Long-term impact of nitrogen addition on the carbon balance of a boreal pine forest in Northern Sweden

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BG3.26
EGU2020-21293

Measuring fluxes

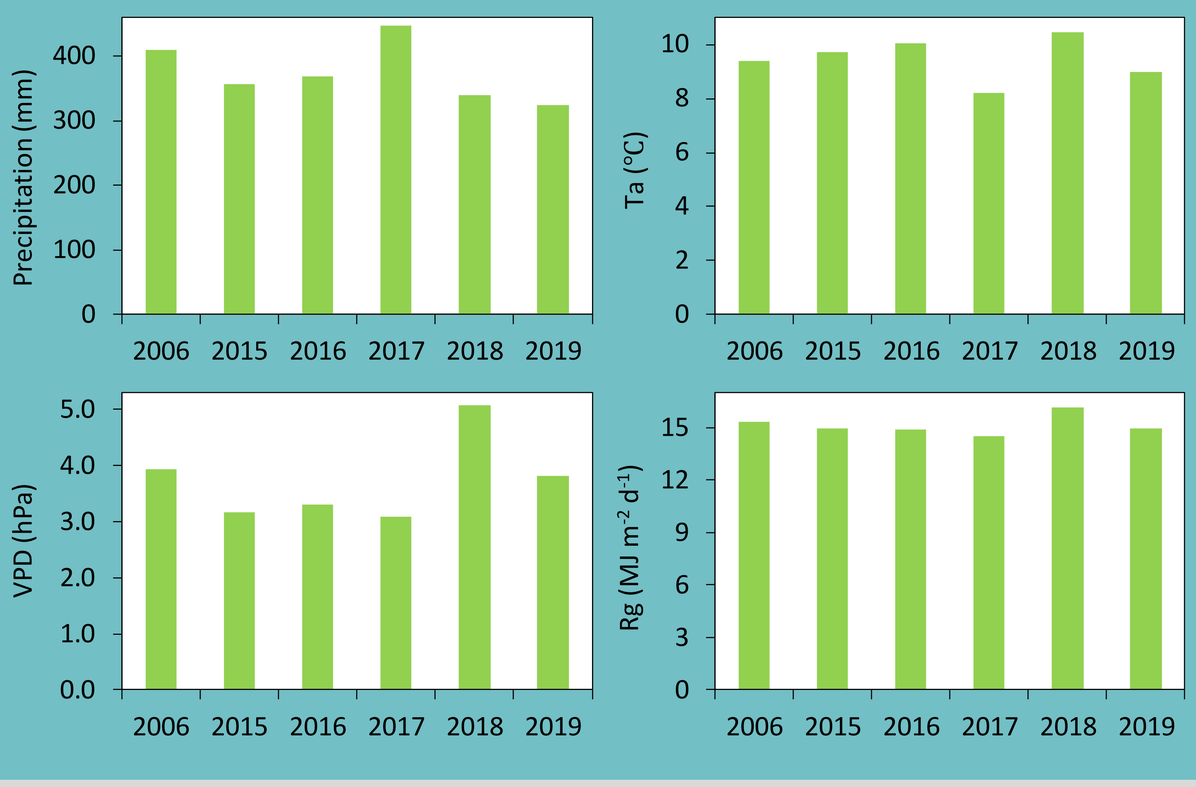
- The aim of this research is to study the effect of nitrogen (N) availability on stand-scale carbon cycling in a boreal forest, including a non-fertilized reference stand (control) and a stand with N addition. Each stand is equipped with an eddy covariance tower above canopy for measuring the turbulent exchange of momentum, sensible heat, latent heat, and CO_2.

Research area

- The field experiment was initiated in 2006 at Rosinedalsheden experimental forest, an ~90 year old Scots pine stand in northern Sweden (64°100N, 19°450E; 155–160 m above sea level).
- The N-addition stand has received 100 kg N ha^{-1} yr^{-1} in summer since 2006 and 50 kg N ha^{-1} yr^{-1} since 2012 as NH_4NO_3, respectively, applied over an area of 15 ha around the EC tower.

