Should peatlands be rewetted to mitigate climate change?

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This presentation will be available at: https://tuhat.helsinki.fi/portal/fi/person/pjojanen

Photography encouraged

Background

- Globally about 33 million ha of peatlands are currently drained for agriculture and forestry (based on NIR/CRF + additional sources)
- By rewetting we can
  - reduce greenhouse gas emissions caused by peat loss = short term goal
  - protect the peat carbon (C) storage = long term goal
- Can we mitigate the current climate change by rewetting?
  1. Carbon dioxide (CO_2) and nitrous oxide (N_2O) emissions from soil decrease.
  2. Methane (CH_4) emissions from soil increase.
  3. Tree growth (CO_2 sink to biomass and products) decreases.

The effect of rewetting peat **soils**

- The effect of rewetting on emissions
  =
  emissions from rewetted soil
  –
  emissions from drained soil
- Instant and constant effect assumed
- 100-year radiative forcing time series calculated based on the effect
  - **warming/cooling ratio:** $-RF(CH_4)/[RF(CO_2) + RF(N_2O)]\times100\%$

IPCC+ soil emission factors, t ha^{-1} $year^{-1}$ of gas (Wilson et al. 2016).

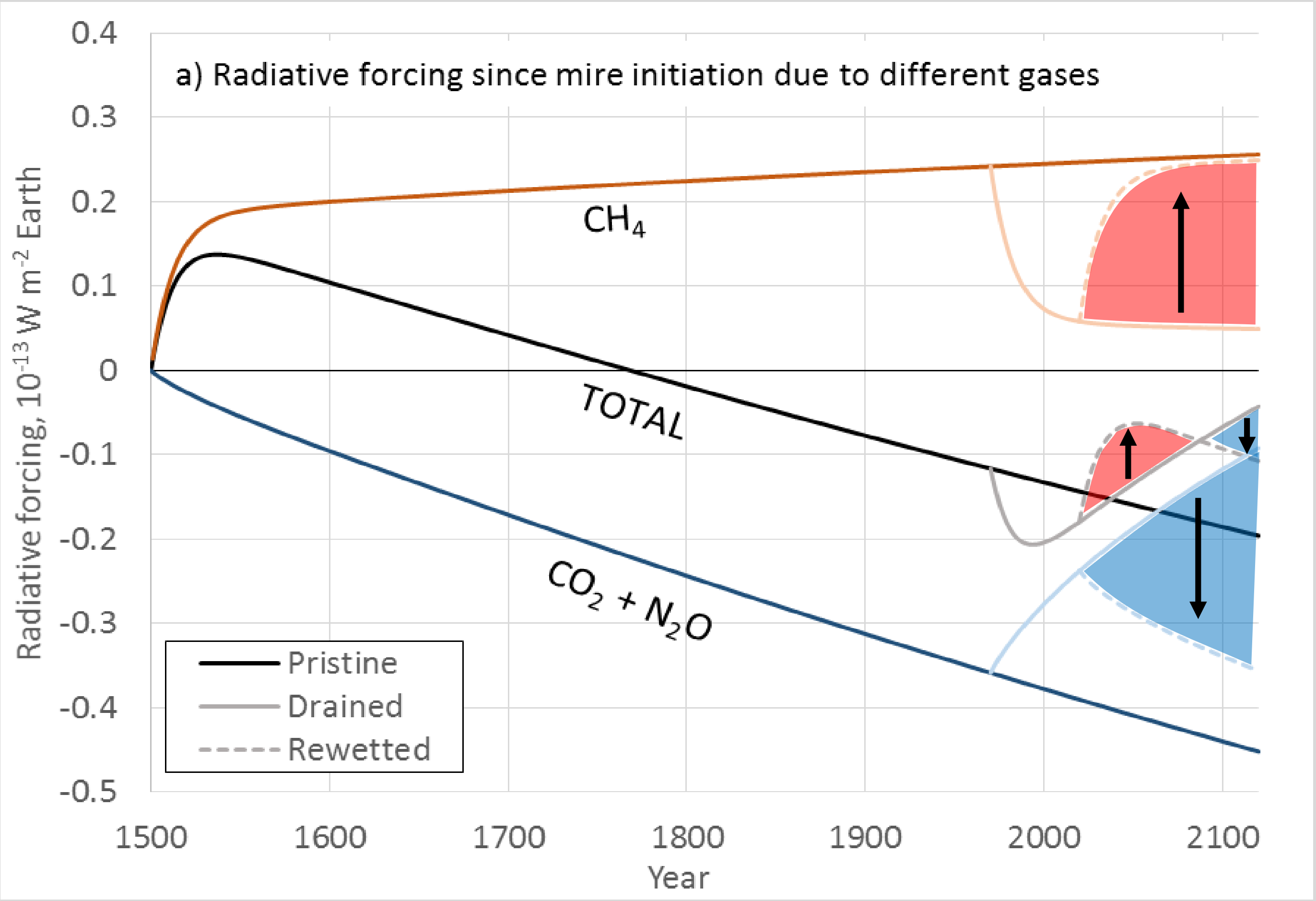
Zone	Land-use	Drained			Rewetted			Effect		
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Boreal	cropland	29.41	0.058	0.0204	-1.64	0.17	0.0001	-31.05	0.11	-0.0203
Boreal	grassland	21.34	0.060	0.0149	-1.64	0.17	0.0001	-22.98	0.11	-0.0148
Boreal	forest NP	1.36	0.012	0.0003	-1.23	0.06	0.0001	-2.59	0.04	-0.0002
Boreal	forest NR	3.85	0.007	0.0050	-1.64	0.17	0.0001	-5.49	0.16	-0.0049
Temperate	cropland	30.11	0.058	0.0204	1.84	0.31	0.0001	-28.27	0.26	-0.0203
Temperate	grassland NP	20.57	0.060	0.0067	-0.34	0.12	0.0001	-20.91	0.06	-0.0066
Temperate	grassland NR DD	23.51	0.074	0.0129	1.84	0.31	0.0001	-21.67	0.24	-0.0128
Temperate	grassland NR SD	14.34	0.064	0.0025	1.84	0.31	0.0001	-12.50	0.25	-0.0024
Temperate	forest NP	10.67	0.008	0.0044	-0.34	0.12	0.0001	-11.01	0.11	-0.0043
Temperate	forest NR	10.67	0.008	0.0044	1.84	0.31	0.0001	-8.83	0.31	-0.0043
Tropical	cropland	54.34	0.052	0.0079	1.89	0.08	0.0015	-52.45	0.03	-0.0064
Tropical	plantation	58.01	0.046	0.0019	1.89	0.08	0.0015	-56.12	0.04	-0.0004

