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Supplement of

Significant underestimation of peatland permafrost along the Labrador Sea coastline in northern Canada

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Section S1: Wetland and peatland distribution in subsection of coastal Labrador

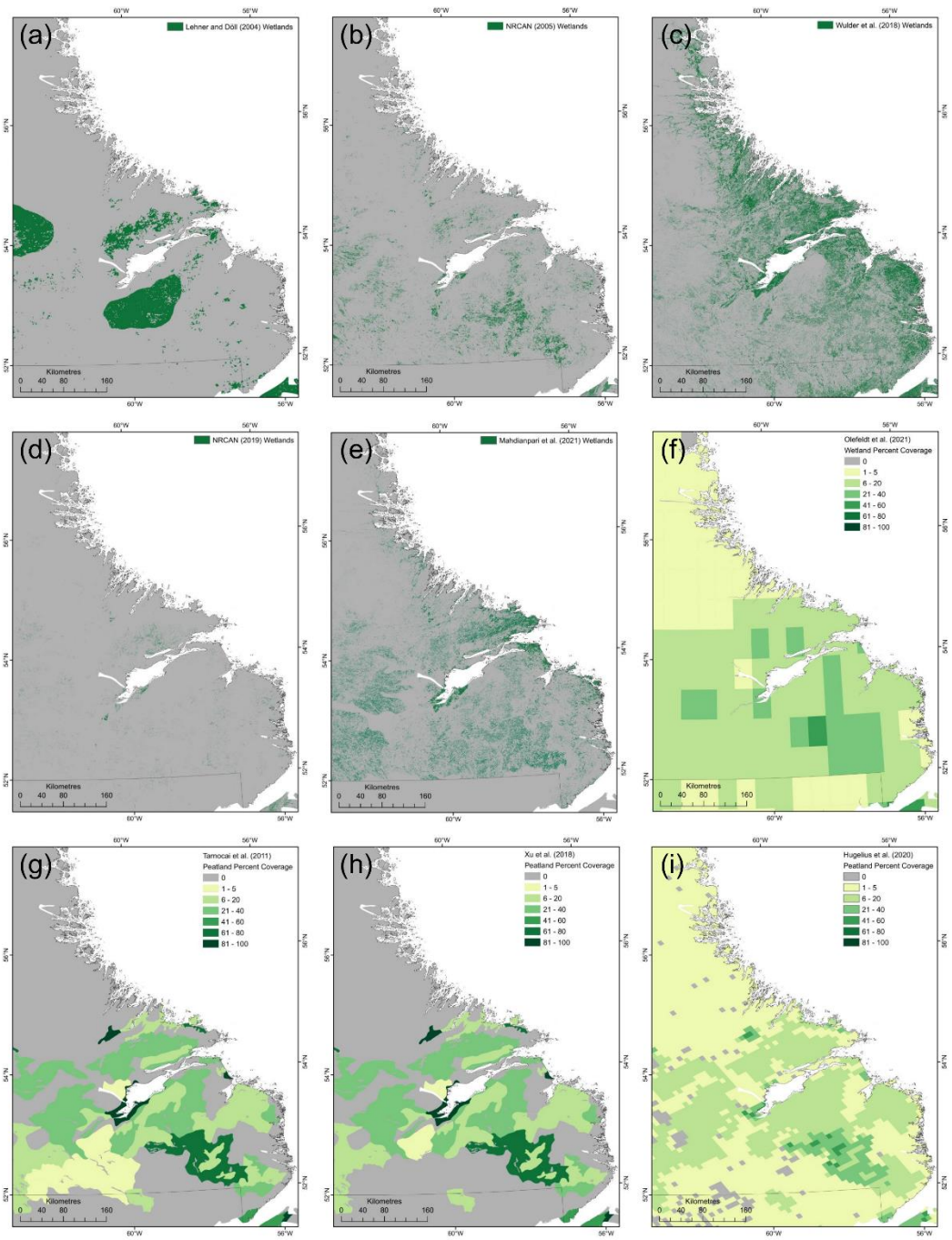

Figure S1. Comparison of wetland or peatland areas in subsection of coastal Labrador from the (a) Global Lakes and Wetlands Database; (b) National Topographic Database; (c) High-Resolution Binary Wetland Map for Canada; (d) Land Cover of Canada 2015; (e) Canadian Wetland Inventory Map; (f) Boreal-Arctic Wetland and Lake Dataset; (g) Peatlands of Canada Database; (h) PEATMAP; and (i) Maps of Northern Peatland Extent, Depth, Carbon Storage and Nitrogen Storage.

Section S2: Additional information on peatland permafrost complex inventorying and validation process

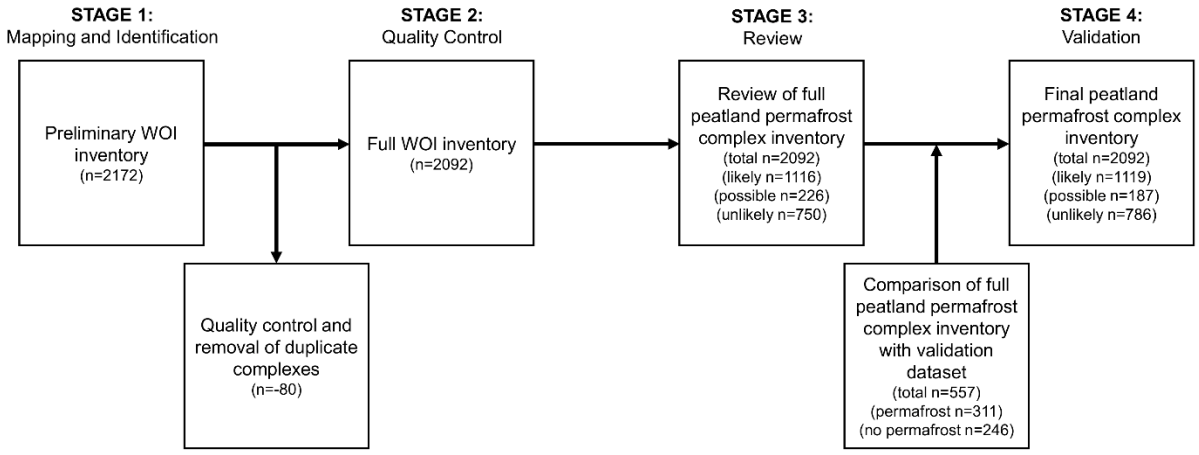

Figure S2. Conceptual diagram of multi-stage inventorying and validation process for the coastal Labrador peatland permafrost inventory.