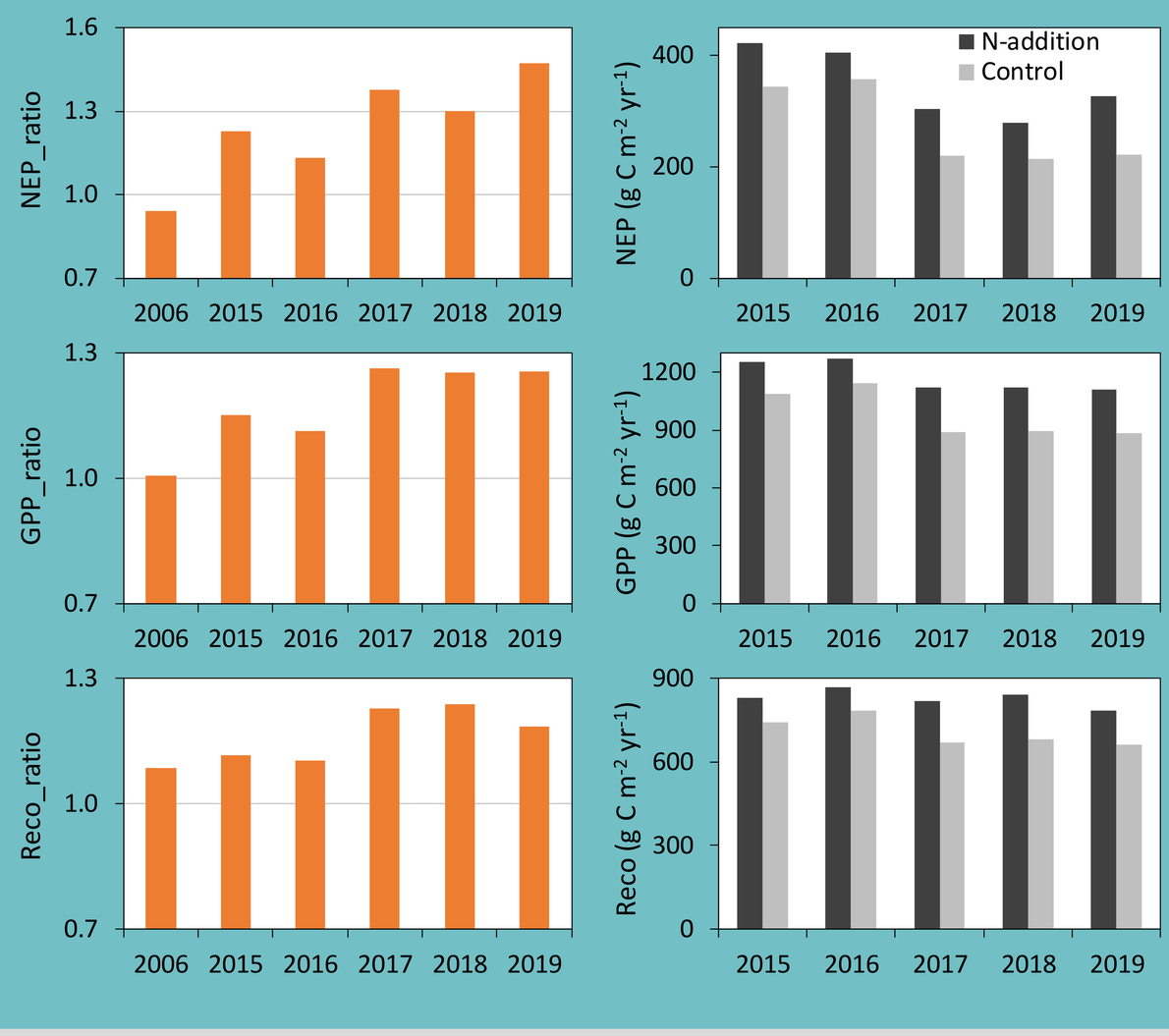
Environmental variables

- Total precipitation, average air temperature, vapor pressure deficit, and global radiation in growing season (April-October) in 2006 and 2015-2019 are presented in the figures.
- 2017 was a cool (lower T_a) and cloudy year (daily mean R_g being mostly in the intermediate range around 100-200 W m^{-2}, data not shown) with more precipitation, while 2018 and 2019 were relative drought years with less precipitation and higher VPD.



