The essential carbon service provided by northern peatlands

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Northern peatlands have cooled the global climate by accumulating large quantities of soil carbon (C) over thousands of years. Maintaining the C sink function of these peatlands and their immense long-term soil C stores is critical for achieving net-zero global carbon dioxide (CO_2) emissions by 2050 to mitigate climate warming. One-quarter of the world's northern peatlands are in Canada, with these mostly intact ecosystems providing a global C service that is increasingly recognized as a critical part of nature-based solutions to combat climate change. However, land-use change and other disturbances threaten these globally important stores of "irrecoverable C" (that is, soil C lost to disturbance that will take centuries to recover). Inadequate policy safeguards to avoid conversion and degradation, and the limited quantification and reporting of peatland greenhouse-gas emissions and removals, increase the vulnerability of these peatlands. Targeted policies from local to global scales will be needed for improved decision making and incentivizing long-term C management of northern peatlands.

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Almost 85% of the total global peatland carbon (C) stock (~550 gigatons [Gt] C) is stored in the northern hemisphere, where peatlands cover large swaths of temperate, boreal, and subarctic regions (Xu *et al.* 2018; Hugelius *et al.* 2020). Although the cool and wet climate limits plant productivity in northern peatlands, decomposition in mostly waterlogged conditions occurs more slowly, resulting in the gradual accumulation of dead organic matter (peat) over thousands of years. As a persistent sink of atmospheric carbon dioxide (CO_2) that offsets C loss as methane (CH_4) and waterborne C, northern peatlands have effectively cooled the global climate (Frolking and Roulet 2007). C also remains in seasonally or permanently frozen (permafrost) northern peat soils for long periods of time (up to ~10,000 years; Loisel *et al.* 2014), particularly when compared to tropical forests (100–500 years; Wang *et al.* 2017). The essential "C service" provided by peatlands is lost when these regions are disturbed, however, as large amounts of C are released to the atmosphere in the form of CO_2 and CH_4 (Turetsky *et al.* 2015; Hugelius *et al.* 2020). Of particular concern is "irrecoverable C", or peatland C stocks lost through land conversion that cannot recover by 2050, as required for net-zero global CO_2 emissions (Masson-Delmotte *et al.* 2018; Goldstein *et al.* 2020).

In a nutshell:

- The world's largest peatland carbon (C) stock is located in Canada; these vast and mostly intact peatlands include the world's second largest peatland complex, the Hudson Bay Lowlands, an area of pronounced interest to the mineral extraction industry
- Land conversion and other disturbances to peatlands across Canada lead to large losses of mostly irrecoverable C
- Proactive protection of northern peatlands must be a critical component of nature-based solutions for climate change; policy initiatives that apply the principle of avoidance rather than mitigation are required, with Indigenous stewardship an essential mechanism for the protection of peatlands across Canada
- Improved quantification and reporting on peatland C stocks and greenhouse-gas emissions and removals to fill knowledge gaps are a necessary prerequisite to informed land-use planning that could accelerate policy action

One-quarter of the world's northern peatlands (~1.1 million km^2; Figure 1), and the world's largest peatland C stock (~150 Gt), is located in Canada (Joosten 2009; Xu *et al.* 2018; Hugelius *et al.* 2020). Canada is therefore a key player in safeguarding these terrestrial C sinks on the pathway to 2050, particularly as most undisturbed, non-permafrost peatlands across the country (Figure 1b) will likely remain long-term sinks for atmospheric CO_2 in all but the worst future climate-change scenarios (Qiu *et al.* 2020). As some of the least impacted ecosystems on Earth (Figure 1c), peatlands across Canada support extensive river networks (Webster *et al.* 2015), provide critical wildlife habitat and potential climate-change refugia (Stralberg *et al.* 2020), and serve as important cultural landscapes and maintain food security for Indigenous Peoples (Townsend *et al.*

