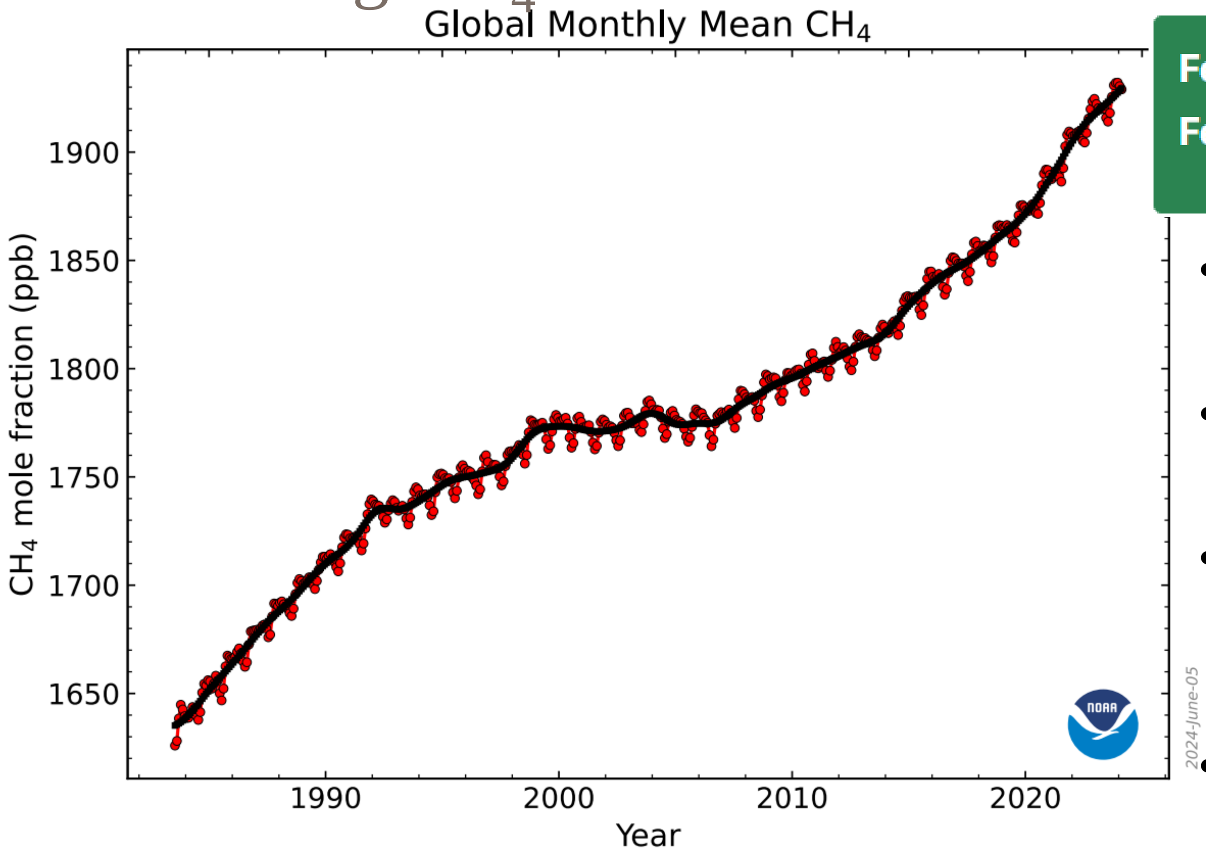
LIFE OrgBalt, LIFE18 CCM/LV/001158

EU LIFE Programme project
"Demonstration of climate change mitigation potential of nutrients rich organic soils in Baltic States and Finland"

State Regional Development Agency Republic of Latvia · SILAVA · Ministry of Agriculture Republic of Latvia · Latvia University of Life Sciences and Technologies · Luke Natural Resources Institute Finland · Lithuanian Research Centre for Agriculture and Forestry · Baltijas Krasti · Succow Stiftung · Partner in the Greifswald Mire Centre

EU LIFE Programme project "Demonstration of climate change mitigation potential of nutrients rich organic soils in Baltic States and Finland"

Increasing CH_4 concentration in the atmosphere

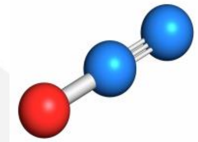


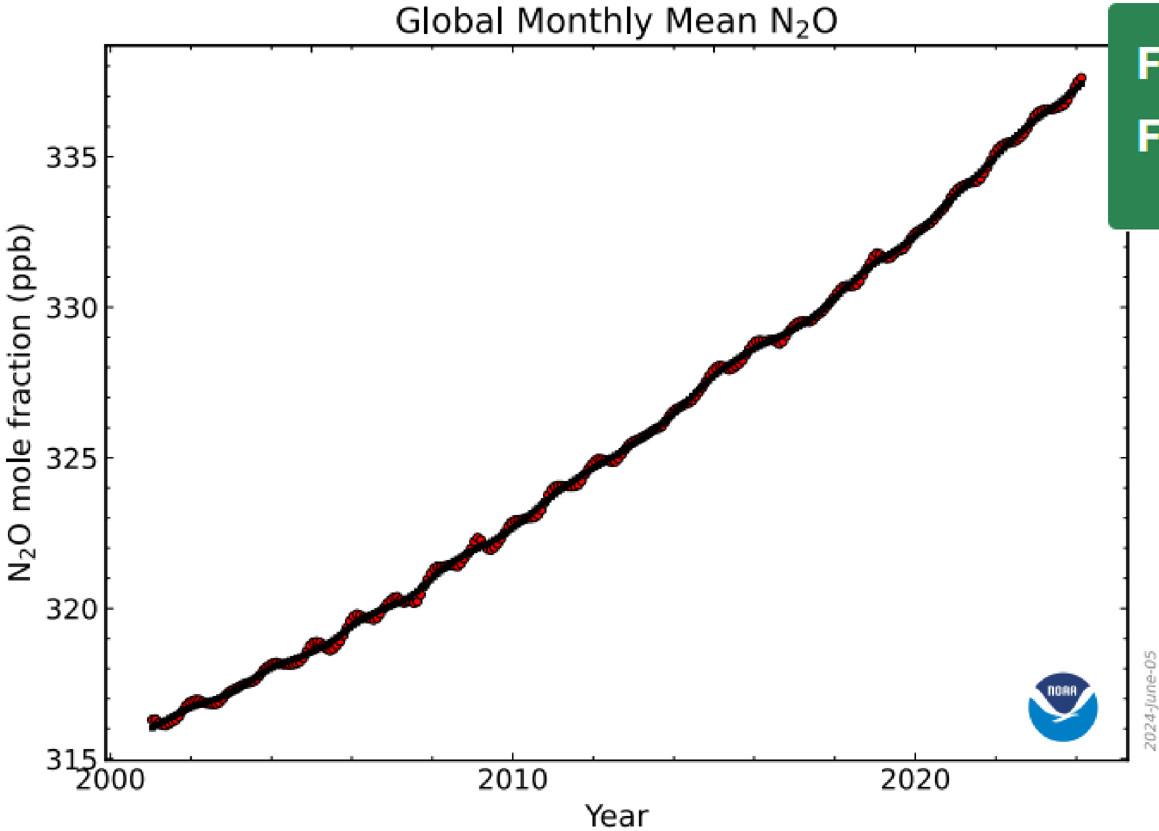
Trend and variations in global monthly mean CH_4 concentrations during 1983 to 2022 (NOAA)

