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Large Carbon Losses From Burned Permafrost Peatlands During Post-Fire Succession

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Key Points:

- Burned permafrost peatlands lost ~130 g C m^{-2} yr^{-1} during the first four years post-fire
- Burned landscapes returned to a net carbon dioxide sink ~15 years post-fire
- Net ecosystem exchange carbon losses post-fire were similar to the initial combustion losses

Supporting Information:

Supporting Information may be found in the online version of this article.

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Abstract

The carbon (C) storage of boreal peatlands is threatened by an intensifying wildfire regime. Between 2019 and 2023 we used eddy covariance and surface closed chambers to monitor two permafrost peatlands in boreal western Canada that burned in 2019 and 2007. Deeper thaw, warmer soils, and slow vegetation recovery caused the 2019 Burn to be a net carbon dioxide (CO_2) source (+130 g C m^{-2} yr^{-1}) for four years post-fire, despite reduced soil respiration. The 2007 Burn was a sink (−11 g C m^{-2} yr^{-1}) 13–15 years post-fire, similar to undisturbed peatlands. We estimate that wildfire caused a loss (~2.9 kg C m^{-2}) from permafrost peatlands, with ~1.7 kg C m^{-2} due to combustion and ~1.2 kg C m^{-2} due to net CO_2 losses during post-fire succession. This highlights the importance of the post-fire CO_2 losses and emphasizes the vulnerability of permafrost peatland soil C to fire.

Plain Language Summary

Boreal peatlands across northwestern Canada with permafrost have accumulated vast amounts of carbon (C) over millennia despite regularly burning in natural wildfires. Ongoing climate change increases fire frequency and intensifies fire severity, possibly transforming the ecosystems of this vast region into long-term future C sources. Losses of C occur during wildfire but also in the years post-fire due to reduced uptake of the greenhouse gas carbon dioxide (CO_2) by vegetation and through decomposition of exposed drier peat on the surface. We report measurements of net CO_2 release from a recently (2019) burned permafrost peatland in the first four years after the fire and compare them to concurrent measurements at a nearby burned peat plateau recovering from a 2007 wildfire. Our results suggest large net CO_2 losses in the first years after fire but a return to net CO_2 gains in burned peatland complexes 15 years after fire. However, active layer deepening post-fire and warmer soil temperatures at depth can cause the release of deep, old C. Future work must account for both the significant magnitude and the origin of post-fire CO_2 emissions, as previously frozen, old C is being reintroduced to the atmospheric C cycle, fueling further global warming.

1. Introduction

An intensifying wildfire regime will likely determine whether the boreal biome will act as a carbon (C) sink or source this century, potentially representing a globally significant climate change feedback (Flannigan et al., 2009; Phillips et al., 2024; Ramage et al., 2024; Walker et al., 2019). Permafrost-affected peatlands cover 1.7×10^6 km^2, store ~185 Pg C (Hugelius et al., 2020), and have characteristics which may result in a different response to wildfire when contrasted to that of non-permafrost peatlands and other boreal ecosystems. Estimating the total impact of wildfire on the net carbon dioxide (CO_2) balance of an ecosystem requires the accounting of both direct combustion CO_2 losses and the net ecosystem exchange (NEE) of CO_2 during post-fire succession. While a period of CO_2 loss during post-fire succession is common in boreal ecosystems due to reduced primary productivity and increased soil respiration, this period can last between a few years for non-permafrost peatlands (Myers-Smith et al., 2007) and several decades for upland forests (Amiro et al., 2006; Rebane et al., 2019). The importance of post-fire NEE for the total impact of wildfire is likely determined by ecosystem properties such as soil type, soil environmental conditions, and vegetation succession, and has not yet been studied for permafrost-affected peatlands (Nelson et al., 2021).

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The Taiga Plains Ecozone in northwestern Canada is a major peatland region with ~200,000 km^2 of peatlands mainly in the zone of discontinuous permafrost (Olefeldt et al., 2021). Peatlands in this region are a mosaic of treed (*Picea mariana*) permafrost-affected peat plateau bogs and non-treed permafrost-free bogs and fens (Baltzer et al., 2014; Quinton et al., 2019). Peat plateaus are raised 1–2 m above their surroundings and are drier than non-permafrost peatlands (Heffernan et al., 2020; N. Pelletier et al., 2017). Treed peat plateaus burn with similar frequency as upland forests (Kuntzemann et al., 2023). Wildfires on the Taiga Plains have increased over the last few decades, with on average 0.5% of the land area burned annually between 1985 and 2015 (Coops et al., 2018) but almost 10% in 2023 alone (F. Pelletier et al., 2024). Wildfire combustion C losses in black spruce forests in western Canada and Alaska average ~3 kg C m^{-2}, but range between <1 and ~9 kg C m^{-2}, with >80% due to belowground soil C combustion (Turetsky et al., 2011; Walker et al., 2018). While wildfire frequency has influenced the historical rate of apparent soil C accumulation of peat plateaus on the Taiga Plains over the last 1,200 years (Robinson & Moore, 2000), the overall impact on C storage and the role of post-fire NEE under the current climate is poorly understood.