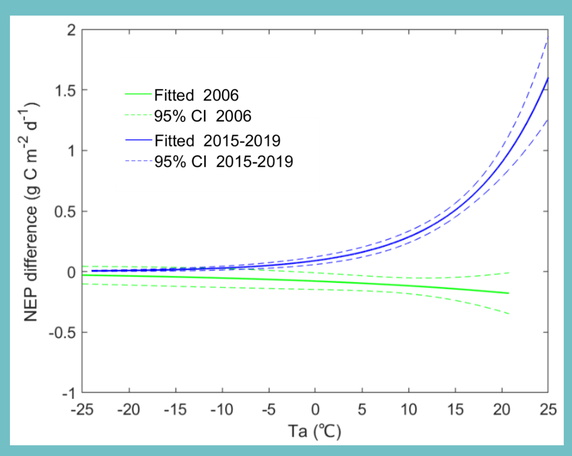
Annual CO_2 fluxes

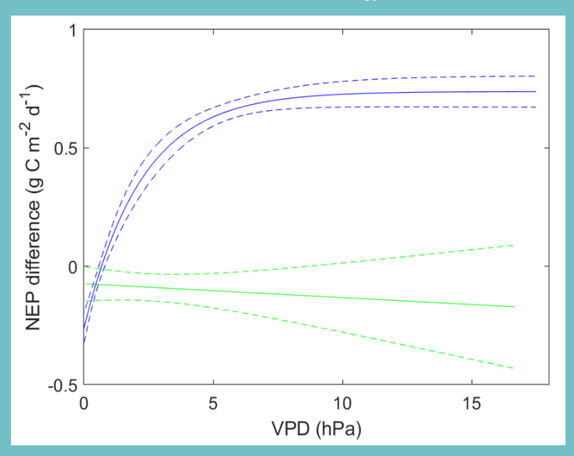
- The ratio of annual C fluxes (NEP, GPP, Reco) at N-addition vs. control stand indicates that the forest net C uptake was initially (in 2006) slightly higher at the control stand. After one decade of N fertilization, NEP and GPP in all five years (2015-2019) was greater in the N-fertilized stand compared to the control stand.
- Forest C balance (NEP, GPP, Reco) was relative similar between stands during years with normal weather conditions (2015-2016) but diverged due to a larger reduction in the control stand in years with environmental constraints (i.e. cloudy summer in 2017, droughts in 2018 and 2019).

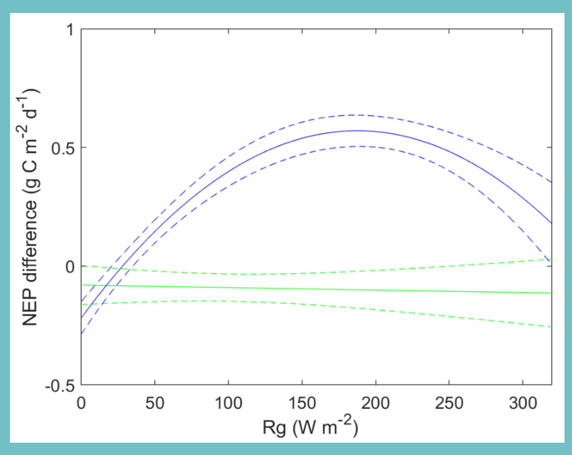


C balance response to climate

Fit to daily NEP difference (N-addition minus control) vs T_a, VPD and R_g







- After one decade of N-addition, NEP at the fertilized stand exceeds that at the control stand during conditions with high VPD, high T_a and intermediate R_g. As a result, the C balance of the fertilized stand is less sensitive to drought events.

Conclusions

- Forest C balance was initially similar between stands, after long-term N addition the C fluxes in the fertilized stand exceeded that in the control stand, especially under environmental constraints.
- Our results indicate that enhanced N input to boreal forests increase and stabilize their C sequestration potential under future climate conditions.

References: **1** Fernández-Martínez, M., et al (2014). Nutrient availability as the key regulator of global forest carbon balance. Nature Climate Change 4, 471–476; **2** Lim, H., et al (2015). Inter-annual variability of precipitation constrains the production response of boreal Pinus sylvestris to nitrogen fertilization. Forest Ecology and Management 348, 31–45; **3** Jocher, G., et al (2017). Apparent winter CO2 uptake by a boreal forest due to decoupling. Agricultural and Forest Meteorology, 232, 23-34.