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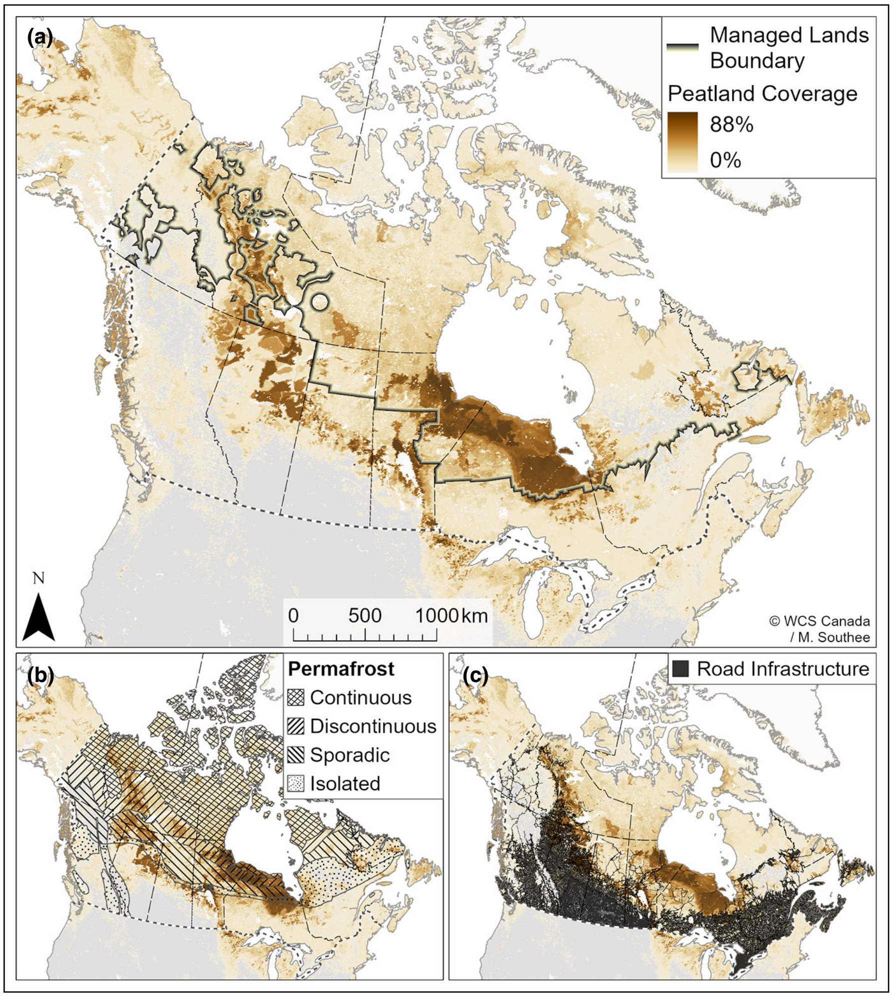

Figure 1. (a) Approximate peatland area across Canada, including the general delineation for "managed land" (south of the boundary) and "unmanaged land" that is based primarily on forest inventory data (peatland coverage from Hugelius *et al.* [2020]); (b) map showing peatland area and permafrost zones across Canada (Brown *et al.* 1997); and (c) map showing peatland area and road infrastructure development across Canada (GFWC 2010).

2020). Major and as yet unconverted peatland regions include the world's second largest peatland complex, the Hudson Bay Lowlands (HBL), which extends over ~370,000 km^2 (WebPanel 1; Figure 2; Packalen *et al.* 2014).

Despite the vital role played by peatlands in addressing global climate and biodiversity crises, we estimate only ~10% of peatlands in Canada are currently within protected areas. There are also few policy safeguards to protect peatland C from the introduction and expansion of economic development and infrastructure (Webster *et al.* 2015). Moreover, many large peatlands located in remote regions and not under direct human influence (eg forest harvesting, peat extraction) are classed as "unmanaged land" (Figure 1a) for the purposes of reporting Canada's national greenhouse-gas (GHG) inventory to the UN Framework Convention on Climate Change (UNFCCC; Eggleston *et al.* 2006; Hiraishi *et al.* 2014; ECCC 2021). Under current UNFCCC guidelines, governments are only required to report human-caused GHG (mainly CO_2 and CH_4) emissions and removals for peatlands (classed as "managed land"), which, in Canada, specifically includes peatlands flooded for hydroelectricity production and peat extraction for horticultural use (UNFCCC 2014; Skukla *et al.* 2019; ECCC 2021). Forested peatlands (with natural tree cover) that are classified in the "Forest Land" category of Canada's National Inventory Report, and are impacted by forest harvesting or deforested as a result of mineral extraction or oil and gas development, are reported as deforestation. Although reporting as deforestation accounts for the loss of trees, the impacts on organic soils are not included (UNFCCC 2017), and therefore losses of peat C are also not included (ECCC 2021). As such, many direct human-caused disturbances to peatlands across Canada are excluded from the national GHG inventory (eg Strack *et al.* 2019), and there is no policy incentive or mechanism to quantify GHG emissions and removals from large areas of peatland that are not under direct human influence.

Here, we describe the imminent impacts of global climate warming, land-use change, and other human disturbances on the globally important C stock and C sink function of peatlands across Canada. We examine the ways that peatland C is quantified and reported, and highlight policy gaps that further expose the vulnerability of this critical ecosystem service. We end by identifying policy mechanisms that range from local development decisions to those at the global scale, which serve as a model for better informed decisions on land use and peatland protection, and promote the long-term C management of these invaluable ecosystems.