Table S1. Example and description of attributes collected for WOIs from the coastal Labrador peatland permafrost inventory.

Attribute	Description
FID	Identification number for the wetland of interest
Latitude	Latitude of the wetland of interest in decimal degrees
Longitude	Longitude of the wetland of interest in decimal degrees
Confidence	Confidence of the initial mapper in the interpretation of the presence or absence of peatland permafrost landforms within the wetland of interest (1 = low confidence, 3 = high confidence)
M01	Interpretation of the presence (1) or absence (0) of peatland permafrost landforms within the wetland of interest by Mapper 1
M01 confidence	Confidence of Mapper 1 in the interpretation of the presence (1) or absence (0) of peatland permafrost landforms within the wetland of interest

M02	Interpretation of the presence (1) or absence (0) of peatland permafrost landforms within the wetland of interest by Mapper 2
M02 confidence	Confidence of Mapper 2 in the interpretation of the presence (1) or absence (0) of peatland permafrost landforms within the wetland of interest
M03	Interpretation of the presence (1) or absence (0) of peatland permafrost landforms within the wetland of interest by Mapper 3
M03 confidence	Confidence of Mapper 3 in the interpretation of the presence (1) or absence (0) of peatland permafrost landforms within the wetland of interest
Mapper agreement	Sum of mapper interpretation of presence of peatland permafrost landforms within the wetland of interest (0 = unlikely, 2 = possible, 4 = likely)
Validation	Validation of presence or absence of peatland permafrost landforms within the wetland of interest (0 = not validated, 1 = validated)
Validation (field)	Validation of presence or absence of peatland permafrost landforms within the wetland of interest via field visits (0 = not validated via field visits, 1 = validated via field visits)
Validation (RPA)	Validation of presence or absence of peatland permafrost landforms within the wetland of interest via RPA imagery (0 = not validated via RPA imagery, 1 = validated via RPA imagery)
Validation (helicopter)	Validation of presence or absence of peatland permafrost landforms within the wetland of interest via helicopter videos (0 = not validated via helicopter videos, 1 = validated via helicopter videos)
Validation (Twin Otter)	Validation of presence or absence of peatland permafrost landforms within the wetland of interest via Twin Otter images (0 = not validated via Twin Otter images, 1 = validated via Twin Otter images)
Validation result	Result of validation of presence (1) or absence (-1) of peatland permafrost landforms within the wetland of interest
Final interpretation	Final interpretation of presence of peatland permafrost landforms within the wetland of interest (0 = unlikely, 2 = possible, 4 = likely)

