



Environment and
Climate Change Canada

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ADVANCES IN CANADIAN METHODS FOR GHG INVENTORY OF PEAT EXTRACTION – THE MAIN TAKEAWAYS FOR THE EU

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Agriculture, Forestry and Other-Land-Use
Pollutant, Inventory and Reporting Division
Environment and Climate Change Canada

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24th Annual Baltic Peat Producers Forum



Canada 

NATIONAL INVENTORY REPORT 1990–2023: GREENHOUSE GAS SOURCES AND SINKS IN CANADA

CANADA'S SUBMISSION TO THE UNITED NATIONS FRAMEWORK
CONVENTION ON CLIMATE CHANGE

PART 1

2025

International Reporting Requirements

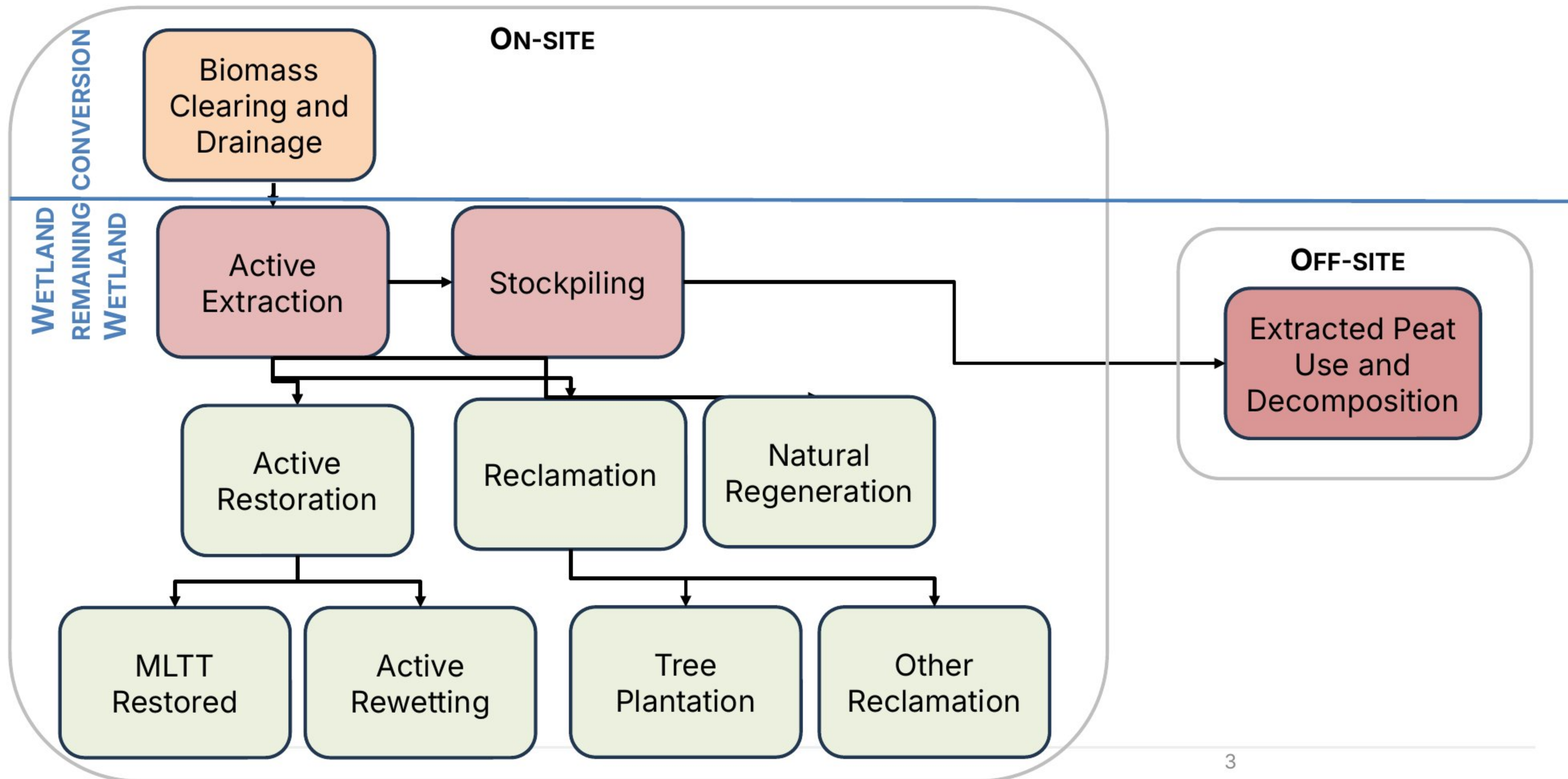
United Nations Framework Convention on Climate Change (UNFCCC) ratified by Canada December 1992

Guidelines:

- International Panel for Climate Change (IPCC) 2006 Guidelines
- 2014 IPCC Wetland Supplement

NIR methodology can be used to inform policies and programs

EMISSION CATEGORIES BY STAGE OF PEAT EXTRACTION



IPCC GUIDANCE AND DEFAULTS

On-site Emissions

Activity	Gas	IPCC Emission Factor (boreal)	IPCC Wetland Supplement 2014
Drainage of inland wetlands	CO ₂	2.8 t CO ₂ -C ha ⁻¹ y ⁻¹	Table 2.1
	CH ₄ (field)	6.1 kg CH ₄ -C ha ⁻¹ y ⁻¹	Table 2.3
	CH ₄ (ditch)	542 kg CH ₄ -C ha ⁻¹ y ⁻¹	Table 2.4
	DOC	0.6 t C ha ⁻¹ y ⁻¹	Table 2.2
	N ₂ O	0.3 kg N ₂ O-N ha ⁻¹ y ⁻¹	Table 2.5
Rewetting	CO ₂	-0.34 to -0.55 t CH ₄ -C ha ⁻¹ y ⁻¹	Table 3.1
	CH ₄	41-137 kg CH ₄ -C ha ⁻¹ y ⁻¹	Table 3.3
	DOC	0.08 t C ha ⁻¹ y ⁻¹	Table 3.2

Off-site Emissions (Peat Products)

- IPCC 2006 Tier 1 assumes 100% oxidation of peat products in first year of extraction

CANADA'S PRE-UPDATE MODEL FOR ESTIMATING GHG FROM PEAT EXTRACTION

- Canada used a Tier 2 approach for on-site emissions
 - **Domestic emission factors** derived from flux measurements reported in Canadian research studies
 - **Did not differentiate restoration** – rewetting vs. Moss Layer Transfer Technique (MLTT; Rochefort et al. 2003)
- Tier 1 for off-site emissions
 - **Assumed 100% peat oxidation**

"...the Canadian peat industry has invested significant resources, both financial and human, in improving the knowledge about peatlands and their restoration through partnerships with the scientific community." - [Canadian Sphagnum Peat Moss Association](#)

THE PEATLAND ECOLOGY RESEARCH GROUP

Founded in 1992 by Line Rochefort, the PERG is the result of **collaboration** between the **academic scientific community**, the **Canadian horticultural peat industry** and **federal and provincial government agencies**. All these stakeholders are committed to the objective of integrated and **sustainable management of peatlands** in Canada.

Moss Layer Transfer Technique (Rochefort et al., 2003):



Donor collection

Photos from [gret-perg](https://gret-perg.ca)



Spore spreading with straw mulch



MLTT- restored



Unrestored



Photo: M.-C LeBlanc from [gret-perg](https://gret-perg.ca)

RATIONALE FOR MODEL UPDATES

Incorporating New Science:

- Incorporate machine learning and remote sensing approach to spatial data
- Additional GHG flux monitoring on active and restored sites
- Decay of peat products

Programs and Policy:

- Enable more accurate projections of emissions reductions from the avoided conversion or restoration of peat extraction sites

Incubation study of peat products used for horticulture (Sharma et al., 2024)



HIGH-LEVEL DESCRIPTION OF UPDATES

Activity data

- Machine learning approach (Dr. Millard at University of Carleton)
- New sampling point for 2022, mapped with high-resolution imagery
- Revised Moss Layer Transfer Technique (MLTT) restored and rewetted areas

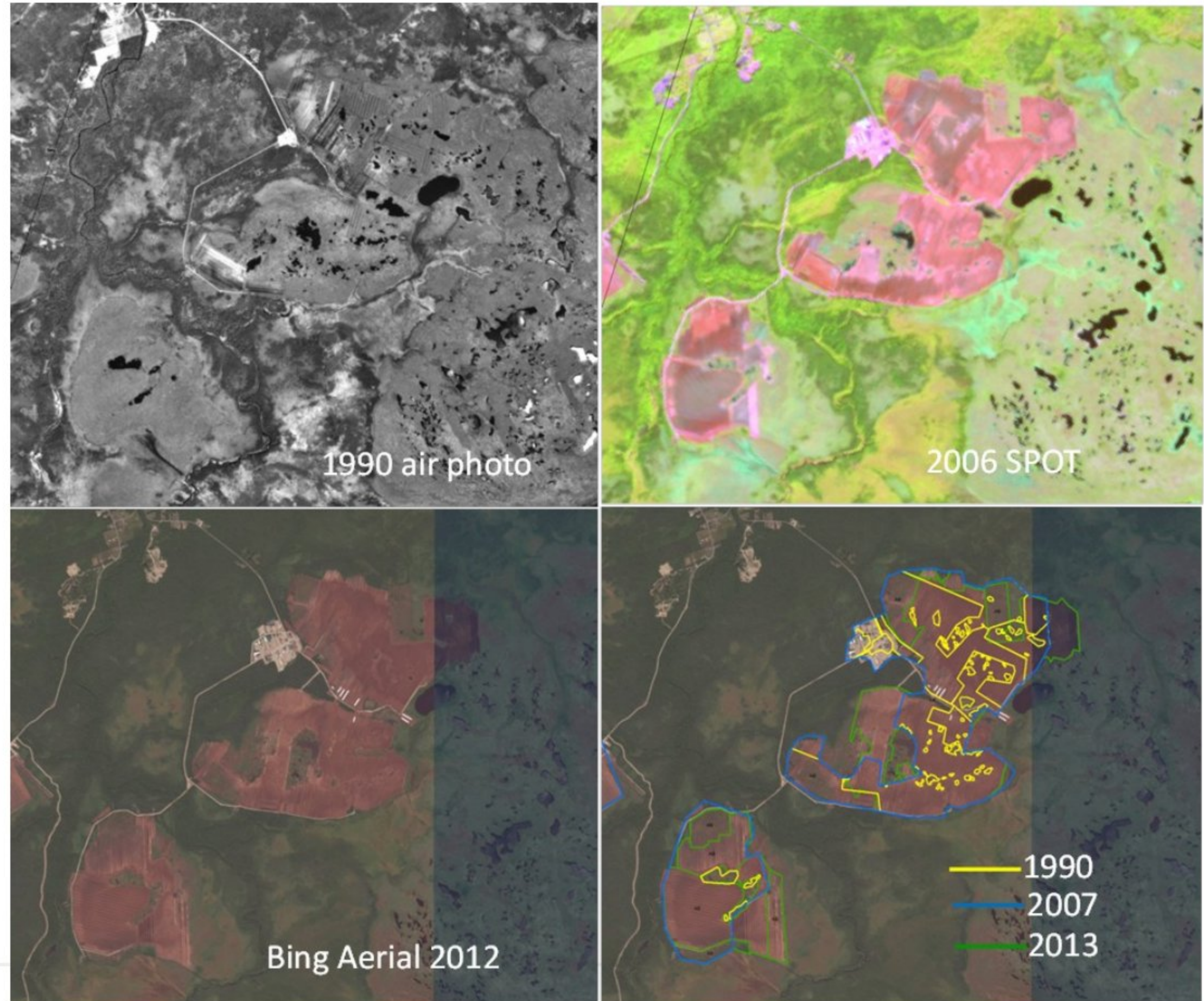
Updated emission/removal factor equations

- Updated constant emission factors
- Extracted peat: Off-site CO₂ emissions
- Restored areas: CO₂ emissions/reductions
 - Constant emission factor → Step-wise emission factor
 - Specific to type of restoration

