GEFÖRDERT VOM Bundesministerium für Bildung und Forschung

SUSALPS – Sustainable use of alpine and pre-alpine grassland soils in a changing climate

BONARES Zentrum für Bodenforschung

Intensive broadcast slurry management and climate warming threaten soil organic nitrogen stocks of montane grasslands

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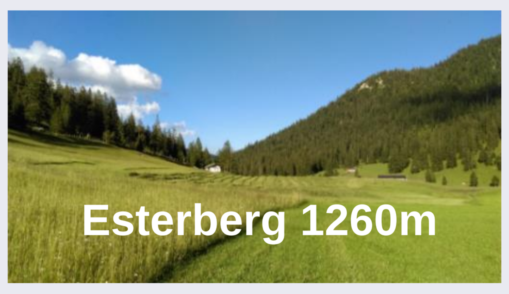
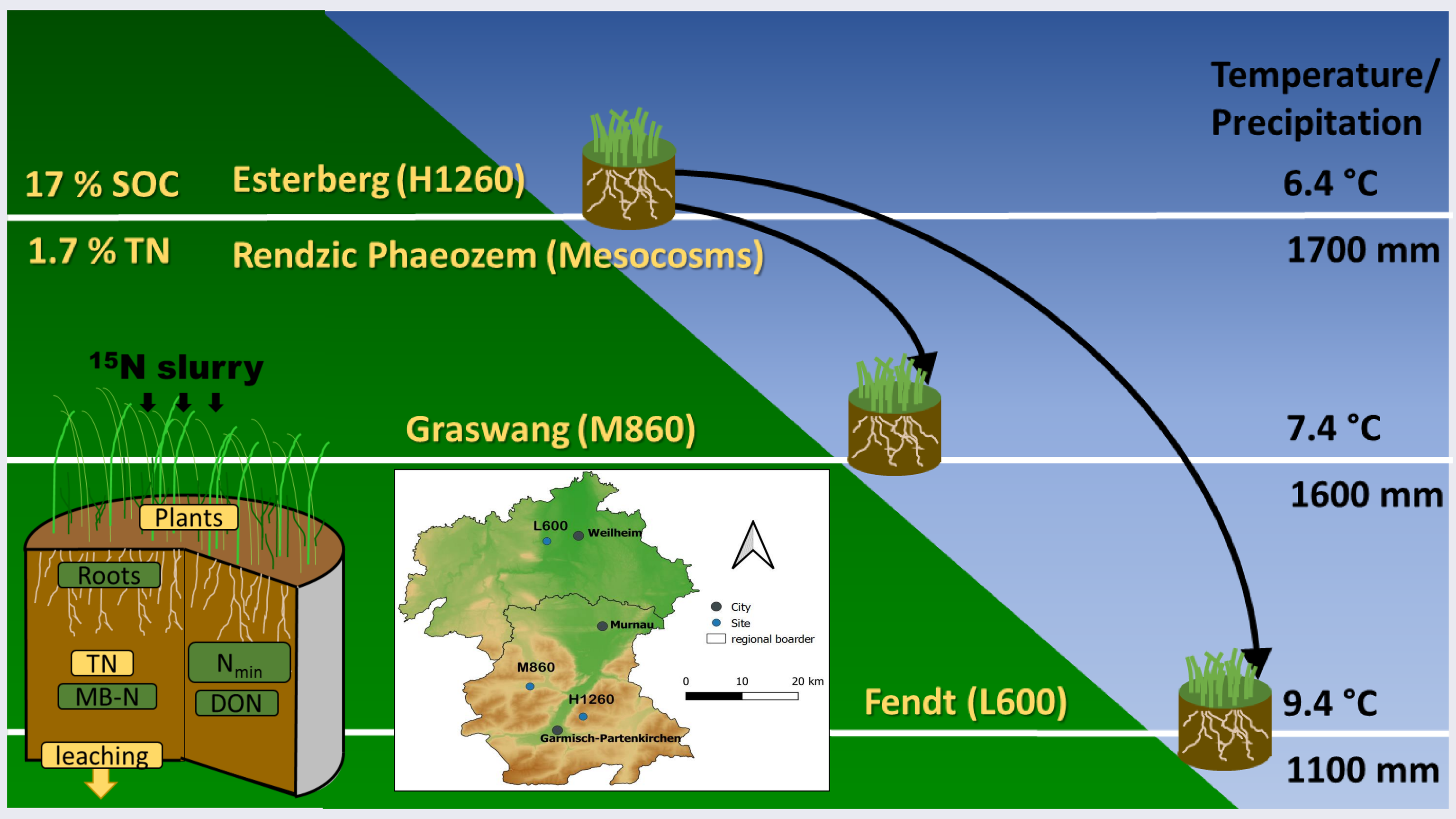
Approach: Combining a mesocosm- based space for time climate change experiment with tracing of ^{15}N labelled slurry and quantification of Nitrogen (N) inputs and outputs of grassland soils

