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# Low evapotranspiration enhances the resilience of peatland carbon stocks to fire

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Highlights:

1. Low evapotranspiration from feather moss peatlands following wildfire.
2. Low evapotranspiration observable at landscape scale through concomitant high surface temperature.
3. Water repellency may act as an important, previously unidentified, control on peatland water loss via evaporation.

## 25    **Abstract**

26    Boreal peatlands may be vulnerable to projected changes in the wildfire regime under future climates.  
27    Extreme drying during the sensitive post-fire period may exceed peatland ecohydrological resilience,  
28    triggering long-term degradation of these globally significant carbon stocks. Despite these concerns, we  
29    show low peatland evapotranspiration at both the plot and landscape scale post-fire, in water-limited  
30    peatlands dominated by feather moss that are ubiquitous across continental western Canada. Low post-fire  
31    evapotranspiration enhances the resilience of carbon stocks in such peatlands to wildfire disturbance and  
32    reinforces their function as a regional source of water. Near-surface water repellency may provide an  
33    important, previously unexplored, regulator of peatland evapotranspiration that can induce low  
34    evapotranspiration in the initial post-fire years by restricting the supply of water to the peat surface.

35

## 36    **1. Introduction**

37    Peatlands represent a global climate regulator and a regionally important water resource, containing one-  
38    third of the global soil carbon pool [Turunen *et al.*, 2002] and accounting for 10% of global surface fresh  
39    water [Holden, 2005]. Wildfire represents the largest disturbance to boreal peatlands, burning almost 1500  
40    km<sup>2</sup> yr<sup>-1</sup> and releasing 6,300 Gg C yr<sup>-1</sup> within Western Canada alone [Turetsky *et al.*, 2002]. However,  
41    peatland carbon stocks are generally resilient to wildfire [Weider *et al.*, 2009]. Despite acting as a net carbon  
42    source in the initial years after fire, peatlands return to a net carbon sink and begin to offset the carbon lost  
43    during wildfires within ~20 years of the disturbance [Weider *et al.*, 2009]. This resilience over multiple fire  
44    cycles arises from a complex array of negative ecohydrological feedback mechanisms that secure peatland  
45    carbon stocks under waterlogged conditions and promote the establishment and growth of keystone moss  
46    species [Waddington *et al.*, 2015; Johnston *et al.*, 2010]. However, changing climatic conditions are  
47    projected to induce drying across the Boreal [Walker *et al.*, 2015], increasing the severity [Turetsky *et al.*,  
48    2011], extent and frequency [Flannigan *et al.*, 2005] of wildfires. Such an alteration to the boreal fire regime  
49    may exceed peatland ecohydrological resilience of carbon stocks [Kettridge *et al.*, 2015b], resulting in their

50 long-term degradation, and providing a critical positive feedback to changing climatic conditions. As a  
51 result, there is an urgent need to identify and understand the key negative feedback mechanisms that regulate  
52 the resilience of peatland carbon stocks to wildfire, which have enabled these ecosystems to persist for  
53 millennia.

54

55 Evapotranspiration (ET) is the dominant water loss mechanism from boreal peatlands [*Lafleur et al.*, 2005;  
56 *Petrone et al.*, 2007; *Brown et al.*, 2010]. The change in ET as a result of wildfire therefore provides the  
57 primary control on the ecosystem's capability to maintain the near-saturated conditions necessary to promote  
58 recovery [*Schouwenaars*, 1988]. Following wildfire, transpiration is substantially reduced due to the loss of  
59 vascular vegetation [*Amiro*, 2001]. Model simulations suggest that these reductions across the Canadian  
60 boreal are largely offset by increased sub-canopy evaporation [*Bond-Lamberty et al.*, 2009]. Further, within  
61 *Sphagnum* dominated boreal peatlands, post-fire ET can exceed pre-fire ET [*Thompson et al.*, 2014]. Canopy  
62 removal increases both the energy availability [*Kettridge et al.*, 2012; *Thompson et al.*, 2015] and the  
63 potential ET within the sub-canopy [*Plach et al.*; 2016]. Within *Sphagnum* dominated peatlands the sub  
64 canopy can account for up to 80% of pre-fire ET [*Gabrielli*, 2016; *Lafleur and Schreader*, 1994]. This may  
65 enhance peatland drying in the initial years following wildfire [*Thompson et al.*, 2014] when ecosystems are  
66 sensitive to perturbation [*Kroel-Dulay et al.*, 2015]. However, continental boreal regions are dominated by  
67 water limited peatlands dominated by feather moss [*Natural Regions Committee*, 2006]. Whilst ET from  
68 peatlands dominated by feather moss are comparable to *Sphagnum* systems [*Kettridge et al.*, 2012], their  
69 post-fire ET are unknown.