Threats to peatlands in Canada and knowledge gaps

Although extensive areas of peatland in Canada have already been lost to agricultural conversion and other direct human disturbances (~12,200 km^2 from limited available records, but this is likely a considerable underestimate; Table 1; Figure 1c), a large areal extent remains mostly intact relative to peatlands in Europe and across the tropics (Page and Baird 2016). Where there has been disturbance, either due to the effects of global climate warming or land-use change, effects on peatland C stocks and the C sink function can be considerable (Turetsky *et al.* 2015; Strack *et al.* 2019; Hugelius *et al.* 2020). However, there are numerous uncertainties regarding the total amount of peat C loss as a result of disturbances across Canada. First, accurate maps are lacking for peatland cover, type, and depth, and of areas impacted by disturbance (WebPanel 2; Webster *et al.* 2018; Bona *et al.* 2020). Second, the magnitude of changes in peatland C stocks and C sink capacity due to disturbance depends on the variable hydrology, vegetation, nutrient dynamics, and permafrost status of different peatland types in different regions and climate zones of Canada (Bona *et al.* 2020). Small sample sizes for GHG flux measurements for the full range of peatland types and disturbances across Canada, and especially limited data for winter emissions, adds to the uncertainty (Webster *et al.* 2018).

Effects of global climate warming

The response of northern peatlands to global climate warming remains somewhat uncertain (Loisel *et al.* 2021). Modeling results suggest that in all but the worst climate-change scenarios, most undisturbed non-permafrost peatlands will continue to remove CO_2 (up to 20 Gt C over the next 100 years) from the atmosphere (Chaudhary *et al.* 2020; Qiu *et al.* 2020). However, the C sink capacity of these peatlands may be substantially reduced by drier and warmer climate conditions, with peatlands in western Canada particularly vulnerable to C loss and reduced C sink capacity (Chaudhary *et al.* 2020; Qiu *et al.* 2020). Conversely, where prevailing climate conditions tend to be warmer and wetter, such as in eastern Canada, the C sink capacity of non-permafrost peatlands may increase due to greater CO_2 uptake by plants (WebPanel 3; McLaughlin *et al.* 2018; Chaudhary *et al.* 2020; Qiu *et al.* 2020).

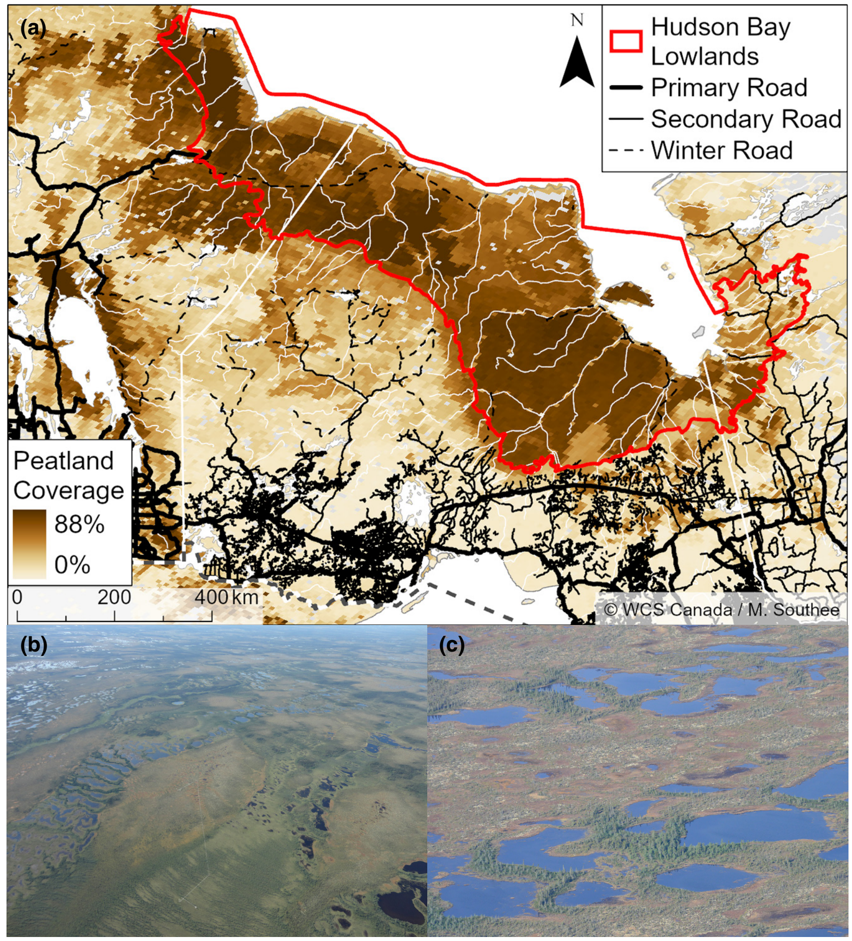

Figure 2. (a) Map of peatland area and infrastructure development in the Hudson Bay Lowlands (HBL), Na Taski Nan in Cree (peatland coverage from Hugelius *et al.* [2020]; road infrastructure data from GFWC [2010]), and (b and c) aerial photographs of undisturbed peatlands in the Attawapiskat River area of the HBL. These peatlands store more carbon (C; ~30 gigatons [Gt] C) than all of Canada's "managed" boreal forest (~28 Gt C, mostly within the area shown as "managed lands" on Figure 1a; Kurz *et al.* 2013; Packalen *et al.* 2014).

