Supplementary materials

Supplement S1

Reconstruction of the density of monthly lightning flashes (Lm) (n/day/km2) between 1901 to 2012

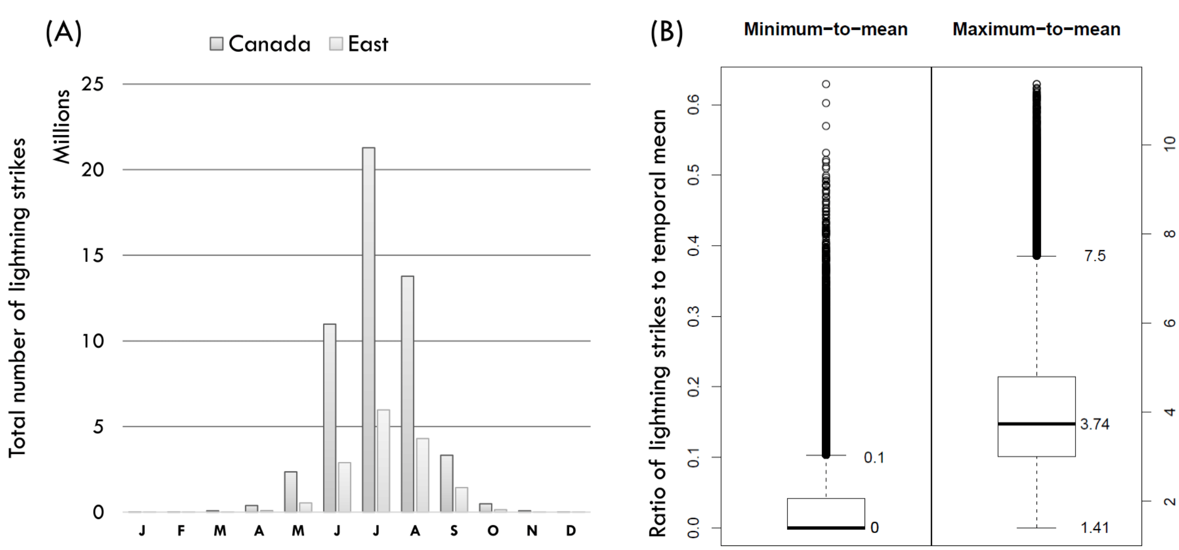
[1] $coef = \max(|\max(\int_t CAPEano)|, |\min(\int_t CAPEano)|)$

[2] $CAPEano_N = CAPEano / coef$

[3] $Lm = \begin{cases} CLDNm*(1+7.5*CAPEano_N), CAPEano_N \geq 0 \\ CLDNm*(1+0.1*CAPEano_N), CAPEano_N < 0 \end{cases}$

CAPE anomalies (CAPEano) correspond to monthly differences on a grid cell level at time t compared to the average of monthly CAPE from 1961 to 1990. For each grid cell, the time-series of CAPEano was normalized to a range between -1 and 1 ($CAPEano_N$) by dividing CAPEano by the maximum value between the absolute value of the largest positive and negative CAPE anomalies of the time series (eq. 1 and 2). Monthly flash density (/day/km^2) between 1901 to 2012 was calculated on the base of the monthly flashes climatology between 1999 to 2010 ($CLDN_m$) but interannual flash variability was applied using $CAPEano_N$ and min-to-mean and max-to-mean ratios (eq. 3). We determined min-to-mean and max-to-mean ratios (0.1 and 7.5, respectively; Fig. S1 B) by compiling grid cell values of CLDN database with more than 5 years of observations in July between 1999 and 2010 across Canada and within our study area (Fig. S1 A).

Fig. S1. (A) Monthly total number of flashes in Canada and in eastern Canada (our study area) from 1999 to 2010. (B) Box plots of minimum-to-mean and maximum-to-mean ratio for flashes in July from 1999 and 2010 based on 60747 grid cells in Canada with more than 5 years reporting observations.