Post-fire succession of peat plateaus differs from that of both non-permafrost peatlands and upland forests (Kasischke & Penner, 2004), likely determining long-term peat plateau NEE. Wildfires on peat plateaus are dominated by stand-replacing crown fires and decrease the albedo significantly as bright lichens are replaced by char (Lyons et al., 2008; Potter et al., 2020; Thompson et al., 2015). While fire accelerates complete permafrost thaw and expansion of non-permafrost peatlands along peat plateau edges, most peat plateau areas in regions with mean annual temperatures below −1°C recover to pre-fire conditions over a 30-to-50-year period (Gibson et al., 2018; Helbig et al., 2016; Seppälä, 2011). Vegetation recovery is slow due to the nutrient-poor and cold conditions, with early succession dominated by woody shrubs and recovery of *Sphagnum* moss while regrowth of trees and lichens takes decades (Gibson et al., 2018; Helbig et al., 2016). The active layer of peat plateaus deepens from ~50 to ~80 cm in the years following fire, and non-frozen layers above the permafrost (taliks) expand, returning to pre-fire conditions only after ~30 years (Gibson et al., 2018). Since peat plateaus are raised, the water table often follows the depth of the active layer. A deeper, drier, and warmer active layer in burned peat plateaus has been shown to increase the contribution of aged, deep soil C to soil respiration (Estop-Aragonés et al., 2018; Gibson et al., 2019), but the annual NEE of burned permafrost peat plateaus has not been studied using near-continuous, ecosystem-scale eddy covariance (EC) measurements.

The objective of this study was to measure the NEE of burned peat plateaus on the Taiga Plains, and to compare combustion C losses and post-fire NEE for the overall impact of wildfire on the long-term C balance. We used EC to measure NEE over four years at two peat plateau sites, one which burned 1 year prior and one which burned 12 years prior to the study initiation. We also monitored the soil thermal regime and measured soil respiration using closed chambers at two burned and an unburned site. Prior studies have monitored post-fire NEE of non-permafrost peatlands (Gray et al., 2021; Wieder et al., 2009), but we hypothesized that the drier conditions and slow vegetation succession of peat plateaus would lead to greater post-fire CO_2 losses similar to that of drained non-permafrost peatlands (Nelson et al., 2021; Wilkinson et al., 2023). Given the intensifying wildfire regime of boreal permafrost regions, our study provides data which are highly sought after for national C inventories and global C models (Bona et al., 2024; Kurz et al., 2013; Nelson et al., 2021; Schuur et al., 2022).

2. Materials and Methods

2.1. Study Sites

This study was conducted at three peat plateau sites located <18 km apart in northern Alberta, Canada (Figure 1). The climate is continental, with a mean annual average temperature of −1.1°C (2011–2020) and mean annual precipitation of 355 mm (Wang et al., 2016). EC systems were deployed at the "2019 Burn" (59.595°, −117.286°; AmeriFlux-ID "CA-LU1") and at the "2007 Burn" (59.441°, −117.242°; AmeriFlux-ID "CA-LU2"). The "Unburned" site (59.484°, −117.176°) had not burned in at least 60 years based on tree ring observations.

All three sites were elevated 1–2 m above their surroundings and had >150 cm of peat. The Unburned site had an open canopy of stunted <6 m black spruce, a ground layer of Labrador tea shrubs (*Rhododendron groenlandicum*) and lichens (*Cladonia* spp.) or *Sphagnum fuscum* hummocks (Figure 1c). The vegetation composition at the burned sites was likely similar to the Unburned prior to the fires (Gibson et al., 2019). A high severity fire affected the 2019 Burn in May 2019, and a moderate severity fire affected the 2007 Burn in June 2007 (see Supporting Information S1). The 2019 fire was of high severity as defined by Kasischke et al. (2008), with all low shrubs