IPCC radiative efficacies (RE, 10^{-13} W/m^2 Earth/kg gas), indirect effects multipliers and atmospheric lifetimes (time constant τ, years) of CO_2, CH_4 and N_2O (Myhre et al. 2013a, b).

Gas	RE	Indirect effects	Fraction	τ
CO_2	0.0176	1	0.2173	∞
			0.2240	394.4
			0.2824	36.54
			0.2763	4.304
CH_4	1.28	1.65	1	12.4
N_2O	3.85	0.93	1	121

(Note: decay of CH_4 in the atmosphere produces CO_2)

What should we expect to see – a **soil** example



Year	Change
1500	mire initiation
1970	drainage (optional)
2020	rewetting (optional)

Gas sinks (−) and sources (+)

pristine/rewetted (g $year^{-1}$ of gas)

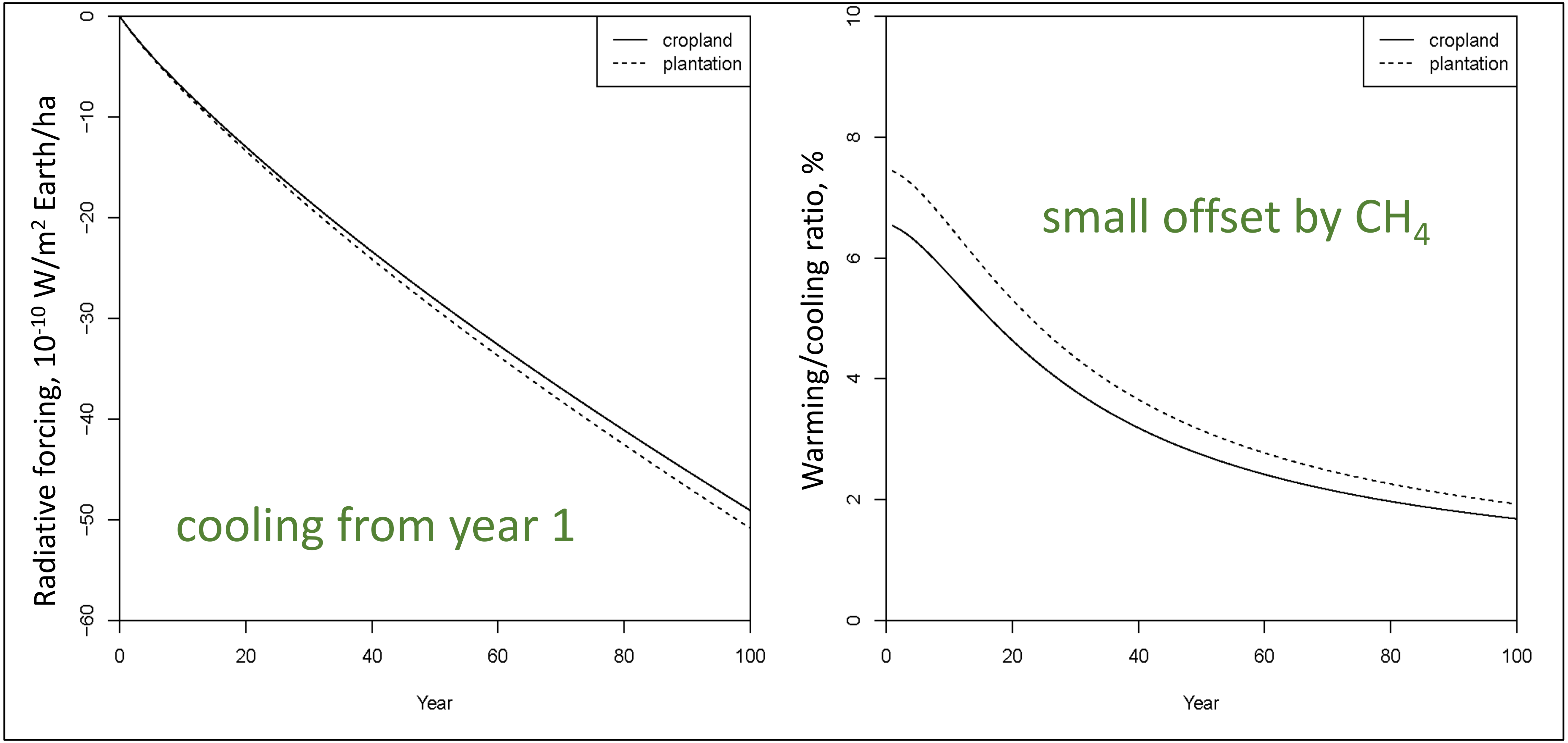
CO_2	−130
CH_4	+7
N_2O	+0.1

Drained (g $year^{-1}$ of gas)