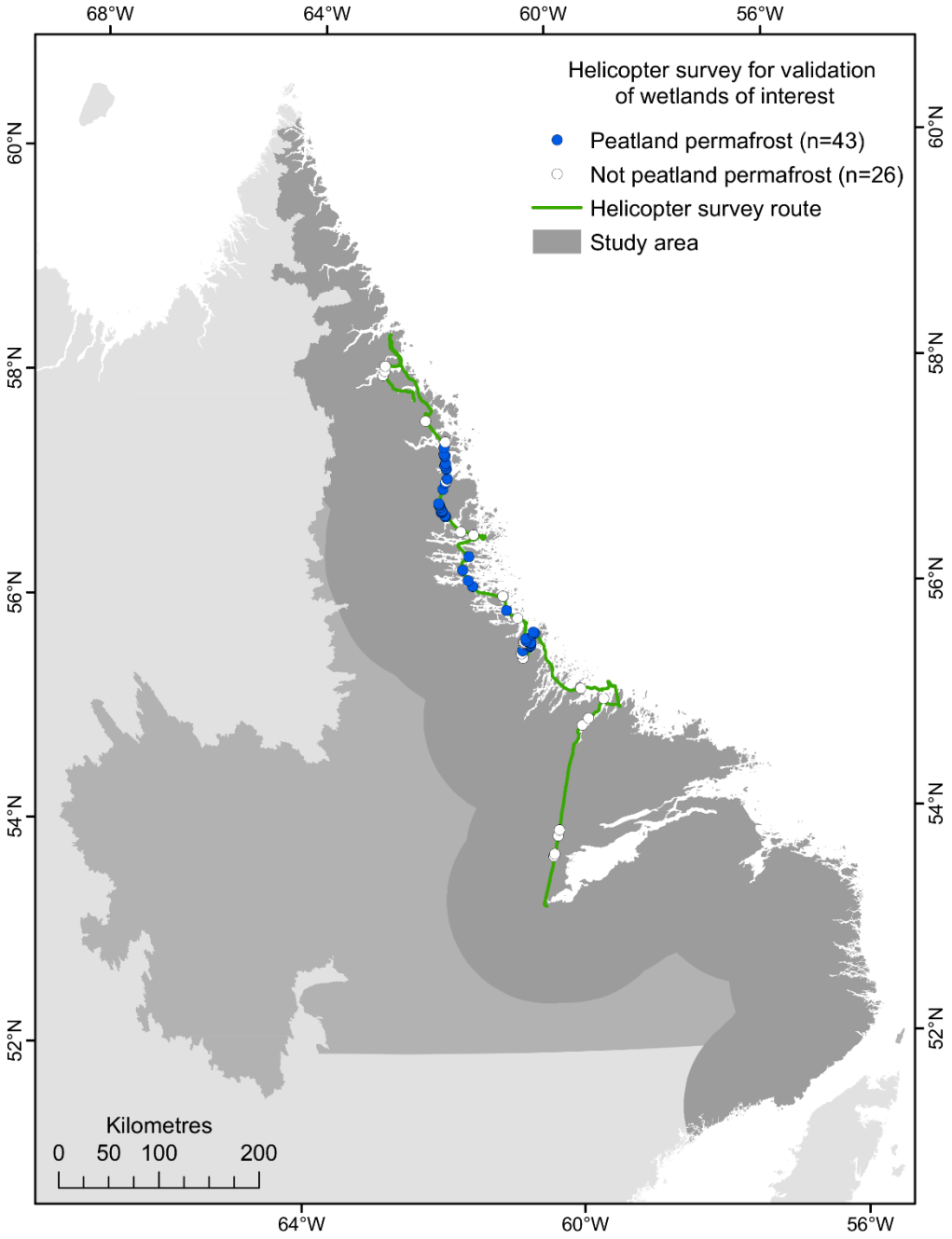

Figure S3. Locations of prospective peatland permafrost complexes validated via videos collected from a helicopter survey flown in summer 2021. The helicopter survey was flown by the Torngat Wildlife, Plants, and Fisheries Secretariat as part of a fuel cache mission on July 30 and August 13, 2021.

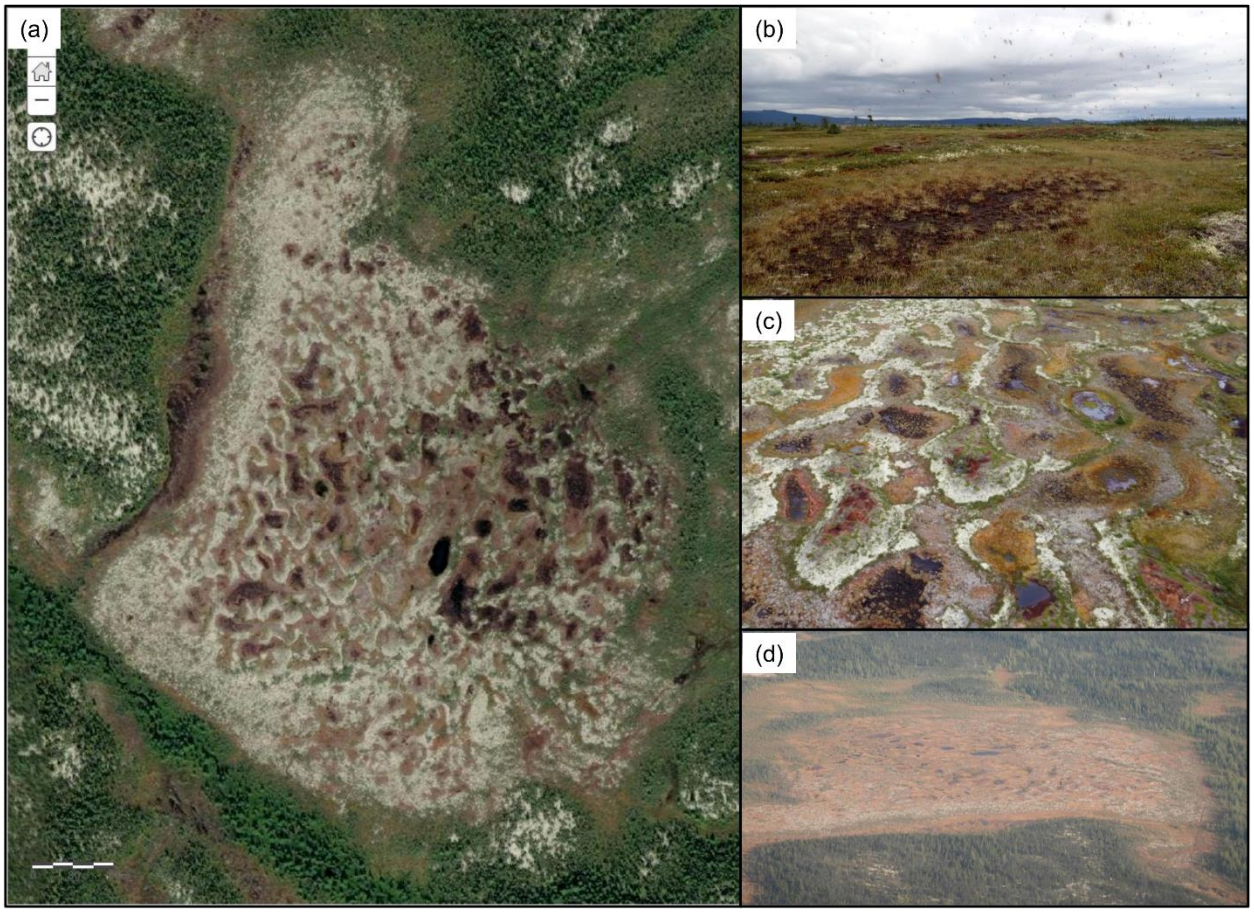

Figure S4. (a) High-resolution satellite image from Esri ArcGIS Online, (b) site photo taken with a digital handheld camera during field visit, (c) photo taken during low-altitude RPA survey, and (d) photo taken with a digital handheld camera during low-altitude Twin Otter overflight for a wetland of interest with validated peatland permafrost presence near Rigolet.

Section S3: Summary of climatic and physiographic characteristics of inventoried peatland permafrost complexes

Table S2. Summary of mean, standard deviation, minimum, and maximum latitude, distance from coastline, elevation, mean annual air temperature, mean annual freezing degree days, mean annual thawing degree days, and elevation relative to marine limit for WOIs classified as likely, possibly, or unlikely to contain peatland permafrost landforms in the final coastal Labrador peatland permafrost complex inventory.