In addition to sustained changes in environmental conditions caused by global warming, rapid or abrupt changes to peatland structure and loss of C may also occur due to permafrost thaw or wildfire (Turetsky *et al.* 2015, 2020; Hugelius *et al.* 2020). As peat thaws in warmer temperatures, peat C decomposes and is released as CO_2 to the atmosphere (Turetsky *et al.* 2020). Methane emissions will also increase in wetlands that develop following thaw (Hugelius *et al.* 2020), with losses of waterborne C also possible if peat that has subsided enters downstream watercourses (Rodenhizer *et al.* 2020). Although the development trajectory of peatlands in thawing permafrost landscapes remains uncertain (Sim *et al.* 2021), large losses of peat C are expected within the next 100 years, with increased CO_2 and CH_4 emissions equal to ~1% of human-caused radiative forcing (WebPanel 3; Hugelius *et al.* 2020; Turetsky *et al.* 2020).

More frequent and extensive wildfires across northern regions also pose a major risk to C stored in peatlands, including in permafrost peatlands where more rapid thaw after fire increases CO_2 emissions from a deeper active layer (Turetsky *et al.* 2015; Gibson *et al.* 2018). As warmer and drier climate conditions persist, non-permafrost peatlands are particularly vulnerable to fire ignition, greater burn severity, and prolonged peat smoldering, with ~5 megatons (Mt) C lost per year due to peatland fires in western Canada alone (WebPanel 3; Turetsky *et al.* 2011).

Impacts of land-use change

The direct human disturbance of peatlands in Canada includes extraction for horticulture, flooding for hydroelectricity production, forest harvesting, conversion to agricultural land, mineral extraction, and associated infrastructure development (Figure 3). These disturbances may cause total C loss through removal of peat, as well as indirect C loss through vegetation clearance, drainage, and flooding (WebPanel 4). However, the extent and intensity of these direct human disturbances across Canada remain unknown (Table 1).

Currently, only horticultural peat extraction and flooding for hydroelectricity production are included in Canada's GHG reporting, with total annual GHG emissions (~2.6 Mt CO_2 equivalents for 2019) for an area of ~790 km^2, accounting for

Table 1. Peatland area and conservative estimates of direct human disturbances across Canada from limited available records

	Estimated area (km^2)	References
Total peatland cover	1,100,000	Tarnocai *et al.* (2011); Xu *et al.* (2018); Hugelius *et al.* (2020)
Permafrost peatland	420,000	Tarnocai *et al.* (2011)
Non-permafrost peatland	680,000	–
Disturbances		
Agriculture (cropland)	7101	Carlson *et al.* (2017)
	1420 (southern Ontario only)	Byun *et al.* (2018)
Mining (including oil and gas exploration)	3700 (Alberta only)	Strack *et al.* (2019); Drever *et al.* (2021)
Forestry operations (drained peat)	250 (early 1990s)	Poulin *et al.* (2004)
	697 (Quebec only)	Poulin *et al.* (2004)
Flooding for hydroelectricity	440	ECCC (2021)
Horticultural peat extraction	350	ECCC (2021)

<1% of Canada's total annual reported human-caused GHG emissions (ECCC 2021). Emissions factors applied in Canada's GHG inventory to quantify peat C lost from drainage for these disturbances are currently not applied for peatlands drained or flooded as a result of other land-use conversion (eg forestry operations, seismic lines, mining; ECCC 2021). GHG emissions from organic soils drained and converted to agricultural land (cropland/grassland) and for forestry operations are included in the inventory, but the portion of this area that is peatland (wetlands) is not estimated (ECCC 2021). This limited reporting for peatland disturbances in the national GHG inventory is hindered by a lack of data on the total area of disturbed peatland across Canada, and total GHG emissions from disturbed peatlands are likely much greater than those presently accounted for.