CO_2	+130
CH_4	±0
N_2O	+0.2

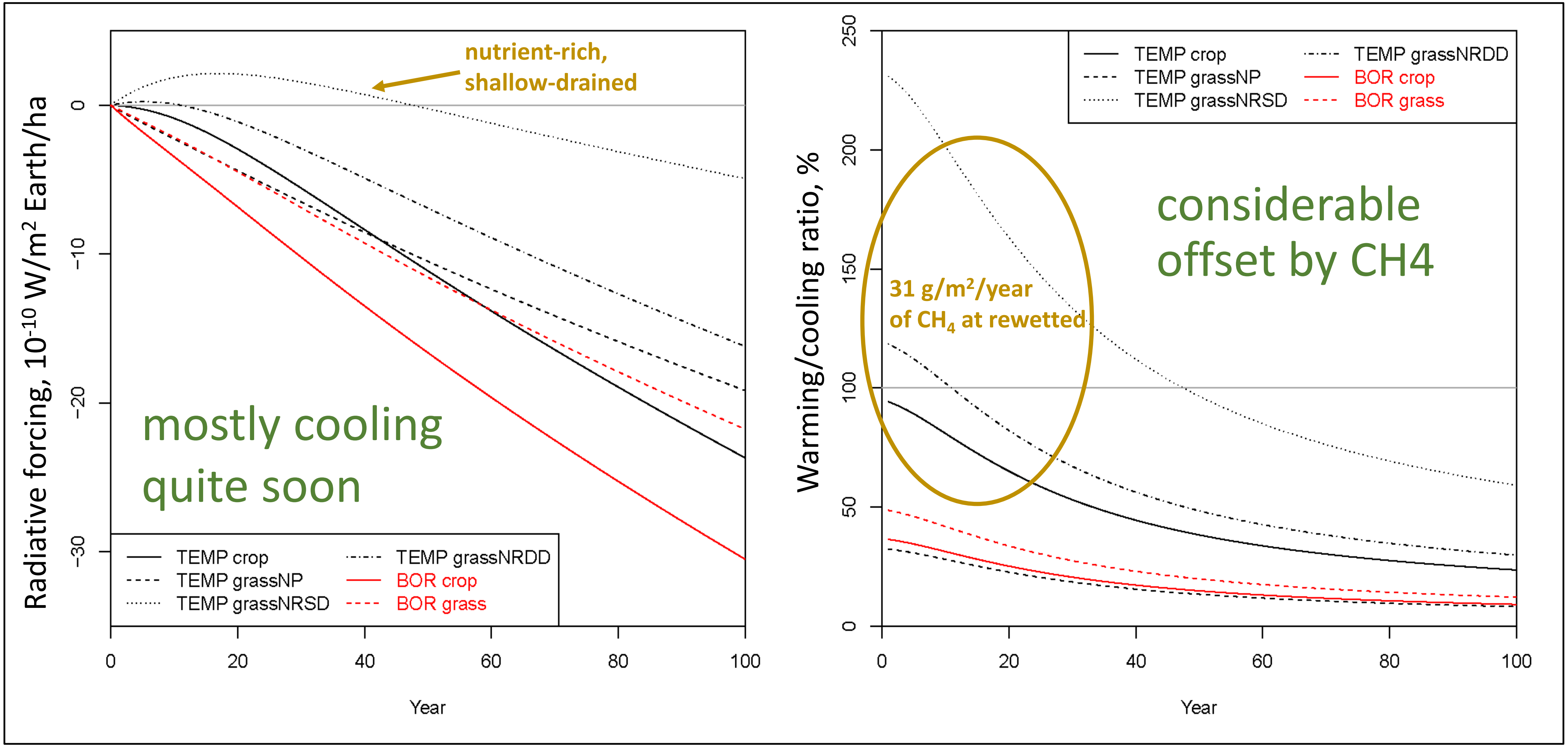
= high emission drained peat soils (58-60 t CO_2 eq./ha/year)

1 ha of tropical **soil** (plantations + agriculture)