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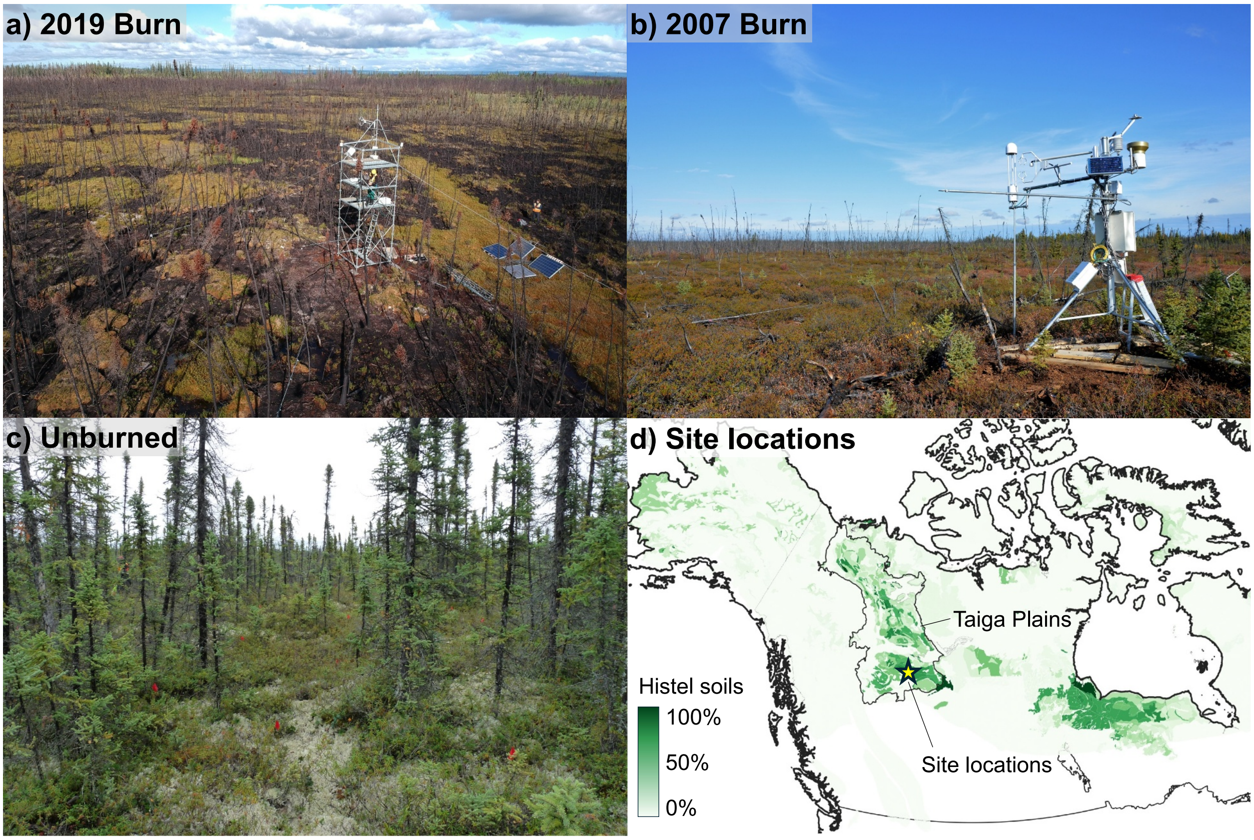

Figure 1. Site locations and photos of the three permafrost peat plateau sites (a, b, c) in the Taiga Plains Ecozone, western Canada, outlined in (d) along with the distribution of histel soils (i.e., organic soils with permafrost; commonly peat plateaus) (Hugelius et al., 2020). All sites were located within 18 km from each other.

consumed by fire, *Sphagnum* mosses singed but not combusted, and all trees deceased with needles, tertiary, secondary branches consumed by fire and <30% of primary branches remaining (Figure 1a). At the 2007 Burn, no black spruce trees had survived fire and lichens were still completely absent during this study, suggesting at least moderate fire severity. Most charred tree boles had fallen over, and vegetation recovery was dominated by dense Labrador tea shrubs (~40 cm tall) and sparse regenerating black spruce (<1 m tall) (Figure 1b).

2.2. Combustion C Losses, Active Layer Depth, and Soil Respiration

Combustion C losses were estimated for both above- and belowground at the 2019 Burn, following the method described by Walker et al. (2018). Active layer depth was measured in late September between 2019 and 2022 at all sites in a 5 m grid with 80 points (8 × 10) using a 150 cm probe. We recorded points where thaw depth was >150 cm, which suggested the presence of taliks (Gibson et al., 2018). We used a kernel density function to estimate a representative depth of the active layer, which is preferred to average or median depths (Gibson et al., 2018; Wessa, 2015).