Effects of disturbance on irrecoverable peat C

Long-term rates of peat accumulation in northern regions are slow (~0.2 mm per year; Bysouth and Finkelstein 2020), as only a small portion of new surface peat C that is more readily decomposed is added to the long-term peat C store. Central to the notion of "irrecoverable C" is the ability and time required to restore the long-term C sink function of peatlands following their conversion, and as such, a large portion of peat C lost to disturbance is considered irrecoverable in the timescales (30 years) required to prevent major climate impacts (Masson-Delmotte *et al.* 2018; Goldstein *et al.* 2020). Recent conservative estimates suggest ~1200 km^2 of peatland across Canada is at risk of development (immediately foreseeable and quantifiable threats) by 2030 (Drever *et al.* 2021), but the threat of loss of irrecoverable peat C is likely to increase substantially as the Government of Canada places greater strategic emphasis on the extraction of critical minerals (NRCan 2021).

Long-term studies of horticultural peat extraction sites suggest careful restoration can shift these peatlands from C sources back to C sinks within two decades (Nugent *et al.* 2019). However, the portion of peat C lost during extraction (typically the top 1 m or greater) and drainage is much greater than the peat C that may be recovered within 20 years of restoration (Figure 4a). Peat clearance for open-pit mining (often the entire peat profile) also leads to substantial loss of irrecoverable C (Figure 4b), given that even if a peat accumulating ecosystem (with *Sphagnum* or brown mosses) is successfully created (Nwaishi *et al.* 2016), it is not possible to build-up the same C stocks as the original peatland within 30 years.

The amount of irrecoverable C lost following resource extraction (eg open-pit mining), forestry, and associated linear disturbances (eg roads, seismic lines) also depends on the magnitude and duration of drainage (Figure 4c). Peat C loss,

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Figure 3. Examples of peatlands in Canada affected by direct human disturbance. (a) A drained peatland pool (due to mine dewatering) surrounded by a raised ridge of dead *Sphagnum* moss in the HBL, (b) an open-pit mining operation in the HBL, and (c) an active peat extraction site in Alberta.

mainly as CO_2, occurs gradually after the onset of drainage through accelerated decomposition of drier peat (Munir *et al.* 2014), which is considered vulnerable until restored. For flooded areas on the "upstream" side of roads, the loss of irrecoverable C may be in the form of CH_4 rather than CO_2 emissions (Strack *et al.* 2019).

Implementing effective measures to restore disturbed peatlands is essential for preventing further C loss and restoring ecosystem function with long-term benefits for GHG emissions (Nugent *et al.* 2019). If a peatland is left in a damaged state or subject to further disturbance, such as increased and prolonged drainage, not only does the portion of irrecoverable C increase (Figure 4d) but the ecosystem may shift to a different state (eg drier forest) and may be more vulnerable to C loss in a warmer climate (Page and Baird 2016).

Wildfire may cause large losses of irrecoverable C due to the long timescales for peat recovery following a disturbance event. A large portion of biomass and peat C (in a non-permafrost peatland) may be immediately lost in a moderate to severe burn (Figure 5a), with continued loss of vulnerable peat C through increased peat respiration and smoldering (eg 106 g C m^{-2} yr^{-1} released to the atmosphere for 10 years after fire; Wieder *et al.* 2009). Depending on the peatland hydrological setting and regional climate, depth of burn may be less than 10 cm but potentially exceed 1 m (Lukenbach *et al.* 2015; McLaughlin *et al.* 2018). Peat lost to combustion may range from less than 1 to ~80 kg C m^{-2} (Lukenbach *et al.* 2015). Post-fire *Sphagnum* recovery is slow (~5–20 years) and therefore peat accumulation is also delayed, with ~50–100 years or more required to recover lost C (Figure 5a; Wieder *et al.* 2009). In drained peatlands, the depth of burn and C loss may triple (Turetsky *et al.* 2011), but rewetting these peatlands can reduce the risk and impact of wildfire on peat C loss and shorten the timeframe for post-fire peat C recovery (Granath *et al.* 2016).

Rates of C loss for thawing permafrost peatlands in different regions range from ~40 to ~300 g C m^{-2} yr^{-1} (Heffernan *et al.* 2020). Although *Sphagnum* growth and post-thaw peat accumulation may be relatively rapid in the wetter and warmer conditions of new wetlands (eg post-thaw peat C accumulation up to ~300 g C m^{-2} yr^{-1} over ~100 years; Heffernan *et al.* 2020), most peat C lost to thaw is likely irrecoverable within the 30-year timeframe for net-zero emissions (Figure 5b). However, if post-thaw hydrological conditions remain stable (Sim *et al.* 2021), increased plant productivity and subsequent peat accumulation may slowly return these thawed peatlands to a long-term C sink.