ACTIVITY DATA

PEAT EXTRACTION ACTIVITY DATA

- Digitize the changes of peat extraction area that occur over time, using Landsat archives and high-resolution imagery
- Quantify the areal polygon changes in QGIS



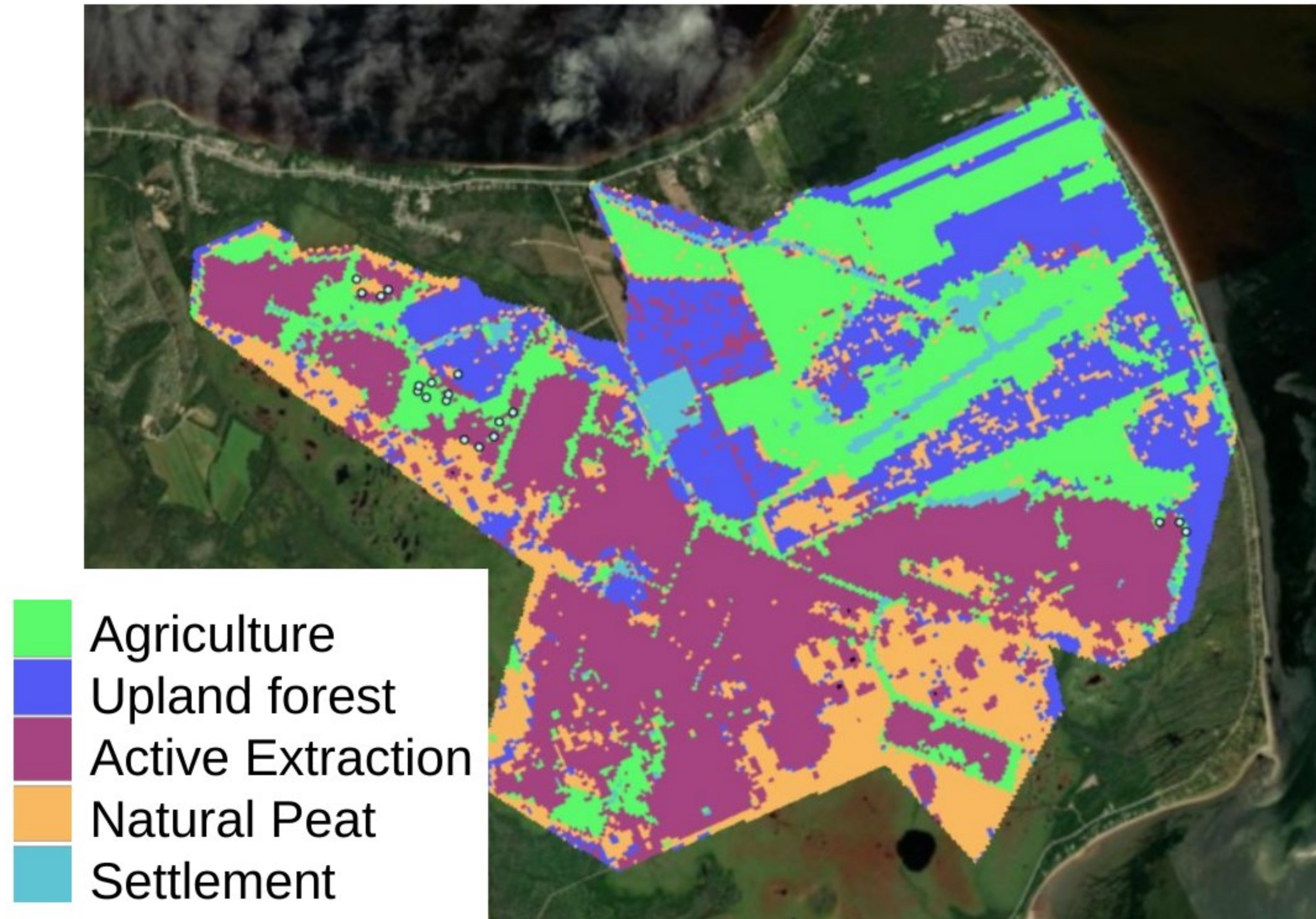
REMOTE SENSING - MAPPING

Machine learning model developed by Koreen Millard (University of Carleton) to classify RS imagery

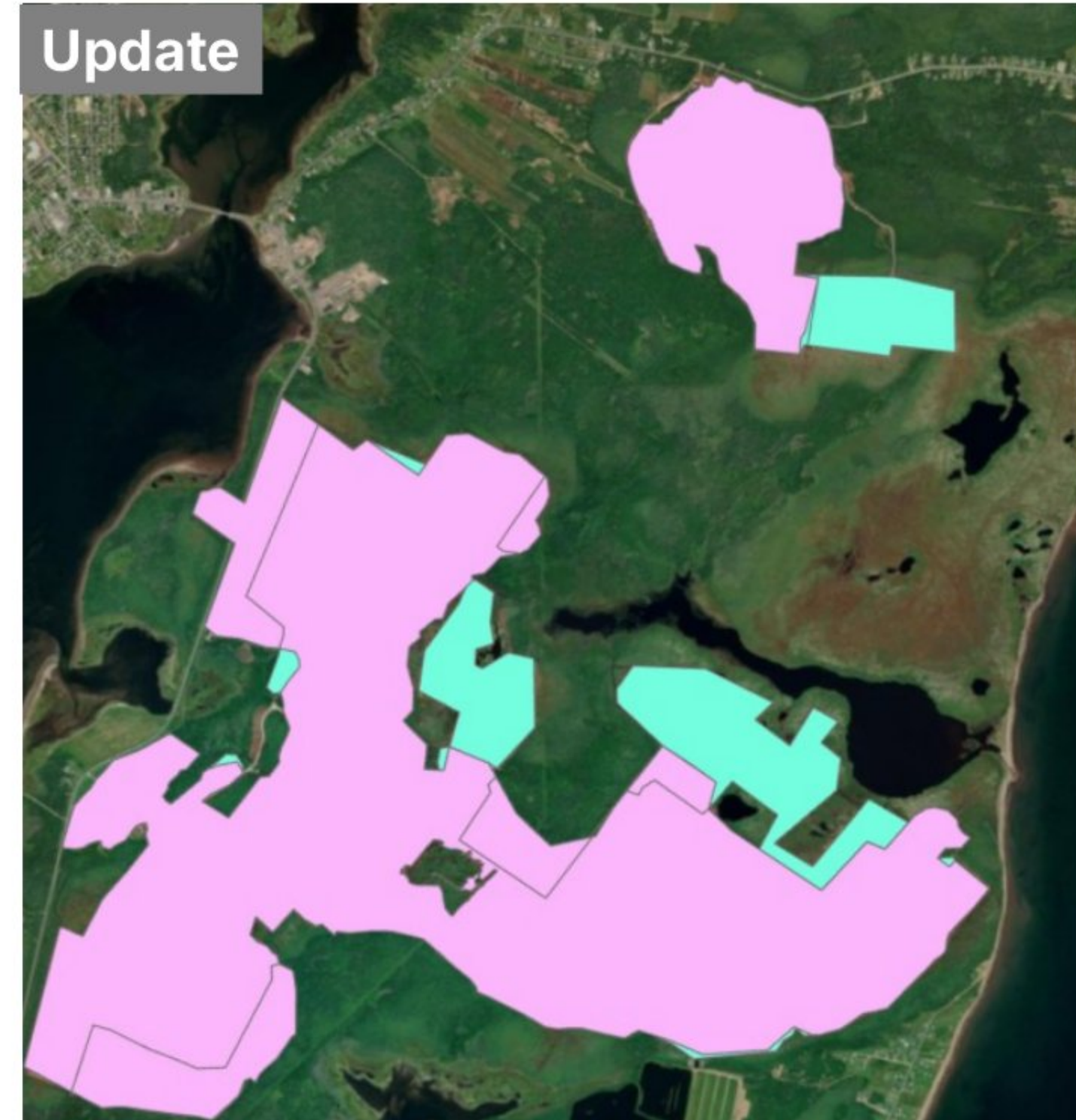
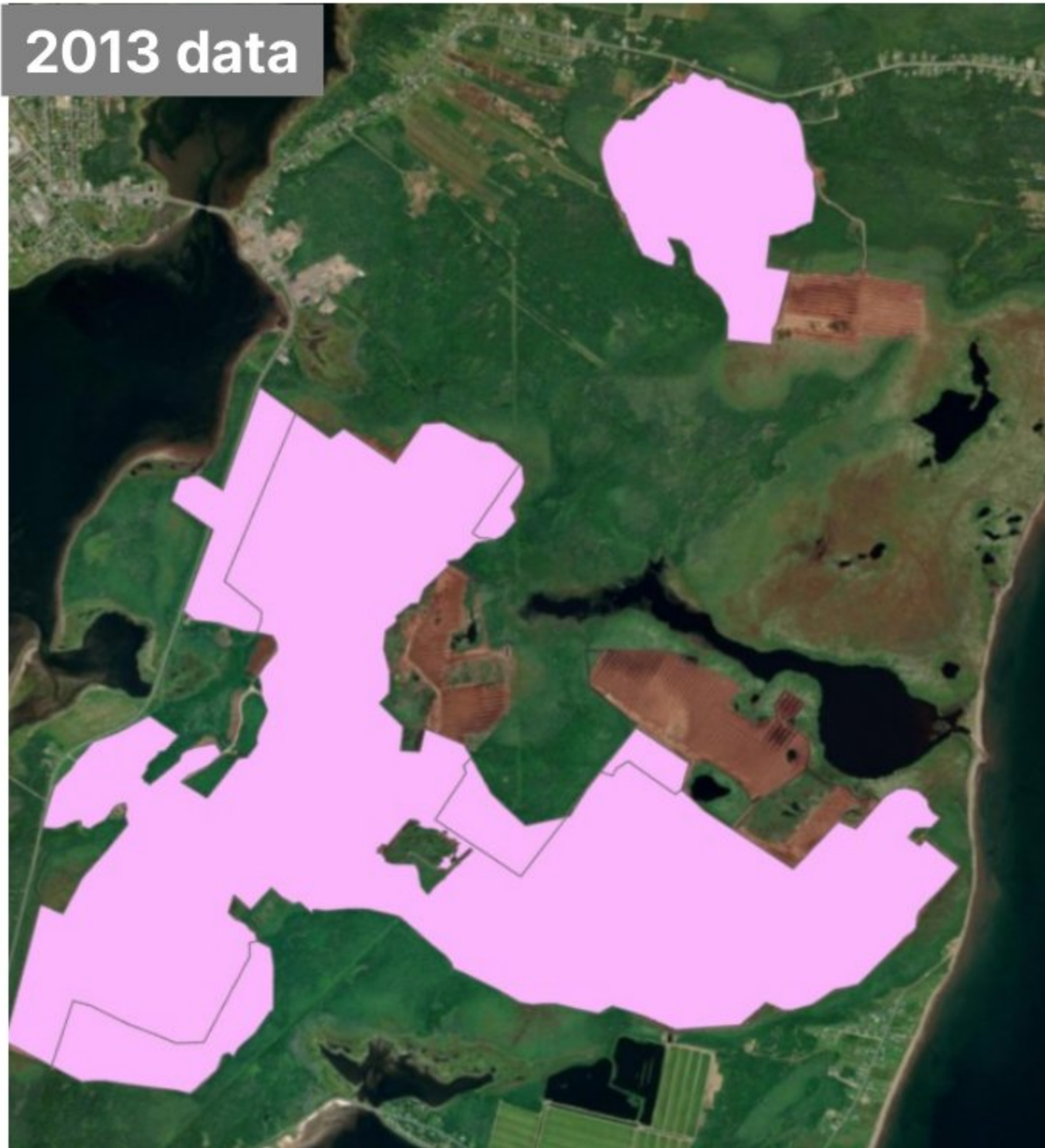
Limitations:

- Natural (undisturbed) vs. restored
- Active vs. unrestored

ML outputs were used as informal data for manual digitization

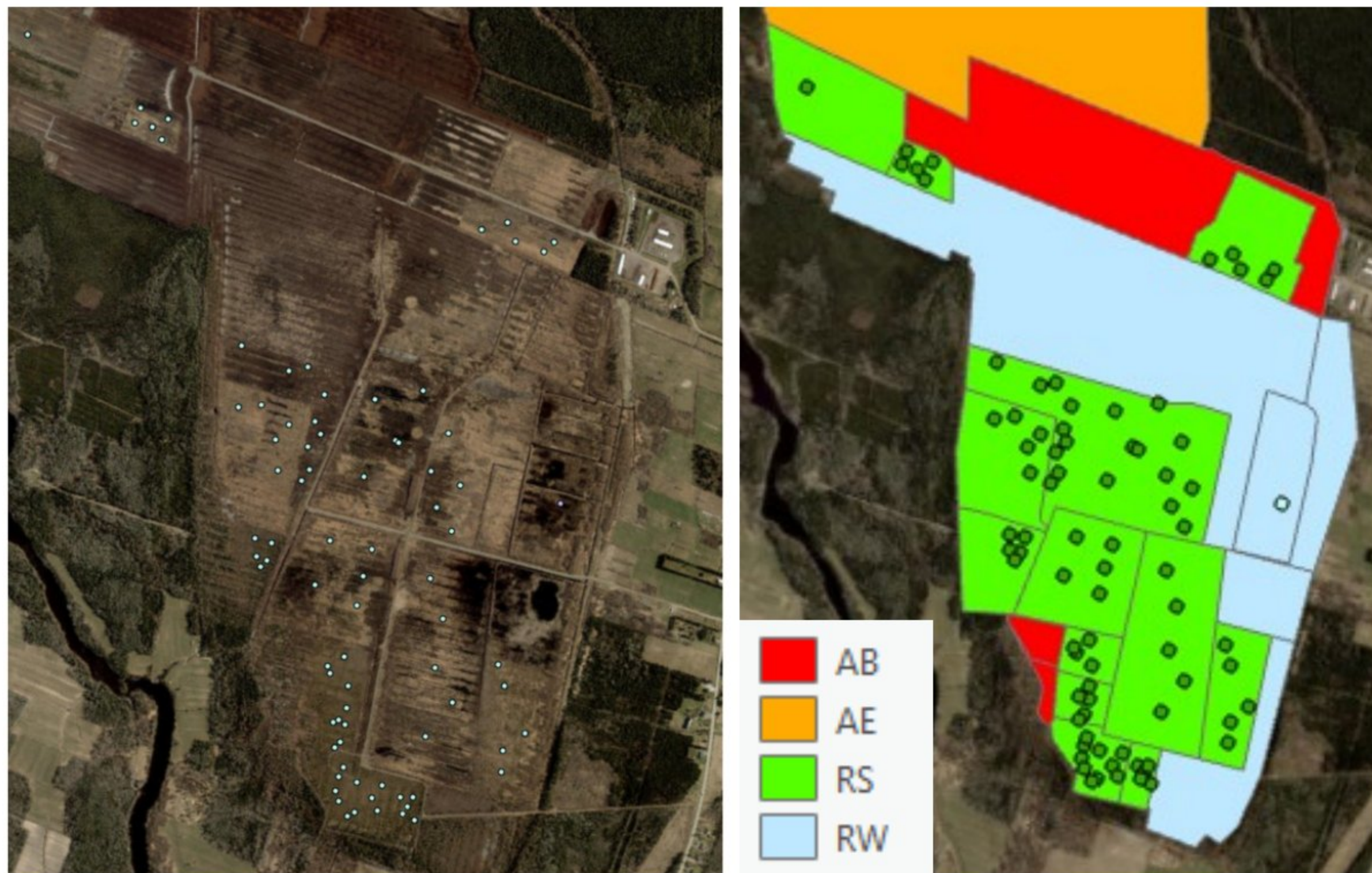


MACHINE LEARNING USED TO UPDATE

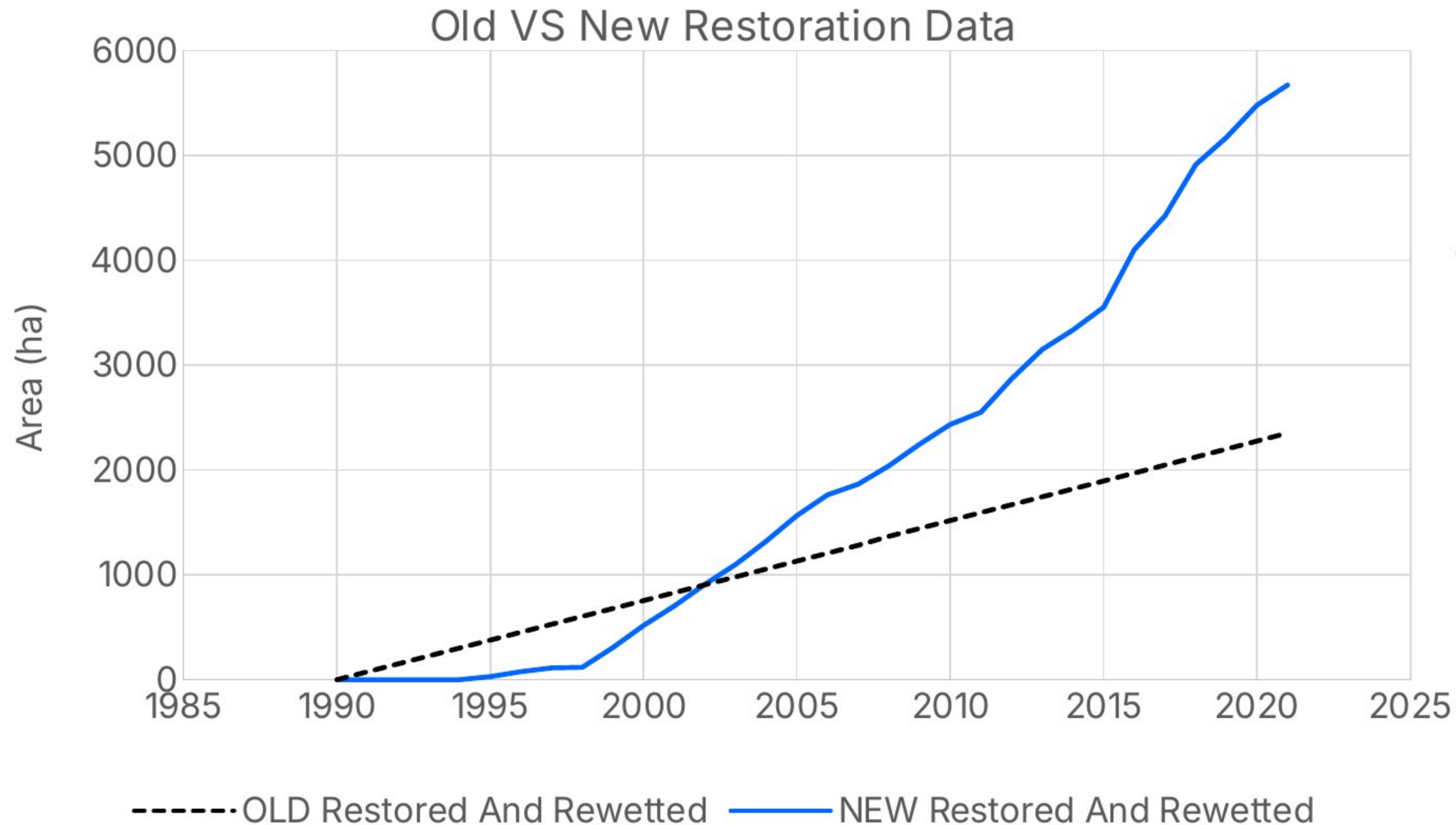


REFINED MAPPING: REWETTED VS. MLTT

- Updated entire time series for restoration and mapped active rewetting and MLTT restoration
- Point data from CSPMA / University of Laval
 - Digitized areas



ACTIVITY DATA UPDATE



Increased ability to detect temporal trends in restored and rewetted areas compared to previous method using extrapolated data.

EMISSION FACTORS AND CALCULATIONS

APPROACH

- Extensive literature review for each category
- Expert consultation
 - 14 leading experts from academia, industry, and government
 - Experts consulted on how best to compile data for emission factors, data confidence..etc.
 - Iterative approach

OFF-SITE CO₂- EXTRACTED PEAT: PREVIOUS METHODOLOGY

CO₂ Off-site Extracted Peat =

Peat Production (t) x Extracted Peat C Fraction (t C t air-dry-peat⁻¹) x
(44/12)

Extracted Peat C Fraction = 0.257 t C t air-dry-peat⁻¹ (Hayne, Jenkins, Garnett, 2004)
IPCC 2006 Guidelines:
0.45 t C t air-dry-peat⁻¹

IPCC 2006 Guidelines:

- Assumes all peat emissions occur in extraction year
- Assumption of instantaneous oxidation can be modified with country-specific data monitoring the off-site fate of extracted peat and its decay

OFF-SITE CO₂- EXTRACTED PEAT : UPDATED METHODOLOGY

Exponential decay function with annual decay rate for peat carbon of 5%:

$$\text{CO}_2 \text{ Off-site Extracted Peat at } t = Cr_{t-1} - Cr_t * 44/12$$

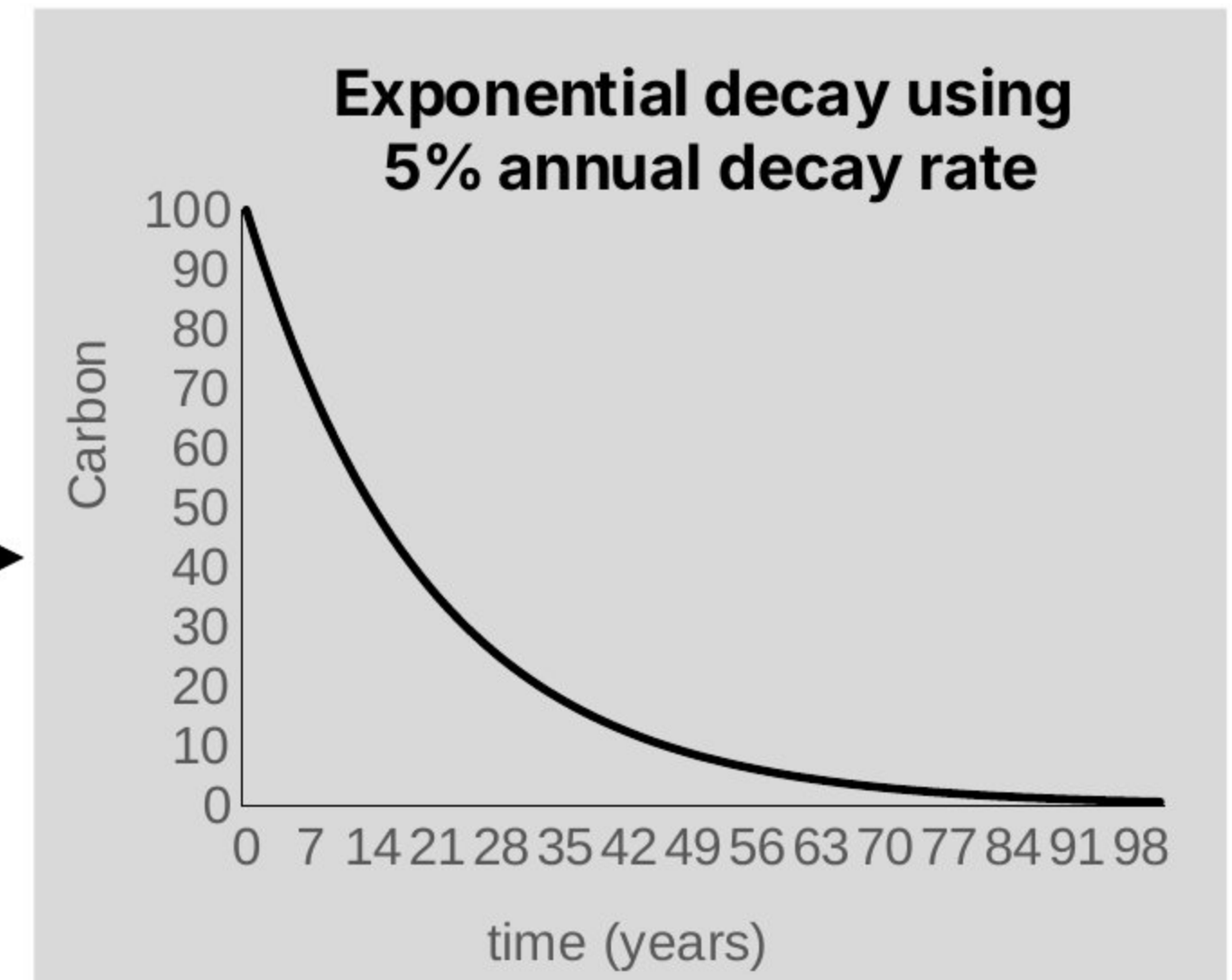
where:

$$Cr_t \text{ (carbon remaining at time } t) = C_o * e^{-kt}$$

$$C_o \text{ (initial carbon pool)} = \text{Peat Production} * \text{Extracted Peat C Fraction}$$

$$k = 0.05 \text{ (Cleary et al., 2005; Hayne et al., 2014; Sharma et al., 2024)}$$

$$\text{Extracted Peat C Fraction} = 0.257 \text{ t C t air-dry-peat}^{-1} \text{ (Hayne et al., 2014)}$$