- GWP in 100-yr time span: 1 mol **CH_4 = 28 mol CO_2**
- Lifetime in atmosphere: approx 12 years
- CH_4 is **responsible for 20% of global warming potential**
- **54% from anthropogenic** sources
- among natural sources, wetlands make up to 55% of emissions

Ed Dlugokencky, NOAA/GML (gml.noaa.gov/ccgg/trends_ch4/)

Increasing N_2O concentration in the atmosphere



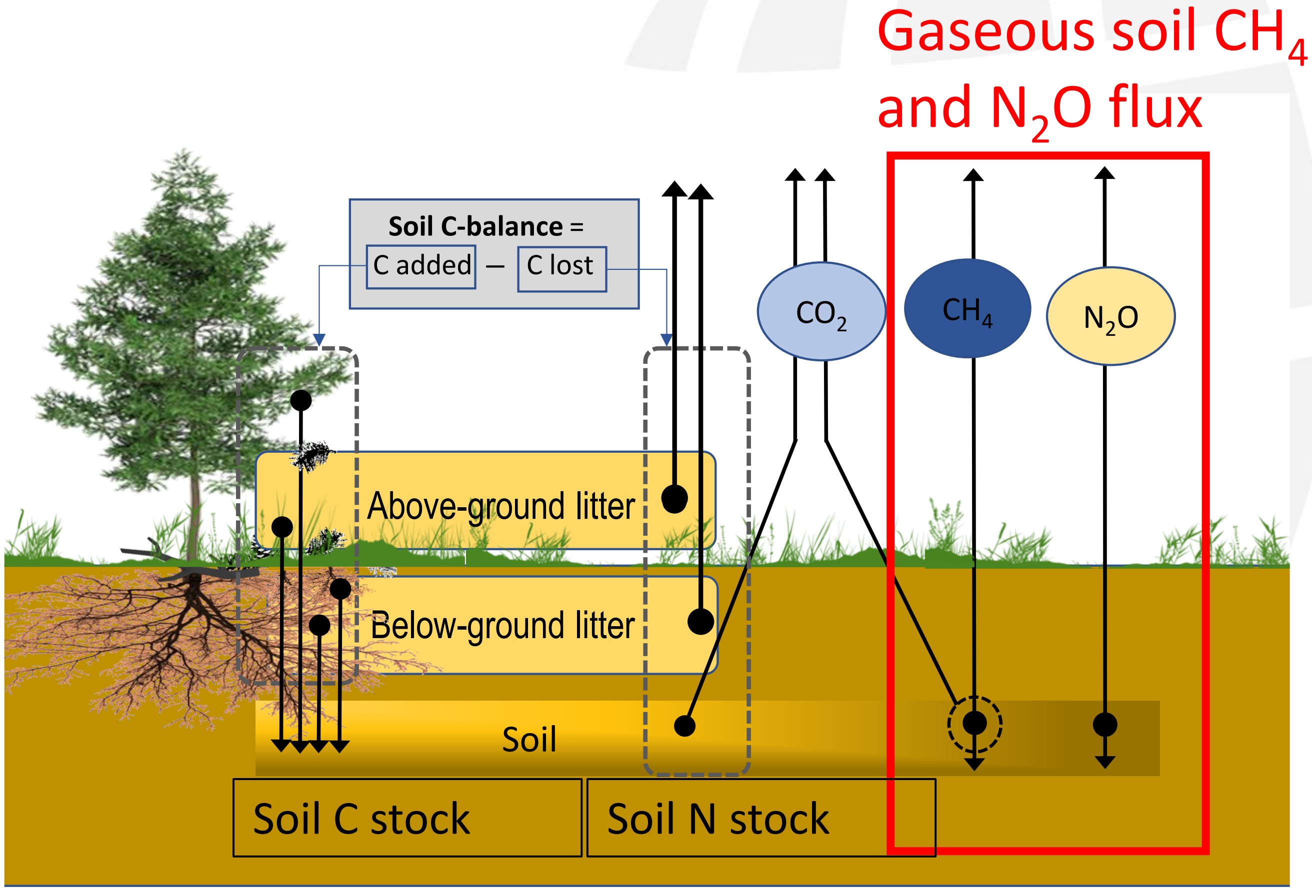


February 2024: 337.61 ppb
February 2023: 336.53 ppb
Last updated: Jun 05, 2024

- GWP in 100-yr time span:
  1 mol N_2O=265 mol CO_2
- Lifetime in atmosphere: **114 years**
- **40% from anthropogenic sources**, 75% of it from agricultural soils, impact of drainage not considered or counted causally
- Responsible for **6% of global warming potential**

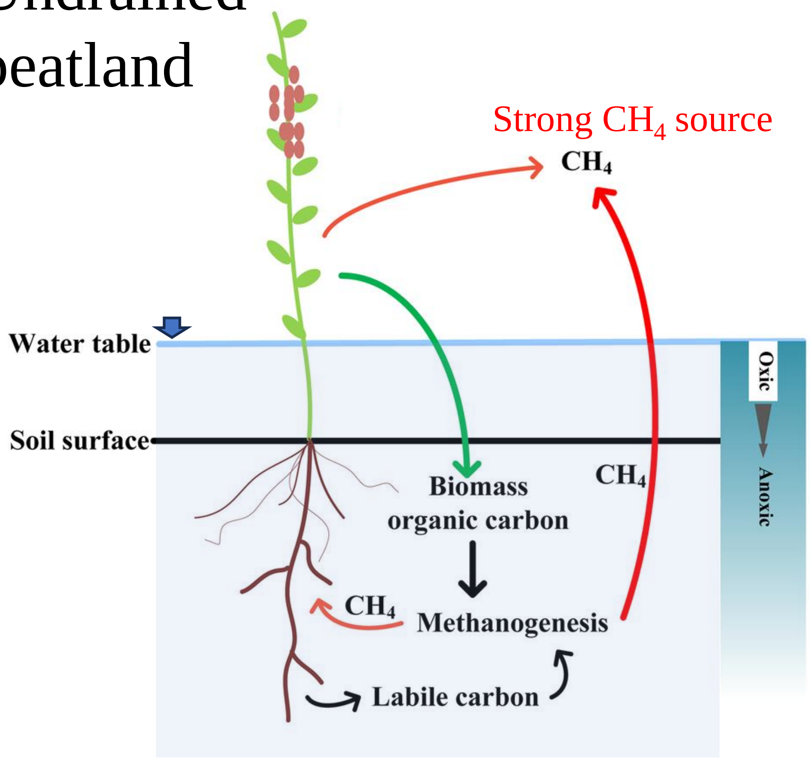
Trend and variations in global monthly mean N_2O concentrations during 1983 to 2022 (NOAA)