We measured soil respiration at all three sites using surface closed chambers (Crill, 1991) connected to a portable EGM-4 infrared gas analyzer (EGM-4, PP Systems, Amesbury, MA). Soil respiration is defined here to include autotrophic respiration of the ground layer, that is, mosses where present. Each site had four to six collars (0.12 m^2) randomly placed on the peat plateau, and included both lichen, char, and *Sphagnum* moss ground cover dominance, but did not include shrubs or trees. Measurement of soil respiration was done three times in 2020 and 2021, and twice in 2022 for a total of 108 measurements. Each soil respiration measurement was paired with measurements of soil temperature at 5, 10, 20, and 40 cm with handheld thermometers (Thermoworks, American Fork, UT). Linear regressions were made between soil respiration and soil temperature at 10 cm depth for each site, and 95% confidence intervals (CI) of the regression's slopes were compared among the three sites.

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2.3. EC Measurements and Annual NEE

EC measurements started in June 2020 at the 2019 Burn (one year after the fire), and in September 2019 at the 2007 Burn (twelve years after the fire). Sites had identical instrumentation, including sonic anemometers measuring high frequency fluctuations of wind and air temperature (CSAT3, Campbell Scientific, Logan, UT), and enclosed-path gas analyzers for concentrations of CO_2 and water vapor (LI-7200, LI-COR Biosciences, Lincoln, NE). The sonic anemometer and gas analyzer inlet were at a height of 6.0 m above the dead trees at the 2019 Burn (Figure 1a), and at a height of 2.1 m above the shrub canopy at the 2007 Burn (Figure 1b). Dataloggers (CR3000-XT, Campbell Scientific, Logan, UT) recorded half hourly data of net radiation, rainfall, air temperature, soil temperature at 10 cm depth, photosynthetic photon flux density (PPFD), soil moisture content, and ground heat flux (Table S3 in Supporting Information S1). Half-hourly fluxes of NEE, ER, and gross primary productivity (GPP), including gap-filling and partitioning, were computed following standardized procedures (see Supporting Information S1).

Long data gaps (>3 weeks) which were not gap filled (Figure S2 in Supporting Information S1) prevented the estimate of cumulative annual NEE, ER, and GPP fluxes for individual years of the study. Instead, we merged the half hourly data from individual years into a single representative annual record for each site by averaging the available data of each half-hour from the four individual years. This approach yielded representative annual NEE, ER, and GPP records with a data coverage of 100% (2019 Burn) and 92% (2007 Burn). The remaining data gaps all occurred during winter months, and we filled these gaps by using the average of available half hourly NEE, ER, and GPP fluxes for the period between November 15th to February 15th. With the gaps in winter filled, we estimated the cumulative annual NEE, ER, and GPP fluxes for a representative year for each site. Uncertainties of these annual NEE, ER, and GPP estimates were based on the half-hourly variability across the four years of measurements (see Supporting Information S1).

2.4. Net CO_2 Balance Over 20 Years After Fire

To estimate the net impact of wildfire on the C balance of peat plateaus, we estimated the total combustion C losses and the cumulative difference in NEE over 20 years between burned and undisturbed peat plateaus. The cumulative NEE of a burned peat plateau was assumed to be represented in years 1–3 after fire by the representative annual NEE of the 2019 Burn, and in years 13–15 by the representative annual NEE of the 2007 Burn. For years 4–12 and 16 to 20, we assumed a linear change in NEE. Based on data on post-fire succession of vegetation and soil thermal regime of peat plateaus in the region (Gibson et al., 2018), we assumed that the NEE of a burned peat plateau returned to pre-fire conditions after 20 years; -20 g CO_2-C m^{-2} yr^{-1} as measured at the unburned Scotty Creek peatland (61.30°, −121.30°; AmeriFlux-ID "CA-SCC") which has a similar land cover as the sites in this study (Helbig et al., 2017).

3. Results

3.1. Combustion C Losses, Soil Temperature, Active Layer Depth, and Soil Respiration

Total combustion C loss at the 2019 Burn was 1.7 ± 0.6 (95% CI) kg C m^{-2}, of which 23% was due to aboveground combustion and 77% due to belowground soil combustion (Table S1 in Supporting Information S1). The depth of burn at the 2019 Burn was 4.9 ± 1.7 cm, while 0–5 cm bulk density at the Unburned was 0.12 ± 0.013 g cm^{-3}, yielding the estimate of 1.3 ± 0.5 kg C m^{-2} in belowground combustion loss (Table S1 in Supporting Information S1).

The 2019 Burn and 2007 Burn had warmer soils at 10, 20, and 40 cm (Figure S1 in Supporting Information S1), deeper active layers (Figure 2a), and spatially more extensive taliks compared to the Unburned. The 2019 Burn and 2007 Burn had on average 43% and 95% of the grid-points indicated as taliks (thaw >150 cm), compared to 28% at the Unburned. Average active layer depth was deeper at the 2007 Burn (120 cm) than at the other sites, and only decreased at the 2019 Burn over the measurement period (Figure 2a).