	Likely (n=1119)		Possible (n=187)		Unlikely (n=786)	
	mean ± std	range	mean ± std	range	mean ± std	range
Latitude (°N)	54.1 ± 1.1	51.4-58.6	54.5 ± 1.9	51.4-60.2	53.9 ± 1.4	51.4-60.2
Distance from coastline (km)	2.6 ± 3.3	0-22.0	7.8 ± 10.0	0-86.3	10.7 ± 11.9	0-98.4
Elevation (m a.s.l.)	29 ± 31	0-413	66 ± 68	0-467	78 ± 66	0-437
Mean annual air temperature (°C)[a]	-0.8 ± 1.1	-7.5-1.2	-1.3 ± 2.1	-7.6-1.2	-0.5 ± 1.5	-6.9-1.3
Freezing degree days (° days)[a]	1577 ± 333	1126-3471	1832 ± 519	1164-3623	1669 ± 362	1076-3383
Thawing degree days (° days)[a]	1283 ± 177	733-1704	1346 ± 295	394-1784	1471 ± 219	397-1960
Elevation relative to marine limit (m)[b]	-63 ± 36	-123-351	-35 ± 71	-111-384	-27 ± 65	-138-337

[a] Note: mean annual air temperature, freezing degree days, and thawing degree days are averaged over the 1981 to 2010 climate normal.

[b] Note: marine limits were interpolated from (Dyke et al., 2005) and do not capture all inventoried peatland permafrost complexes. Marine limit information could only be interpolated for 1574 out of 2092 WOIs.

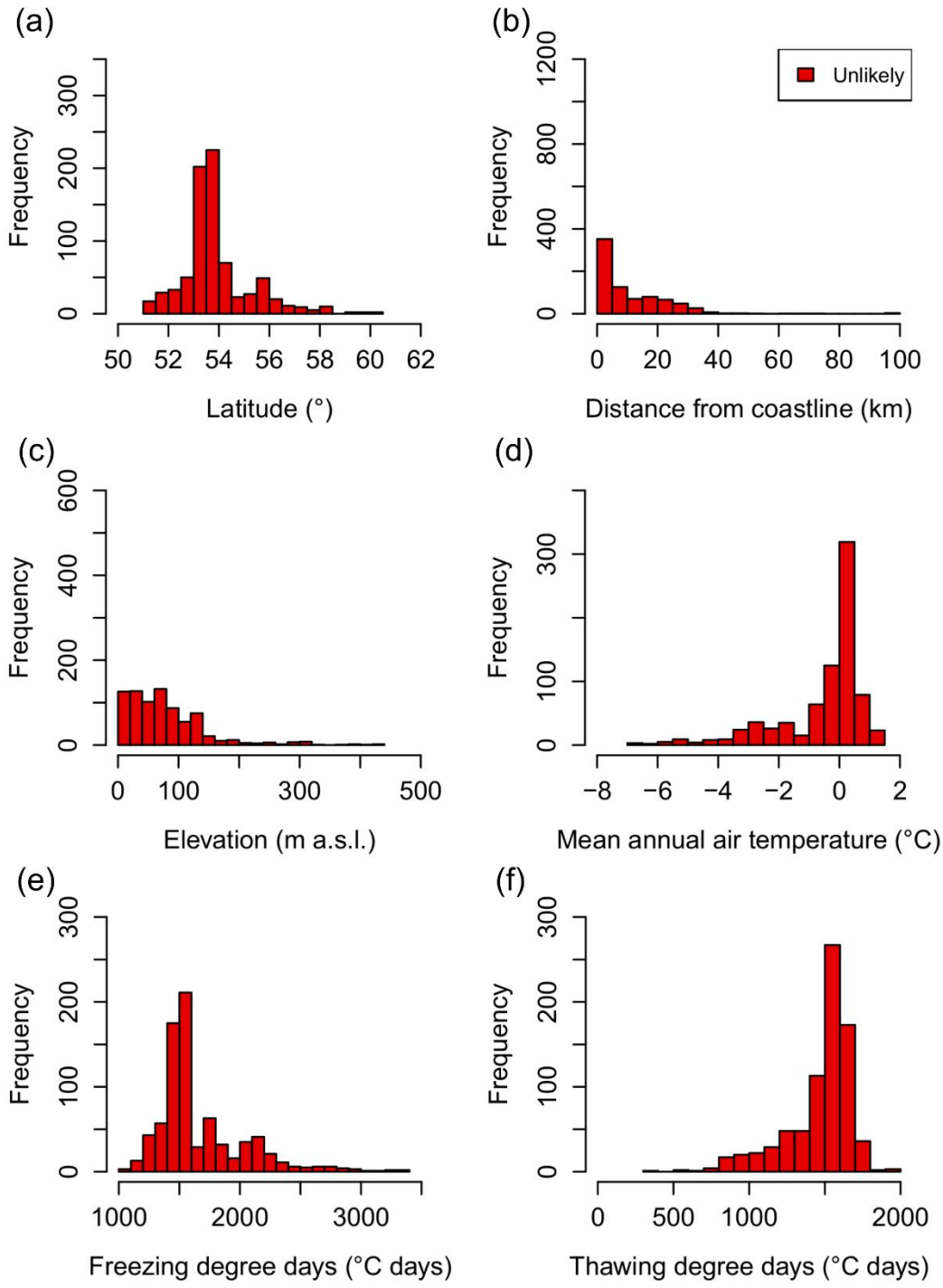

Figure S5. Distribution of wetland complexes unlikely to contain peatland permafrost landforms by (a) latitude; (b) distance from the coastline; (c) elevation; and (d) mean annual air temperature; (e) mean annual freezing degree days; and (f) mean annual thawing degree days for the 1981 to 2010 climate normal.