Soil C/N and GHG balance monitoring methods



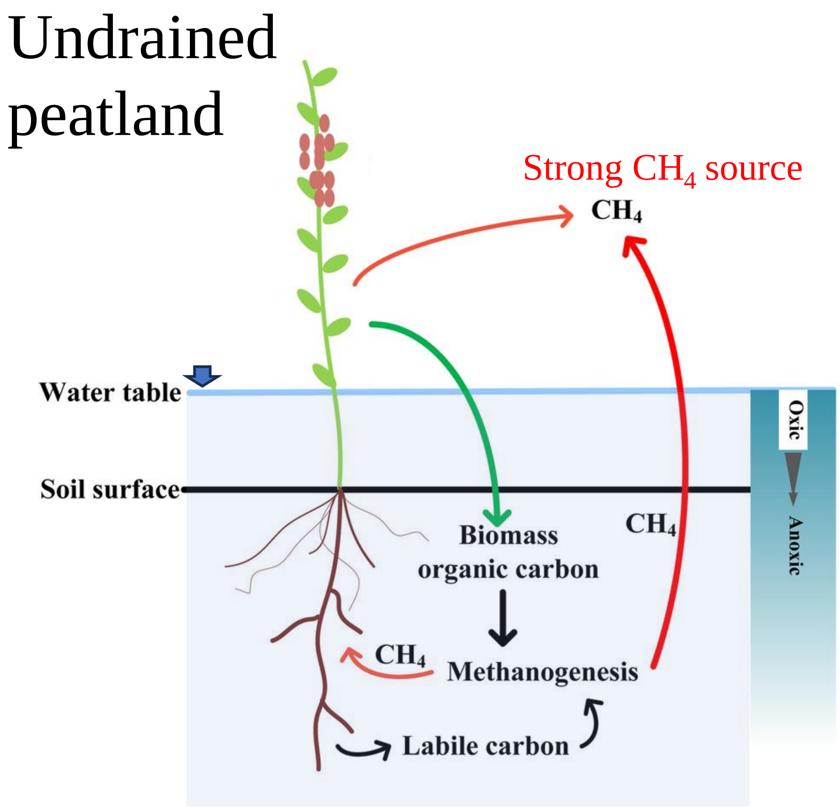
Soil CH_4 balance = methanogenesis vs methanotrophy

