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Drought response of the boreal forest carbon sink is driven by understorey–tree composition

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Supplementary information for

Drought response of the boreal forest carbon sink is driven by understorey-tree composition

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Supplementary Figures

***Figure S1*. Forest-floor environmental conditions during drought and reference period.**

The upper panels a), c), and e) show the below-canopy air temperature (Ta_{bc}, °C), soil temperature at 10 cm depth (Ts, °C), and soil volumetric water content at 5 cm depth (SWC, %), respectively, for the baseline period 2016–2017 ($BL_{16–17}$) and the drought year 2018 (D_{18}). The values in the upper panels represent annual means ± 95% confidence intervals, while the solid lines show the mean monthly values. The lower panels b), d) and f) show the annual and monthly absolute anomalies (ΔX), which annual means are presented in brackets, while the grey bars represent the monthly values. The lower values at the bottom show the annual and monthly relative anomalies (δX), which annual means are presented in brackets, while the values represent the monthly values. For both ΔX and δX, positive and negative anomalies are highlighted in red and blue, respectively.

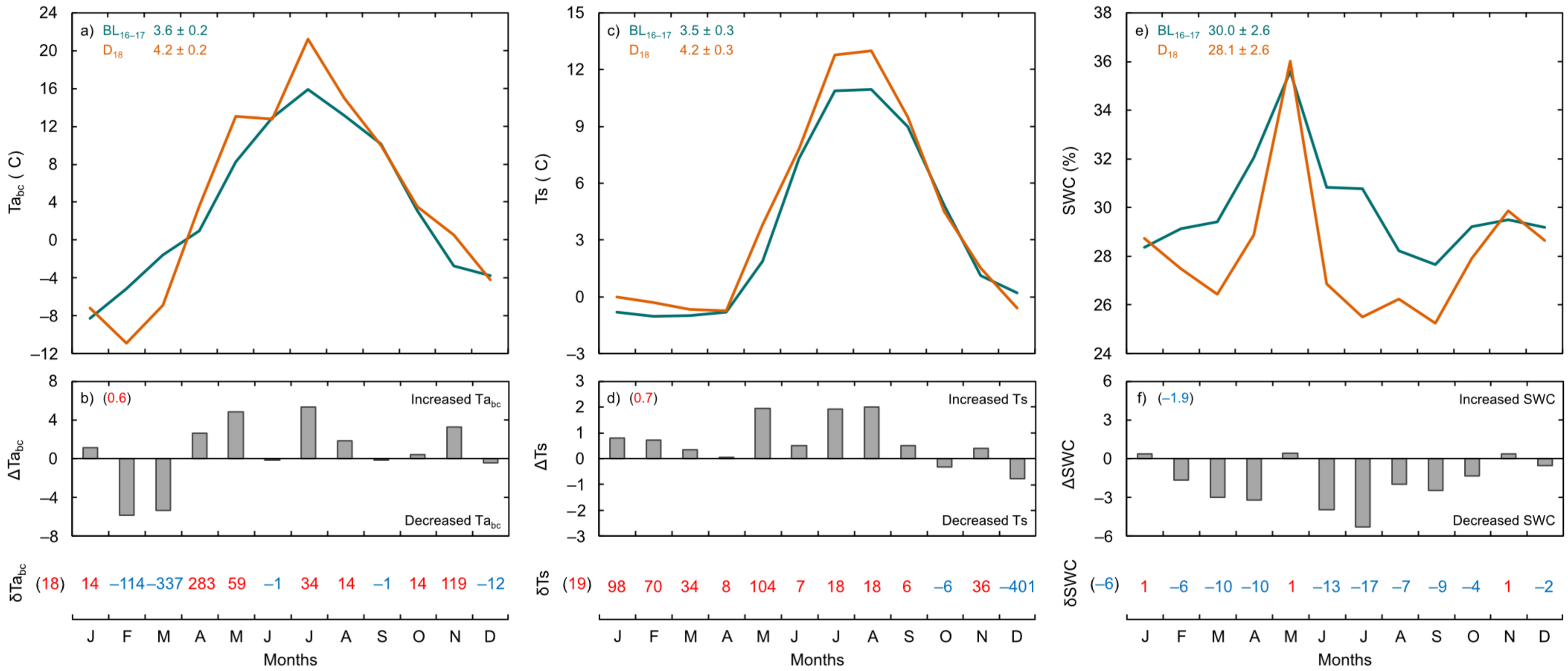


***Figure S2.* Effect of soil type and tree species on the drought response of forest-floor environmental conditions.**

The panels a)–c) show the absolute anomalies of below-canopy air temperature (ΔTa_{bc}), soil temperature at 10 cm depth (ΔTs), and soil volumetric water content at 5 cm depth (ΔSWC), respectively. Data are based on measurements carried out during May–August. The boxes represent the 25th (bottom) and 75th (top) percentiles, the central line the median, and the cross the mean. Whiskers above and below the boxes denote data within 1.5 times of the interquartile range, with outliers presented as individual points. The *p*-values for the non-parametric Kruskal–Wallis rank sum test comparing the differences between soil type and tree species means are also shown. n = 49 forest stands.

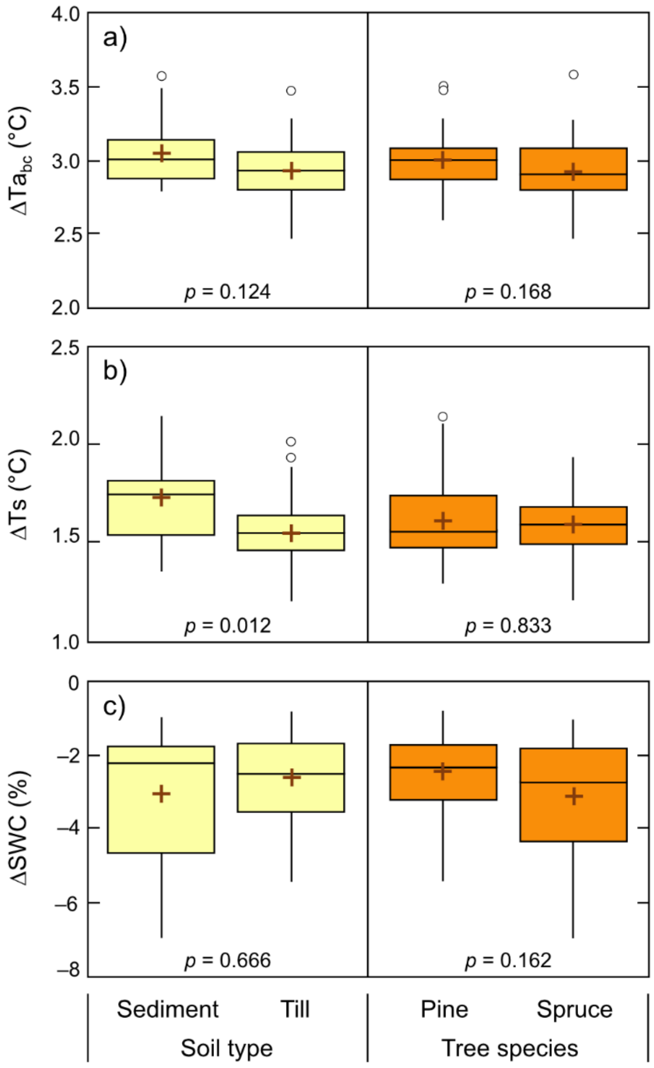
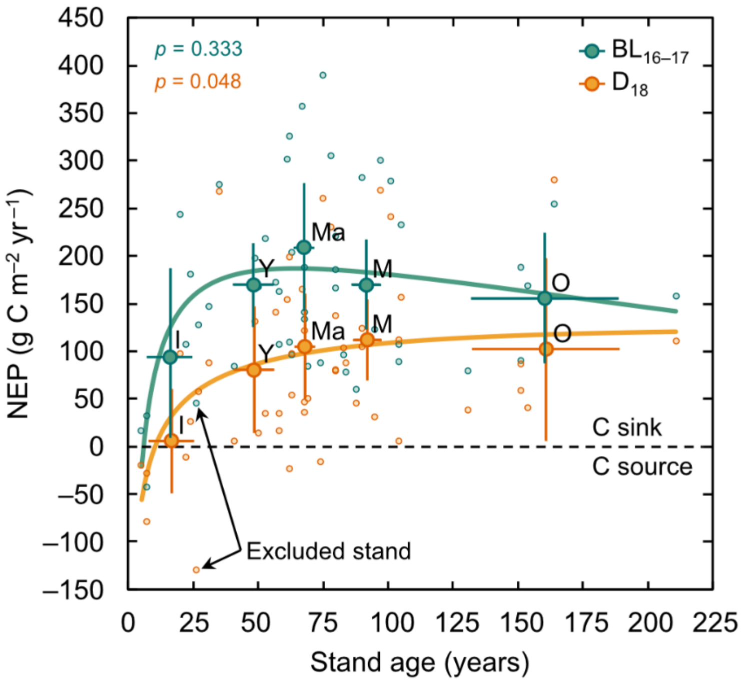