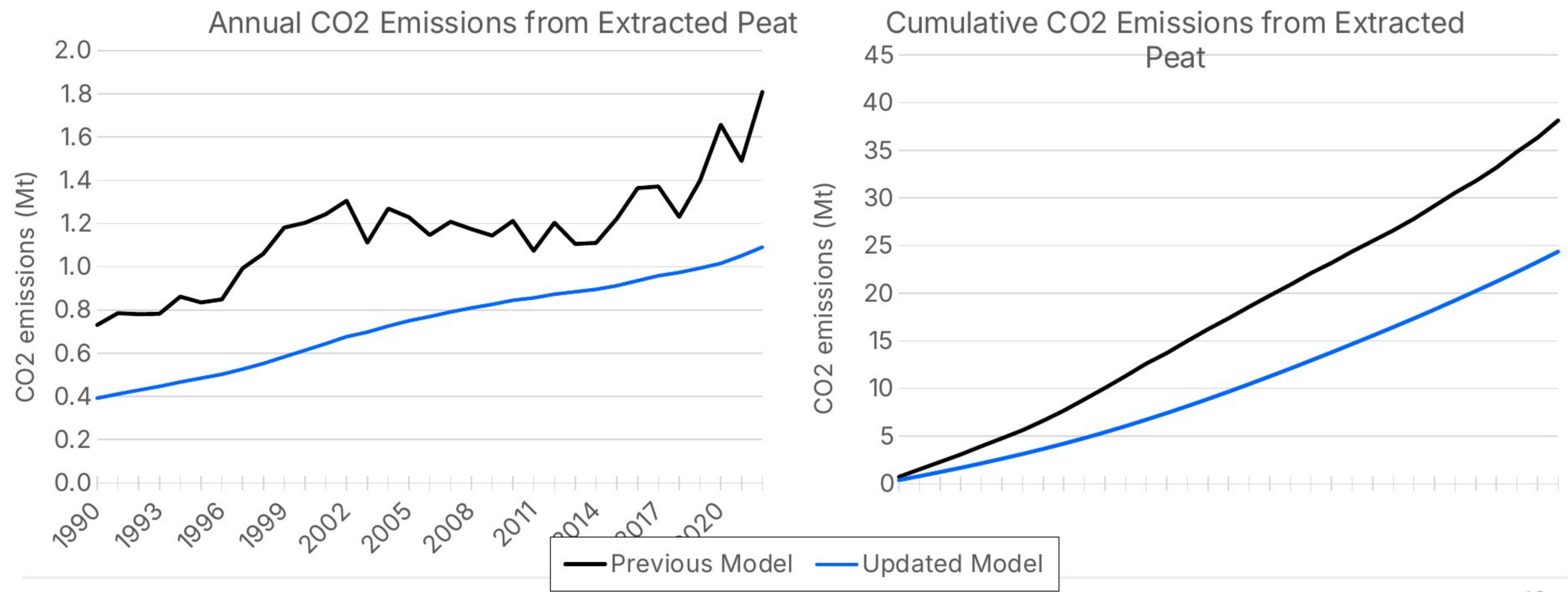


Assumption: All peat products are used for horticultural purposes (within Canada and exported products)

Timeline: 100 years

OFF-SITE CO₂ FROM EXTRACTED PEAT: METHOD CHANGE

Cumulative (1990-2022) CO ₂ Emissions from Extracted Peat (Mt) :		% Difference
Previous Model:	38	
Updated Model:	24	-36%



ON-SITE EMISSION FACTORS: CO₂

Land Management Activity	Emission Factor (t CO ₂ ha ⁻¹ yr ⁻¹)	
	Previous	Update
Biomass Clearing	Forest land: 19.2 t C ha ⁻¹ Open peatland: 2.8 t C ha ⁻¹	No update
Drained (includes active extraction, unrestored, other reclamation)	11.4	9.4
MLTT Restored ≤12 years	7.6	7.9
MLTT Restored >12 years		-3.3
Active Rewetting		-4.5
Tree plantation peat efflux	11.4	14.6
Tree plantation biomass uptake	-0.32	Growth rate dependant on t (time since plantation)
Natural Regeneration Vacuum	7.6	No update
Natural Regeneration Block-cut	8.6	No update

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EMISSION FACTORS: CO₂- DOC

Land Management Activity	Emission Factor (t CO ₂ ha ⁻¹ yr ⁻¹)	
	Previous	Update
Drained (includes active extraction, unrestored, tree plantation, other reclamation)	0.60	1.38
MLTT Restored	0.13	0.33
Active Rewetting	0.13	0.33
Natural Regeneration Vacuum	0.13	0.33
Natural Regeneration Block-cut	0.60	1.38

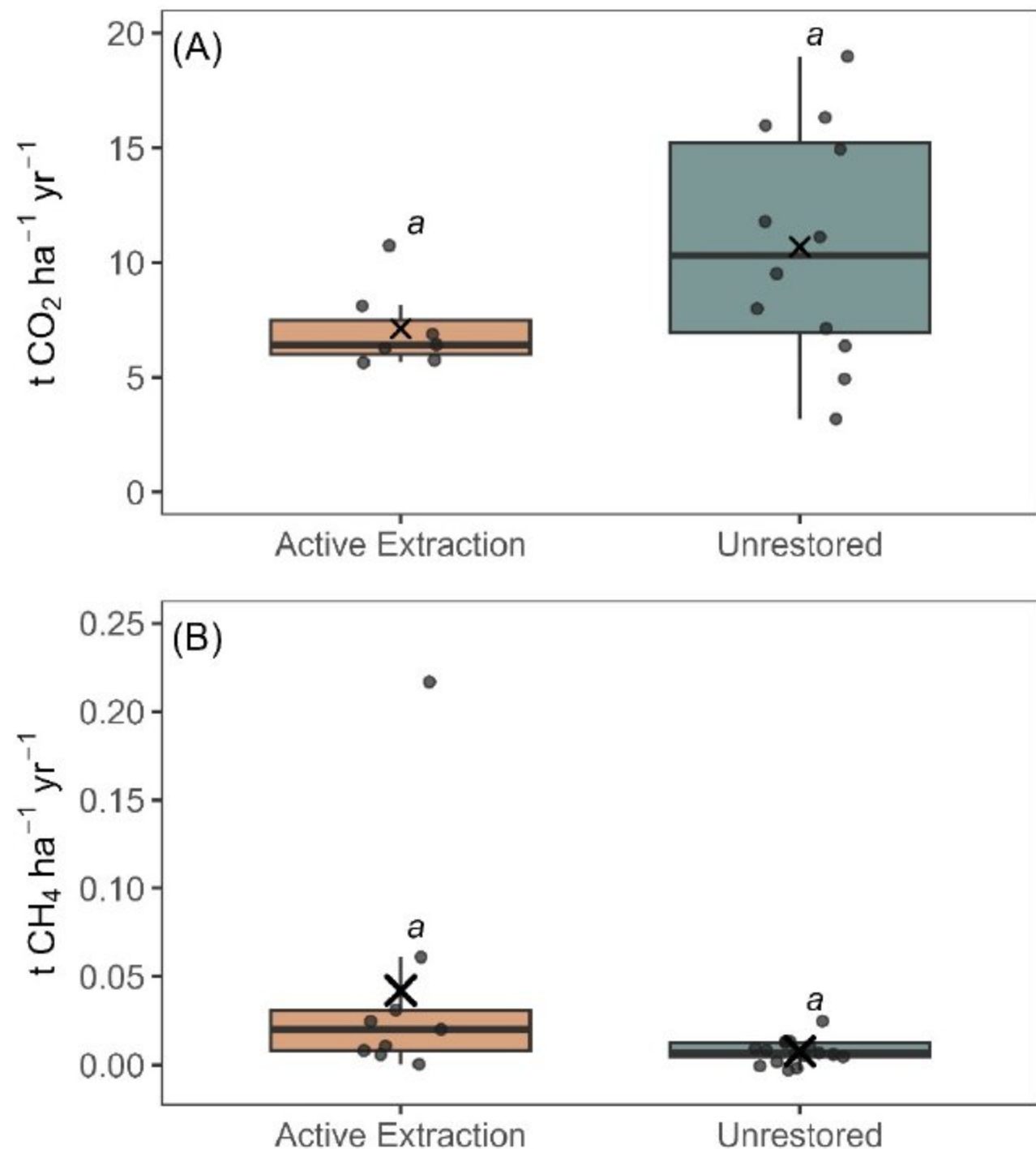
EMISSION FACTORS: CH₄

Land Management Activity	Emission Factor (t CH ₄ ha ⁻¹ yr ⁻¹)	
	Previous	Update
Drained [includes active extraction, unrestored, tree plantation, other reclamation]	0.015	0.02
MLTT Restored (all years)	0.043	0.03
Active Rewetting		0.19
Natural Regeneration Vacuum	0.043	No Update
Natural Regeneration Block-cut	0.012	No Update