70

71 Substantial reductions in peatland evaporation due to drying have been observed under laboratory conditions  
72 [*Kettridge and Waddington*, 2014] and are incorporated in peatland hydrological simulations [*McCarter and*  
73 *Price*, 2012; *Kettridge et al.*, 2015a]. Reductions in evaporation are triggered by low near-surface hydraulic  
74 conductivities that limit upward capillary flow under periods of drying [*Aluwihare and Watanabe*, 2003;

75 *McCarter and Price*, 2012]. Water repellency may also reduce evaporation, as evidenced by laboratory-  
76 based sand column experiments [*Shokri et al.*, 2009], because it causes a hydraulic disconnect and/or a  
77 reduction in the capillary driving force between the soil water store and surface [*Shokri et al.*, 2008]. Given  
78 that water repellency is observed in burned organic soils and peat [*O'Donnell et al.*, 2009; *Beatty and Smith*,  
79 2013], notably within feather moss peat [*Kettridge et al.*, 2014], it may counteract enhanced post-fire drying,  
80 providing an important restriction on peatland ET.

81

82 Post-fire sub canopy ET ( $ET_{sc}$ ) has not been observed within feather moss peatlands, despite their  
83 dominance across continental boreal regions and their functional role as global carbon stock and boreal head  
84 water sources [*Devito et al.*, 2017]. For this reason, we directly measure post-fire  $ET_{sc}$  at the plot scale  
85 within a feather moss dominated peatland that may be vulnerable to post-fire drying. Furthermore, we  
86 expand this examination of  $ET_{sc}$  to the landscape scale, across multiple peatlands. We couple remote sensing  
87 with the dependence of high peat surface temperature on low  $ET_{sc}$  [*Kettridge et al.*, 2012], recognizing that  
88 if  $ET_{sc}$  is low because the water supply to the surface is impeded then evaporative cooling of the surface is  
89 reduced, resulting in high surface temperatures. We determine how  $ET_{sc}$  responds to the high evaporative  
90 demand post disturbance and consider: i) the ecological and hydrological controls that regulate this primary  
91 water loss mechanism and ii) the implications of this response to the ecohydrological resilience of these  
92 carbon rich landscapes.

93

## 94 **2. Methods**

### 95 **2.1 Study site**

96 Field measurements were conducted within a peatland located on a coarse-textured outwash plain [*Smerdon*  
97 *et al.*, 2005; *Lukenbach et al.*, 2015, 2016] within the Utikuma Region Study Area (URSA), north-central  
98 Alberta (56.107°N 115.561°W). Prior to fire, the study site had a dense black spruce tree canopy (stem  
99 density of approximately 7,000 stems per hectare). The peatland burned in May 2011 during the ~90,000 ha

100 Utikuma complex forest fire. The fire resulted in complete mortality of above ground biomass. We classified  
101 the central portion of the peatland into two dominant surface covers based on the vegetation communities  
102 [Lukenbach *et al.*, 2015]. The first microhabitat was dominated by feather moss (*Pleurozium schreberi*; 73%  
103 coverage [Lukenbach *et al.*, 2015]). Combustion of the feather moss microhabitat occurred to a depth of  $0.02$   
104  $\pm 0.01$  m [Lukenbach *et al.*, 2016]. The second microhabitat was dominated by *Sphagnum* (*Sphagnum*  
105 *fuscum*; 19 % coverage [Lukenbach *et al.*, 2015]), which remained largely intact following the wildfire, with  
106 only slight observable combustion (singeing) of the peat surface (*Sphagnum capitula* intact) [Lukenbach *et*  
107 *al.*, 2016].

108

## 109 2.2 Plot scale sub-canopy evapotranspiration measurement

110  $ET_{sc}$  was measured at three representative locations within each microhabitat every hour between May and  
111 August 2012, one year after the fire, using Perspex® chambers (surface area,  $0.2\text{ m}^2$ ; volume  $\sim 0.05\text{ m}^3$ ).  
112 Each chamber closed for two minutes each hour, during which the air within the chamber was continuously  
113 mixed by a fan.  $ET_{sc}$  at each measurement time was calculated from the rate of increase in humidity within  
114 the closed chamber (ACS-DC; Licor LI-840) [cf Kettridge and Waddington, 2014; McLeod *et al.* 2004]. The  
115 controls of the different microhabitats on daily  $ET_{sc}$  were analyzed using a general linear model [R Core  
116 Team, 2016] with the zone as a fixed effect and the chamber as a random effect to account for the lack of  
117 independence among collar measurements. Surface temperature was measured every hour within each  
118 chamber using a type-T thermocouple inserted just below the moss/peat surface. Leaf area index (LAI) was  
119 determined for each chamber throughout the growing season from the classification of digital images of the  
120 chambers [Kettridge and Baird, 2008], and at the end of the growing season (August 2012) using the leaf  
121 count approach [Strack *et al.*, 2004]. Stomatal conductance of three leaves on three plants of each species  
122 within each chamber was measured where available using an AT4 Delta-T porometer. In combination with  
123 measured LAI, the stomatal conductance was used to calculate the proportion of  $ET_{sc}$  lost via evaporation  
124 (see S.1).