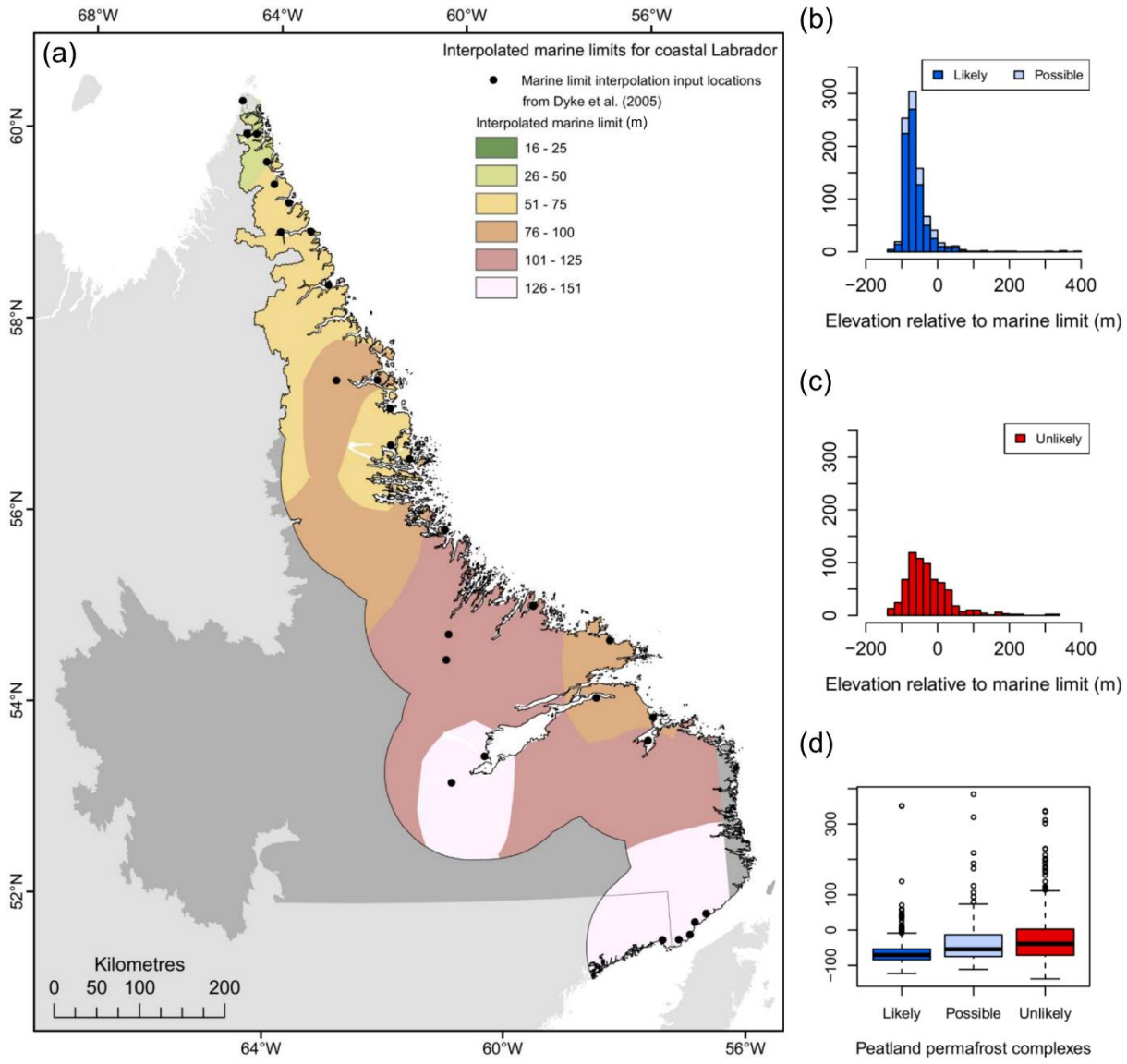

Figure S6. (a) Estimated marine limits for coastal Labrador based on inverse distance weighted interpolation of marine limit observations compiled in Dyke et al. (2005). Distribution of wetland complexes (b) likely, possibly, and (c) unlikely to contain peatland permafrost landforms by elevation relative to marine limit, as interpolated from Dyke et al. (2005). (d) Boxplot comparing distribution of wetland complexes likely, possibly, and unlikely to contain peatland permafrost landforms by elevation relative to marine limit.

Section S4: Comparisons of inventoried peatland permafrost complexes with selected wetland, peatland, and peatland permafrost distribution products

Table S3. Number of inventoried likely, possibly, and unlikely peatland permafrost complexes classified as wetlands or peatlands by selected products.

Product	Reference	Number of inventoried peatland permafrost complexes classified as wetlands or peatlands			
		All (n=2092)	Likely (n=1119)	Possible (n=187)	Unlikely (n=786)
Wetland products					
Global Lakes and Wetlands Database	Lehner and Döll (2004)	100	74	5	21
National Topographic Database	Natural Resources Canada (2005)	828	262	90	476
High Resolution Binary Wetland Map for Canada	Wulder et al. (2018)	793	275	82	436
Land Cover of Canada 2015	Natural Resources Canada (2019)	258	46	33	179
Boreal Arctic Wetlands and Lakes Dataset	Olefeldt et al. (2021)	1972	1046	176	750
Canadian Wetland Inventory Map 3 (Coastal)	Mahdianpari et al. (2021)	1185	679	99	407
Peatland products					
Peatlands of Canada	Tarnocai et al. (2011)	915	369	87	459
PEATMAP	Xu et al. (2018)	915	369	87	459
Northern Peatland Extent, Depth, Carbon Storage, and Nitrogen Storage	Hugelius et al. (2020)	1997	1073	171	753

Table S4. Number of inventoried likely, possibly, and unlikely peatland permafrost complexes classified as peatland permafrost by selected products.