- The effect of climate change and management on N balances of a **C- and N-rich grassland soil (Rendzic Phaeozem)** in Southern Germany is investigated.
- **Climate change** is simulated by space for time translocation of intact plant-soil mesocosms (diameter: 17 cm, depth: 25 cm) originating from a **montane grassland site** (Esterberg) down an elevational gradient.
- Full factorial combination with **slurry management treatments: extensive** (2 cuts, i.e., harvests by mowing, 2 slurry fertilization events) vs. **intensive** (5 cuts, 5 slurry fertilization events).
- Quantification of **slurry N fates** by ^{15}N tracing of labeled ($^{15}NH_4^+$ and ^{15}N-urea) slurry N, quantification of **N inputs** (slurry, atmospheric deposition, biological nitrogen fixation (BNF)), **internal N cycling, and N outputs** (yield, gaseous losses, leaching).

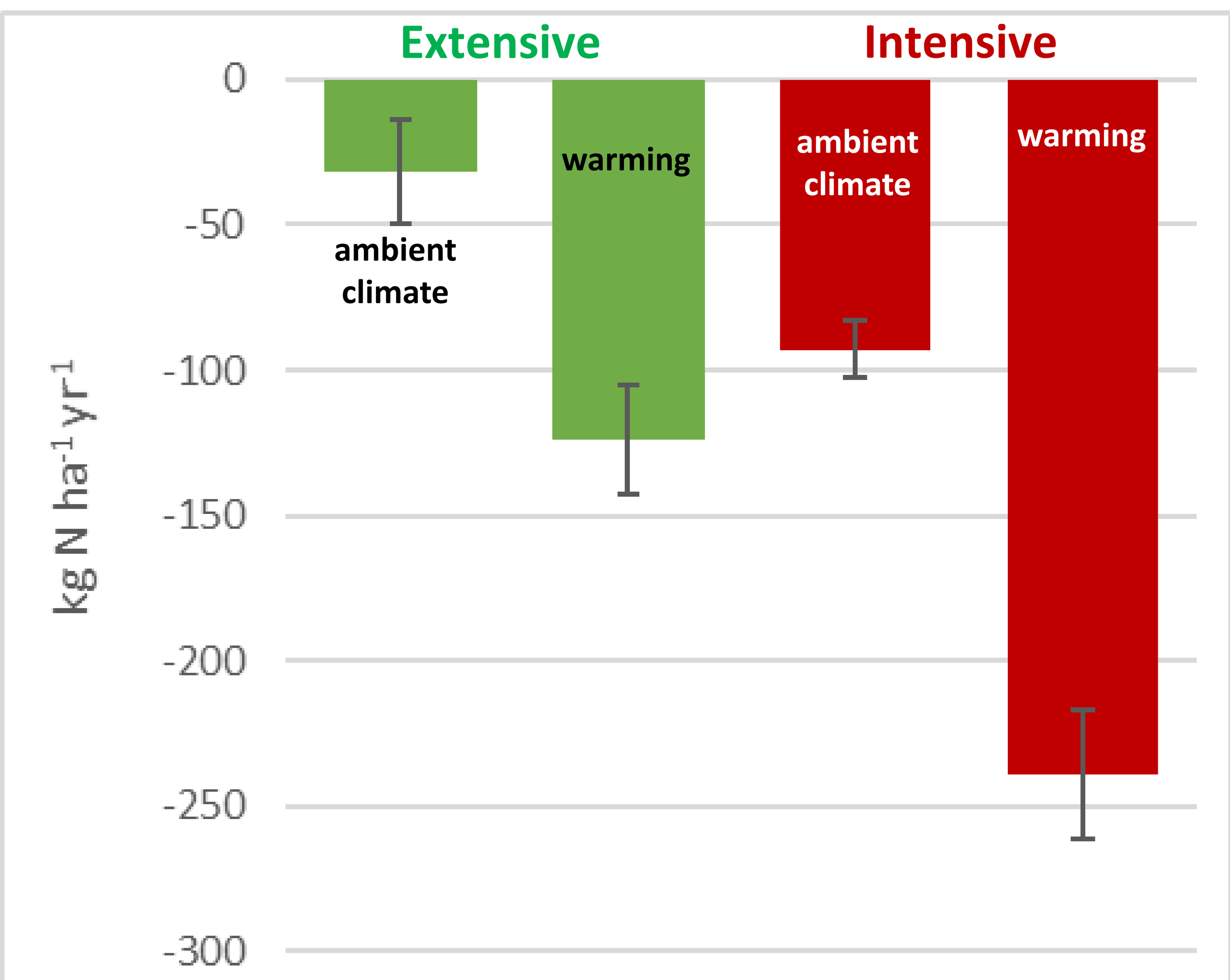




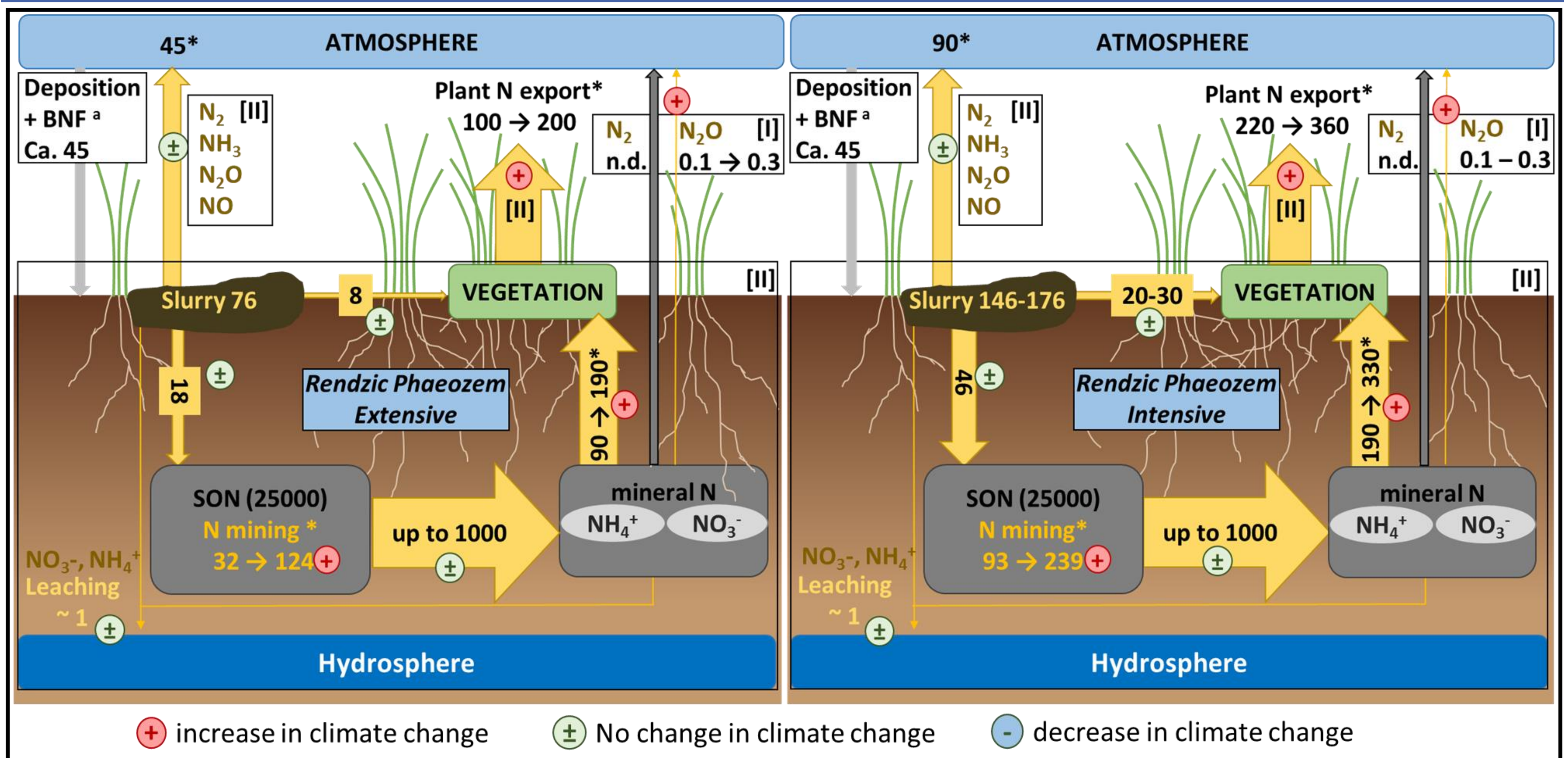
Key findings and implications

- The investigated **grasslands are highly productive** with **plant N exports exceeding slurry N inputs** in all management and climate treatments.
- Surface **slurry** application **contributes little to plant N nutrition** (8-15% of slurry-N in plants), but rather **serves to refuel soil organic nitrogen** (SON) stocks (20-32 % of slurry N in unextractable soil N).