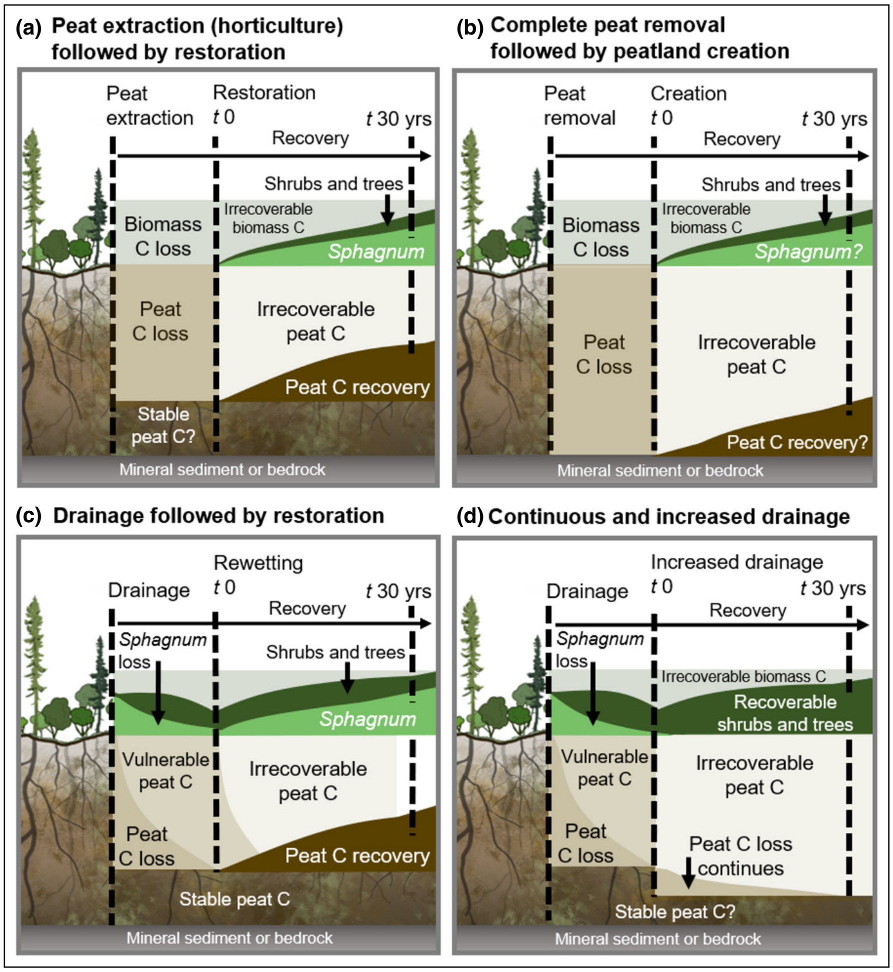

Figure 4. Conceptual diagrams of the effects of direct human disturbance and restoration on "irrecoverable C" in northern peatlands, including (a) peat extraction for horticulture, (b) peat removal for open-pit mining or other infrastructure, (c) drainage for mining or other infrastructure development, and (d) increased drainage (based on Goldstein *et al.* [2020]).

The imperative for long-term C management

The path to net-zero emissions by 2050 assumes that global ocean and terrestrial C sinks, including peatlands, will continue to remove about half the amount of CO_2 emitted from fossil-fuel combustion and land-use change annually (Masson-Delmotte *et al.* 2018; Skukla *et al.* 2019). If emissions from disturbed peatlands are large, efforts to mitigate direct emissions from other sectors (eg industry, transportation, energy production) to meet global CO_2 reduction targets will be more difficult. Addressing this assumption will therefore require a fundamental change to how we value and manage northern peatlands, which, as a large and long-term C sink, play a disproportionate role in global C management relative to other terrestrial ecosystems.

Canada is well positioned to become a global leader in developing practices and enhancing research to better measure and report on peatland C in the northern regions of the world. As many peatlands in Canada remain largely intact, there is an