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In early June 2013, two years after fire,  $ET_{sc}$  was measured at a further 37 locations (18 feather moss, 19 *Sphagnum*) across the full extent of the peatland during a period of high potential evaporation: humidity =  $25.8 \pm 6.0\%$  (average  $\pm$  standard deviation); air temperature =  $29.8 \pm 2.7$  °C.  $ET_{sc}$  was measured using a mobile chamber system equivalent to the automatic system described above (PP systems EGM-4 infrared gas analyzer, chamber dimensions: diameter 0.3 m, height 0.5 m). Following  $ET_{sc}$  measurement, water repellency was measured at each location at a depth of 0.02 m (i.e., the zone within the moss/peat profile of extreme water repellency [Kettridge *et al.*, 2014]) using the water drop penetration test (WDPT). This approach is used widely to characterize and compare the persistence of soil water repellency [Doerr, 1998; Dekker *et al.*, 2000; Letey, 2001] and involves measuring the time taken for a water droplet placed on the surface to infiltrate completely. Water repellency was determined from the classification of five water drops applied at separate positions within each chamber area. Each water drop location was classified as hydrophilic (<5 s), slightly hydrophobic (5-60 s), strongly hydrophobic (60-600 s) or severely hydrophobic (>600 s) [Dekker *et al.*, 2000]. The water drop penetration time of each plot was taken as the average of the five discrete water droplet classes applied.

### 2.3 Thermal remote sensing and landscape classification

Remotely observed surface temperatures have been used widely to derive ET [Fisher *et al.*, 2017]. However, direct calculation of ET can be difficult [Zhang *et al.*, 2016]. Small variations in surface temperatures (<1°C) result from numerous controls that vary in response to fire [Rocha and Shaver, 2011]. Detailed simulations of adjacent burned and unburned peatlands (<40 km from the study site) examined the magnitude of different controls on peat surface temperatures; notably, differences in microclimate, moisture content, vegetation cover, albedo, surface roughness and potential difference in  $ET_{sc}$  were the primary controls [Kettridge *et al.*, 2012]. The impact on peat surface temperatures of these above differences were limited; the compound impact of these variations increased maximum surface temperature by only 2.3 °C [Kettridge *et*

150 *al.*, 2012]. In comparison, reducing  $ET_{sc}$  to zero increased simulated surface temperature by  $>6^{\circ}C$  more than  
151 a freely evaporating peat surface. Therefore, only low/near-zero  $ET_{sc}$  can induce substantial increases in peat  
152 surface temperatures. Surface temperature of peat can thus be used to differentiate between regions in which  
153 ET is occurring freely and areas in which ET is severely restricted. This capability maps directly onto i) the  
154 bimodal nature of laboratory measures of peat evaporation (peat cores demonstrate rapid transitions in  
155 evaporation when threshold drying is exceeded [Kettridge and Waddington, 2014]), ii) the bimodal ET  
156 applied in peatland modelling studies [Kettridge *et al.*, 2015a; McCarter and Price, 2012] and iii) the  
157 characteristic transitions between stage I and stage II evaporation for soils more generally [Or *et al.*, 2013].  
158

159 To classify landscape-scale peatland ET, Airborne LiDAR (Light Detection and Ranging) and forward-  
160 looking thermal FLIR digital imagery (FLIR Inc. S60, Boston, MA, USA) were captured from an aircraft  
161 between 16:00 and 16:30 on August 12, 2011, approximately three months after the wildfire. Measurements  
162 were taken during clear conditions (Figure S.1), with an air temperature of  $25^{\circ}C$ , relative humidity of 34%  
163 and average wind speed of  $2.0\text{ m s}^{-1}$  (recorded at an adjacent unburned peatland) [*cf. Thompson et al.*, 2014].  
164 Four adjacent and overlapping flight lines of approximately 800 m width were flown for FLIR imagery,  
165 covering  $40\text{ km}^2$  across the region, with measurements obtained at a ground sample spacing of  $\sim 1.3\text{ m}$  along  
166 and across track. Of this region,  $8.7\text{ km}^2$  was burned as part of the Utikuma Complex forest fire. The thermal  
167 imaging used the infrared range of the electromagnetic spectrum, quantifying skin (surface) temperatures  
168 from the amount of radiation emitted from the surface in accordance with Stephan-Boltzman Law.  
169 Measurements assumed a black body with emissivity equal to 0.95, which is the emissivity of wet soil  
170 [Weast, 1986]. Thermal imagery was linearly ramped from 10 to  $50^{\circ}C$  and manually georegistered to the  
171 corresponding LiDAR imagery and resampled to  $1\text{ m} \times 1\text{ m}$  pixel resolution following methods first  
172 described in Hopkinson *et al.* [2010]. Wetland and forestland areas were classified by Chasmer *et al.* [2016]  
173 from LiDAR images obtained prior to the fire.  
174

### 3. Results

ET<sub>sc</sub> of burned feather moss ( $0.63 \pm 0.27 \text{ mm day}^{-1}$ ) was significantly lower than that of burned *Sphagnum* ( $3.03 \pm 0.13 \text{ mm day}^{-1}$ ) (Figure 1a;  $df = 4$ ,  $t = -22.32$ ,  $p < 0.001$ ). The lower ET<sub>sc</sub> of feather moss throughout the day (Figure 1b) was associated with daily maximum surface temperatures more than 20 °C greater than the surface temperature of *Sphagnum* (Figure 1c). The LAI was low within *Sphagnum* chambers (*Ledum groenlandicum* and *Vaccinium oxycoccus*), increasing from an average of 0.22 to 0.45 over the measurement period (May to August). Given these values, evaporation accounted for between 55% and 78% of ET<sub>sc</sub> in the *Sphagnum* chambers through the growing season (see S.1). Within the feather moss chambers, there was no leaf cover. Therefore, ET<sub>sc</sub> was entirely attributable to evaporation.