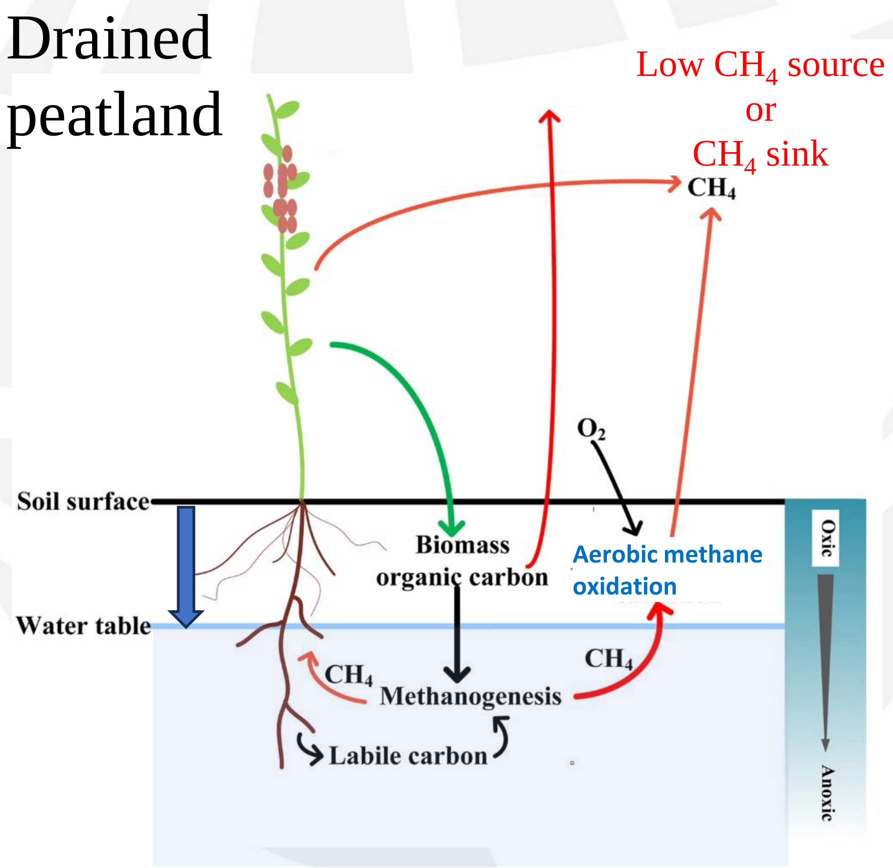
Undrained peatland



Modified by Yang et al., 2022 Wetlands

Soil CH_4 balance = methanogenesis vs methanotrophy

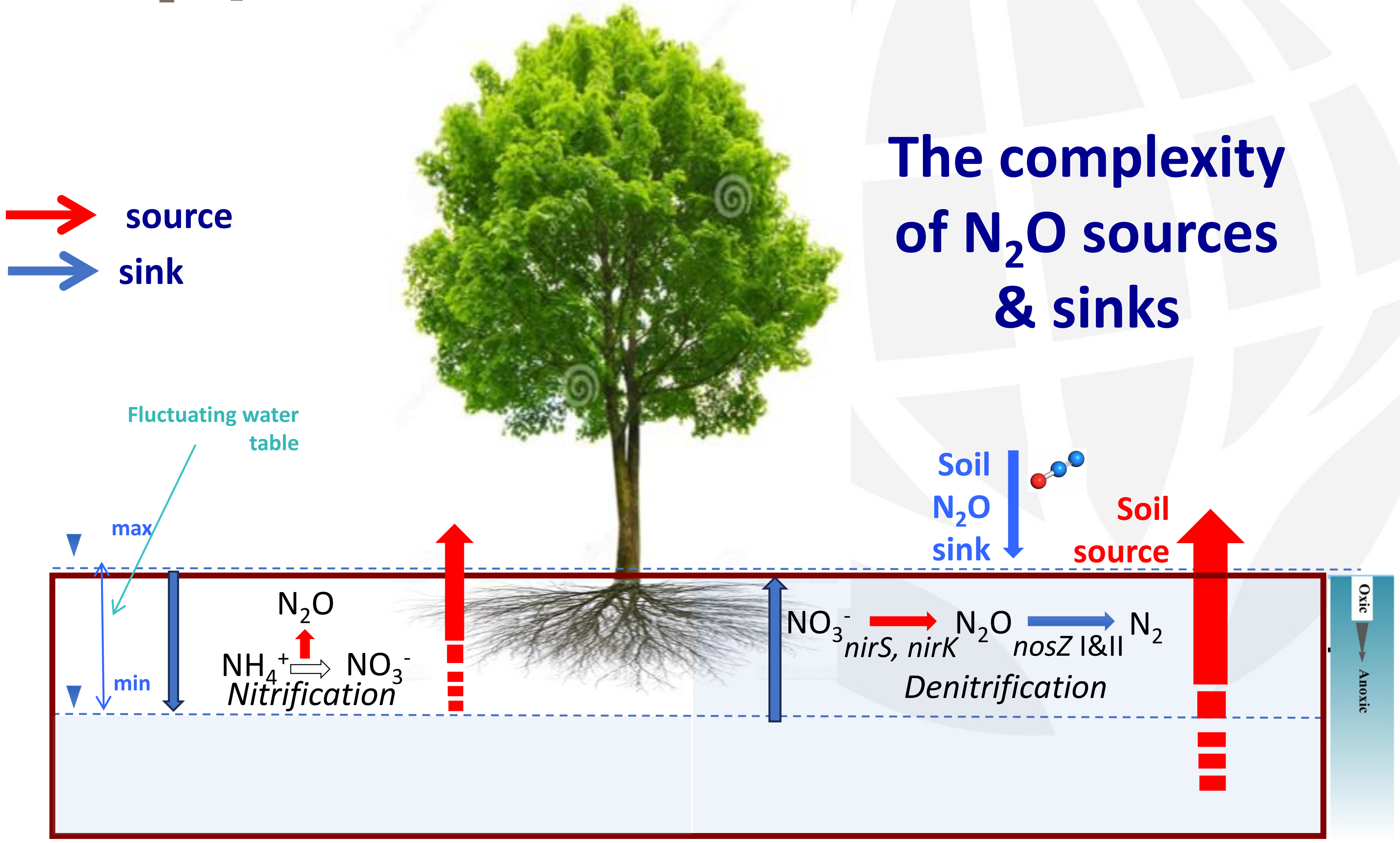




Modified by c

Soil N_2O production = nitrification and denitrification

The complexity of N_2O sources & sinks



Objectives

(1) to **provide annual estimates** of **soil CH_4 and N_2O effluxes**

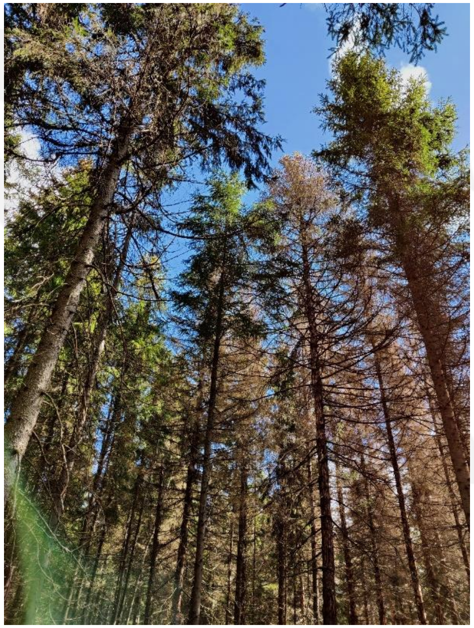
(2) to **quantify factors influencing** dynamics of these **effluxes**

(3) to **determine country/region-specific emission factors** for drained and undrained peatland forests and agricultural lands in the temperate/hemiboreal region.

Study Areas

- ✓ Fieldworks in Estonia, Latvia and Lithuania + similar studies in Latvia were included.
- ✓ Drained nutrient-rich organic soil
- ✓ Forests with different main tree species:
  (Downy Birch, Norway Spruce, Scots Pine, Black Alder)
- ✓ Drained grasslands and croplands





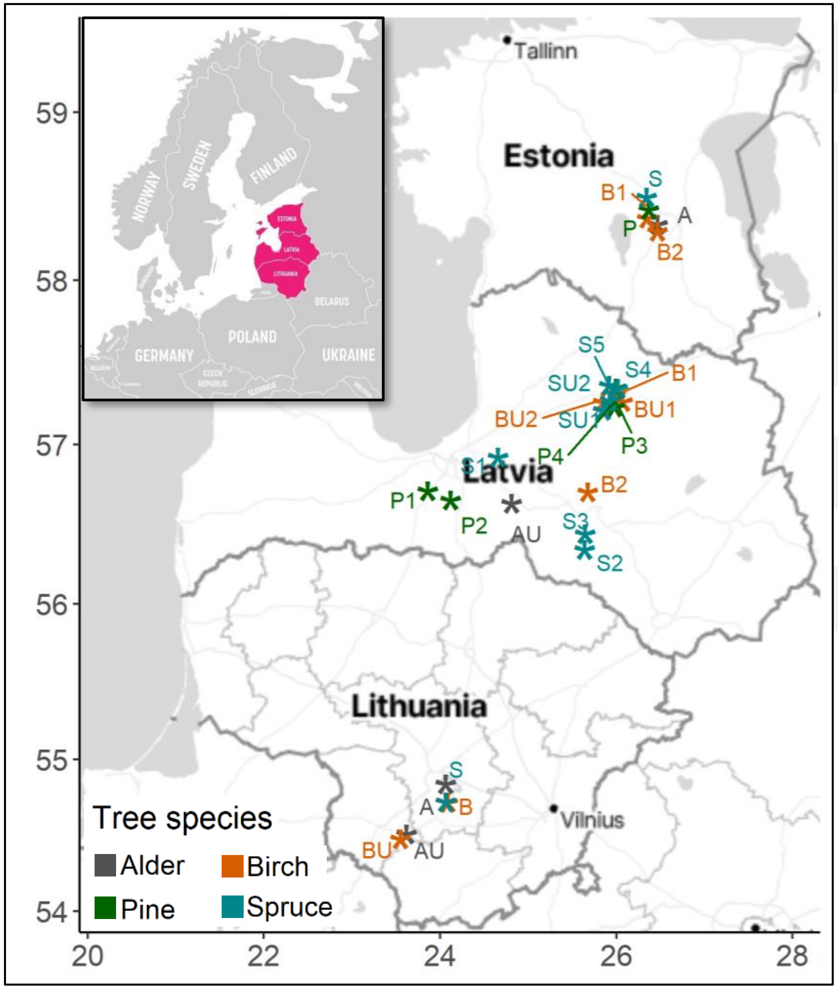

Methods

- GHG flux measurements: monthly and twice per month, 2021 – 2023.
- Manual static closed dark chamber method for CH_4, N_2O, analysis by GC.
- Auxiliary parameters: Tair, soil; temperature, moisture, water level depth.
- Soil-water chemical analysis
- Soil nutrient contents (0-100 cm)