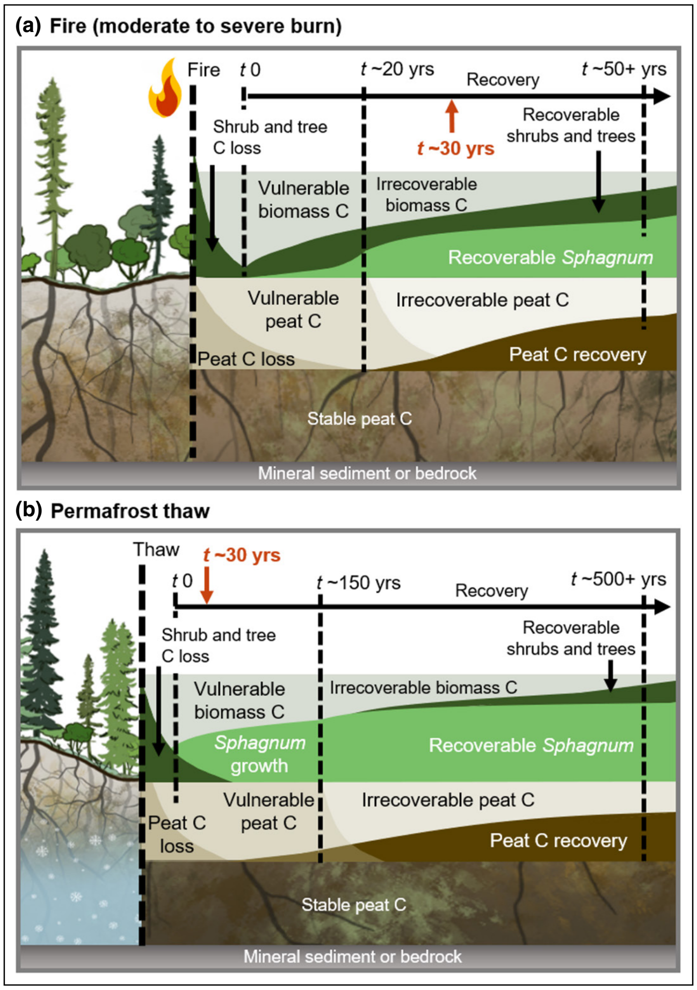

Figure 5. Conceptual diagrams of the effects of indirect human disturbance on "irrecoverable C" in northern peatlands: (a) wildfire and (b) permafrost thaw (based on Goldstein *et al.* [2020]).

opportunity to shift from piecemeal and short-term decision making to strategic and long-term management that is necessary to protect and enhance peatland C. Initiatives to proactively protect peatlands across Canada may be achieved through various policy mechanisms and strategies that focus on (1) reducing or eliminating disturbances that cause the loss of stored peat C, (2) maintaining major and mostly intact peatland C sinks, and (3) supporting local restoration of degraded peatlands. As there are few scenarios where the recovery of peat C will be rapid enough (ie within 30 years) to offset C loss due to disturbances, policy mechanisms for the protection of undisturbed peatlands across Canada are critical. These policies must be integral to land sector strategies that contribute to the global climate-change mitigation needed by 2050 (Roe *et al.* 2019), and be delivered against a backdrop of complex governance systems and institutions (Fuss *et al.* 2019). Effective implementation also requires support and innovation by appropriate financial incentives and more substantial investment to improve models and estimates for peatland C across Canada.

Land protection and Indigenous stewardship

Recent announcements by the Government of Canada to join the so-called High Ambition Coalition of countries calling for 30% protection of lands and waters (ECCC 2020b) elevate the potential for proactive protection of peatlands in Canada. Notably, the most intact peatland complexes in Canada coincide with lands managed by Indigenous Peoples (Artelle *et al.* 2019), within areas of major interest for Indigenous Protected and Conserved Areas (IPCAs; eg ECCC 2018). Indigenous-led stewardship is necessary for advancing any conservation within these territories, and the most recent protections and proposals signify the considerable scale of potential conservation benefits (Artelle *et al.* 2019). IPCAs that include extensive undisturbed peatlands and provide an array of ecosystem services would also serve to proactively protect peatland C stores as an alternative to waiting for them to be at risk of conversion before they are valued through C offsets. However, a key challenge to this model as far as C stewardship is concerned is that the responsibility for maintaining terrestrial C stocks has not yet been clearly established. Legislative authority for land use, including protection, lies predominately with provincial and territorial (and to a lesser extent, federal) governments. Recognition of Indigenous Peoples' jurisdiction by governments over their territories on public land is still limited and "C rights" have yet to be defined, including related potential revenues (Townsend *et al.* 2020).

Regulatory tools for impact assessment

Additional protection for peatlands will need to be achieved through planning for development with an eye toward minimizing project-level impacts and managing cumulative effects from multiple projects. The Canadian federal Impact Assessment (IA) Act (2019) does not explicitly consider peatland C stores and potential C losses per se but has provisions to require an assessment of GHG emissions for a development project throughout its life cycle (IAAC 2020a). The Strategic Assessment of Climate Change (SACC; ECCC 2020c) requires industry projects undergoing federal IA to quantify and report on the direct C emitted as a result of construction (ie land-use change), as well as the longer term impact to C sinks. However, because Canada's National Inventory methodology (ECCC 2021) and Intergovernmental Panel on Climate Change (IPCC) guidelines (Eggleston *et al.* 2006; Hiraishi *et al.* 2014; Skukla *et al.* 2019) do not yet provide appropriate default values for calculating emissions for all potential land-use conversions, other methods and tools to quantify C loss from developments on peatland (eg Scottish Government 2021) are required to meet the requirements of the SACC.