Across the peatland, between 11:00 and 16:00 on a day of high evaporative demand, ET<sub>sc</sub> varied between -0.008 (dewfall) and 0.17 mm hr<sup>-1</sup> ( $\mu = 0.038 \text{ mm hr}^{-1}$ , standard error = 0.0058 mm hr<sup>-1</sup>,  $n = 41$ ). During this period (i) ET<sub>sc</sub> ( $p < 0.0001$ ,  $Z = -4.892$ ,  $n = 37$ ), (ii) surface temperature ( $p < 0.001$ ,  $F = 5.202$ ,  $n = 37$ ) and (iii) mean water drop penetration time at a depth of 0.02 m ( $p < 0.0001$ ,  $Z = -5.318$ ,  $n = 37$ ), all differed significantly between burned *Sphagnum* and feather moss microhabitats. All *Sphagnum* microhabitats were hydrophilic. Feather moss plots were predominantly strongly hydrophobic (78%), with a small proportion classified as severely hydrophobic (17%) and slightly hydrophobic (6%).

Average surface temperatures of the previously treed and non-treed peatland areas within the fire perimeter were 11 °C higher than outside the fire perimeter (Figure 2). Outside the burn, mean surface temperature within the treed and non-treed peatland area averaged  $23 \pm 4 \text{ °C}$  ( $\pm$  standard deviation). Within the perimeter, treed and non-treed peatland surface temperatures averaged  $34 \pm 10 \text{ °C}$ . These high surface temperatures within the burned region strongly suggest that the low post-fire ET<sub>sc</sub> observed over time within the auto chambers and across the peatland from the roving chamber measurements, are evident at the landscape scale across multiple peatlands within the burn scar. It is not currently feasible to confidently classify the

200 subsurface micro habitats from post fire remote sensing imagery and thus to directly compare temperatures  
201 between feather moss and *Sphagnum* micro habitats at the landscape scale.

202

## 203 **4. Discussion**

### 204 4.1 Cross-scale post-fire sub-canopy evapotranspiration

205 Differences in post-fire  $ET_{sc}$  between feather moss and *Sphagnum* microhabitats are stark and are far in  
206 excess of differences observed previously within unburned peatlands (Figure 3a; [Heijmans *et al.*, 2004;  
207 Brown *et al.*, 2010; Kettridge *et al.*, 2013]). Average post-fire *Sphagnum*  $ET_{sc}$  is similar in magnitude to  
208 previous studies. Concurrently,  $ET_{sc}$  from feather moss microhabitats is lower than any previous peatland  
209 study, including those in which the vascular vegetation cover is removed reducing transpiration to zero  
210 [Heijmans *et al.*, 2004]. As a result, the ratio between *Sphagnum* and feather moss  $ET_{sc}$  was equal to 5.0,  
211 three times that of the unburned sites (Figure 3b). Further, this ratio was even higher (8.1) under a period of  
212 extreme evaporative demand during the spatial survey. The response of the peatland sub-canopy thus  
213 appears to show a diverging pattern in response to fire, with post-fire  $ET_{sc}$  from *Sphagnum* microhabitats  
214 being largely maintained, and  $ET_{sc}$  from feather moss microhabitats reducing to rates equivalent to black  
215 spruce boreal forests above a mineral soil [Heijmans *et al.*, 2004].

216

217 Post-fire ET can exceed pre-fire losses in *Sphagnum* dominated-boreal peatlands (Figure 4) [Thompson *et*  
218 *al.*, 2014]. Pre-fire, feather moss peatland ET is similar to *Sphagnum* dominated ecosystems [Kettridge *et al.*,  
219 2012]. However, ET within these ecosystems is reduced substantially post-fire due to the loss of tree  
220 transpiration and the inability of the burned feather moss sub canopy to respond to the increased evaporation  
221 potential (Figure 4). Elevated surface temperatures in the burnt peatland areas of the remotely surveyed  
222 region highlight the wide spatial extent of this low post-fire ET at the landscape scale. Whilst complex  
223 feedback mechanisms regulate near-surface soil temperatures [Kellner *et al.*, 2001; Kettridge and Baird,  
224 2010], only near-zero ET can induce the high surface temperatures observed [Kettridge *et al.*, 2012]. Where

the remote sensing was undertaken, wetlands accounted for 47% and 60% of the land surface area within the till moraine and clay plain hydrogeological settings, respectively [Chasmer *et al.*, 2016]. Therefore, low post-fire ET within feather moss peatlands not only influences the ecohydrological function the individual wetlands, but also has the potential to result in large-scale transitions in water conservation within the western boreal plain; with such peatlands acting as regional scale head water sources in the sub-humid climate of the Boreal Plains [Devito *et al.*, 2017].