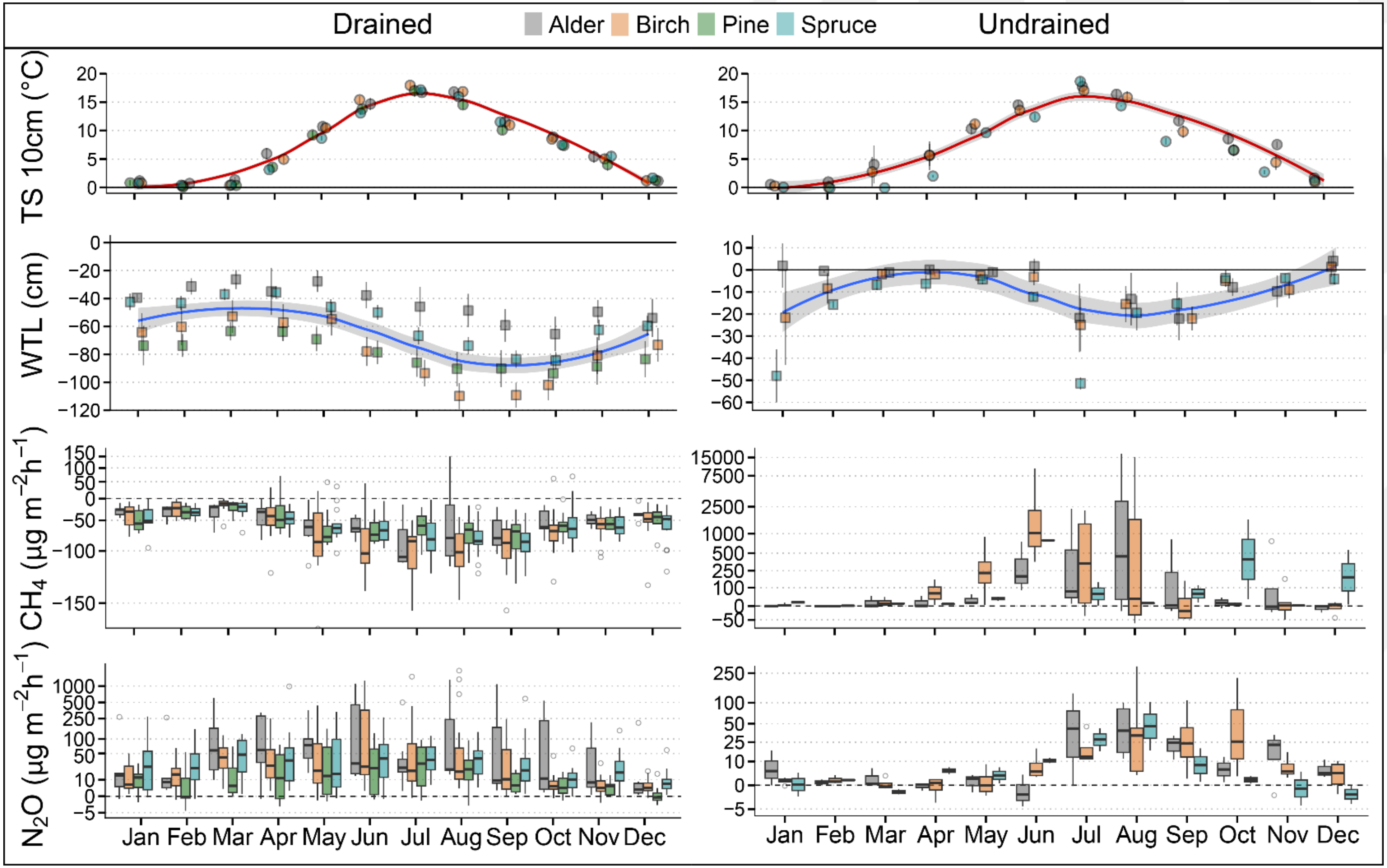


Description of the study sites – forests



Water regime and Drainage Status		Local name	Site code	Tree Stands	WTL Mean/median (cm)	Peat depth (cm)	Stand age (years)
Drained	Deep	Laeva	EE_DP	Pine	-82/-87	93	60
	Deep	Smiltene	LV_DP2	Pine	-52/-47	138	141
	Deep	Dubrava	LT_DS	Spruce	-71/-66	120	70
	Deep	Laeva	EE_DB1	Birch	-70/-54	76	35
	Deep	Ulila	EE_DB2	Birch	-57/-55	95	45
	Deep	Dubrava	LT_DB	Birch	-156/-166	150	43
	Deep	Pļaviņas	LV_DB2	Birch	-94/-88	56	33
	Deep	Olaine	LV_DP3	Pine	-112/-118	28	101
	Deep	Laeva	EE_DS	Spruce	-66/-58	87	60
	Deep	Ropaži	LV_DS1	Spruce	-80/-82	50	40
	Deep	Smiltene	LV_DS5	Spruce	-53/-49	212	141
	Deep	Dubrava	LT_DA	Alder	-67/-55	120	30
	Shallow	Smiltene	LV_DP1	Pine	-32/-33	165	141
	Shallow	Smiltene	LV_DB1	Birch	-27/-13	90	24
	Shallow	Viesīte	LV_DS2	Spruce	-31/-28	86	55
	Shallow	Viesīte	LV_DS3	Spruce	-42/-36	95	55
	Shallow	Smiltene	LV_DS4	Spruce	-31/-28	68	162
Undrained	Wet	Karevere	EE_DA	Alder	-29/-36	35	80
	Wet	Amalva	LT_UA	Alder	-2/-3	130	44
	Wet	Birzgale	LV_UA	Alder	-8/-1	100	74
	Wet	Amalva	LT_UB	Birch	-1/-2	140	44
	Wet	Smiltene	LV_UB1	Birch	-10/-4	230	61
	Wet	Smiltene	LV_UB2	Birch	-18/-7	134	81
	Wet	Smiltene	LV_US1	Spruce	-12/-5	205	88
	Wet	Smiltene	LV_US2	Spruce	-20/-12	221	96

Results: Seasonal variation of soil temperature (TS), water table level (WTL) and CH_4 and N_2O fluxes in all Baltic states



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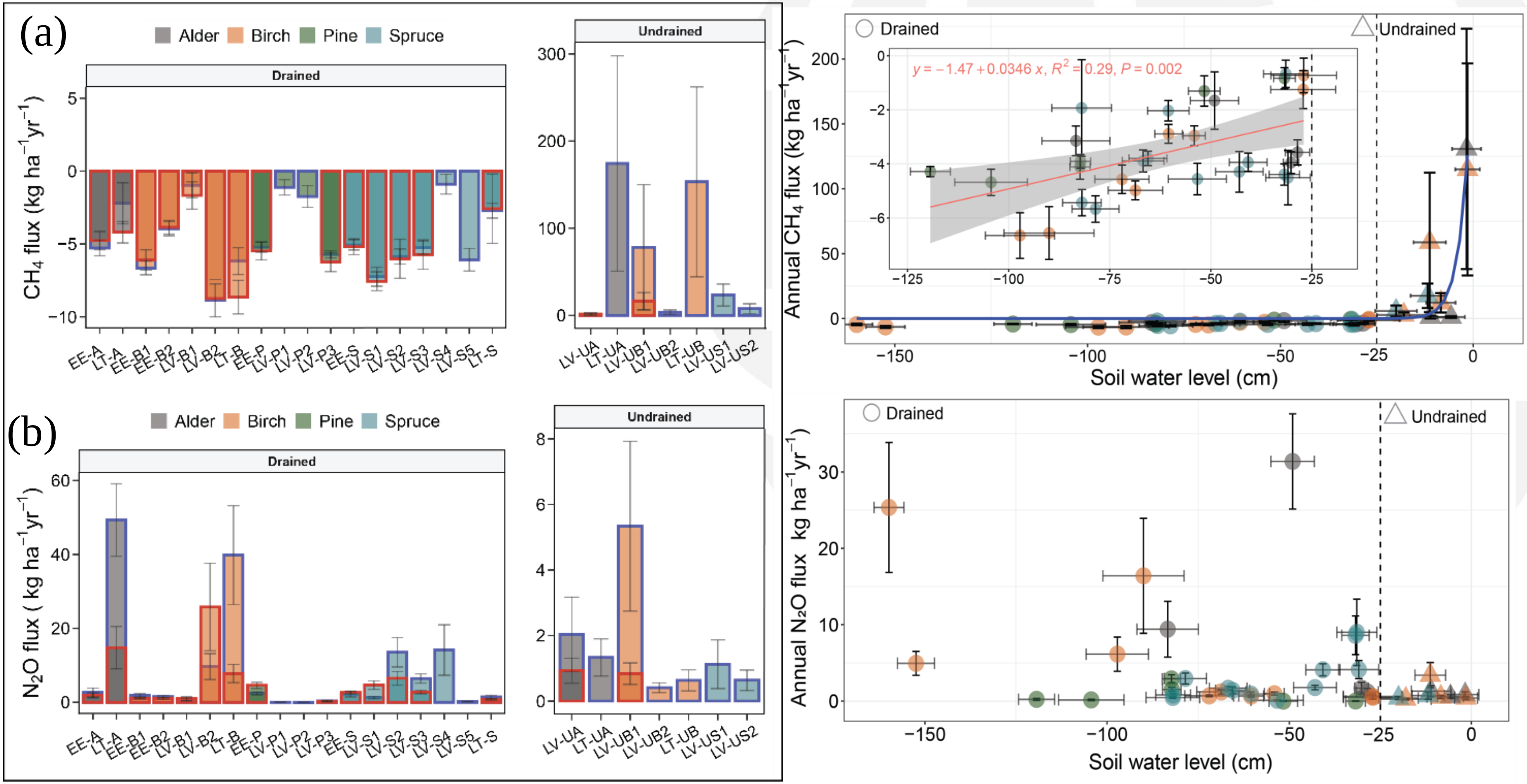
Variation of annual a) CH_4 and b) N_2O fluxes and relationship with mean water level depth