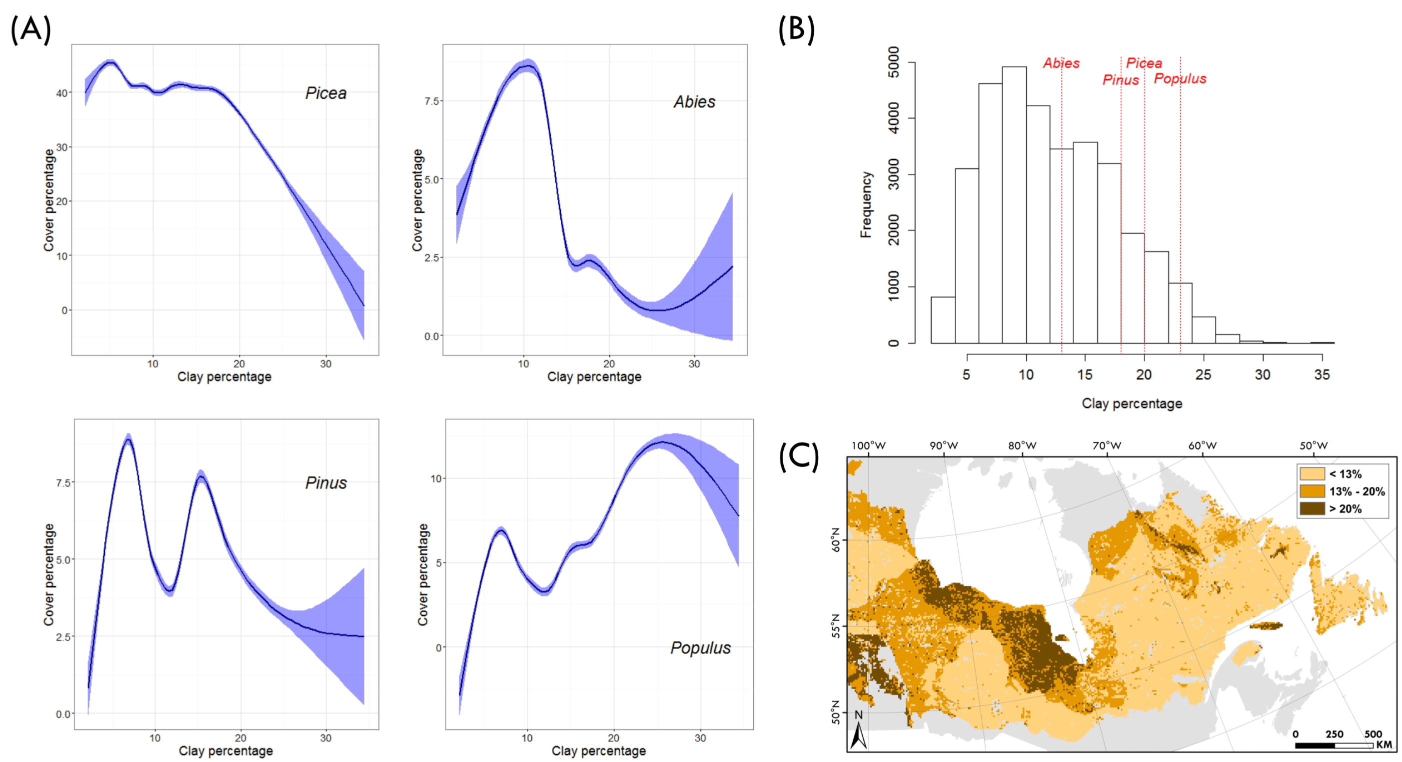
Supplement S2

Table S1. LPJ-LMfire PFT parameter values in this study (boreal needleleaved evergreen tree and summergreen tree parameters values from (Pfeiffer et al., 2013) were assigned for the others parameters not presented in this table).

Parameters		Genus-specific PFT				References
		Picea	*Abies*	*Pinus*	*Populus*	
	Fraction of roots in upper soil layer (50cm)	0.9	0.5	0.5	0.3	Natural resources Canada 2017 and US forest service
	Sapwood turnover period	20	40	20	30	
	Leaf to root ratio under non-water stressed conditions	0.190	0.165	0.165	0.14	Poorter et al. (2012)
	Summergreen phenology ramp GDD5 requirement to grow full leaf canopy	800	1400	766	180	Girardin et al. (2011)
	Sapling (or grass on initialisation) LAI	3.4	9.3	4.4	3.2	Calculated from Iio et al. (2014)
	Min./Max. temperature of the coldest month for establishment (ºC day)	-31.65/-6.80	-25.25/-4.85	-29.25/-9.15	-29.30/3.70	
	Min GDD5 for establishment (ºC day)	300	400	550	345	
	Max. temperature of the warmest month to persist (ºC day)	20.70	20.65	20.60	24.85	
	Crown length	1	1	0.4	0.5	Derived from Groot and Schneider (2011) and Hély et al. (2003)
	Bark thickness	0.032	0.031	0.040	0.027	Andrews et al. (2005)
Fire resistance	Crown damage parameter	1	3	2	0.2	*personal communications*

Supplement S3

Fig. S2. (A) Local polynomial regression (with 95% confidence interval) between genus-specific cover percentage from Beaudoin et al. (2014) and clay percentage from Hengl et al. (2014) in eastern boreal Canada. Only grid cells with a total cover for 4 species studied greater than 10% have been taken into account in these analyses. (B) Clay percentage distribution in eastern boreal Canada. Each vertical red lines corresponds to the upper limit of the 90% CI of the distribution of clay percentage for each PFTs. (C) Map of clay percentage in eastern boreal Canada with threshold of the upper limit of the 90% CI of the distribution of clay percentage for *Abies* and *Picea* PFTs.