***Figure S3.* Forest net ecosystem production over stand age.**

The data show the forest net ecosystem production during the baseline period 2016–2017 ($BL_{16–17}$) and the drought year 2018 (D_{18}). Circular open symbols indicate values for each forest stand (n = 50), while circular closed symbols indicate means for each of the stand age classes, including initiation (I), young (Y), middle-aged (Ma), mature (M), and old-growth (O). The horizontal and vertical bars represent the 95% confidence intervals, while the solid lines show the best-fit regressions. Stand age class means and fitted lines are based on data from 49 forest stands (see Figure 2a in the main text for further details). The forest stand excluded due to confounding effects of drought and thinning operations carried out in 2018 is shown. The horizontal dashed line indicates the carbon (C) source-to-sink transition.



Supplementary Tables

Table S1. **Coefficients (standard errors in brackets) and goodness-of-fit statistics of the regressions used to estimate the age-related shift in understorey versus tree production that regulates the drought response of forest net ecosystem production.**

The regressions are displayed in Figure 4a in the main text. A moving-window approach was used to examine the correlation between the absolute anomaly of net ecosystem production (ΔNEP) and the absolute anomalies of net primary production of trees and understorey (ΔNPP_t and ΔNPP_u, respectively), using the stand age as the predictive variable. The stand age corresponded to the mean age of a 7-forest-stand-window. The equation forms are as follows: Eq. (1) $\mathrm{r}(\Delta\mathrm{NEP} - \Delta\mathrm{NPP_t}) = \exp(\mathrm{b_0} + \mathrm{b_1}/\mathrm{Age})$ and Eq. (2) $r(\Delta\mathrm{NEP} - \Delta\mathrm{NPP_u}) = \mathrm{b_0} + \mathrm{b_1} \times \mathrm{Age} + \mathrm{b_2} \times \mathrm{Age}^2 + \mathrm{b_3} \times \mathrm{Age}^3$. The coefficient of determination (R^2) and standard error of estimate (SEE) of the regressions are shown.

Eq.	**b_0**	**b_1**	**b_2**	**b_3**	**R^2**	**SEE**
1	–0.095 (0.037)	–7.48 (1.77)	–	–	0.30	0.13
2	0.11 (0.27)	0.04 (0.01)	–0.0007 (0.0002)	0.000003 (0.0000007)	0.49	0.21

Table S2. **Eddy covariance-based estimates of forest net ecosystem production.**

The data show the forest net ecosystem production (NEP) estimates obtained from eddy covariance observations conducted within (Svartberget, SVB) and in close vicinity (Rosinedalsheden, ROS) of the Krycklan Catchment Study (KCS) during the baseline period (BL) and the drought year 2018 (D_{18}). Note that the BL for the SVB site is the year 2016, while the mean value of the years 2015 and 2017 was used to define the BL for the ROS site. The absolute and relative NEP anomalies (ΔNEP and δNEP, respectively) are also shown. The annual NEP values were previously reported in Ref.[1].

Site	Period	NEP (g C m^{-2} yr^{-1})	ΔNEP (g C m^{-2} yr^{-1})	δNEP (%)
Svartberget (SVB)	BL_{16}	163	–59	–36
	D_{18}	105		
Rosinedalsheden (ROS)	$BL_{15–17}$	275	–41	–15
	D_{18}	234		

Supplementary References

1. Lindroth A., Holst J., Linderson M.-L., Aurela M., Biermann T., Heliasz M., et al. Effects of drought and meteorological forcing on carbon and water fluxes in Nordic forests during the dry summer of 2018. *Philos. Trans. R. Soc. B. Biol. Sci.*, **375**(1810)**:** 20190516 (2020).