Product	Reference	Number of inventoried peatland permafrost complexes classified as peatland permafrost			
		All (n=2092)	Likely (n=1119)	Possible (n=187)	Unlikely (n=786)
Peatland permafrost products					
Peatlands of Canada	Tarnocai et al. (2011)	0	0	0	0
North American Peatland Permafrost Climate Envelope	Fewster et al. (2020)	204	68	31	105
Northern Peatland Extent, Depth, Carbon Storage, and Nitrogen Storage	Hugelius et al. (2020)	1998	1072	173	753
Boreal Arctic Wetlands and Lakes Dataset	Olefeldt et al. (2021)	337	167	46	124

Section S5: Comparisons of inventoried peatland permafrost complexes with permafrost distribution zones from the Permafrost Map of Canada and the Northern Hemisphere Permafrost Map

Several maps are presented below, comparing the Coastal Labrador peatland permafrost inventory with existing permafrost distribution products. While differences in scale may be responsible for some of the discrepancies between products, we present these comparisons in the absence of higher resolution, larger scale permafrost distribution products for this region. National and circumpolar scale maps are still often used to provide context and to inform local and sub-regional infrastructure and land use initiatives, particularly in the absence of more appropriate products.

It is also important to note that estimates of permafrost distribution and extent in The Permafrost Map of Canada (Heginbottom et al., 1995) and the related Circumarctic Map of Permafrost and Ground Ice Conditions (Brown et al., 1997) were compiled based on existing studies or observations of permafrost and periglacial landforms, but they were also strongly influenced by regional information on elevation, physiography, and surficial geology. Boundaries between permafrost distribution zones followed landscape or physiographic units, rather than area-based estimates of permafrost based on observations or inventories of periglacial landforms or processes.

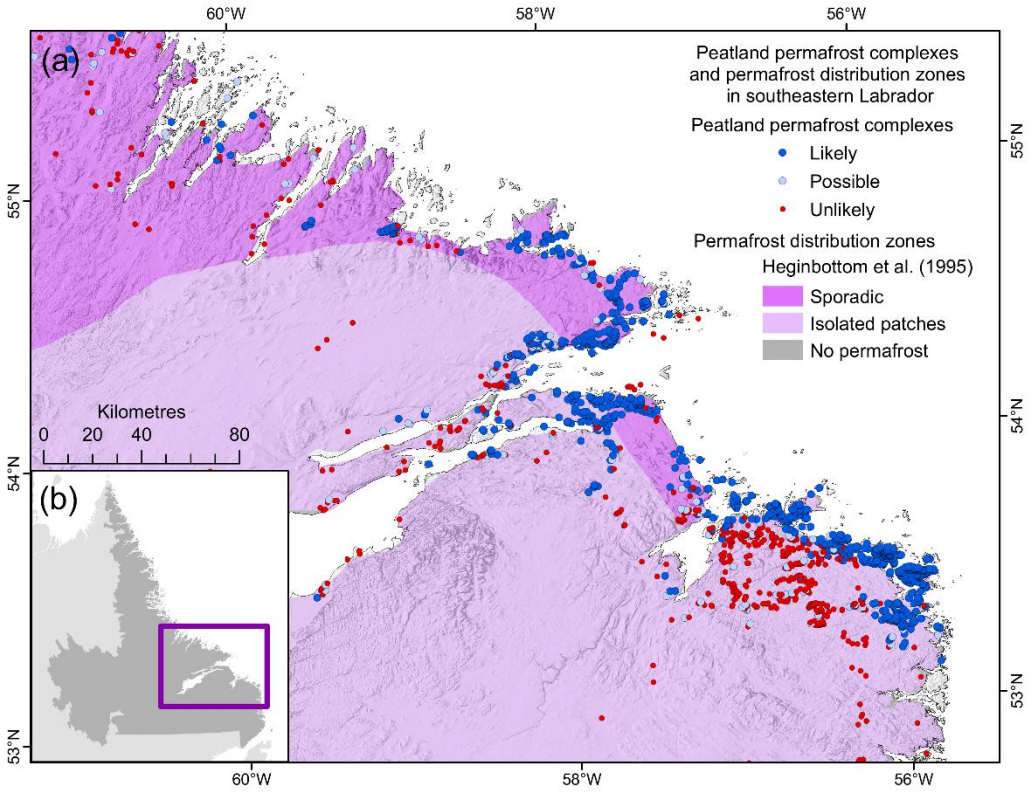

Figure S7. (a) Comparison of inventoried peatland permafrost complexes with permafrost distribution zones from the Permafrost Map of Canada (Heginbottom et al., 1995) for (b) southeastern Labrador near Rigolet, Cartwright, and Black Tickle.