Supplement S4

Fig. S3. Location of stand-replacing fire history studies in eastern Canada with correspondence ID number to Table S2.

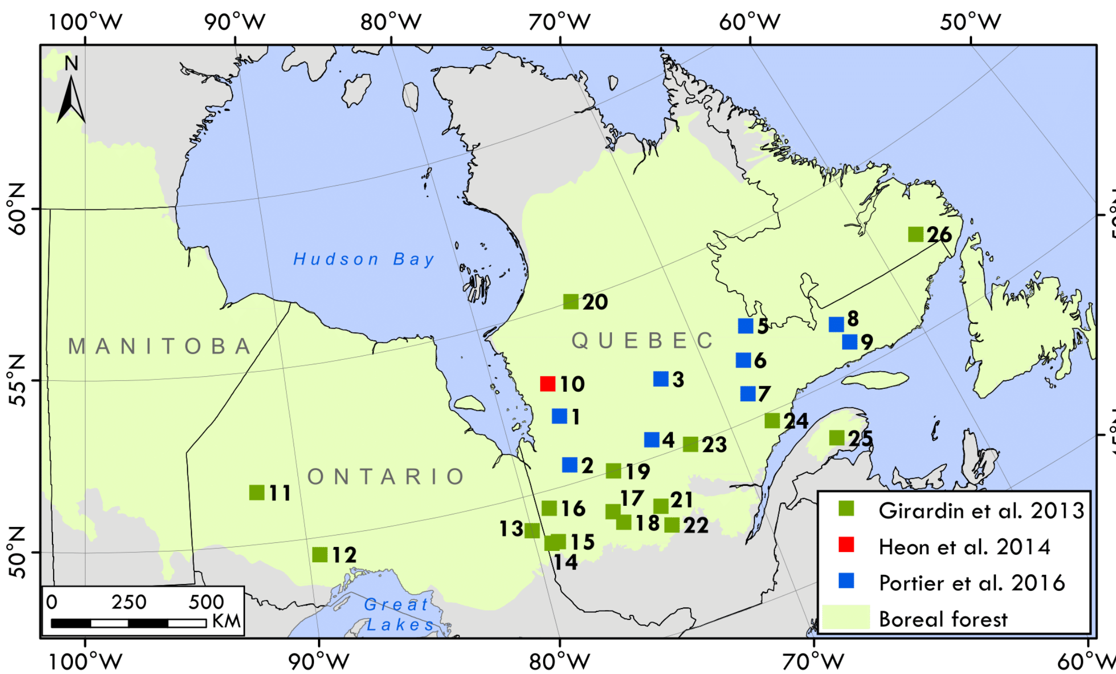
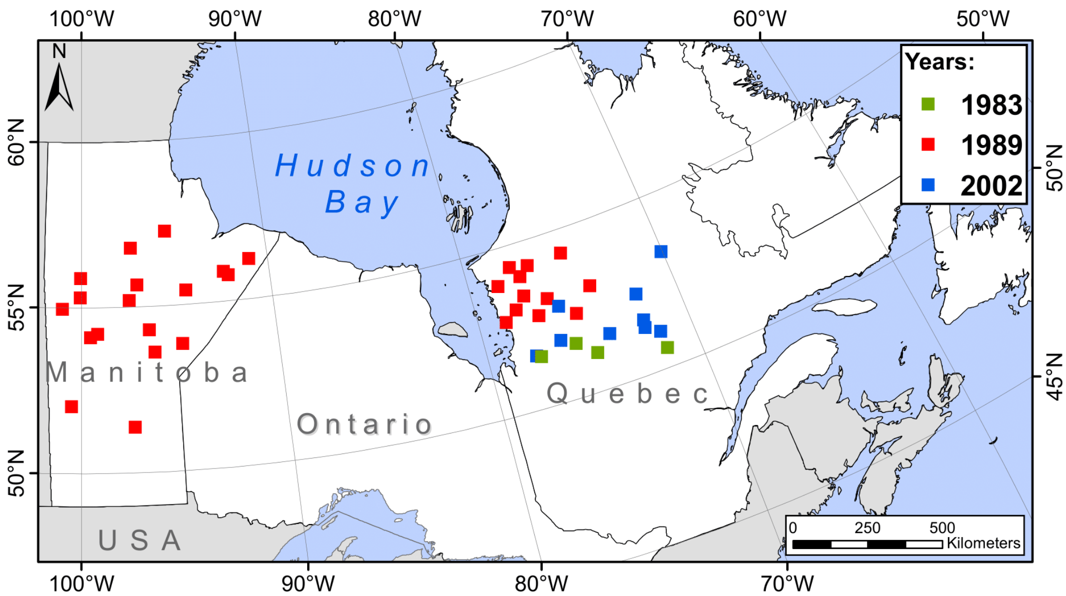


