# Quantifying nitrogen input and output flows of mountain farms in Grisons to support site-adapted fertilisation

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## Background

- Mountain grasslands exhibit high spatial heterogeneity (e.g. topography, slope orientation, yield potential).
- This heterogeneity poses a risk for mismatch between standardised fertiliser recommendations and local nitrogen (N) demand.
- Potential consequence: N surpluses, which are linked to harmful N losses to the environment.
- Hence, there is need for site-adapted fertilisation strategies that account for local differences in nutrient demand and supply.

## Case study (2020-2023)

- 14 predominantly organic, grassland-based mountain farms in the canton of Grisons
  - available data: fertilisation records, soil organic matter and clay content of soils

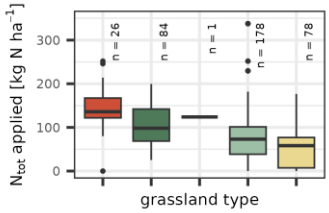
**Objectives:**
- Quantify ex-post N input and output flows (yearly)
- Assess whether current fertilisation practices are site-adapted
- Identify potential for improved site-adapted N management

## Methods & Results

### 1. Inputs

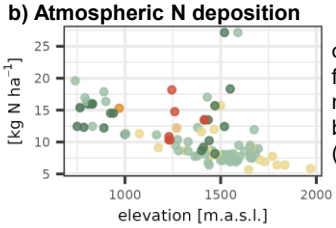
grassland type: high-intensity (temporary) | high-intensity (natural) | medium-intensity (temporary) | medium-intensity (natural) | low-intensity

**a) Fertilisation**



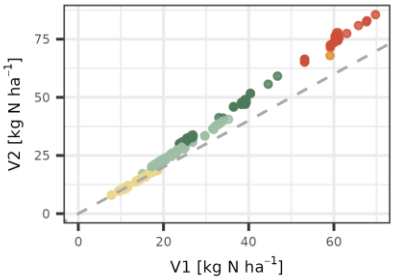

total N ($N_{tot}$) applied as specified in fertilisation records of farmers

**b) Atmospheric N deposition**



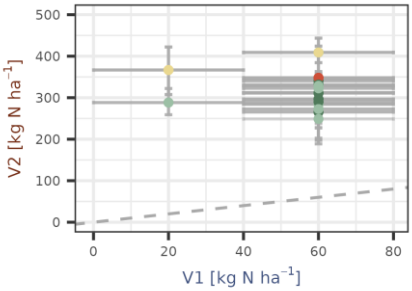

data extracted from modelled map (500x500m$^2$) by Rihm & Künzle (2023)

**c) Symbiotic $N_2$ fixation**




- V1: estimation based on yield and legume content (Sinaj & Richner et al., 2017)
- V2: empiric model based on yield, legume content & $N_{tot}$ applied (Nucera et al., 2023)

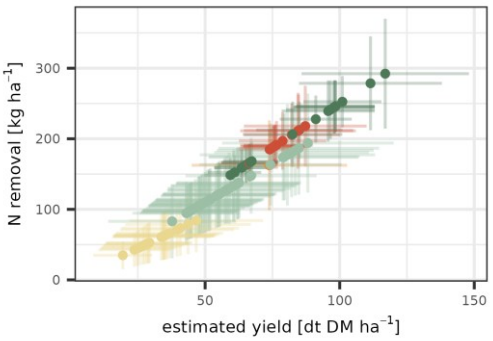
**d) Soil N mineralisation**




- V1: estimation based on clay and organic matter (OM) content (Sinaj & Richner et al., 2017)
- V2: derived from modelled yearly carbon stock changes (RothC, Coleman & Jenkinson, 1996) using an (assumed) C:N ratio of 10:1

### 2. Output

**N removal**



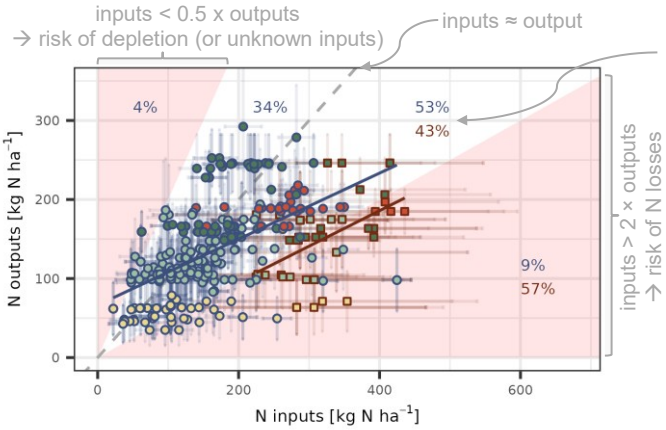

estimated based on yield assumptions (~ elevation) and grassland type using reference values for annual N removal (Sinaj & Richner et al., 2017)

### 3. Inputs vs. Output

N mineralisation estimation: V1 (Sinaj & Richner et al., 2017) | V2 (RothC)

Comparison of total inputs to outputs as an efficiency indicator:

●/■ = best estimate
— = uncertainty range




% = share of plots per area (per mineralisation estimation)

Between **9-57%** of plots showed more than double the N inputs relative to N outputs, indicating an elevated risk for N losses to the environment.

## Conclusions & outlook

- Uncertainties linked to yield estimation, symbiotic $N_2$ fixation and soil N mineralisation are considerable.
- Yet, results point to the potential for site-specific adjustments of N fertilisation practices, as currently N inputs often exceed outputs.
- Future work could leverage remote-sensing based approaches to improve yield estimates and thereby refine N flow quantification.

**References**

- Coleman, K., & Jenkinson, D. S. (1996). RothC-26.3—A Model for the turnover of carbon in soil. In D. S. Powlson, P. Smith, & J. U. Smith (Eds.), Evaluation of Soil Organic Matter Models (pp. 237–246). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-61094-3_17
- Nucera, E., Huguenin-Elie, O., Mayer, J., Liebisch, F., & Spiess, E. (2023). Method for estimating nitrogen input by symbiotic fixation on Swiss farms. Agroscope Science, 164. https://doi.org/10.34776/as164e
- Rihm, B., & Künzle, T. (2023). Nitrogen deposition and exceedances of critical loads for nitrogen in Switzerland 1990-2020. Meteotest commissioned by the Federal Office for the Environment
- Sinaj, S., & Richner, W. (Eds.). (2017). Grundlagen für die Düngung landwirtschaftlicher Kulturen in der Schweiz (GRUD) (Spezialpublikation, Vol. 6). Agroscope