The dominance of peatland communities varies widely among peatlands driven by differences in climate, hydrogeology [Devito *et al.*, 2005], age [Benscoter and Vitt, 2008], disturbance regime [Turetsky *et al.*, 2012] and recovery period [Benscoter and Vitt, 2008; Lukenbach *et al.*, 2016]. *Sphagnum* dominated systems, where increased evaporation may exceed small reductions in tree transpiration post-fire (Figure 4) [Thompson *et al.*, 2014], tend to be wetter and deeper peatlands with larger water and carbon stocks available to endure discrete disturbances. In comparison, feather moss dominated peatlands are associated with low available light, shallow peat depths and deeper water table positions [Bisbee *et al.*, 2001]. Importantly, these drier peatland systems with higher pre-fire tree transpiration and limited carbon stocks will likely show a strong negative feedback response to fire, with both reduced  $ET_{sc}$  and tree transpiration post-disturbance (Figure 4).

#### 4.2 Controls on post-fire sub-canopy evapotranspiration

The extreme contrast in post-fire  $ET_{sc}$  between *Sphagnum* and feather moss microhabitats results, in part, from the lack of recovery of vascular vegetation within the feather moss microhabitats and thus the low sub-canopy transpiration. Despite that,  $ET_{sc}$  remains lower than in manipulation experiments in which the vascular vegetation is removed [Heijmans *et al.*, 2004] (Figure 3), with the exposed moss unable to meet the high post-disturbance potential evaporative demand [Kettridge and Waddington, 2014; McCarter and Price, 2014]. Even under high post-fire evaporative demand, *Sphagnum* profiles maintain connectivity with

250 subsurface water stores. In comparison, within the study site, a severe disconnect occurs between the burned  
251 feather moss surface and saturated water stores just 0.33 m below [Lukenbach *et al.*, 2016]. This results from  
252 the nature peat moss structure which unlike *Sphagnum* does not have an effective external wicking system  
253 along the moss surfaces [Callaghan *et al.*, 1978] and the low moisture content observed at the study site  
254 within the near-surface of the peat [Lukenbach *et al.*, 2016]. Lower water contents reduce the unsaturated  
255 hydraulic conductivity, which limits the supply of water to the peat surface, leading to further drying of the  
256 near-surface [Waddington *et al.*, 2015; McCarter and Price, 2014]. Here, we hypothesize that this feedback  
257 response is further enhanced by the water repellent nature of the feather moss profile, induced by drying and  
258 enhanced by fire [Kettridge *et al.*, 2014].

259  
260 Water repellency is more severe under dry conditions and can arise from bonding of organic substances to  
261 soil particles because of the temperatures experienced during the wildfire [Doerr *et al.*, 2000]. Thus, the low  
262 moisture content in the near-surface of the burned feather moss induces water repellent conditions. A  
263 severely hydrophobic layer is observed at a depth of 0.02 m, and extends between a depth of 0.01 and 0.07  
264 m with a slightly hydrophobic layer above and a hydrophilic layer below [Kettridge *et al.*, 2014]. The direct  
265 control of this water repellent layer on water transport through the peat profile is not certain. Further, the  
266 codependence of evaporation, water repellency, hydraulic conductivity and moisture content prevents the  
267 direct control of water repellency on evaporation being defined here. This may be examined within future  
268 research in which the water repellent nature of moss species is altered by without impacting the soil  
269 structure. Within laboratory-based sand columns experiments such an approach has shown water repellency  
270 to substantially reduce evaporation, causing a hydrological disconnect and/or reduction in the capillary  
271 driving force between the soil-water store and the evaporation surface [Bachmann *et al.*, 2001; Shokri *et al.*,  
272 2008]. The water repellent layer may accordingly act as a figurative one-way valve, permitting rainfall to  
273 percolate down through preferential flow pathways to the water table beneath because of the high porosity of  
274 the peat and the abundance of macro pores [Holden, 2009], but restricting its loss via evaporation at local

and regional scales [Rye and Smettem, 2017]. Such a feedback response would limit peatland evaporation during periods of high solar radiation resulting from the burning of the shrub and canopy cover [Thompson *et al.*, 2015]. Whilst water repellency in the studied peatland persisted for at least two years, depending upon site conditions, water repellency can remain for of several years [Doerr *et al.*, 2000]. Water repellency therefore has the potential to conserve water during this period, protecting the peatland until a shrubs and canopy cover increases shading and reduce evaporative demand.

## 5. Conclusion

Sub canopy evapotranspiration ( $ET_{sc}$ ) is a critical determinant of peatland carbon stock vulnerability to wildfire and has the potential to influence landscape-scale transitions in water availability. Despite increased energy availability due to the open post-fire canopy and increased turbulent exchange from the sub-canopy post-fire, feather moss  $ET_{sc}$  was extremely low, equivalent to rates observed within a black spruce boreal forests above a mineral soil. Thus, rather than counteracting post-disturbance reductions in tree transpiration from the canopy,  $ET_{sc}$  enhances such reductions in systems dominated by feather moss (Figure 4). Reduced  $ET_{sc}$  results from the poor recovery of the sub-canopy vascular vegetation cover and the hydraulic disconnect of the surface from the saturated peat just decimeters below. The latter is likely due to the low hydraulic conductivity of the dry near-surface peat and the severely hydrophobic nature of the post-disturbance feather moss peat. Moreover, low post-fire ET was evident at the landscape scale. Thus, shallow water tables and associated near-saturated conditions will be maintained across the burned regions, protecting boreal peat by reducing decomposition rates [Waddington *et al.*, 2015] and increasing the resilience of their carbon stocks to disturbance over multiple fire cycles. Further it will enable peatlands to act as important post-fire water sources within boreal landscape.