Table S2. Observed annual burn rates (with 2.5 and 97.5 percentiles) from stand-replacing fire history studies and from LPJ-LMfire since 1911 to 2012. Significant differences are underlines.

ID	X	Localisation	Observed	Simulated	References
1		North	4.875 (3.119 – 10.642)	0.384 (0.175 – 0.773)	
2		South	0.637 (0.410 – 1.030)	0.427 (0.211 – 0.768)	
3		North	3.190 (1.462 – 11.151)	0.345 (0.069 – 0.752)	
4		South	0.477 (0.323 – 0.762)	0.484 (0.231 – 0.879)	
5		North	2.859 (2.110 – 4.827)	0.186 (0.043 – 0.373)	
6		Center	0.354 (0.177 – 0.791)	0.199 (0.042 – 0.458)	
7		South	0.146 (0.070 – 0.326)	0.262 (0.054 – 0.597)	
8		North	1.761 (0.923 – 3.800)	0.163 (0.026 – 0.373)	
9		South	0.129 (0.052 – 0.386)	0.151 (0.025 – 0.362)	
10	1910-2013	Baie James	2.400	0.415 (0.164 – 0.835)	(Héon et al. (2014)
11	~1870-1974	Northern Ontario	1.920	0.648 (0.335 – 1.164)	
12	unknown -2000	Lake Nipigon	0.711	0.689 (0.379 – 1.116)	
13	1740-1998	LAMF	0.580	0.466 (0.000 – 0.855)	
14	~1750-1988	Western Quebec	0.720	0.414 (0.000 – 0.726)	
15	1580-2000	Western Abitibi South	0.334	0.415 (0.000 – 0.753)	
16	1530-1996	Western Abitibi North	0.604	0.531 (0.297 – 0.892)	
17	1770-1995	Eastern Abitibi	0.708	0.435 (0.226 – 0.746)	
18	1760-1998	Abitibi east Quebec	0.900	0.441 (0.241 - 0.747)	
19	1720-2000	Waswanipi	0.812	0.439 (0.238 – 0.788)	
20	1920-1984	Northern boreal	1.000	0.196 (0.074 – 0.378)	
21	1720-1998	Central Quebec 2	0.665	0.513 (0.224 – 1.067)	
22	1720-1998	Central Quebec	0.790	0.505 (0.192 – 0.930)	
23	unknown-2000	Lac Saint Jean	0.286	0.411 (0.093 – 0.791)	
24	1640-2000	North Shore	0.367	0.272 (0.048 – 0.555)	
25	1680-2000	Gaspesie	0.643	0.150 (0.000 – 0.419)	
26	1870-1975	Southeastern Labrador	0.200	0.124 (0.000 – 0.272)	