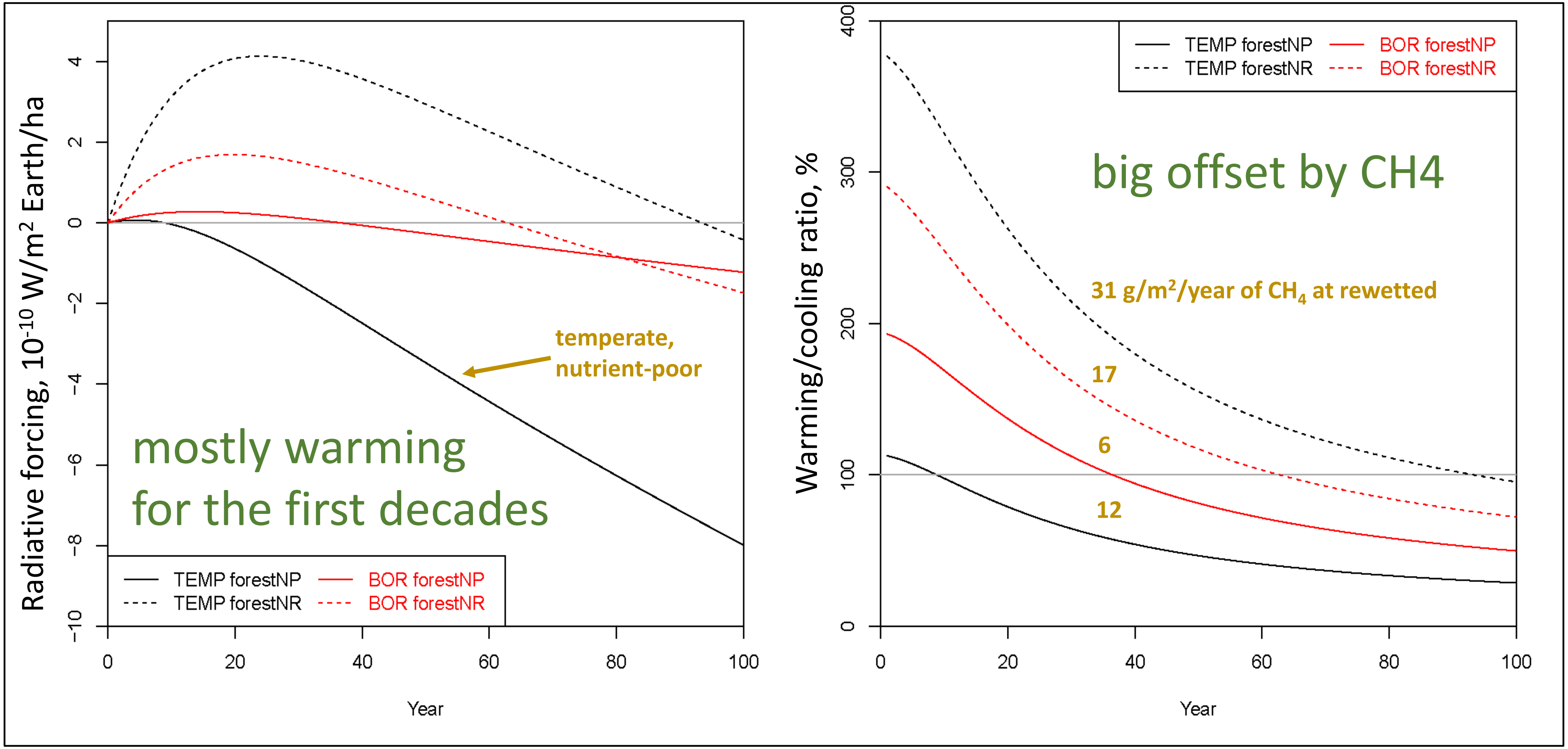
= moderate emission drained peat soils (17-38 t CO2 eq./ha/year)