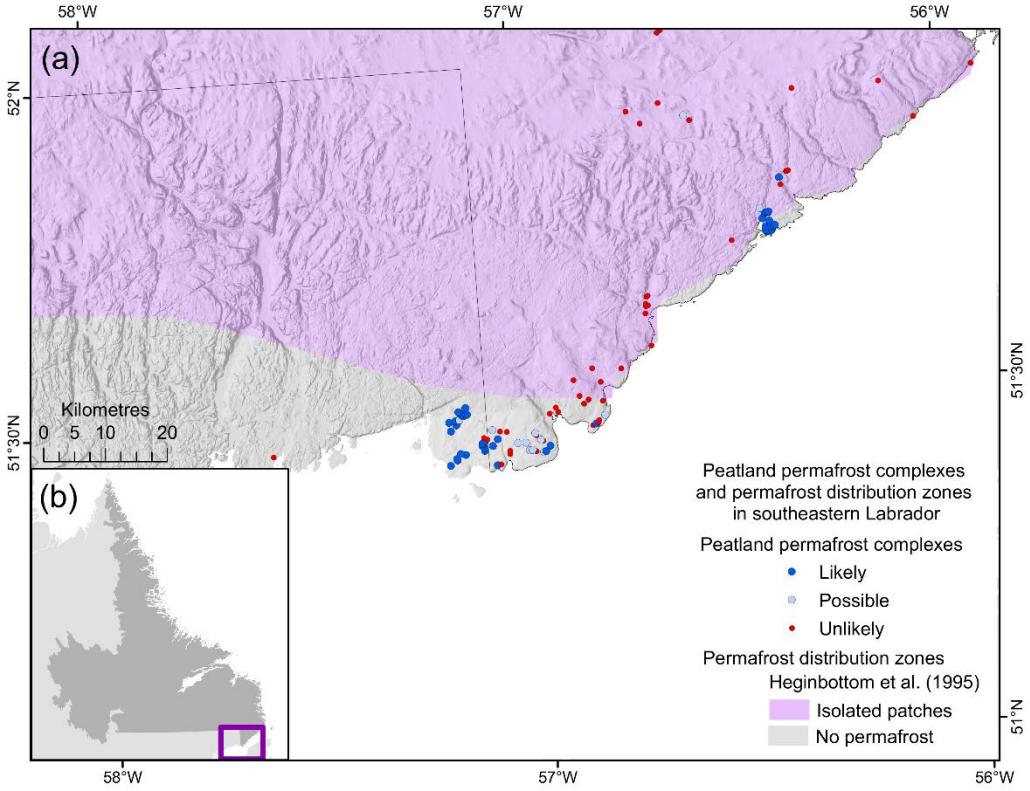

Figure S8. (a) Comparison of inventoried peatland permafrost complexes with permafrost distribution zones from the Permafrost Map of Canada (Heginbottom et al., 1995) for (b) southeastern Labrador and adjacent areas of Quebec near Red Bay and Blanc-Sablon.

The map presented below compares the Coastal Labrador peatland permafrost inventory with the 2000-2016 Northern Hemisphere Permafrost Map (Obu et al., 2019), which was developed using the TTOP equilibrium model. The TTOP model investigates the relationship between climate and permafrost under equilibrium conditions, so caution is typically advised when interpreting results from this approach, as the distribution of permafrost may be underestimated if it is in disequilibrium with the current climate. Peatland permafrost, especially when found near its southern limit, is often believed to be relict permafrost that may be in disequilibrium with climate conditions (Dionne, 1984), but one-dimensional thermal modelling of two peatland permafrost mounds in southeastern Labrador showed that the palsas at these locations are in equilibrium with the current climate (Way et al., 2018). Thick peat deposits are expected to facilitate large thermal offsets in the order of ~ -2 °C in southeastern Labrador (Way et al., 2018), which can help to preserve relict permafrost under unfavourable climate conditions.

The comparison between the Coastal Labrador peatland permafrost inventory and the 2000-2016 Northern Hemisphere Permafrost Map (Obu et al., 2019) is presented below. TTOP models do incorporate and consider both the surface and thermal offset, so it is possible to model permafrost, even relict permafrost, if appropriate inputs, including a large enough thermal offset, are applied. Unpublished work by Way and Lewkowicz (2017) presented at the 74th Annual Eastern Snow Conference showed that discrepancies between TTOP spatial models (e.g., Way and Lewkowicz, 2016) and observations of peatland permafrost along the southern coast of Labrador could largely be reconciled with improved snow redistribution algorithms and more precise land cover maps.

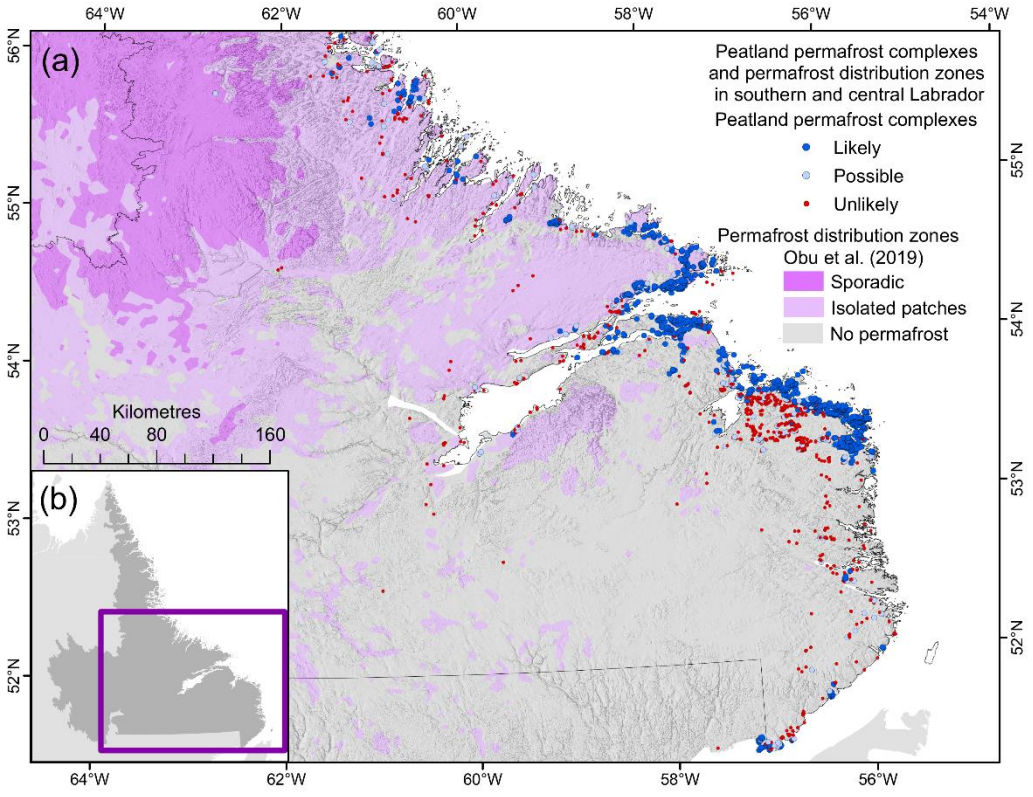

Figure S9. (a) Comparison of inventoried peatland permafrost complexes with permafrost distribution zones from the 2000-2016 Northern Hemisphere Permafrost Map (Obu et al., 2019) for (b) southern and central coastal Labrador.