Soil respiration increased with soil temperature at 10 cm (Figure 2b). Linear regressions between soil respiration and soil temperature at 10 cm depth were all significant ($p < 0.05$) (Table S2 in Supporting Information S1) and the 95% CI of the estimated slopes did not overlap (Figure 2b). An ANCOVA analysis showed that soil respiration was different among the sites after accounting for soil temperature (F (2,103) = 13.78, $p < 0.001$), with the

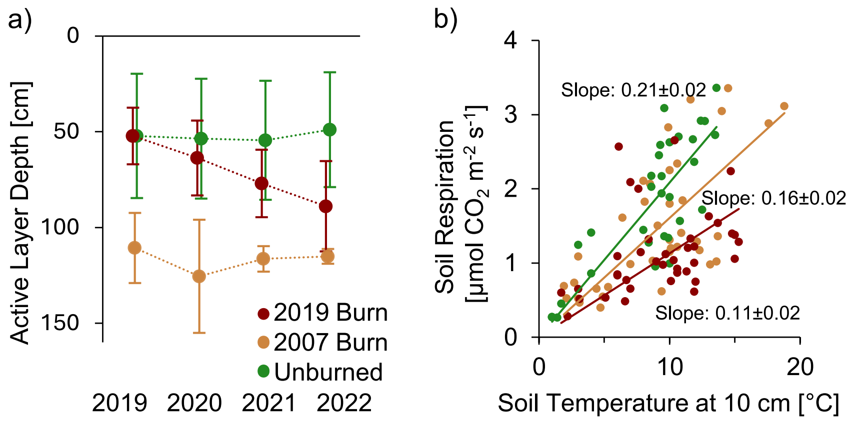

Figure 2. Comparison among the 2019 Burn, 2007 Burn, and Unburned peat plateau sites of (a) active layer depth, and (b) the relationship between soil temperature at 10 cm depth and soil respiration. Error bars for the active layer depth represent the standard deviation of the 80 thaw depth measurements, excluding points with taliks (>150 cm thaw depth). The 95% confidence intervals for the slope of the linear regressions did not overlap for the three sites.

adjusted mean being lowest at the 2019 Burn and highest at the Unburned (1.10, 1.49, and 1.87 μmol CO_2 m^{-2} s^{-1}, respectively).

3.2. NEE, GPP, and ER

Diurnal patterns of NEE were different between the sites during the summer, with lower CO_2 uptake during daytime at the 2019 Burn (Figure 3a), primarily due to lower GPP (Figures 3c–3f). The 2019 Burn had lower ER during spring, but equal or greater ER during late summer and fall. Cumulative NEE was similar during winter until late spring when 2007 Burn shifted to a net CO_2 sink while 2019 Burn remained a source throughout the summer (Figure 3b). Cumulative annual NEE was +130 ± 33 g C m^{-2} yr^{-1} at the 2019 Burn (±95% CI, see Supporting Information S1) and −11 ± 48 g C m^{-2} yr^{-1} at the 2007 Burn. Cumulative annual GPP was −290 ± 38 g C m^{-2} yr^{-1} at the 2019 Burn and −414 ± 50 g C m^{-2} yr^{-1} at the 2007 Burn, while cumulative ER was +400 ± 22 g C m^{-2} yr^{-1} at the 2019 Burn and +428 ± 24 g C m^{-2} yr^{-1} at the 2007 Burn. The 2019 Burn and 2007 Burn had no difference in meteorological conditions during the study with regards to air temperature and PPFD (Figures 3g and 3h) and their energy balance closures were at 0.75 and 0.67, respectively (Figure S3 in Supporting Information S1).

3.3. Long-Term Cumulative C Balance

The total net impact of wildfires on the C balance of the studied peat plateaus on the Taiga Plains over 20 years was estimated to be ~2.9 kg C m^{-2} (Figure 4). Based on data from the 2019 Burn and 2007 Burn, we estimated the 20-year cumulative NEE of a burned peat plateau to be +0.8 kg C m^{-2}, while that of an intact peat plateau at Scotty Creek is −0.4 kg C m^{-2} (Helbig et al., 2017), for a total net difference of 1.2 kg C m^{-2}. Thus, the difference in NEE between a burned and unburned peat plateau represents 42%, while combustion C losses represent 58% of the total net impact of wildfire on the C balance of peat plateaus over a 20-year period post-fire (Figure 4b).

4. Discussion

The combustion C loss at the 2019 Burn (1.7 kg C m^{-2}) was within the lower range (1–5 kg C m^{-2}) of combustion losses reported for undrained northern peatlands (Kasischke et al., 1995; Turetsky & Wieder, 2001; Zoltai et al., 1998), despite evidence of a high severity fire. Combustion C losses at the 2019 Burn were also lower than the average combustion loss (3.3 kg C m^{-2}) reported for non-peatland black spruce forests in western Canada (Walker et al., 2018). However, the 2019 Burn had a relatively sparse black spruce forest and extensive *Sphagnum fuscum* hummocks which may have suppressed combustion, causing losses like that of non-treed organic-rich tundra sites in Alaska (Moubarak et al., 2023).