Regional assessments (RA) that explicitly quantify the cumulative effects of development on peatlands in their terms of reference would provide a stimulus to improve the consideration and quantification of peat C. For example, an RA has recently been initiated for the proposed "Ring of Fire" mining development in the HBL in northern Ontario (IAAC 2020b). Although potential C loss and GHG emissions from individual developments on peatlands in the HBL may be deemed "small", the cumulative and interacting effects of multiple developments on peat C, downstream water quality, and local communities may be very large. For the ~2127 km^2 area of peatlands covered by mining claims that represent the Ring of Fire development (Ontario MNDM 2021), the impacts of multiple direct disturbances on these peatlands – including the direct and indirect emissions resulting from the vast road network needed to service the area – will likely be considerable and long term, with a reduction in the capacity of the peatland C sink and loss of large quantities of irrecoverable C. For example, using a simple map overlay of the ~2127 km^2 peatland area covered by mining claims and estimates of peat C for the region from Hugelius *et al*. (2020), we estimate that between ~130 and 250 Mt C could be directly lost to the development.

Financial incentives

There is burgeoning global C market demand for nature-based solutions for climate change, but financing to date has been focused primarily on forest and agriculture offsets, with intact terrestrial C sinks (eg stable forests, intact peatlands) receiving little attention (Funk *et al*. 2019). Incentives to protect peatlands may be helped by recognizing the financial value of peatland C sinks (Anielski and Wilson 2005), with financing mechanisms designed to incentivize protection of intact peatland C sinks as a complement to C offsets.

Finance mechanisms must also balance funding for the protection of undisturbed peatlands with expensive restoration efforts. Considerable resources have recently been directed toward restoring damaged peatlands throughout Europe, but incentives and funding opportunities to protect the few remaining intact peatlands from disturbance are much more scarce (Andersen *et al*. 2017). Although the restoration and management of disturbed peatlands will limit further C loss and speed recovery, the portion of irrecoverable C lost to disturbance is always likely to be greater than the portion of recoverable C gained through restoration within the 30-year timeframe. Funding to conserve undisturbed peatlands from further C loss should therefore be prioritized, as the impact for global climate-change mitigation is much greater than restoration alone (Humpenoder *et al*. 2020).

GHG reporting and climate models

Accurate assessments of peatlands in land-use planning require improved quantification and reporting on GHG emissions and removals for all peatlands and disturbances across Canada (Bernier *et al*. 2012). Under the current GHG reporting requirements, Canada only reports GHG emissions from peatlands impacted directly by anthropogenic disturbances (land-use change) and does not track natural emissions on what is classified as "unmanaged" land (ECCC 2021). The IPCC guidelines (Eggleston *et al*. 2006; Skukla *et al*. 2019) for the delineation of "managed" and "unmanaged" land are intended to simplify GHG reporting in instances where it may be difficult to separate direct and indirect human disturbances on forest and peatland GHG emissions (Ogle *et al*. 2018). However, the question of whether peatland GHG emissions are caused directly or indirectly by humans is irrelevant to atmospheric GHG totals, and the effects of increased GHG emissions on global climate warming are the same, regardless of origin. Given their size, C stocks and GHG emissions and removals for peatlands across Canada must be included in Earth system models used to predict future climate change. A change in national policy for assessing GHG emissions and removals for peatlands across Canada for UNFCCC reporting is slowly emerging, but incentives to develop targeted research strategies to help fill knowledge gaps and better inform decision making in land-use planning could accelerate action.

An integrated framework for peatland protection in Canada

Canada's recently revised Climate Plan (ECCC 2020a) recognizes the important role of nature in addressing climate change, and includes substantial investment in nature-based solutions. While there is acknowledgment of the importance of intact natural spaces in Canada, as well as the need for protection of lands and waters, mention of peatlands is limited to restoration. Implementation of this plan, along with updates to Canada's Nationally Determined Contributions under the Paris Agreement, must include measures for safeguarding the high mitigation potential and climate adaptation opportunities provided by northern peatlands. These may be outlined in a pan-Canadian peatland strategy that describes a shared vision and goals for peatland protection and restoration across Canada, with this strategy informing coherent policies and coordinated actions across jurisdictions, co-developed with First Nations, Inuit, and Métis Peoples.

Conclusions

Amid growing recognition that the climate crisis will not be resolved without attention to the essential role of nature, the avoided conversion and restoration of northern peatlands are key components of global climate-change mitigation strategies. Proactive safeguarding of peatland C stores can have enormous co-benefits by conserving biodiversity and ecosystem integrity, potentially at vast scales. As the steward of the world's largest peatland C stock, Canada has a disproportionate responsibility to implement effective policies and strategies to protect potentially irrecoverable C that can serve as a model for other countries. Initiatives that specifically protect peatlands through Indigenous stewardship and apply the principle of avoidance rather than mitigation show great promise in Canada. These community and science-based policy initiatives can be achieved with urgent collaborative and coordinated action.

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Data Availability Statement

No data were collected for this study.

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