EFs for drained forests vs *IPCC, 2014*

Forests	Water regime	CH_4 kg ha^{-1} yr^{-1} (95% CI)	N_2O kg N ha^{-1} yr^{-1} (95% CI)
IPCC 2013, Temperate	Drained	**2.5 (−0.6, 5.7)**	**2.8 (−0.57, 6.1)**
IPCC 2013, Boreal, N-rich	Drained	**2.0 (−1.6, 5.5)**	**3.2 (1.9, 4.5)**
Estonia	Drained	−5.2 (−6.2, −4.1)	1.4 (0.7, 2.1)
Latvia	Drained	−4.2 (−6.6, −1.9)	3.18 (0.25, 6.18)
Lithuania	Drained	−4.4 (−10.9, 2.0)	12.1 (1.59, 17)
Baltic states	**Drained**	**−4.7 (−5.8, −3.5)**	**4.2 (1.27, 7.1)**
	Undrained	58.7 (-9.5, 127)	0.76 (0.25, 1.34)

OrgBalt project EF are significantly lower in case of CH_4!

Description of the study sites - grasslands

Site name & country	Measurement period	Mean / median GWL	Organic layer depth	Management and plant community	Fertili-zation
Drained grasslands					
Kasku LV	Dec 2016–Nov 2018	-85/-81	42	Periodically cut grassland. Hydro-morphic soil with **drained** peat layer.	No
Saverna EE	Jan 2021–Dec 2022	-59/-54	45	Periodically cut grassland. Hydro-morphic soil with **drained** peat layer.	Yes
Krista LV	Dec 2016–Nov 2018	-47/-46	50	Periodically cut grassland. Hydro-morphic soil with **drained** peat layer.	No
Stabul LV	Dec 2016–Nov 2018	-43/-42	50	Periodically cut grassland. Hydro-morphic soil with **drained** peat layer.	No
Dubrava LT	Jan 2021–Dec 2022	-39/-39	90	Periodically cut grassland. Hydro-morphic soil with **drained** peat layer.	No
Maramaa EE	Jan 2021–Dec 2022	-31/-23	100	Periodically cut grassland. Hydro-morphic soil with **drained** peat layer.	No
Nīca LV	Jan 2021–Dec 2022	-27/-21	30	Periodically cut grassland. Hydro-morphic soil with **drained** peat layer.	No
Undrained peatland					
Ķirbas purvs LV	Jan 2021–Dec 2021	-17/-13	200	Grassland on **undrained** peatland.	No
Žuvintas I LT	Jan 2022–Dec 2022	4/0	130	Bushland growing on **undrained** peatland.	No
Žuvintas II LT	Jan 2022–Dec 2022	8/6	130	Grassland on **undrained** peatland.	No

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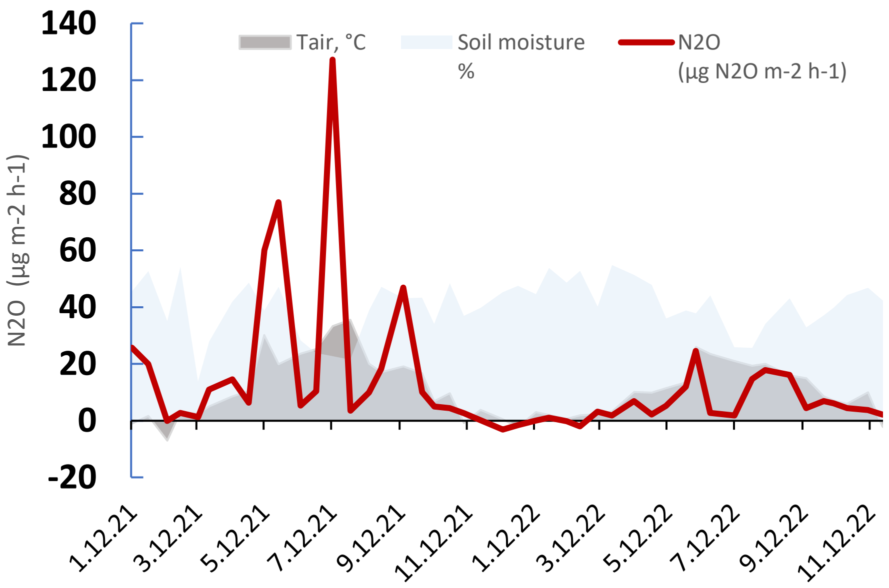
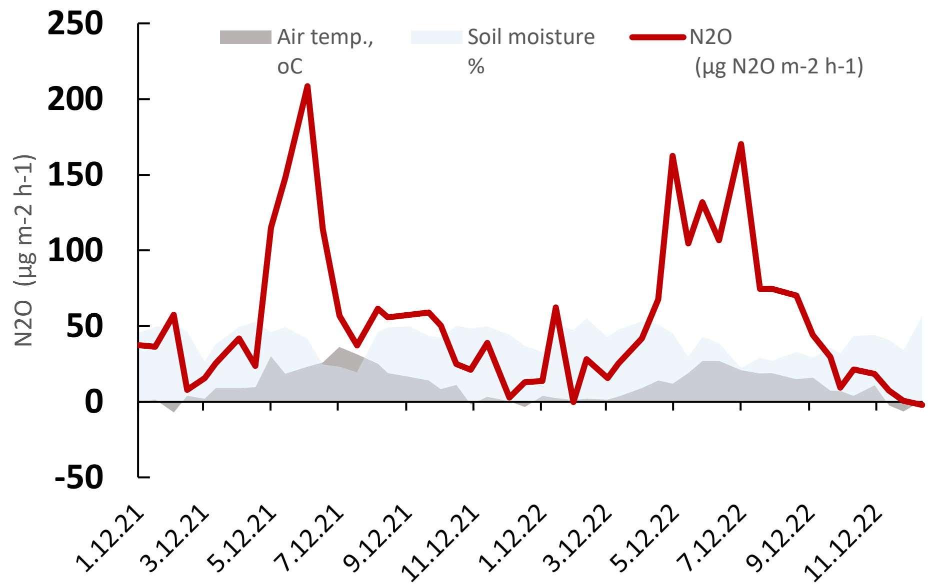
Dynamics of soil N_2O fluxes