We hypothesized that the deeper, drier, and warmer active layer at the burned peat plateaus would cause increased soil respiration compared to the Unburned. However, like other recent chamber flux studies on burned peat

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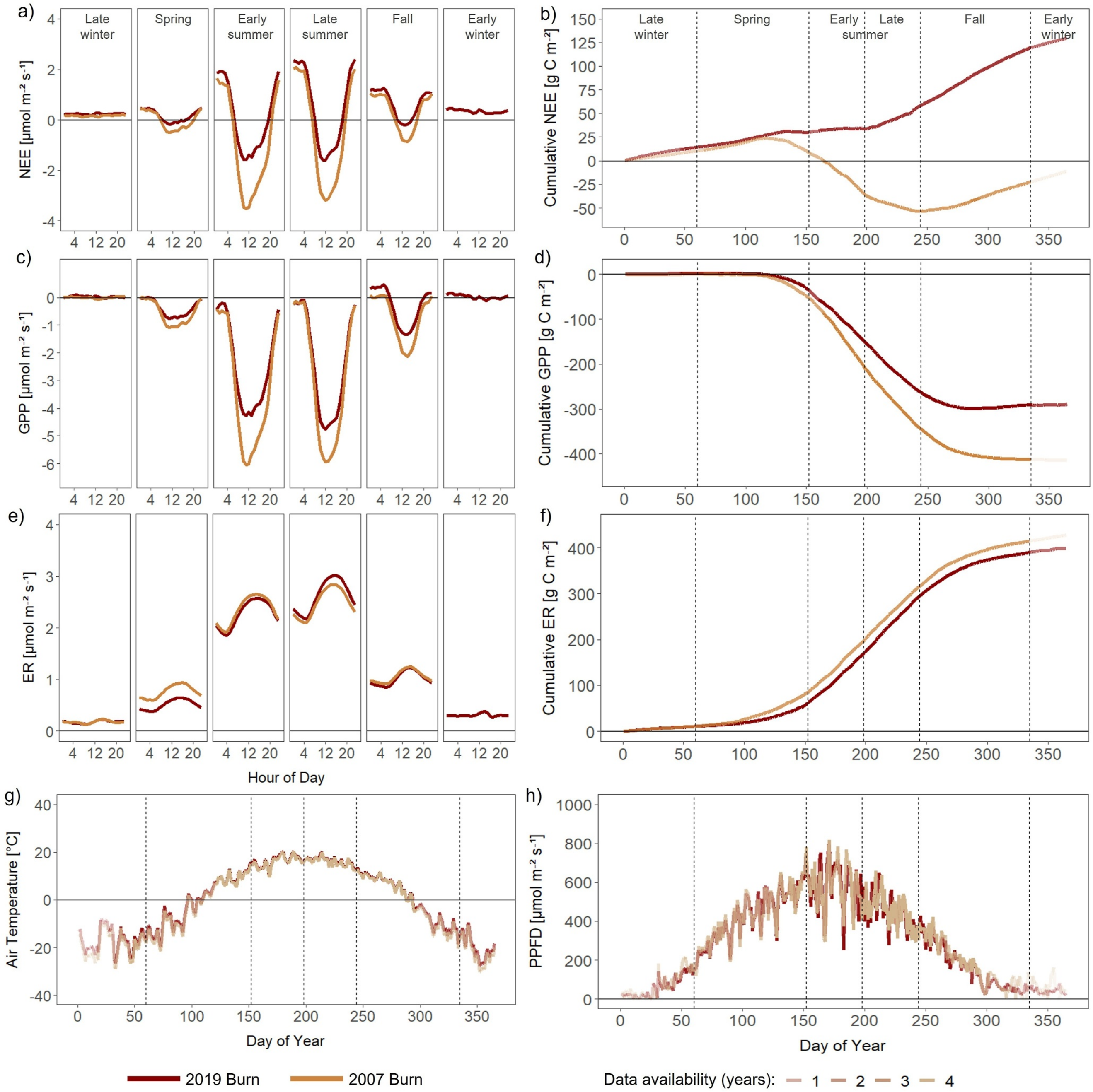

Figure 3. Annual patterns of (a) diurnal net ecosystem exchange (NEE), (b) cumulative NEE, (c) diurnal gross primary productivity (GPP), (d) cumulative GPP, (e) diurnal ecosystem respiration (ER), (f) cumulative ER, (g) air temperature, and (h) photosynthetic photon flux density (PPFD) for the 2019 Burn and 2007 Burn. The annual patterns were calculated based on half-hourly averages with up to four years of data (2020–2023).