Section S6: Location of inventoried peatland permafrost complexes near selected communities

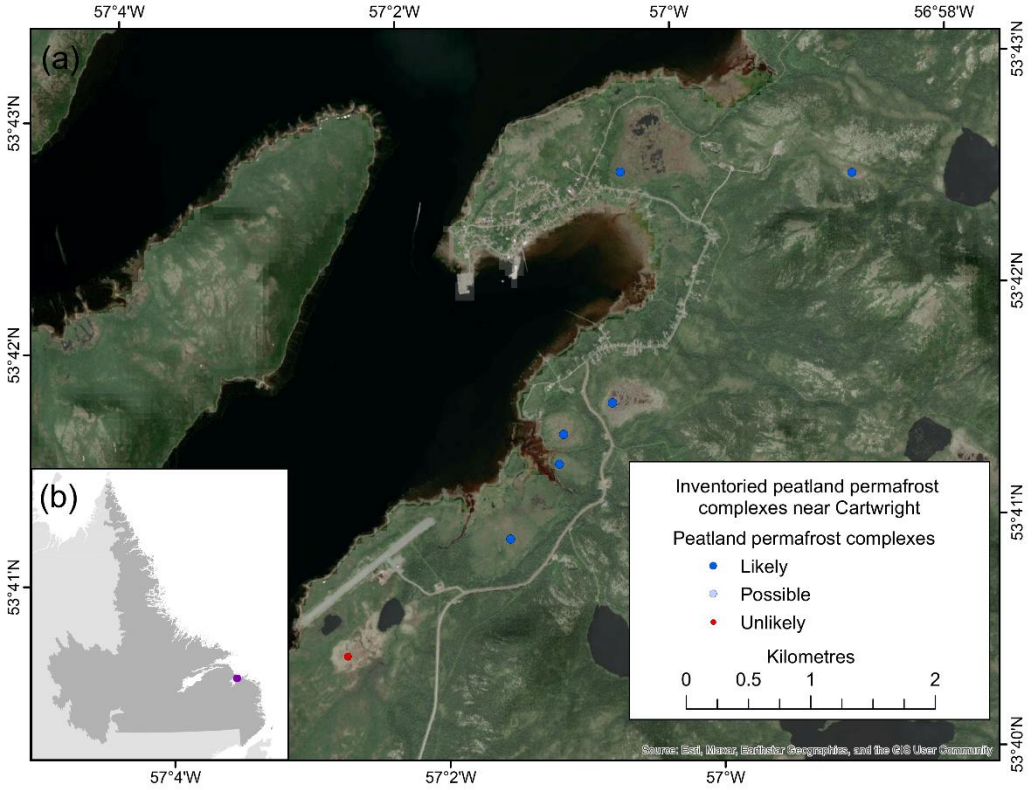

Figure S10. (a) Location of likely, possible, and unlikely peatland permafrost complexes near the community of Cartwright; (b) Location of Cartwright in relation to Labrador.

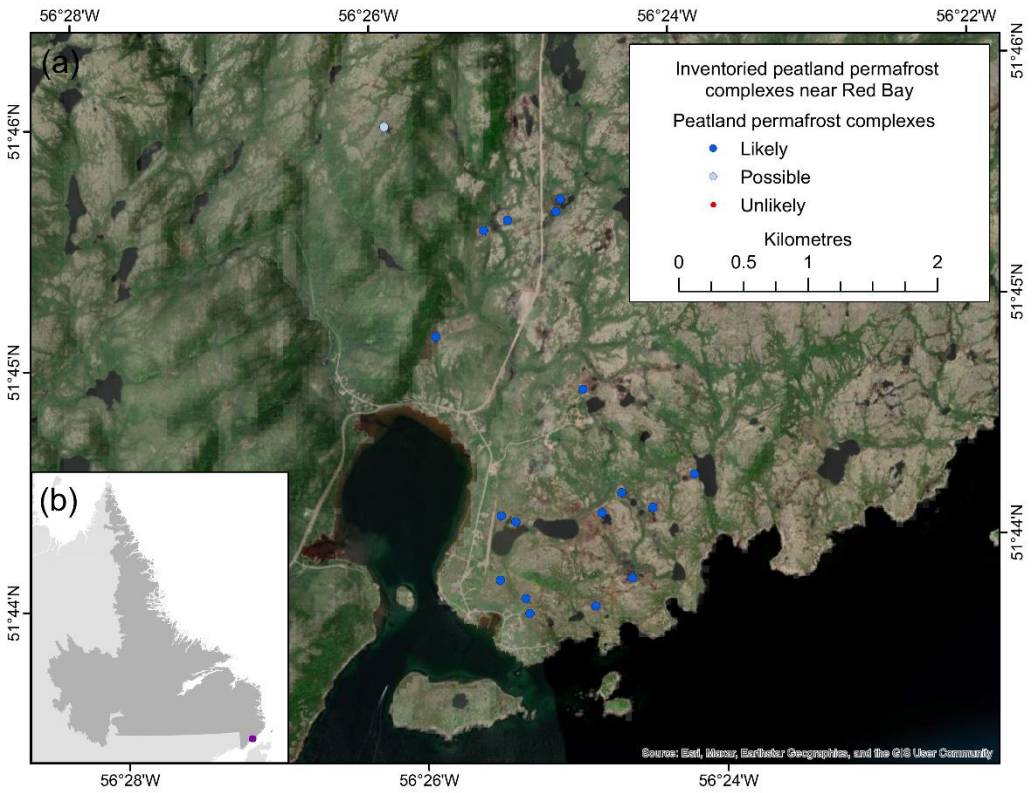

Figure S11. (a) Location of likely, possible, and unlikely peatland permafrost complexes near the community of Red Bay; (b) Location of Red Bay in relation to Labrador.

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