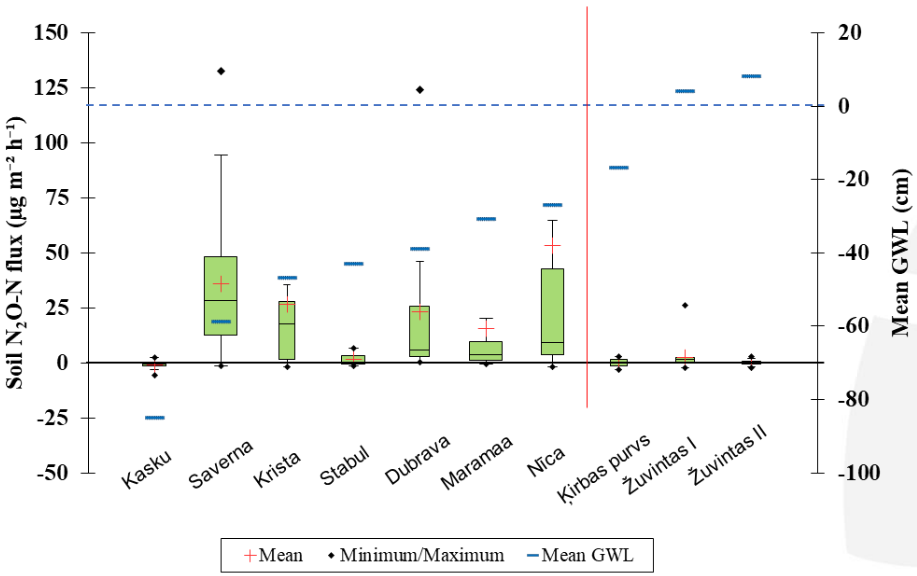


Drained cropland in Saverna, EE



Deeply drained grassland, Saverna II, EE

High annual variation -> more frequent site visits are needed!!!



Soil N_2O-N flux variability and mean GWL.

- ✓ Soil N_2O fluxes variation high: from -8.1 to 684.1 µg N m⁻² h⁻¹
- ✓ Mean soil N_2O flux:

  drained sites was 22 µg N m⁻² h⁻¹

  undrained sites was 1.1 µgN m⁻² h⁻¹

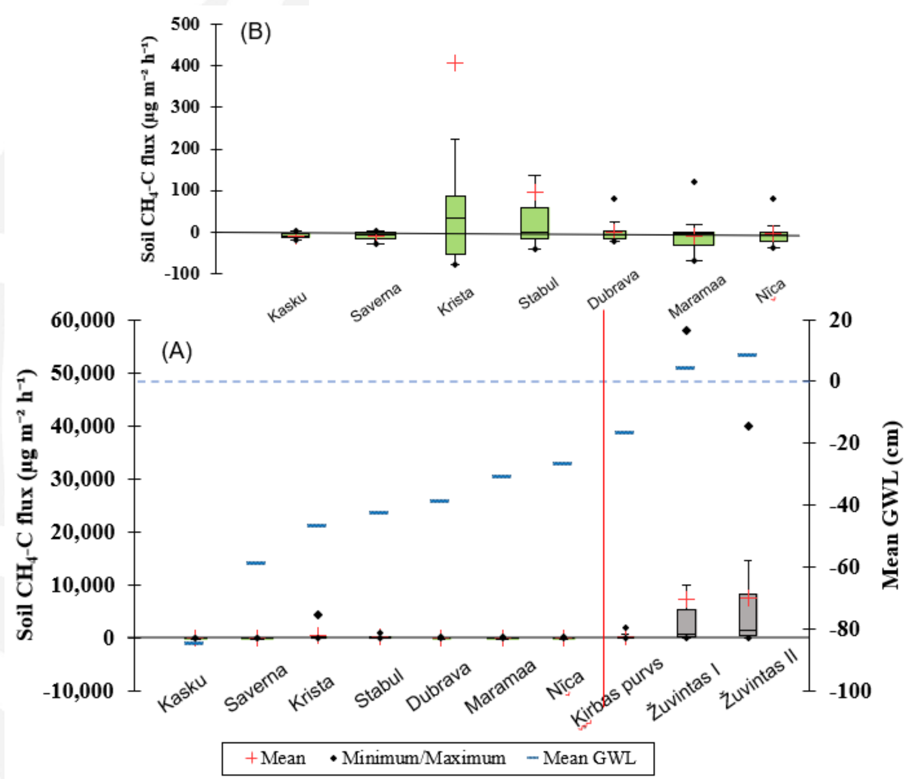
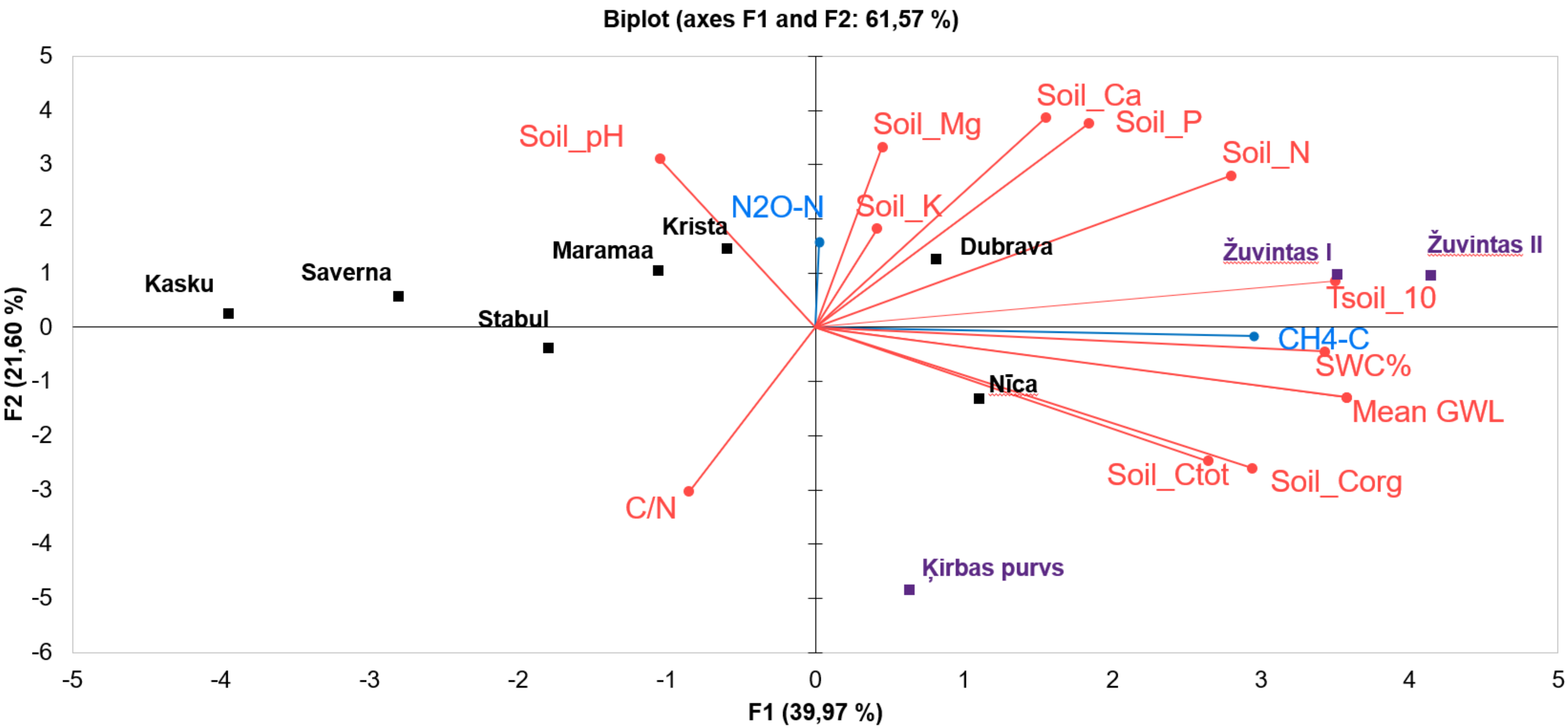