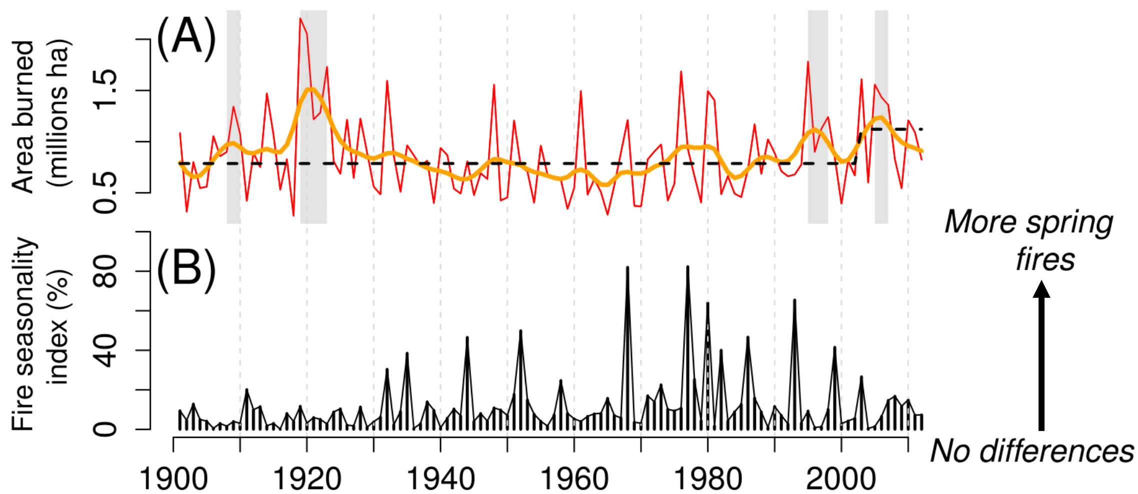
Supplement S5

Fig. S4. Location of fires exceeding 50,000 ha in eastern Canada for three years of extreme fire activity.