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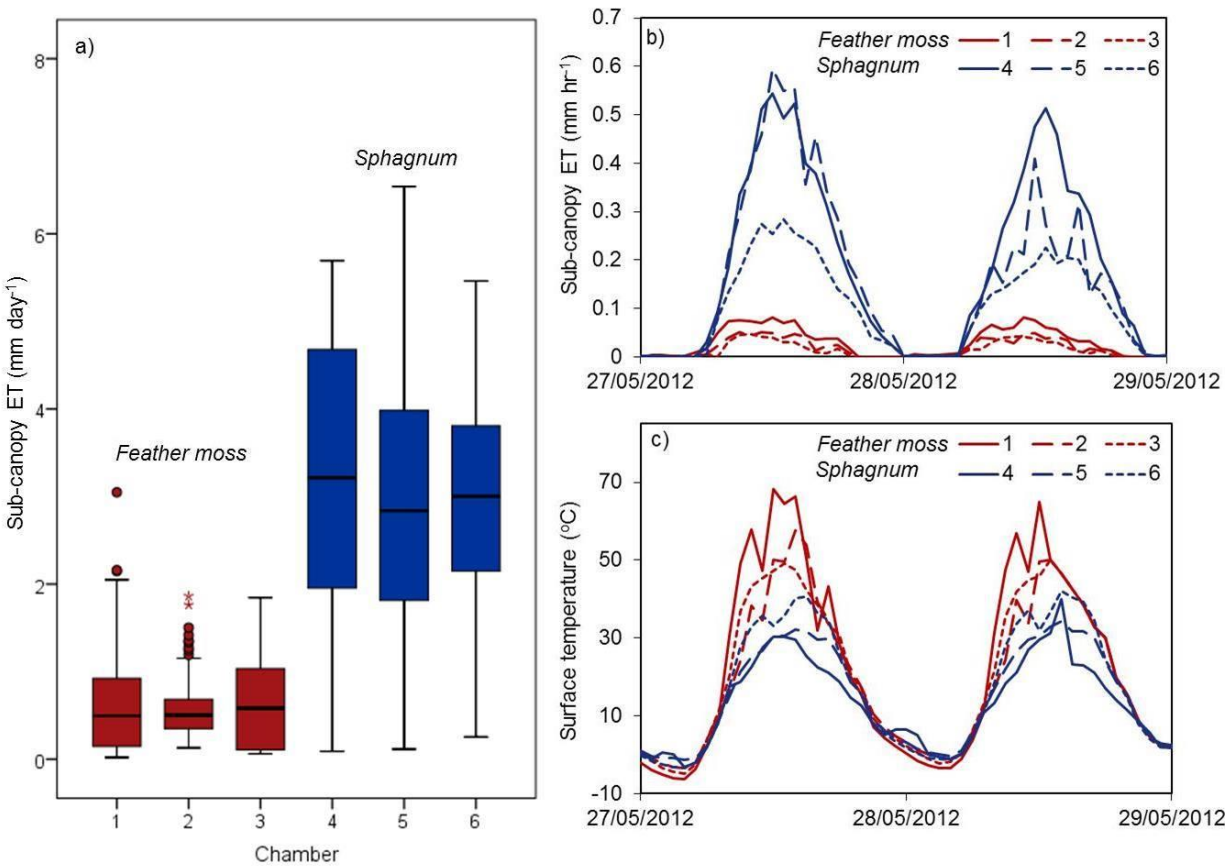
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505 Figure 1: a) Distribution of median (total) daily sub canopy evapotranspiration measured in six auto  
506 chambers within burned feather moss and *Sphagnum* microhabitats for the entire measurement period.  
507 Diurnal fluctuation in b) hourly sub-canopy evapotranspiration and c) hourly surface temperature across two  
508 representative days for the six auto chambers.