Figure: Soil CH_4-C flux variability and mean GWL.

- Soil CH_4 fluxes variation high: from -87.5 to 11 032.5 µg C m⁻²
- Mean soil CH_4 flux:

  drained sites as 27.6 µg C m⁻² h⁻¹

  undrained sites was 5030 µgC m⁻² h⁻¹



Principal component analysis (PCA) of soil physical (SWC%, Tsoil_10) and chemical parameters (pH, Mg, Ca, K, P, N, Ctot, Corg, C/N), and soil N_2O-N and CH_4-C fluxes on drained (black) and undrained (purple) sites.

EFs for drained grasslands vs *IPCC, 2014*

Grasslands		**N_2O (kg N ha^{-1} yr^{-1})**	**CH_4 (kg ha^{-1} yr^{-1})**
IPCC 2013, Boreal	**Drained**	**9.5 (4.6, 16)**	**1.4 (-1.6, 4.5)**
IPCC 2013, Temperate, N-rich	**Deeply drained**	**8.2 (4.9, 11)**	**16 (2.4, 29)**
IPCC 2013, Temperate, N-rich	Shallow drained	1.6 (0.56, 2.7)	39 (-2.9, 81)
Estonia (n=2)	Drained	2.18	-1.4
Latvia (n=4)	Drained	1.64	3.92
Lithuania (n=1)	Drained	1.94	-0.63
Baltic regioon (EE, LV, LT)			
Baltic region (EE, LV, LT) (n=6)	**Deeply drained**	**1.9 ± 2.2 (SE)**	**6.7 ± 19.4 (SE)**
Baltic region (EE, LV, LT) (n=3)	Undrained	0.06 ± 0.01 (SE)	458 ± 377 (SE)

OrgBalt project EF: for **CH_4** lower compared to boreal and temperate
for **N_2O** lower compared to temperate and higher: boreal!

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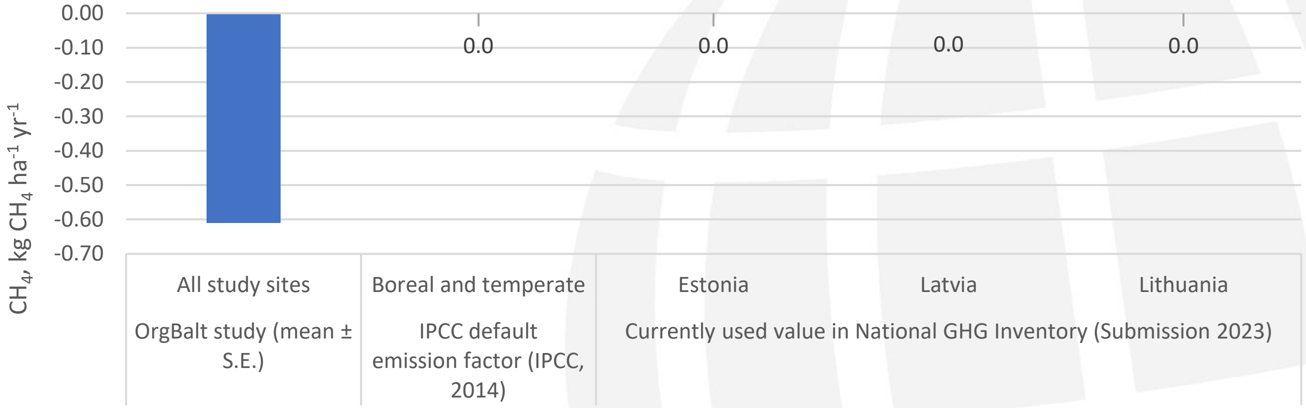
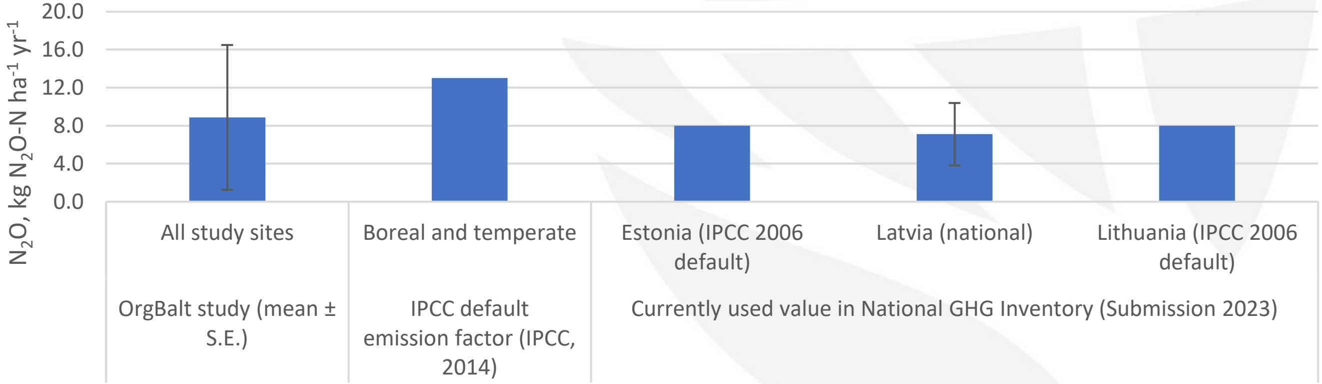
EFs for drained croplands vs *IPCC, 2014*





OrgBalt project EF for **N_2O** at the same range!

Conclusion

- Clear Land-use effect on GHG emissions => Forests vs Agriculture
- Climate zone variability, soil nutrient status and WTL affects annual CH_4 and N_2O emissions.
- Drainage reduce CH_4 while may increase N_2O emissions, mainly in afforested sites with previous agricultural use and vegetation (Alder trees).
- This study can be used for updating regional (Tier 1) or country-specific (Tier 2) emission factors.
- Further studies required in site categories, that could reduce the variation for CH_4 and N_2O EFs for nutrient-rich organic soils.

Thank you!

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