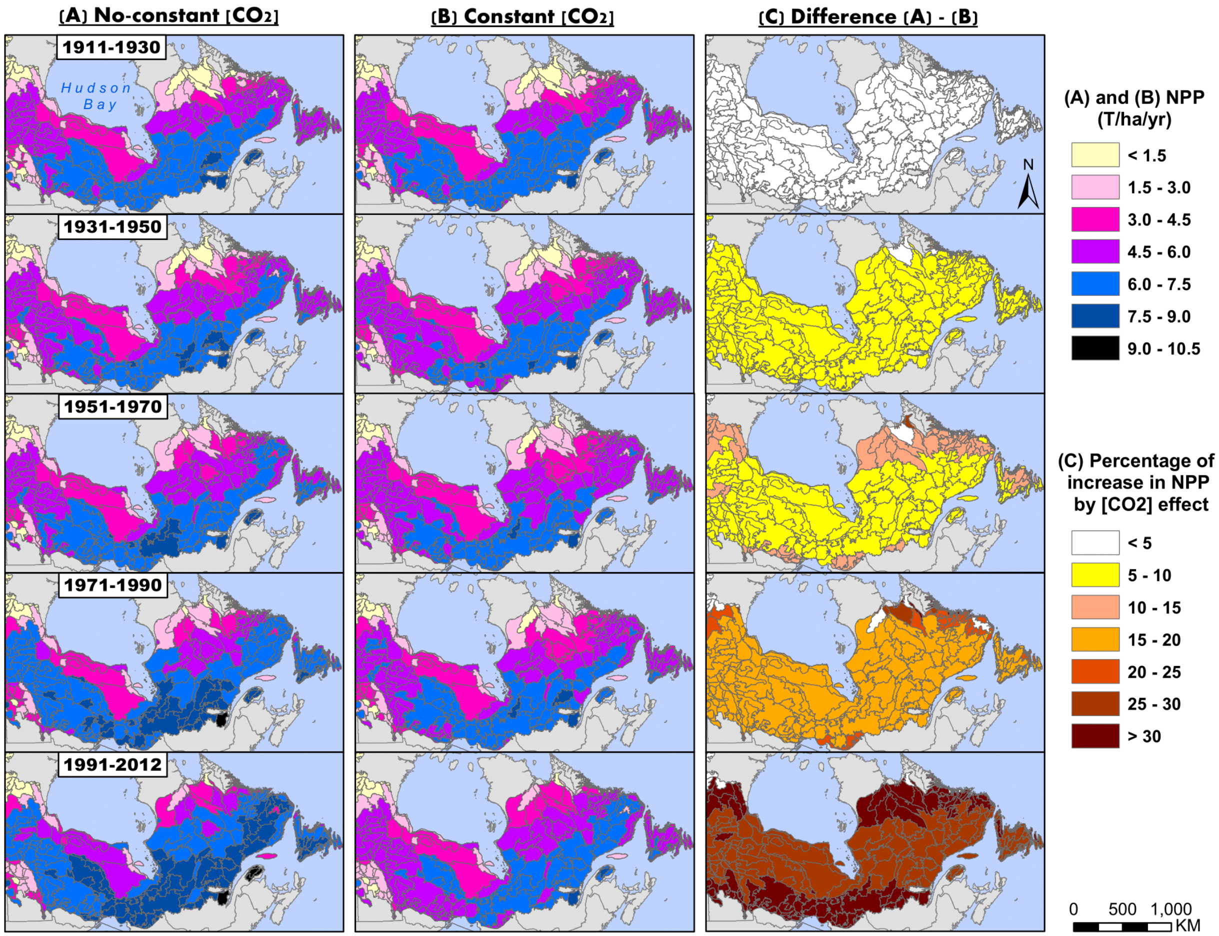
Supplement S6

Fig. S5. **(**A) Time-series of total annual area burned from 1901 to 2012. Gray blocks correspond to periods with at least three years of annual area burned above the mean annual burn rates for the 1901-2012 period. Orange line correspond to the smooth lines (spar = 0.4) of the temporal series. Black dashed line correspond to the weighed means of the regimes obtain by the sequential application of the Student's t-test (B) The percentage difference between spring and summer total area burned (named the fire seasonality index; FSI) from 1901 to 2012. Black dashed lines is equal to FSI = 50%)



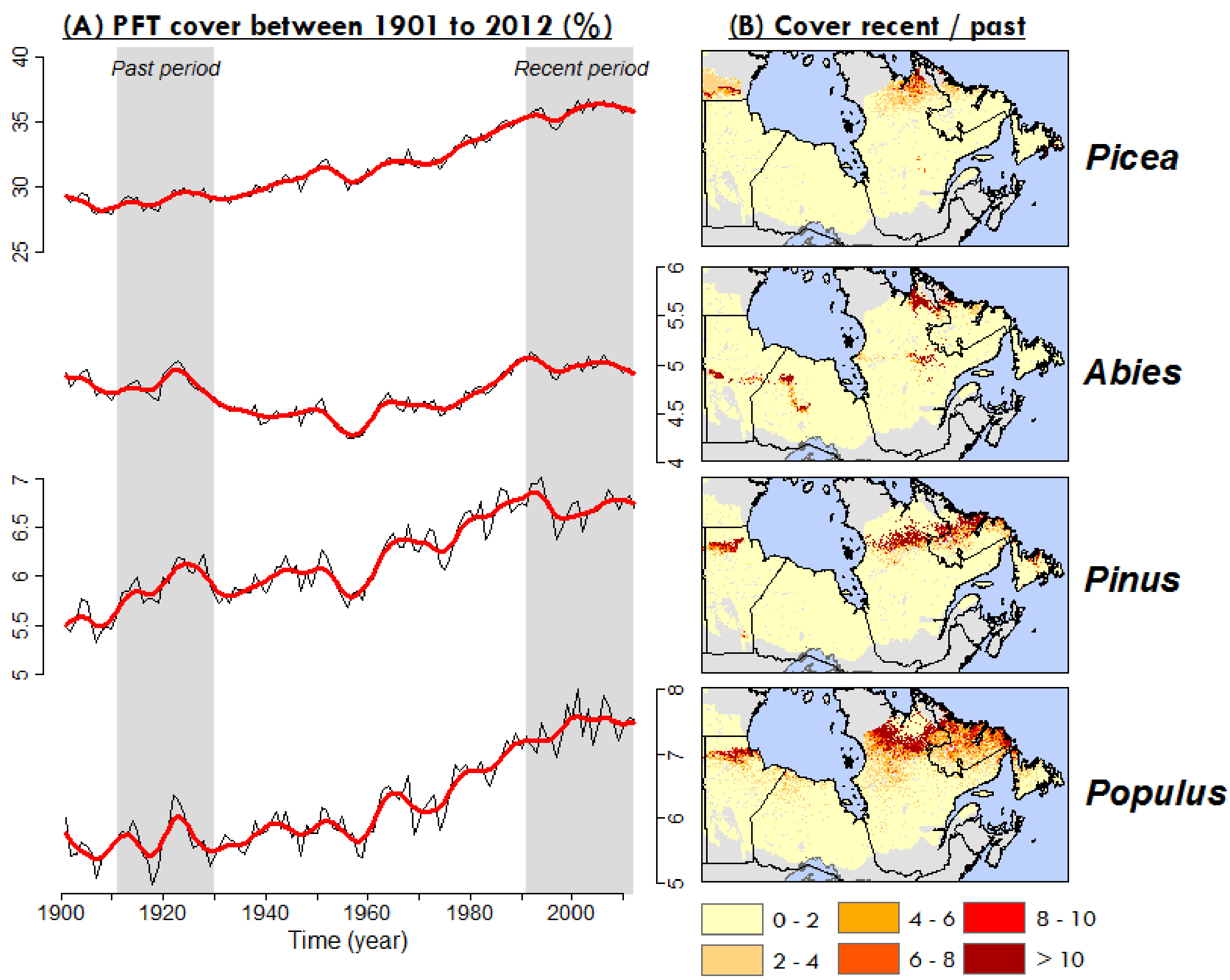
Supplement S7

Fig. S6. LPJ-LMfire net primary productivity (T/ha/yr) simulated across eastern boreal Canada with non-constant (A) and constant (B) atmospheric CO_2 concentration through five periods from 1911 to 2012. (C) Percentage of increase in NPP by [CO_2] effect.