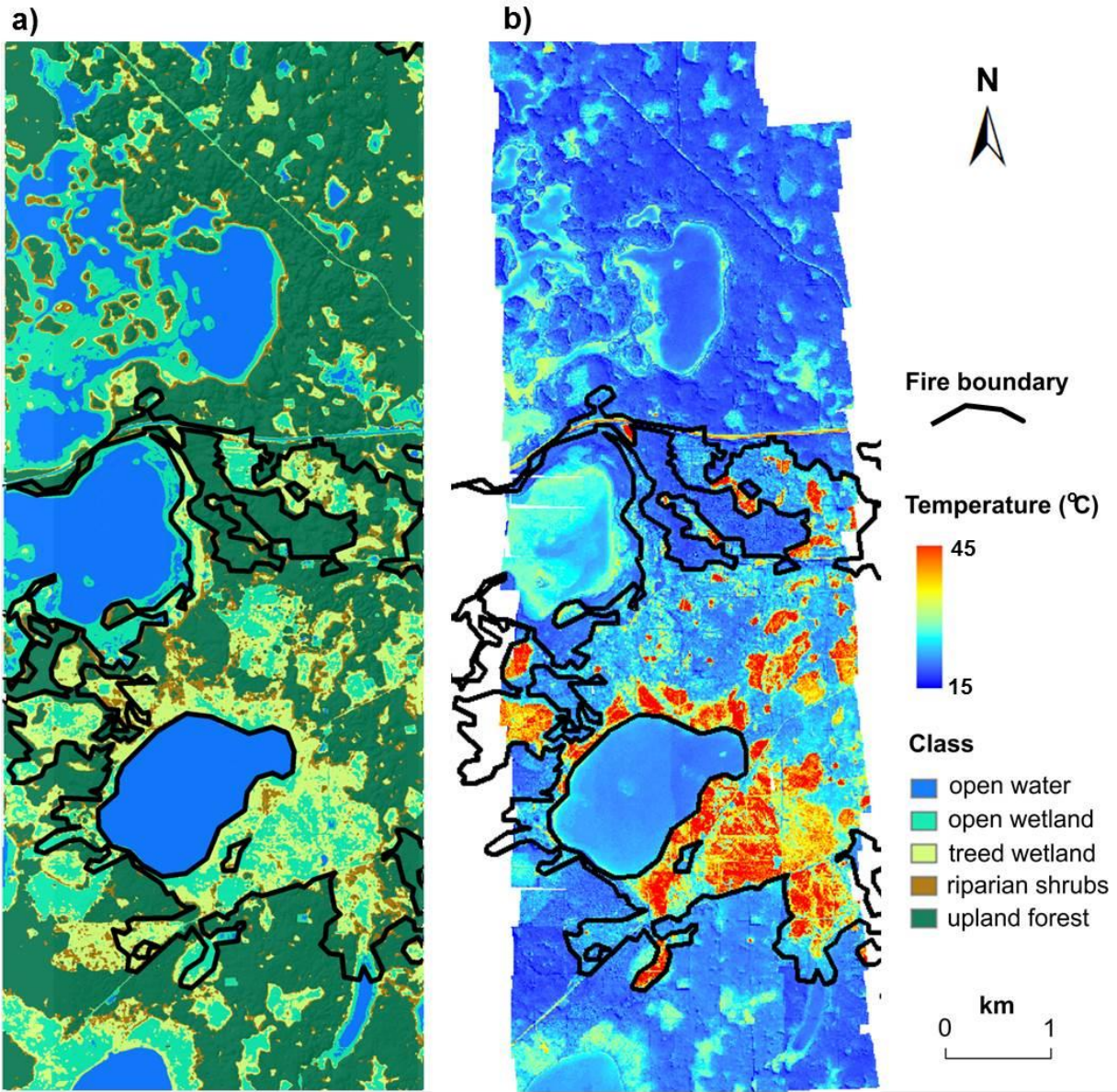


Figure 2: (a) Landcover classification (after *Chasmer et al.* [2016]) and (b) thermal image of remote sensing area. Burned area is within the solid black lines in lower half of images.

