Supplementary Materials 1:
Estimating the impact of reduced temperature on phloem sap

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This pdf was generated from an Rmarkdown file, which includes all R code necessary to reproduce the estimatations. The Rmarkdown file is available on github (https://github.com/TTRademacher/Exp2018Analysis) and is permanently and publicly archived on the Harvard Forest Data Archive as part of the data set HF???.

Dependence of phloem sap viscosity and density on temperature

To quantify the effect of chilling on dynamic viscosity of phloem sap and thus resistance to phloem transport, we estimate the effect of temperature (T_{phl}) on the viscosity of water (η_w) using the Vogel-Fulcher-Tamman equation:

$$\eta_w = \eta_0 e^{\frac{B}{(T_{phl} - T_{VF})}} \tag{1}$$

, where η_0, T_{VF} and B are empirical constants. In addition to water phloem sap contains sugar, the sugar concentration (c in $\%weight/weight$) also affect the phloem sap viscosity. According to Jensen et al. (2013), phloem sap viscosity (η_s) can be estimated from sap sugar concentration as follows:

$$\eta_s = \eta_w e^{(Ac - (Bc)^2 + (Cc)^3)} \tag{2}$$

, where A, B, and C are empirical constant, which we set to 0.032, 0.012, and 0.023 according to Jensen et al. (2013). At low Reynolds numbers, viscous forces dominate laminar flow, such as phloem flow through sieve tubes (Jensen et al., 2012). While temperature also affects sap density, the effects of density on flow are comparatively negligible with about 10% variation for realistic temperatures and sugar concentrations compared to up to 500% for viscosity (Fig.**??**). Knowing the sugar concentration and viscosity of the phloem sap we can then estimate the resistance to flow in the lumen of sieve tubes according to the Hagen-Poiseuille equation.

References

Jensen, K.H., Mullendore, D.L., Holbrook, N.M., Bohr, T., Knoblauch, M., Bruus, H., 2012. Modeling the Hydrodynamics of Phloem Sieve Plates. Frontiers in Plant Science 3.

Jensen, K.H., Savage, J.A., Holbrook, N.M., 2013. Optimal concentration for sugar transport in plants. Journal of The Royal Society Interface 10, 20130055–20130055.