1 ha of agricultural **soil** outside tropics

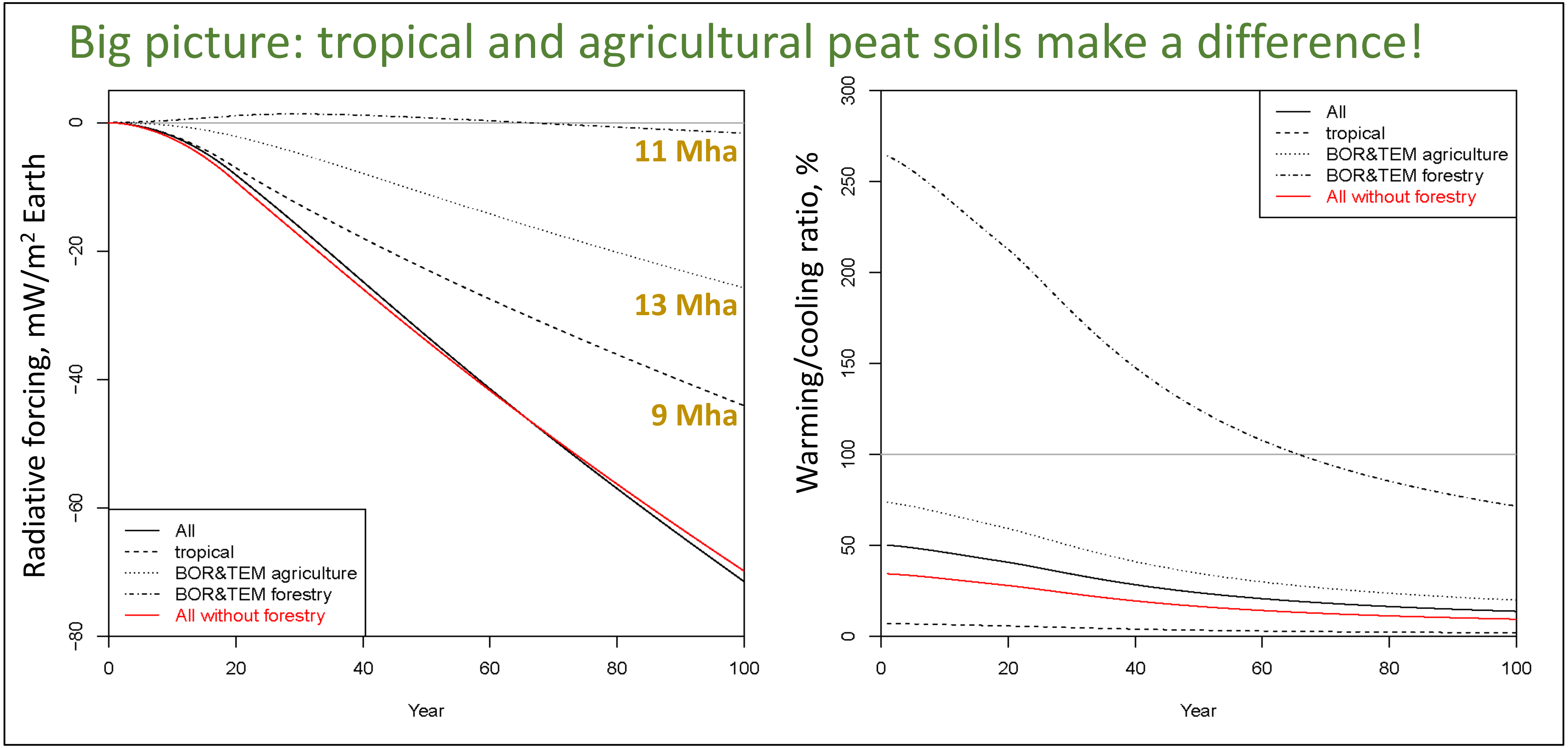


= low emission drained peat soils (2-12 t CO2 eq./ha/year)

1 ha of forestry-drained **soil** outside tropics



33 Mha: global peat **soil** rewetting in 20 years



The effect on **tree biomass + wood products**, parameters **FINLAND**…

Starting values: National Forest Inventory, etc.

Table 3. Tree stand initial volume[1], maximum volume of unmanaged stand[2], rotation-mean volume of managed stand[2], area[1] and areal share of pine dominated stands[1]. Sources: [1]Finnish National Forest Inventory for the years 2009–2013 (Korhonen et al. 2017; Antti Ihalainen/Natural Resources Institute Finland). [2]Minkkinen et al. (2001). *Maximum and mean volumes not available in the original publication, estimated through linear regressions with initial growth.