- Refueling of SON through liquid slurry however is inefficient because about **half of slurry-N is lost to the atmosphere** mainly as N_2 and NH_3, while nitrate leaching is hardly significant.
- **Plant N acquisition is largely based on mineralized soil organic nitrogen (SON)** and thus little affected by fertilization.
- **The overall N balance is negative for all treatments mainly due to high plant N exports, i.e., there is SON mining.**
- Surprisingly, **intensive management further increases SON mining** compared to extensive management, possibly through priming effects that result in additional SON mineralization and associated plant N exports that exceed the additional net N gain from fertilization
- **Climate change strongly increases N mining** for the extremely C- and N-rich Rendzic Phaeozem soil due to a stimulation of productivity and associated increases in plant harvest N exports.

N balance (kg N ha^{-1} yr^{-1})



N flows (kg N ha^{-1} yr^{-1})



Pathways of N in the soil under extensive (left) and intensive (right) management. ᵃ Deposition is obtained from LfL (2011) and BNF from Keuter et al. (2014). Asterisks indicate significant differences between management treatments, significant differences for slurry N flow to SON or plant biomass are given for relative recovery in the respective pool, all other differences refer to the absolute pool or flow size.

Conclusion

- We conclude that **broadcast surface slurry application is triggering N mining especially under intensive management and climate change** and thus should be replaced by alternative management techniques that minimize fertilizer N losses.

Literature

Zistl-Schlingmann M, Tobler U, Berauer B, Garcia-Franco N, Wilfarth P, Wiesmeier M, Jentsch A, Wolf B, Kiese R, Dannenmann M 2020. Intensive slurry management and climate change promote nitrogen mining from humus-rich montane grassland soils. *Agriculture, Ecosystems & Environment*, submitted.

Zistl-Schlingmann M, Kwatcho Kengdo S, Kiese R, Dannenmann M 2020. Management intensity controls N-use-efficiency and flows in grasslands - a ^{15}N tracing experiment. *Agronomy*, submitted.

Wang C, Chen Z, Unteregelsbacher S, Lu H, Gschwendtner S, Kolar A, Kiese R, Schloter M, Butterbach-Bahl K, Dannenmann M 2016. Climate change amplifies gross nitrogen turnover in montane grasslands of Central Europe both in summer and winter seasons. *Global Change Biology*: 22, 2963-2987.

Fu, J., Gasche, R., Wang, N., Lu, H., Butterbach-Bahl, K., Kiese, R., 2017. Impacts of climate and management on water balance and nitrogen leaching from montane grassland soils of S-Germany. Environmental Pollution 229, 119–131.

Zistl-Schlingmann M, Feng J, Kiese R, Stephan R, Zuazo P, Willibald G, Wang C, Butterbach-Bahl K, Dannenmann M 2019. Dinitrogen emissions: an overlooked key component of the N balance of montane grasslands. *Biogeochemistry*, 143, 15-30.

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