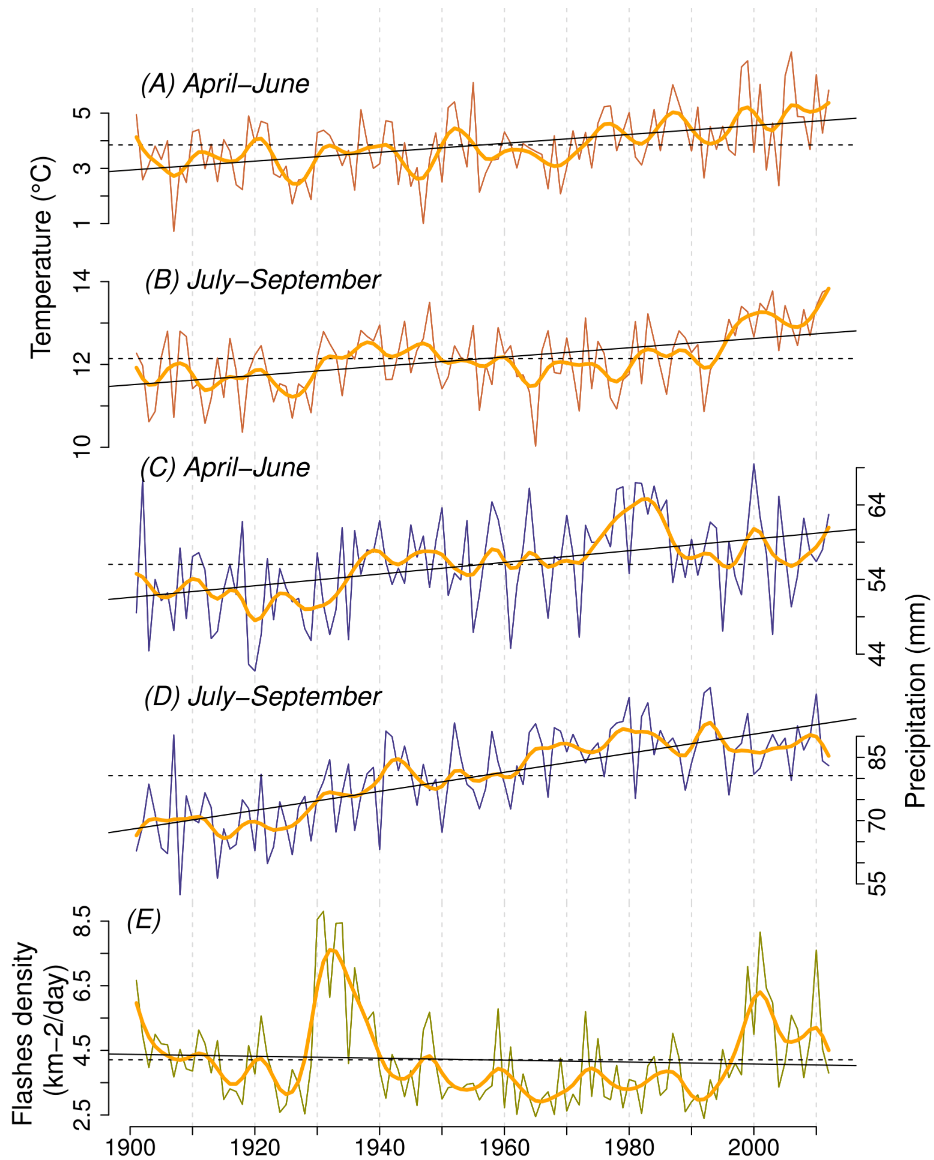
Supplement S8

Fig. S7. (A) Average of cover percentage for each PFT in eastern boreal Canada from 1901 to 2012 (red line are the smooth lines (spar = 0.4). (B) Ratio of cover percentage between recent period (1911-1930) to past period (1991-2012). Both periods corresponds to grey background on figure A.