plateaus (Gibson et al., 2019; Schulze et al., 2023), both burned sites had lower soil respiration than the Unburned site, with the lowest soil respiration at the 2019 Burn. This may be due to a combination of reduced autotrophic respiration (Song et al., 2019), and reduced heterotrophic respiration following the chemical alteration or combustion of near-surface peat during wildfires. Near-surface peat (top 10 cm) is an order of magnitude more microbially labile than deeper, more humified peat (Estop-Aragonés et al., 2022; Harris et al., 2023), and partial combustion of near-surface peat can significantly reduce its lability (O'Donnell et al., 2009). Previous findings from the 2007 Burn showed increased contribution from aged soil C to overall soil respiration, associated with the

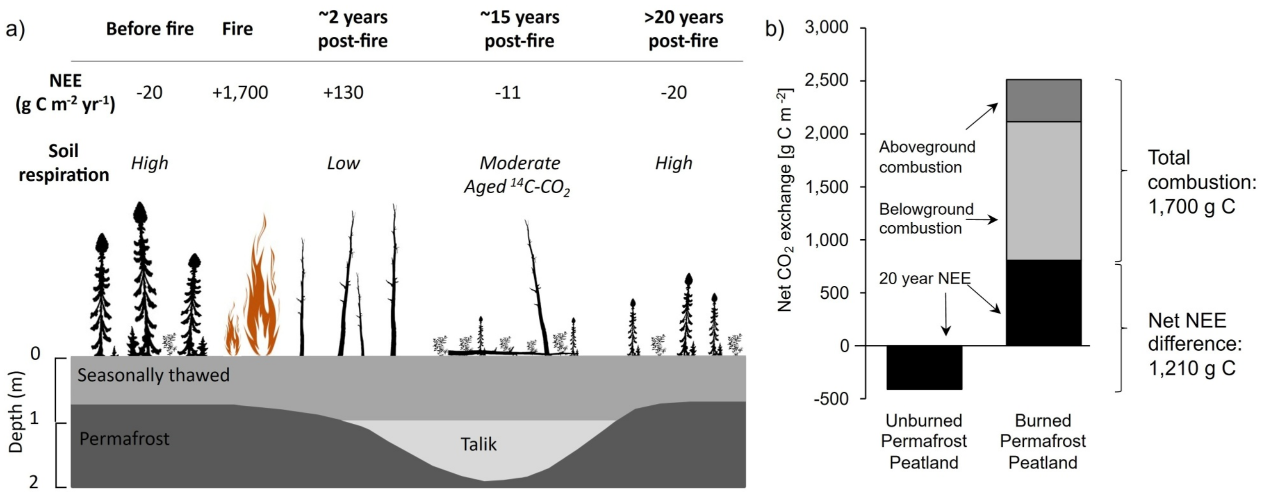

Figure 4. Impacts of wildfire on the Carbon (C) balance of peat plateaus during post-fire succession. (a) Summary of wildfire combustion C losses and annual net ecosystem exchange (NEE) for a permafrost peat plateau pre-fire and post-fire, along with relative rates of soil respiration and its observed radiocarbon signature, and a schematic of the recovery of soil thermal regime and vegetation. This study provided data for the combustion C losses, NEE ~2 and ~14 years after fire, and the relative rates of soil respiration, while NEE of undisturbed peat plateaus is based on Helbig et al. (2017), radiocarbon signature of soil respiration is based on Estop-Aragonés et al. (2018), and the recovery of vegetation and taliks ~20 years after fire is based on Gibson et al. (2018). (b) Cumulative impact of wildfire on the net C balance over 20 years after wildfire when compared to an intact peatland, accounting for both above- and belowground combustion and the difference in annual NEE.

deeper active layer (Estop-Aragonés et al., 2018; Gibson et al., 2018), yet this appears secondary to the dominant effect of reduced autotrophic and near-surface heterotrophic respiration.