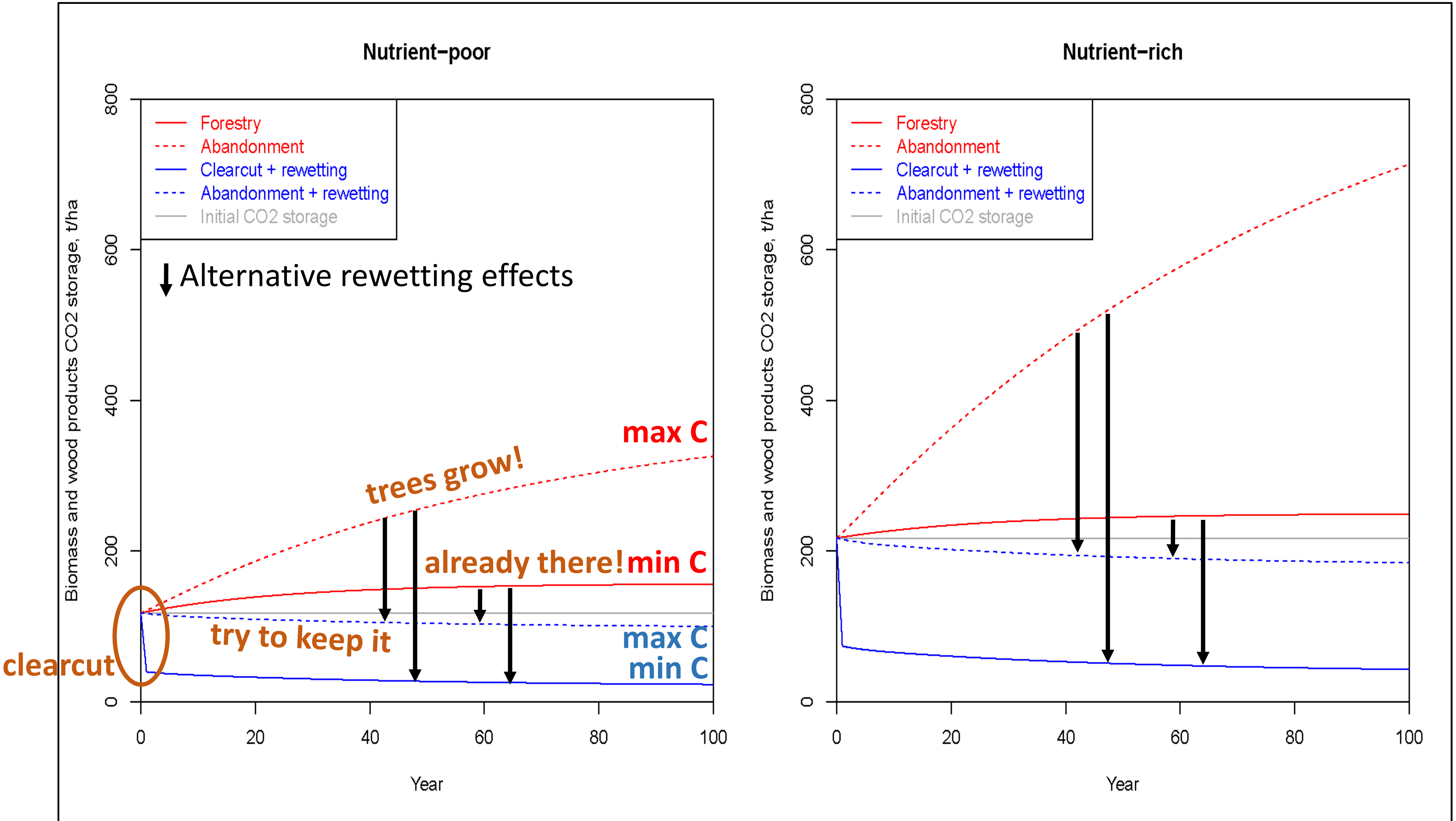
Site type	Initial volume	Initial growth	Max volume	Mean volume	Area	Share of pine
	m^3 ha^{-1}	m^3 ha^{-1} $year^{-1}$	m^3 ha^{-1}	m^3 ha^{-1}	1000 ha	%
Southern Finland, nutrient-rich sites						
Herb-rich	150	8.1	774	217	391	0.23
V. myrtillus	150	7.1	729	149	646	0.49
unproductive*	24	1.0	154	43	5	1.00
wasteland	NA	NA	NA	NA	12	NA
Southern Finland, nutrient-poor sites						
V. vitis-idaea	122	5.6	361	159	679	0.96
Dwarf shrub	78	3.5	357	110	390	1.00
*Cladina**	42	2.4	273	71	18	1.00
unproductive*	24	1.0	154	43	102	1.00
wasteland	NA	NA	NA	NA	19	NA
Northern Finland, nutrient-rich sites						
Herb-rich	103	5.5	657	137	218	0.34
V. myrtillus	105	5.0	589	83	495	0.61
unproductive*	22	0.2	78	24	41	0.97
wasteland	NA	NA	NA	NA	12	NA
Northern Finland, nutrient-poor sites						
V. vitis-idaea	79	3.9	382	103	901	0.97
Dwarf shrub	56	2.6	316	84	330	1.00
*Cladina**	39	1.4	190	51	2	1.00
unproductive*	22	0.2	78	24	344	0.97
wasteland	NA	NA	NA	NA	46	NA

More parameters…:

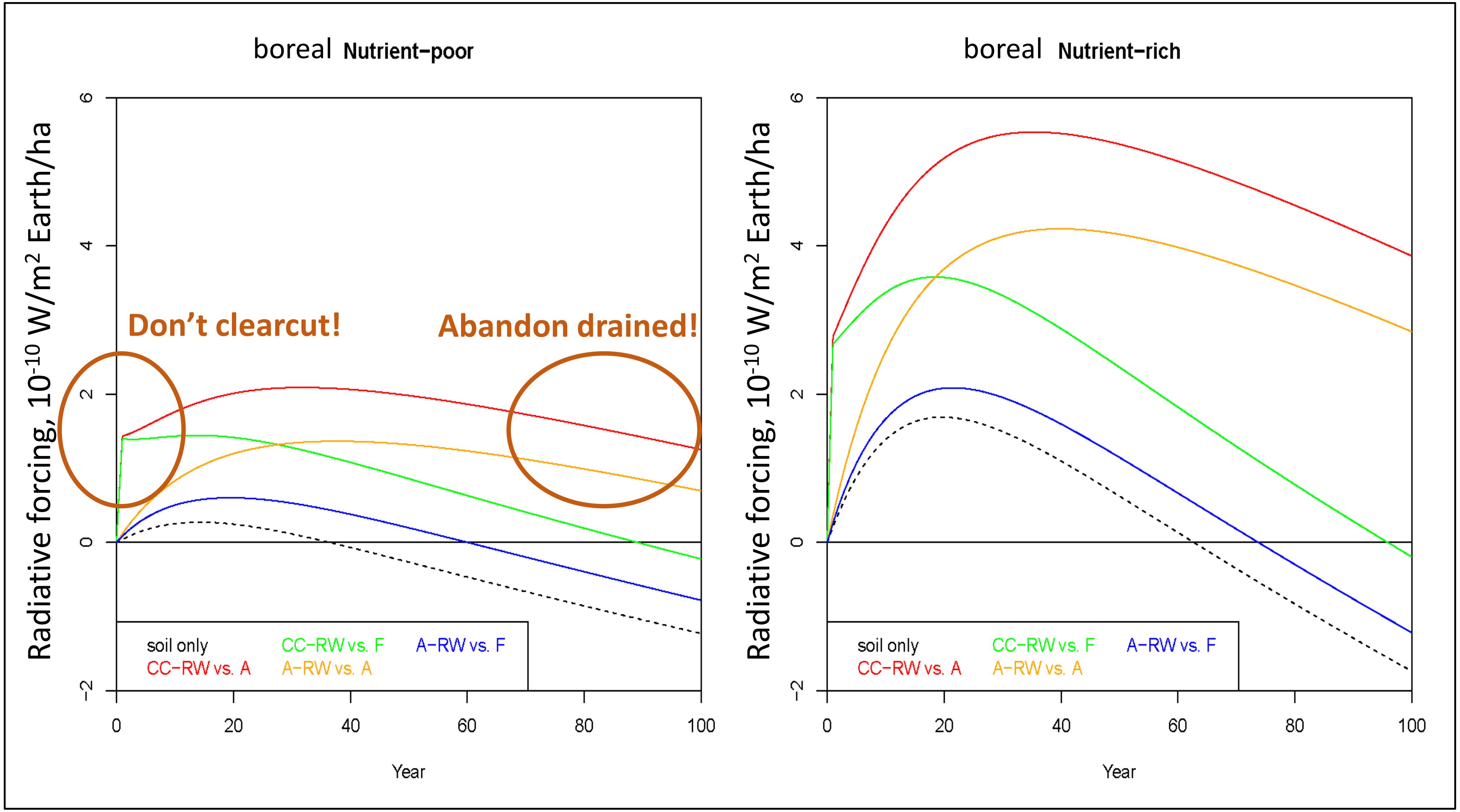
Table 4. Additional parameters for calculating the tree stand and wood product C storages.

Parameter	**Value**	**Source**
ratio of mean annual tree stand stem volume increment and stem volume growth 2010–2017	0.28	Natural Resources… 2018
Biomass expansion factor	t dry mass/m^3 stem volume	Lehtonen et al. 2004
pine dominated stands total	0.71	
pine dominated stands aboveground	0.56	
spruce dominated stands total	0.83	
spruce dominated stands aboveground	0.65	
ratio of wood products C storage and tree stand C storage	0.205	Minkkinen et al. 2002
Life times of different wood products and their share in wood product C storage (2016)	τ, years/share	Statistics Finland 2018/ Hiraishi et al. 2014
sawnwood	35/0.78	
wood panels	25/0.10	
paper and paperboard	2/0.11	

Mean tree biomass + wood product C storage



Mean **tree & products + soil** rewetting effect



Conclusions: should peatlands be rewetted to mitigate climate change?

- **Yes:** Rewet high & moderate emission drained peatland soils
  - tropical and many agricultural boreal and temperate peatlands
- **No?:** Don’t rewet forestry-drained boreal and temperate peatlands?
  - climate warming effects for decades
  - current soil emissions relatively low
  - releasing tree and product C / halting tree growth
  - disagreement between short and long term climate change mitigation
- **Soil emissions have linear/nonlinear relationship with water table**
  - many options for managing water table, not only rewetting vs. drainage!
    - spontaneus rewetting, partial rewetting…

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