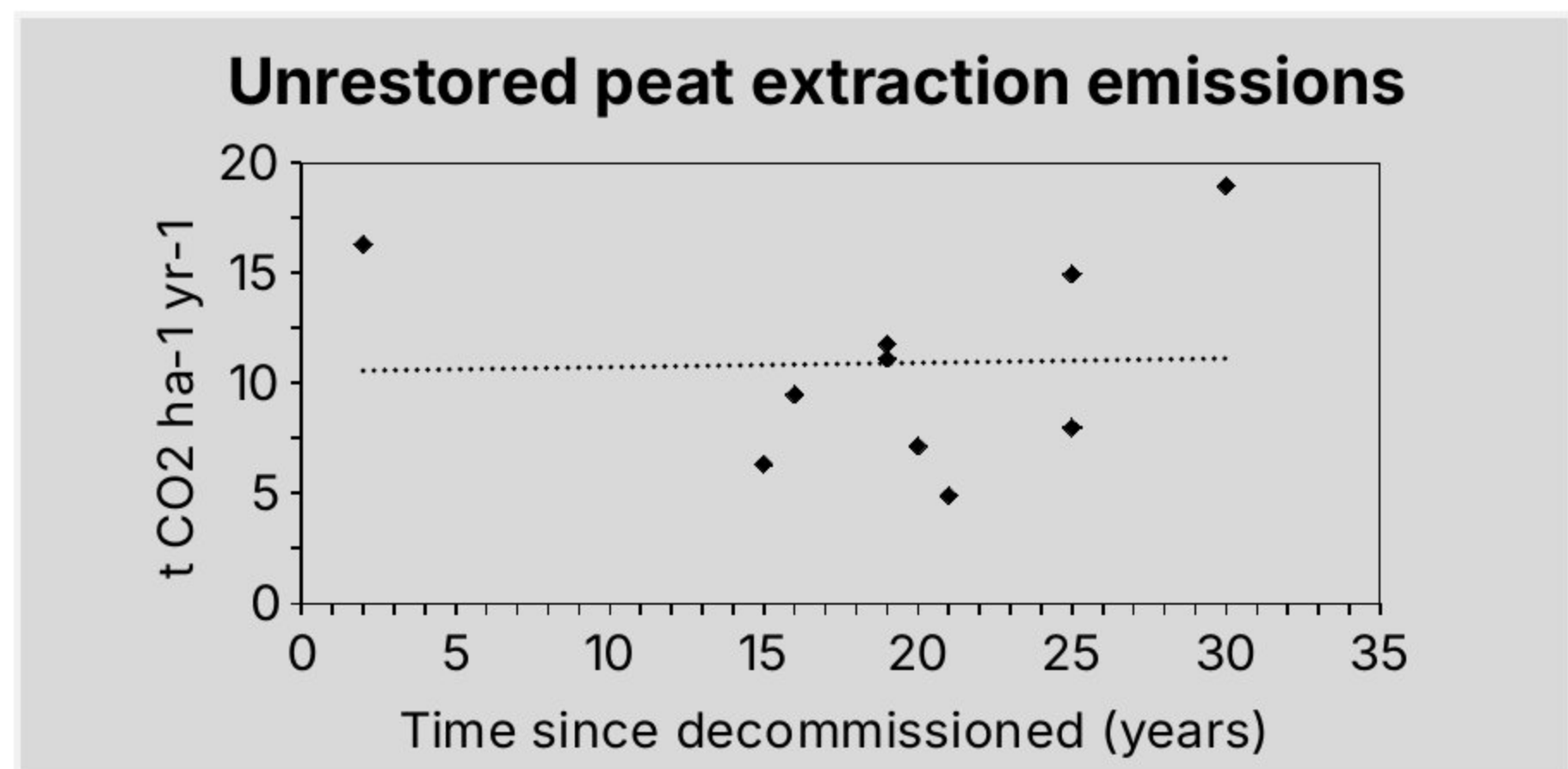
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ACTIVE VS UNRESTORED EMISSIONS



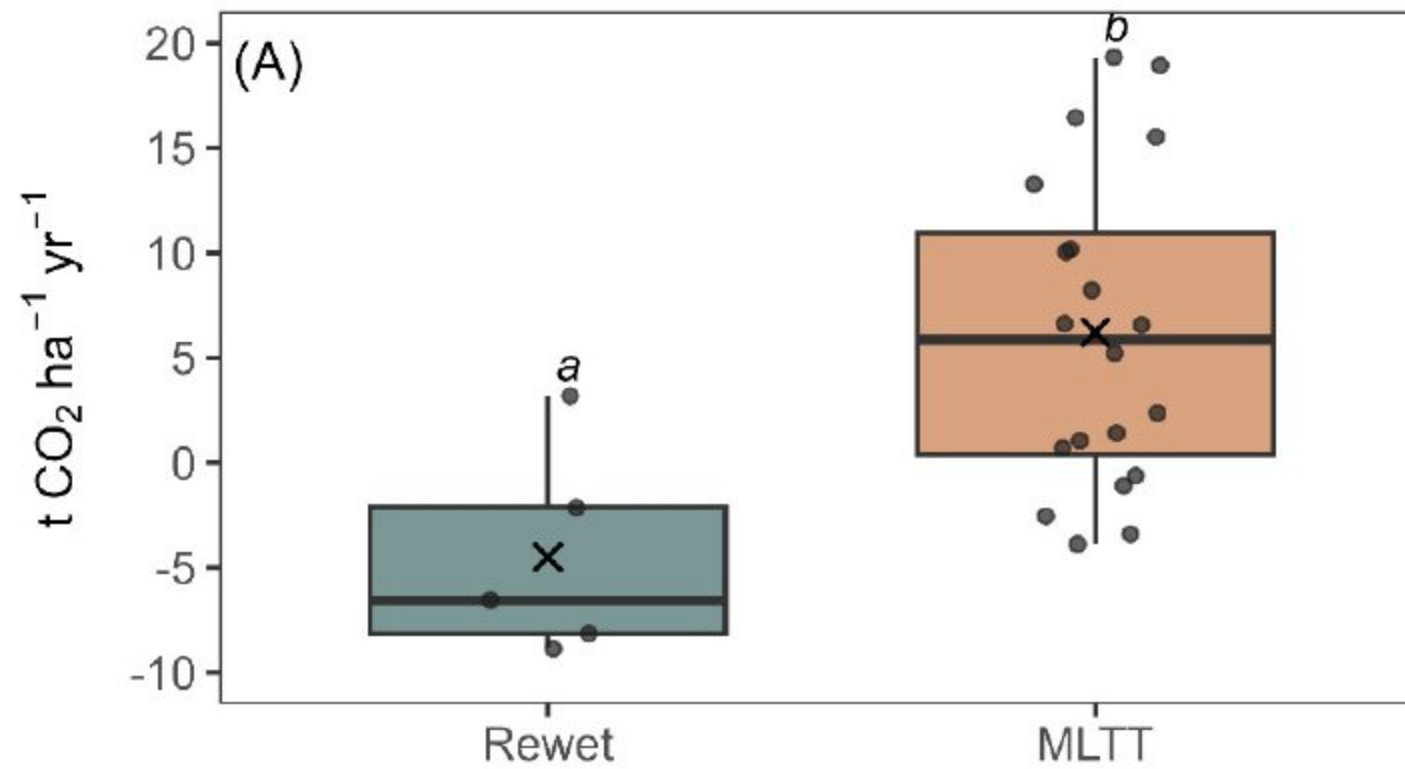
- No significant difference in CO₂ or CH₄ emissions
- Consistent with findings of He and Roulet, 2023



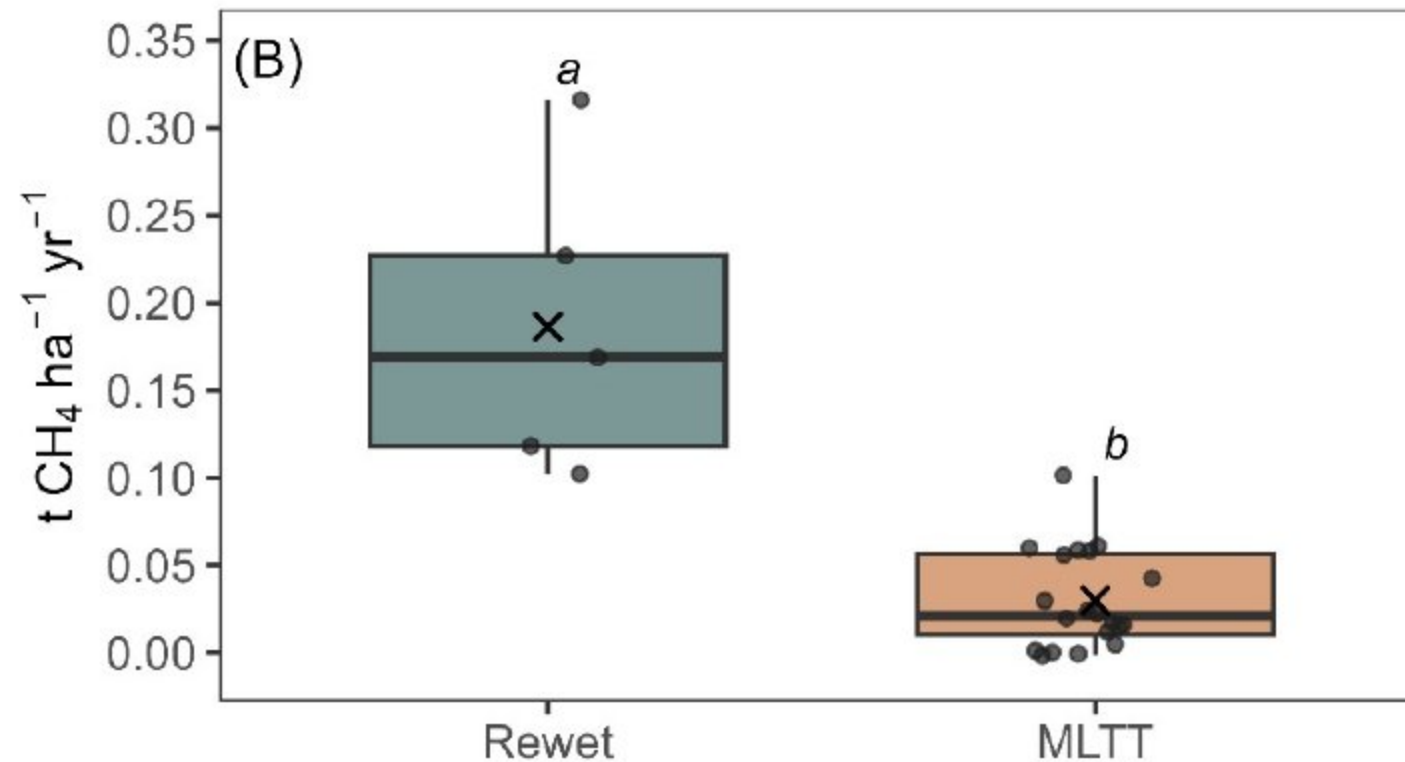
- Found no relationship with time

RESTORED AND REWETTED CO₂ AND CH₄

Statistically significantly different emissions for MLTT and Rewetting



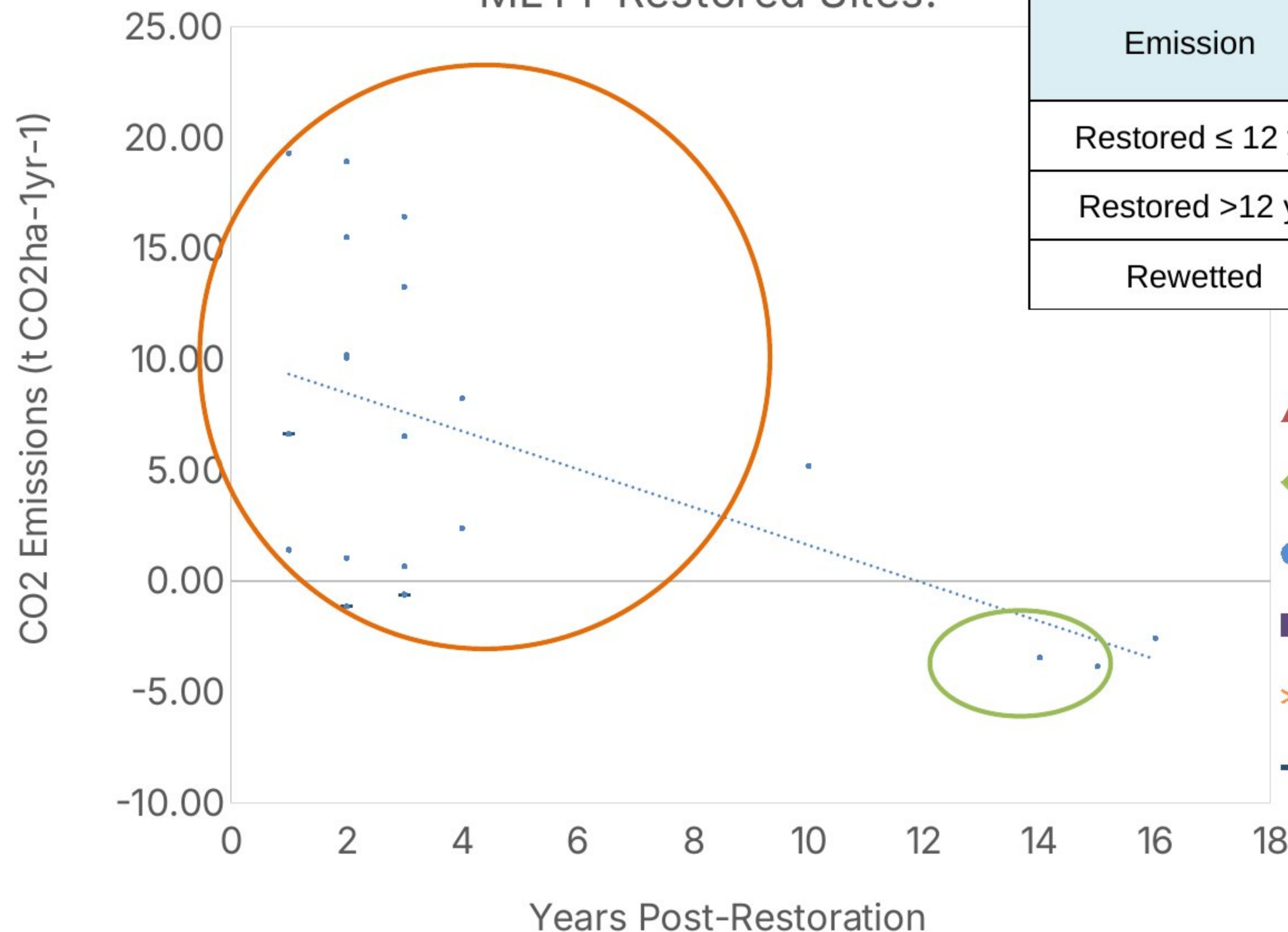
	t CO ₂ ha ⁻¹ y ⁻¹
Previously	7.6
Rewet	-4.5
MLTT	6.2



	t CH ₄ ha ⁻¹ y ⁻¹
Previously	0.043
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MLTT	0.19