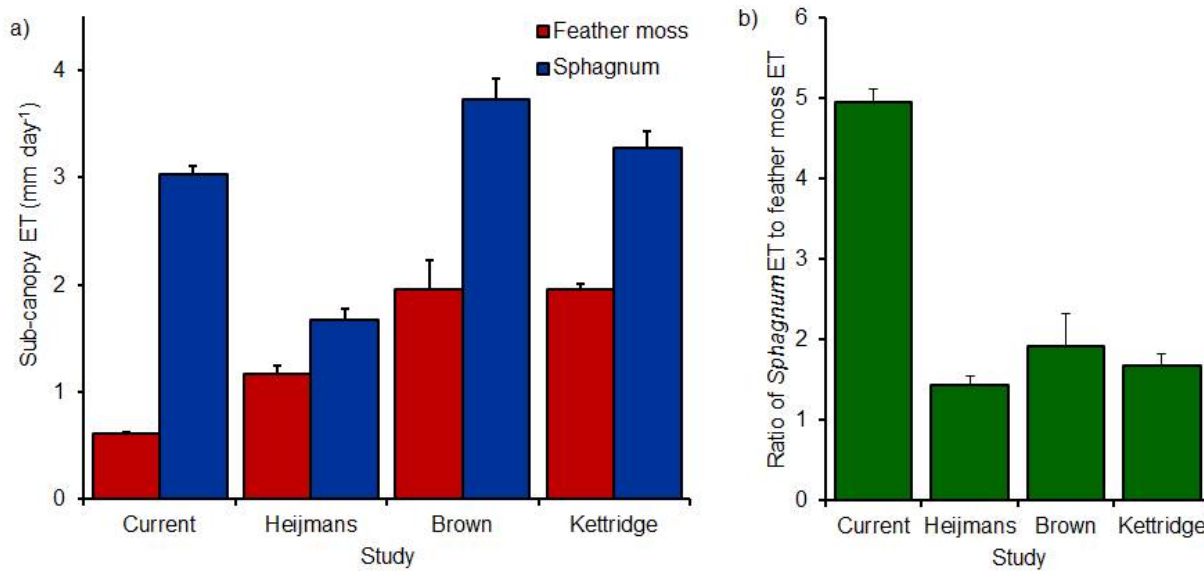


Figure 3: a) Sub-canopy evapotranspiration (ET<sub>sc</sub>) from *Sphagnum* and feather moss microhabitats in the current study, and from the studies of *Heijmans et al.* [2004], *Brown et al.* [2010] and *Kettridge et al.* [2013]. b) Ratio of *Sphagnum* and feather moss ET<sub>sc</sub> presented within a). *Sphagnum* communities consist of *S. fuscum* only in the current study and the study of *Kettridge et al.* [2013]. *S. fuscum* dominates *Sphagnum* microhabitats in *Heijmans et al.* [2004] and *Brown et al.*, [2010]. However, *S. capillifolium* is also present in microhabitats of *Brown et al.*, [2010] and *S. capillifolium* and *S. magellanicum* are present in micro habitats of *Heijmans et al.* [2004]. ET<sub>sc</sub> is measured diurnally within the current study and in *Heijmans et al.* [2004]. Within *Brown et al.* [2004] and *Kettridge et al.*, [2013], ET<sub>sc</sub> is measured between 10:00 and 16:00. Daily totals presented are calculated assuming the ratios with the current study are maintained over the entire diurnal cycle.

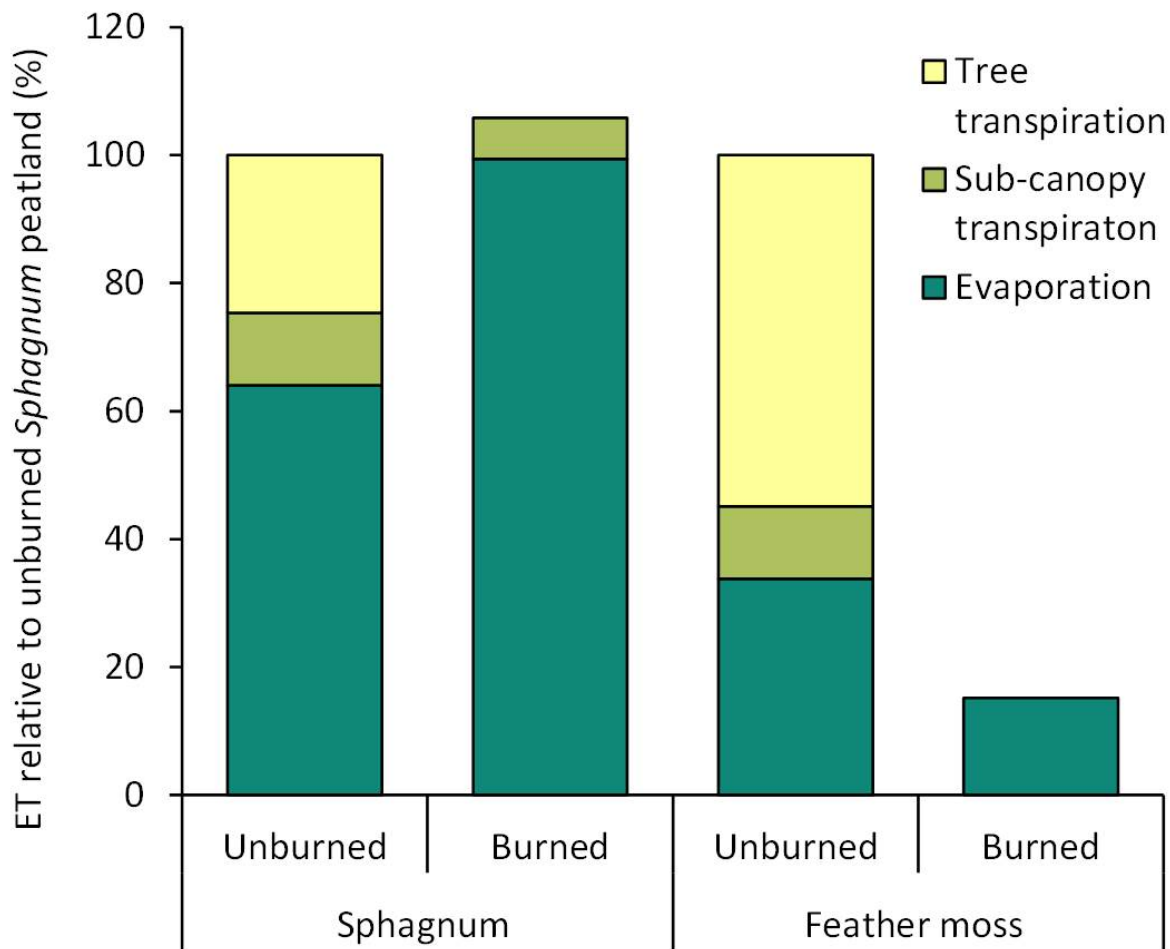


Figure 4: Evapotranspiration (ET) from burned and unburned *Sphagnum* and feather moss dominated peatlands and their associated components relative to ET from a *Sphagnum* dominated peatland. *Sphagnum* evapotranspiration fluxes were derived from Thompson *et al.* [2014]. Unburned feather moss ET equal to unburned *Sphagnum* peatland [cf. Kettridge *et al.*, 2013]. Unburned feather moss sub-canopy evapotranspiration from Heijmans *et al.* [2004], Brown *et al.* [2004] and Kettridge *et al.*, [2013], with sub-canopy transpiration component assumed equivalent to the unburned *Sphagnum* peatland (Figure 3). Burned feather moss ET derived within this study.