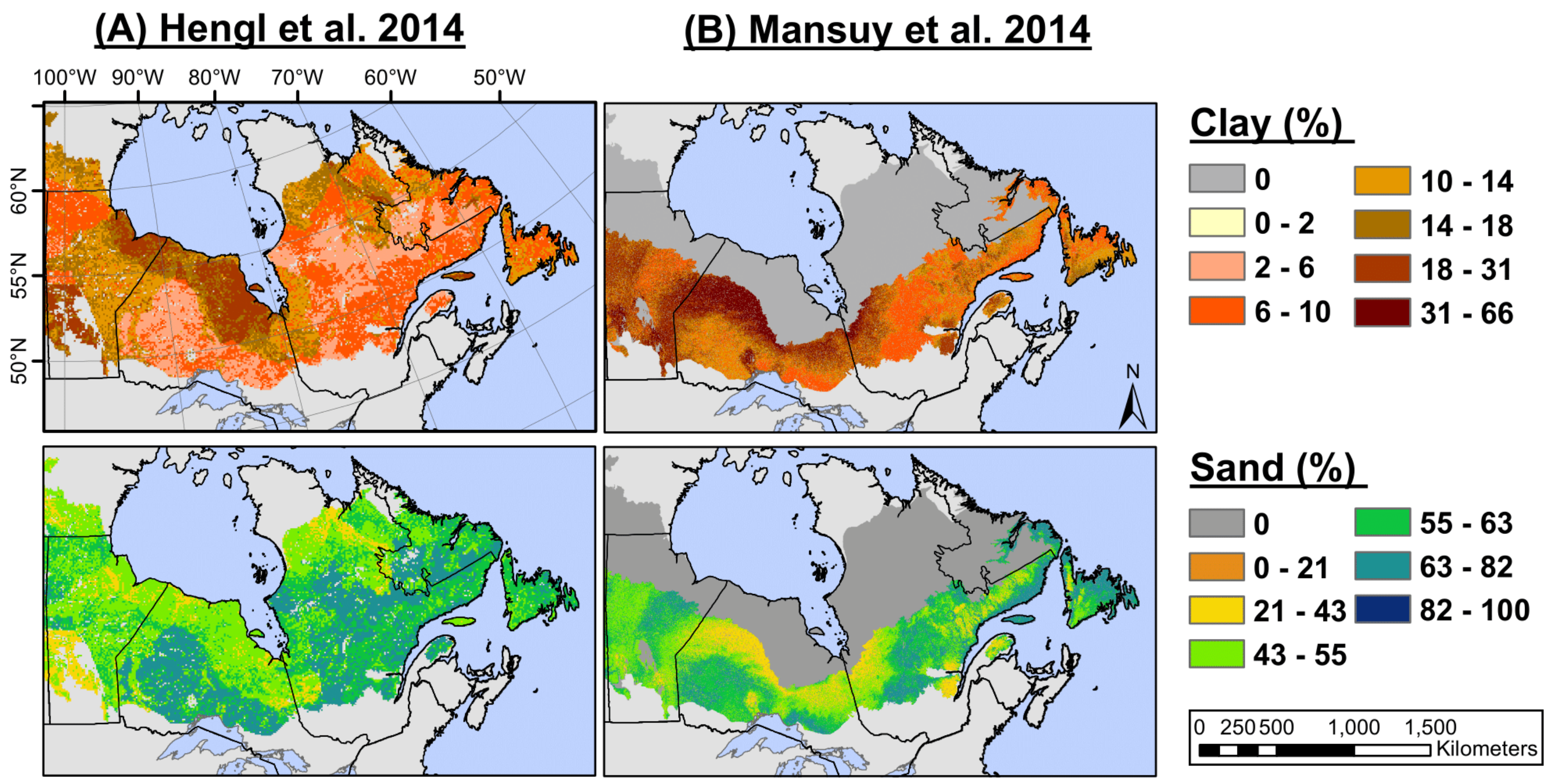
Supplement S9

Fig. S8. Temporal changes in three climate variables: (A) spring and (B) summer mean temperatures, (C) spring and (D) summer mean precipitations, and (E) mean flashes density. Black dashed lines, black full black lines and orange lines correspond respectively to the mean, the regression lines, and the smooth lines (spar = 0.4) for each time-series.



Supplement S10

Fig. S9. Percent of clay and sand in the mineral horizons across eastern boreal Canada at 10km of resolution from (A) Hengl et al. (2014) (0-30cm depth) and (B) Mansuy et al. (2014) (0-15cm depth).



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