RESTORATION AND TIME

MLTT Restored Sites:



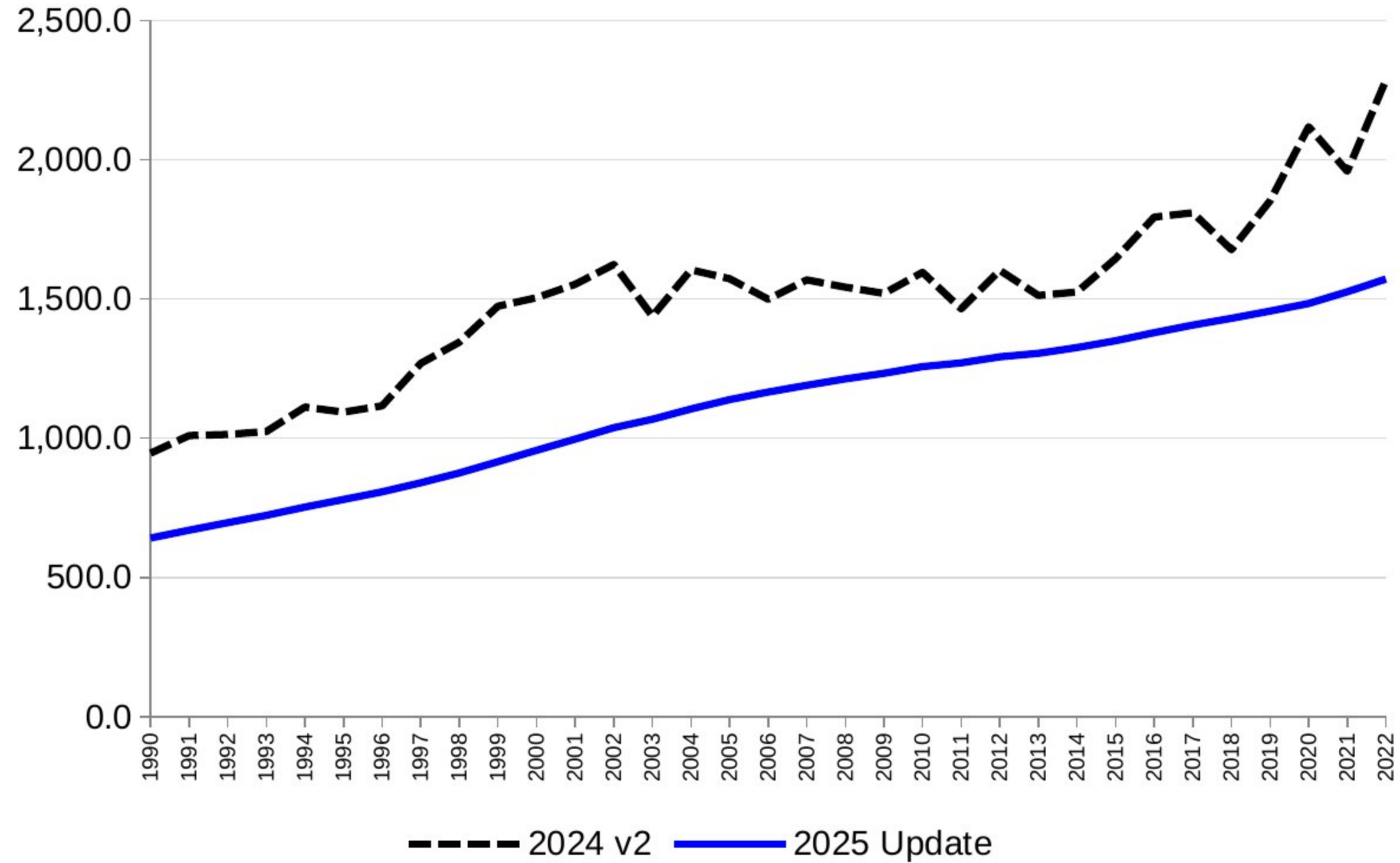
Emission	Previous EF (t CO ₂ ha ⁻¹ yr ⁻¹)	New EF (t CO ₂ ha ⁻¹ yr ⁻¹)
Restored ≤ 12 yr	7.6	7.9
Restored >12 yr	7.6	-3.3
Rewetted	7.6	-4.5

- ▲ Rivière du Loup, QC
- ◆ Shippagan, NB
- Bois-des-Bel, QC
- Wandering River, AB
- * Seba Beach, AB
- Bic-Saint-Fabien, QC

IMPACT OF UPDATE ON NATIONAL TOTALS

NATIONAL IMPACT OF UPDATES

Recalculations		
	kt CO ₂ eq	%
1990	-300	-32%
2005	-430	-27%
2022	-710	-31%



UPDATED EMISSIONS AND REMOVALS IN CANADA NATIONAL GHG INVENTORY

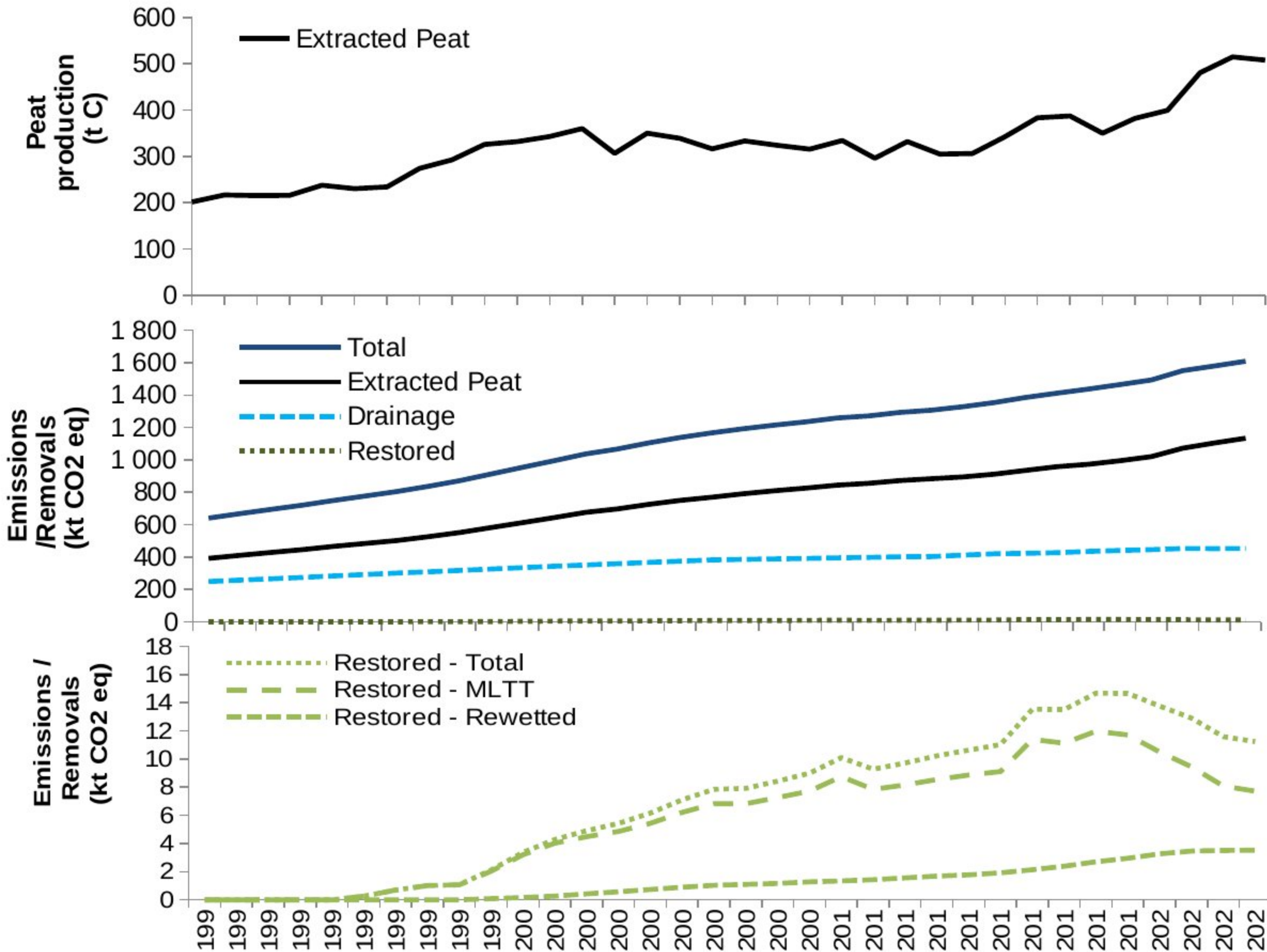


Figure 6-8 [2025 NIR - Part 1.pdf](#)

SCENARIO PROJECTIONS

3×4 scenarios were tested for impact to the long-term carbon flux:

Peat production

- **Business as usual (BAU):** current upward trend is maintained indefinitely
- **Level :** 5-year average is taken and carried forward
- **Stop production:** Assumes all peat production stops tomorrow