The EC measurements showed that the 2019 Burn was an annual net CO_2 source ($+130 \pm 33$ g C m^{-2} yr^{-1}) between one and three years after the fire, but that there was a shift to a weak annual net CO_2 sink (-11 ± 48 g C m^{-2} yr^{-1}) for the 2007 Burn which burned 13–15 years prior. The annual net NEE at the 2007 Burn was similar to an intact peat plateau (-20 g C m^{-2} yr^{-1}) (Helbig et al., 2017), despite the disturbed soil thermal regime and limited regrowth of black spruce. The annual GPP of both the 2019 Burn (-290 ± 38 g C m^{-2}) and the 2007 Burn (-414 ± 50 g C m^{-2}) were less than the average of twelve studied northern peatland and tundra sites (-514 g C m^{-2}) (Lund et al., 2010) and the GPP of a peat plateau site in Alaska (-779 g C m^{-2}) (Euskirchen et al., 2024). In contrast, annual ER at the two studied sites (400 ± 22 and 428 ± 50 g C m^{-2}, respectively) was similar to the average of the twelve peatland and tundra sites (411 g C m^{-2}) and less than the peat plateau in Alaska (792 g C m^{-2}). Hence suppressed GPP rather than enhanced ER was the main cause of net CO_2 emissions at the 2019 Burn.

Our results suggest that the influence of wildfire on long-term C storage is greater for permafrost peat plateaus than for non-permafrost peatlands and non-peatland boreal forest ecosystems. Non-peatland black-spruce forests in Alaska and Manitoba are similar net CO_2 sources during early succession and shift to CO_2 sinks after 10 to 15 years (Goulden et al., 2011; Ueyama et al., 2019). While the timing of the shift from C source to sink is like the peat plateaus in this study, the subsequent net C uptake of upland forests is greater at 70–100 g C m^{-2} yr^{-1} and thus leads to faster C recovery (Goulden et al., 2011; Ueyama et al., 2019). Burned non-permafrost peatlands also act as net CO_2 sources during early succession (Morison et al., 2021; Wieder et al., 2009), and shift from net CO_2 sources to sinks between two and 13 years after fire (Grau-Andrés et al., 2019; Ingram et al., 2019; Wieder et al., 2009). However, while Wieder et al. (2009) estimated ~60 years for a non-permafrost bog in Alberta to reach C neutrality (i.e., recover the C lost in fire and during early post-fire succession), we estimate it takes ~140 years to reach C neutrality for permafrost peat plateaus due to their lower CO_2 uptake associated with dominance of lichen rather than *Sphagnum* moss groundcover (Germain Chartrand et al., 2023; Harris et al., 2018; Treat et al., 2015). With the contemporary fire return interval for the Taiga Plains estimated at ~65 years (Erni et al., 2019), this suggests that permafrost peat plateaus currently are net CO_2 sources overall.

A key difference between boreal upland and peatland ecosystems is that upland ecosystems reach stable C storage 100–150 years after a disturbance (Amiro et al., 2010; Bonan, 2016), while peatlands continue to accumulate soil C for millennia (Frolking & Roulet, 2007; Treat et al., 2021). As such, the C storage of a burned peatland will conceptually never equal a peatland site which has not burned (Harris et al., 2022), and the total impact of wildfire on peatland C storage thus needs to account also for the foregone C accumulation of an undisturbed peatland during post-fire succession (Figure 4b) (Robinson & Moore, 2000). Our study suggested that the total impact of wildfire on peat plateau C storage after 20 years was ∼2.9 kg C m^{-2}, of which 42% was due to the difference in NEE between a burned and unburned peat plateau during post-fire succession. Our estimate is similar to a previous estimate of reduced C storage in peat plateaus due to wildfire (∼2.1 kg C m^{-2} per fire), but this prior estimate was based on peat archives which do not separate the effects of combustion and post-fire NEE (Robinson & Moore, 2000).

Our study emphasizes the need to account for post-fire NEE of permafrost peatlands when modeling impacts of wildfire at national or global levels (Bona et al., 2024; Schuur et al., 2022). The effect of wildfire on methane and nitrous oxide fluxes from burned peat plateaus is conversely minor, with radiative forcing of wildfire being dominated by CO_2 emissions (Schulze et al., 2023). Future modeling of the impact of wildfire should however also account for increased methane emissions associated with accelerated permafrost thaw along peat plateau edges (Bäckstrand et al., 2010; Heffernan et al., 2024). Our study suggests that peat plateaus burned on the Taiga Plains in 2023 alone (∼15,000 km^2) are releasing 2.0 million tons C per year for the first few years post-fire.

Conflict of Interest

The authors declare no conflicts of interest relevant to this study.

Data Availability Statement

Additional Text, Figures (Figures S1, S2, and S3 in Supporting Information S1), and Tables (Tables S1, S2, and S3 in Supporting Information S1) are available in the Supporting Information S1. The EC data is available at the corresponding AmeriFlux sites: CA-LU1 (Olefeldt & Sonnentag, 2025a) and CA-LU2 (Olefeldt & Sonnentag, 2025b). All other data for this piece of research is publicly available and licensed under CC BY-NC 4.0 (Schulze et al., 2024). All statistic software and functions used for this piece of research are available to be downloaded under https://cran.r-project.org/ (R Core Team, 2020).

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