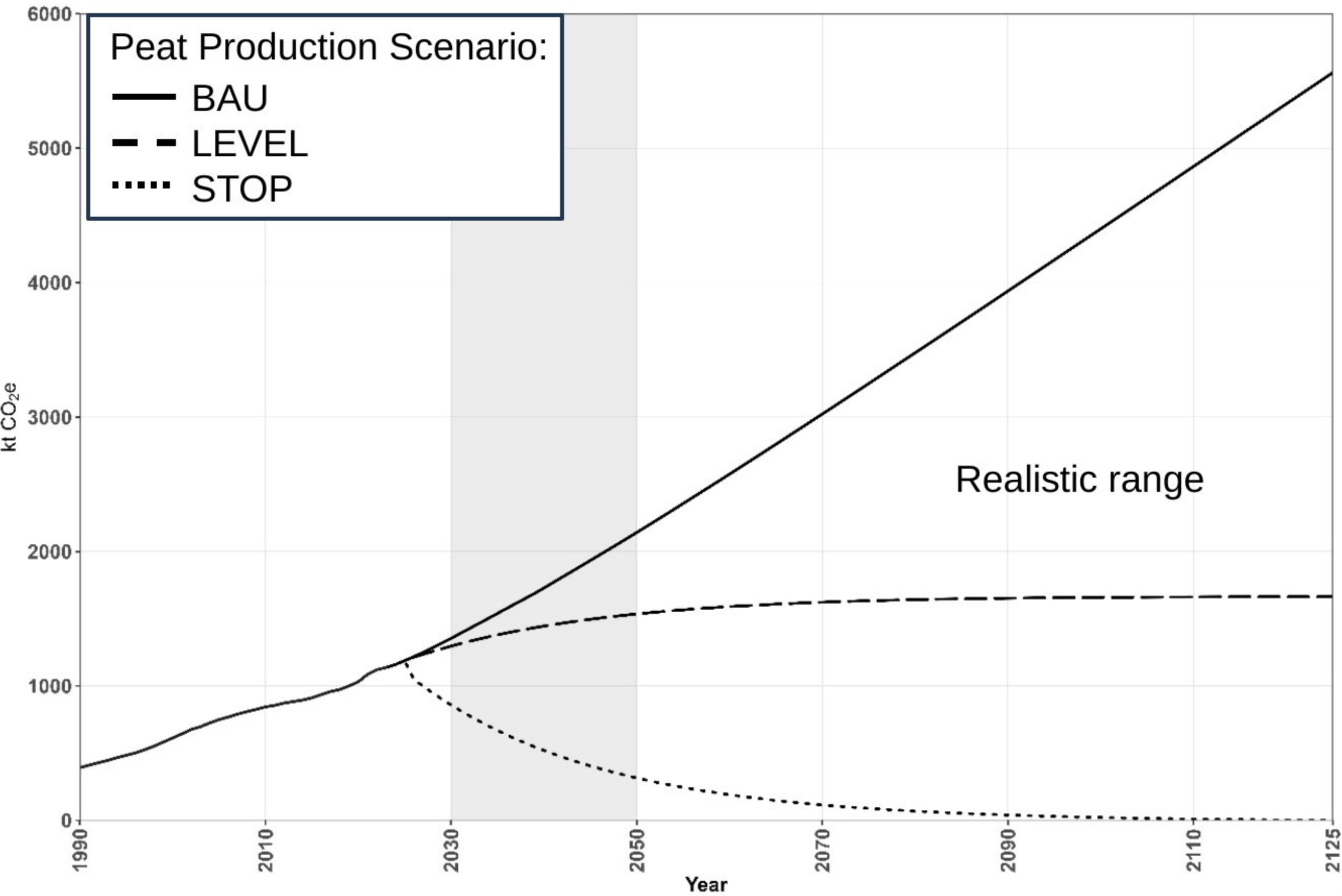
X

Decommissioned Land Management

- **No Restoration:** No new restoration treatments are applied to decommissioned sites
- **Baseline:** management ratios are maintained as they are currently by province
- **Rewet:** Active rewetting is applied to all new decommissioned sites
- **MLTT:** Moss layer transfer technique is applied to all new decommissioned sites

**Only carbon dynamics are considered in this analysis, co-benefits (e.g.biodiversity) should also be considered when thinking about land-use change and management

SCENARIO PROJECTIONS: OFF-SITE EMISSIONS FROM PEAT PRODUCTS



SCENARIO PROJECTIONS: TOTAL NET EMISSIONS

Projected total cumulative emissions by scenario between 1990–2030, –2050 or –2125				
Mt CO ₂ e				
Scenarios ²		2030	2050	2125
1A	BAU no restoration	53	104	492
1B	BAU Baseline	52	101	466
1C	BAU Rewet	52	98	452
1D	BAU MLTT	52	99	455
2A	Level No restoration	52	92	280
2B	Level Baseline	52	92	272
2C	Level Rewet	51	89	252
2D	Level MLTT	52	90	250
3A	Stop No restoration	50	68	104
3B	Stop Baseline	49	66	96
3C	Stop Rewet	47	59	72
3D	Stop MLTT	49	61	66

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Similar cumulative emission outcomes in all scenarios in 2030

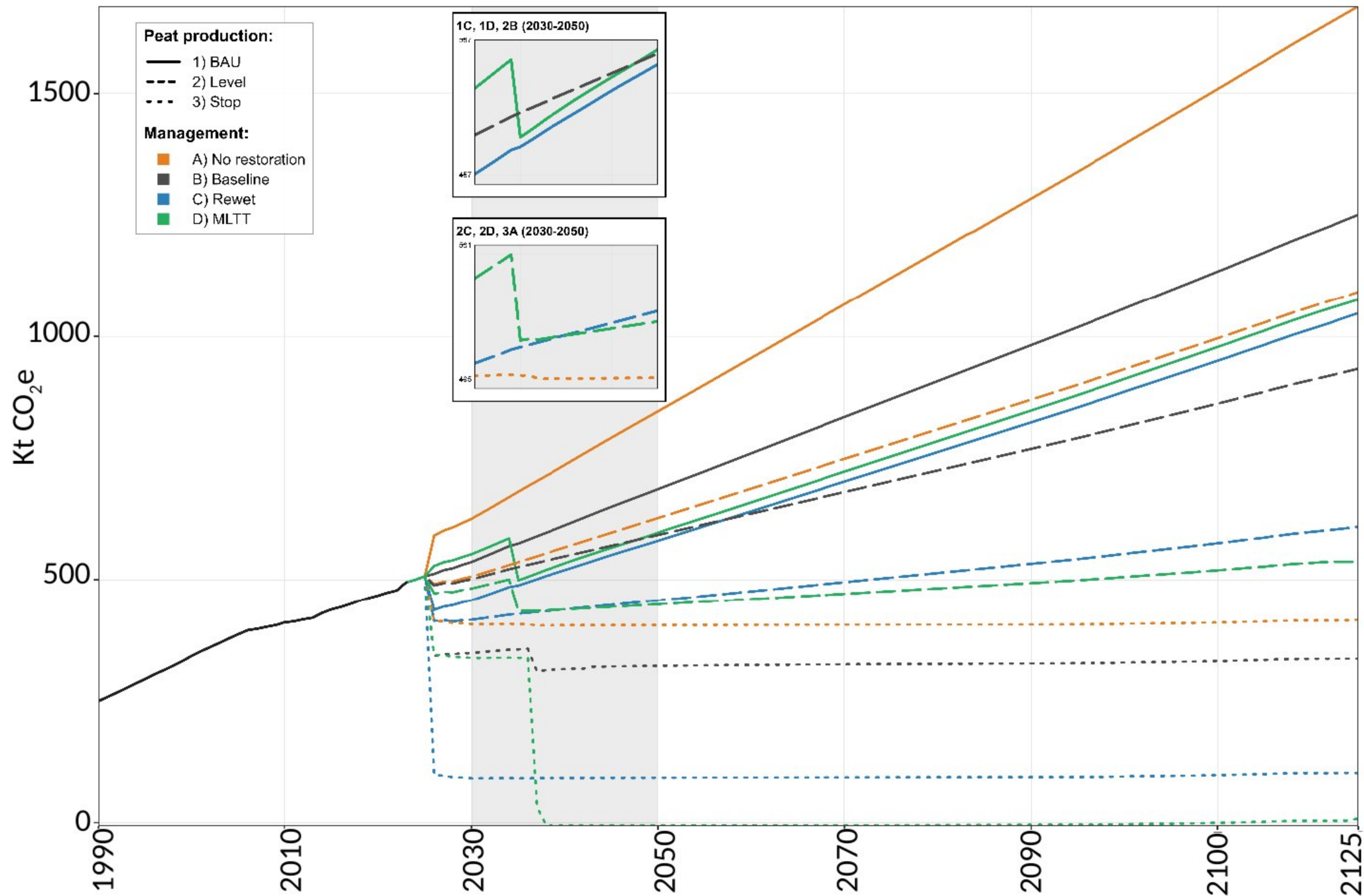
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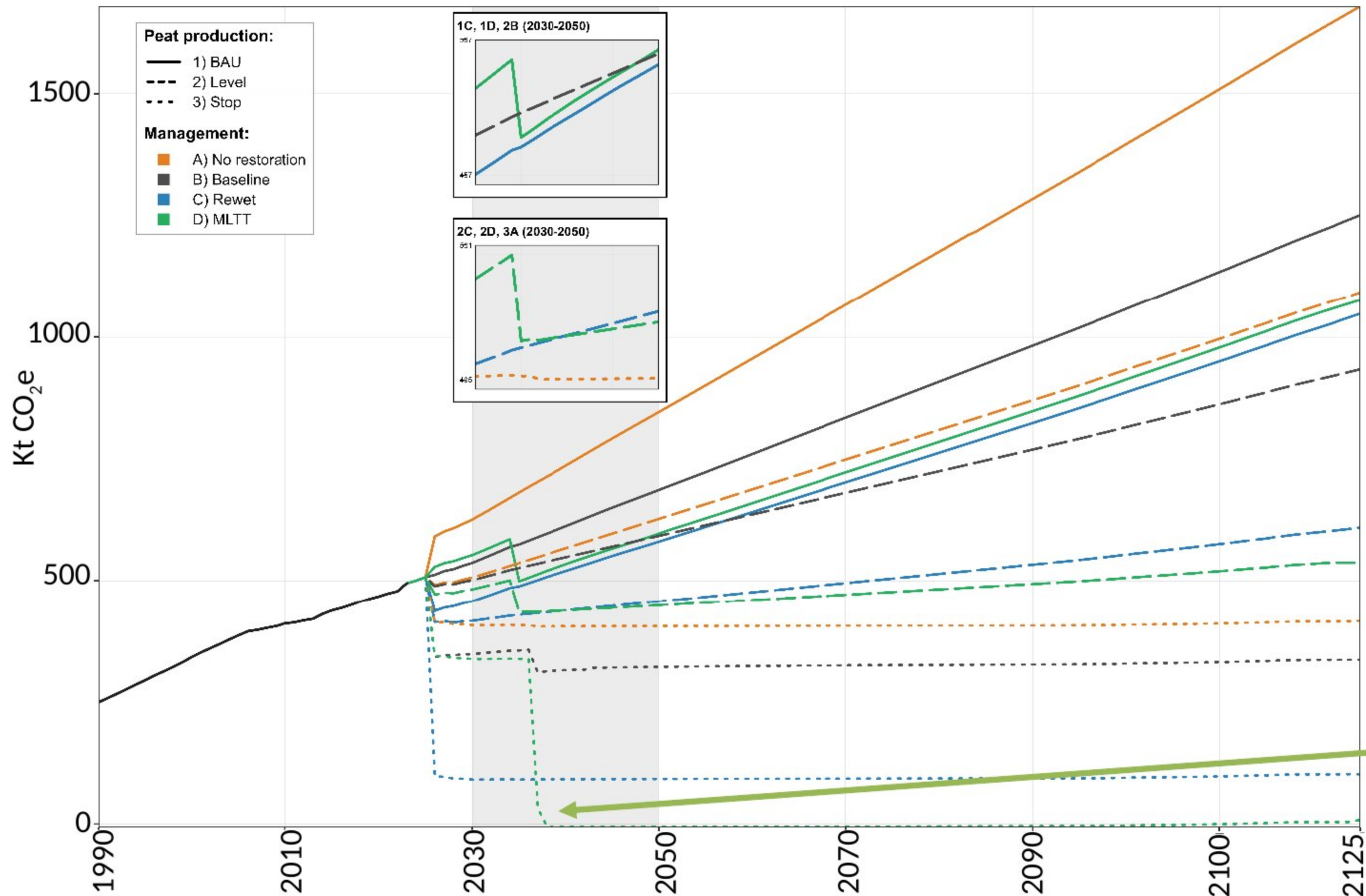
Similar cumulative emission outcomes in all scenarios in 2030

Scenarios diverge as time passes – dependent mainly on peat production – land management has little impact

SCENARIO PROJECTIONS: ON-SITE EMISSIONS FROM PEAT PRODUCTS

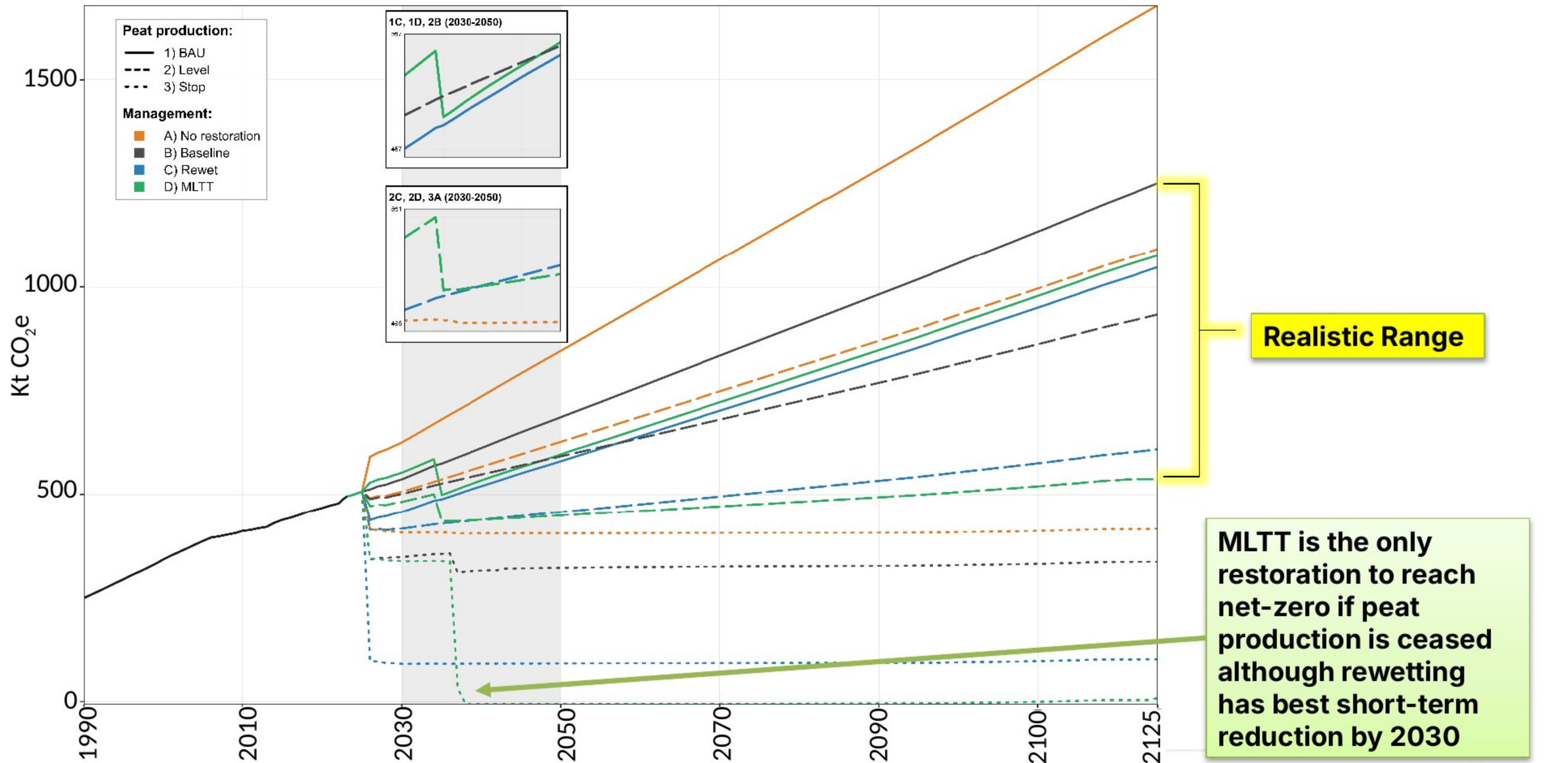


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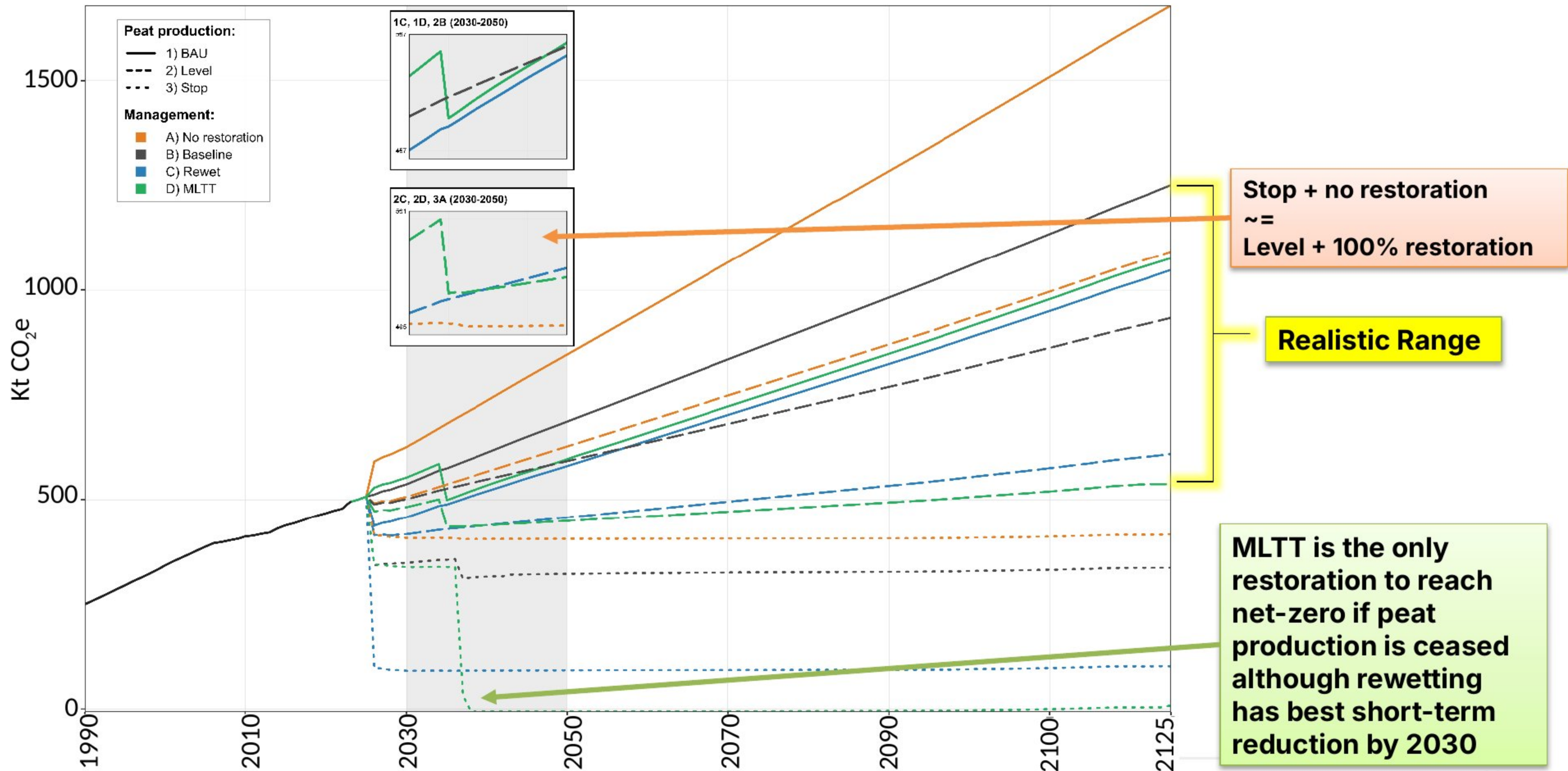


MLTT is the only restoration to reach net-zero if peat production is ceased although rewetting has best short-term reduction by 2030

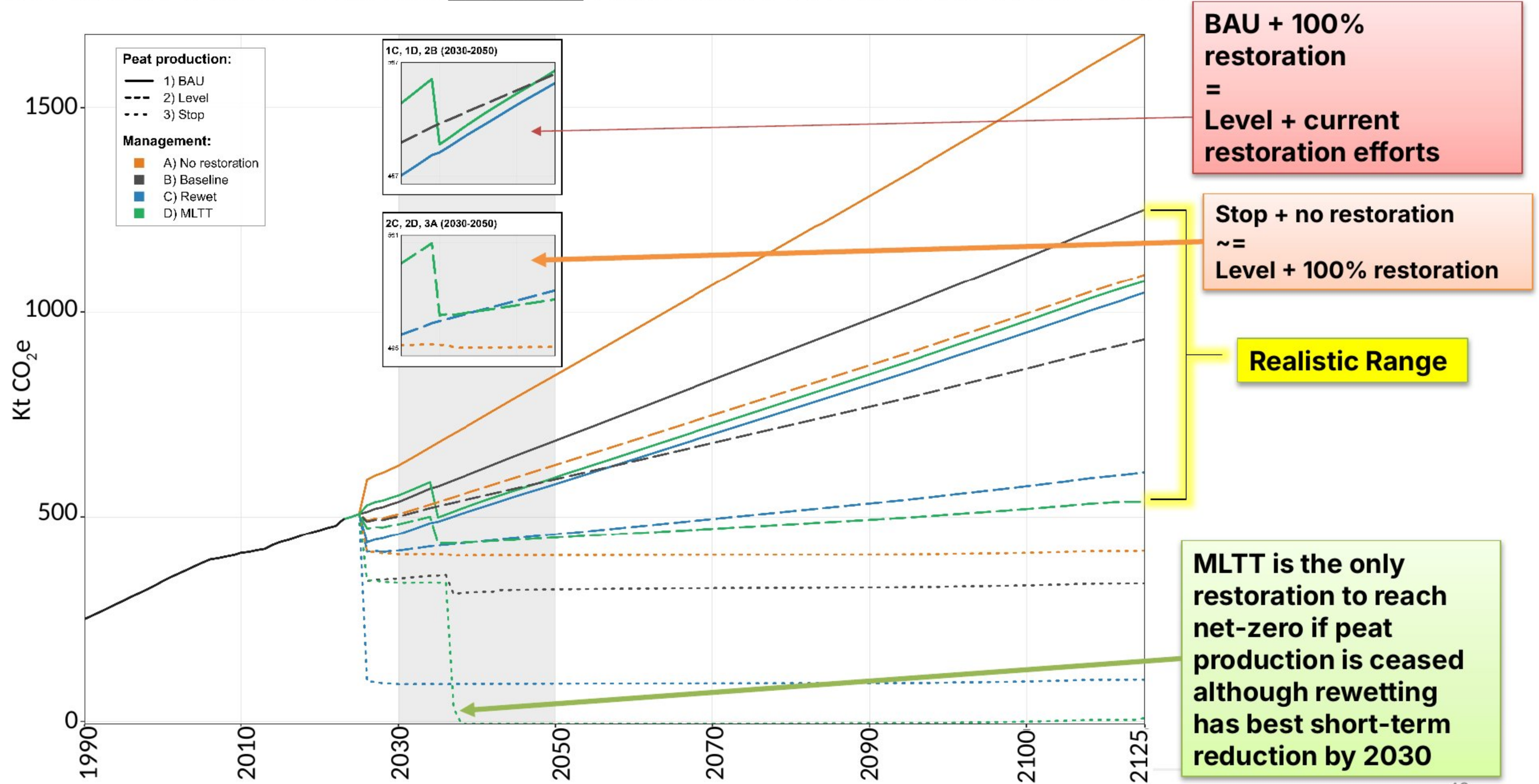
SCENARIO PROJECTIONS: ON-SITE EMISSIONS FROM PEAT PRODUCTS



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SCENARIO PROJECTIONS: ON-SITE EMISSIONS FROM PEAT PRODUCTS



TAKE HOME MESSAGES

- Remote sensing and machine learning models were not sufficient on their own to pick up on restoration sites therefore spatial data from CSPMA will be continually required for updates
- Active restoration significantly impacts emissions from LUC and management – comparable to stopping peat production with no restoration
- Based on current, relatively small dataset active rewetting has larger sink potential in the short term but smaller sink potential in the long-term
 - Larger sample of studies needed as well as longer-term studies
- Restored data is temporally limited (e.g. 15-year study)
 - Longer-term monitoring and data on restoration needed
- All of these updates are possible due to close collaboration with government, academic researchers, and industry

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PUBLICATION AND CONTACT INFORMATION

Contact me with questions, feedback, or opportunities to collaborate!

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This work was submitted to the journal of Carbon Management June 2026 and is in Review, contact me if you would like to be updated on the status of this publication, or a copy of the unpublished draft manuscript