

Assessment of current and critical nitrogen inputs on European agricultural soils

Wim de Vries

Hans Kros and Jan Cees Voogd



Planetary N boundaries?

- Rockström et al. (2009) estimated a planetary N boundary at 25% of current reactive N production (guessed).

- Critiques

Need for including spatial variability since a global threshold for N is absent (except for N₂O).

Need to include both food security versus harmful effects of over application to avoid misuse



Available online at www.sciencedirect.com

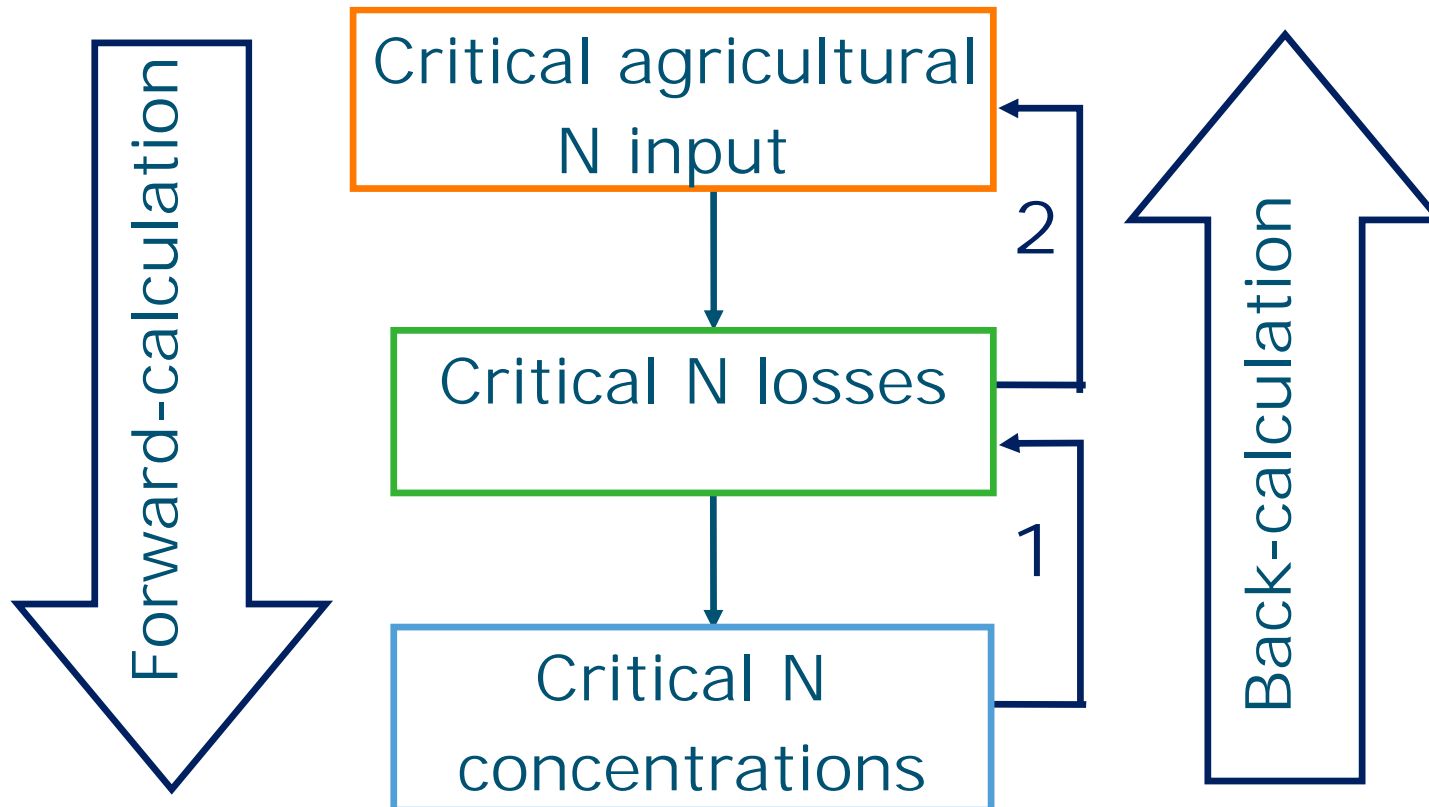
SciVerse ScienceDirect



Assessing planetary and regional nitrogen boundaries related to food security and adverse environmental impacts

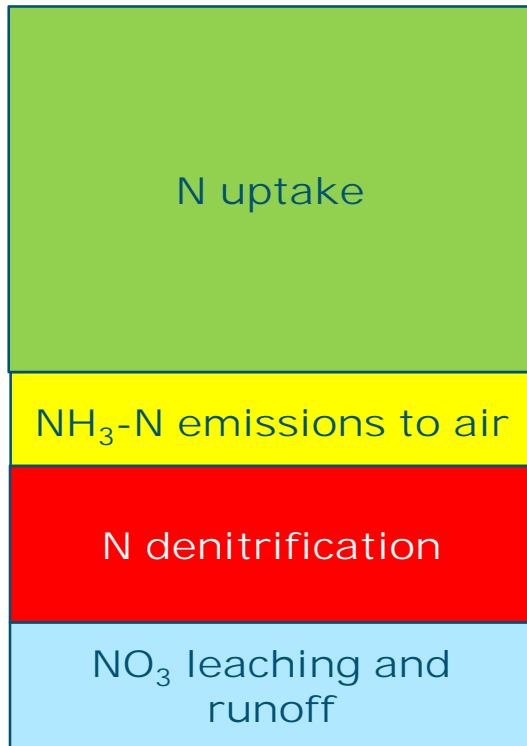
Wim de Vries^{1,2}, Johannes Kros¹, Carolien Kroeze² and Sybil P Seitzinger³

Assessment of critical N loads

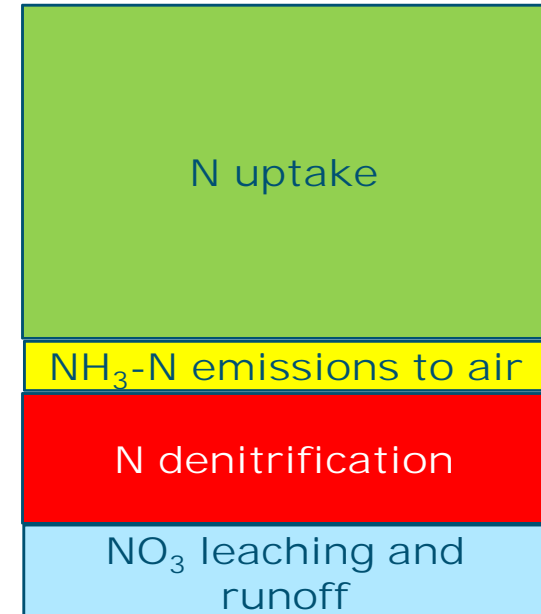


Comparison of current and critical N fluxes

Current N sinks



Critical N sinks



The critical N input is exceeded when the current NH₃-N emission rate or N runoff rate input exceeds critical values

Assessment of critical N loads

Assess critical inputs (loads) for agricultural N in view of:

- NH_3 emissions
- N_2O emissions
- N leaching
- N surface runoff

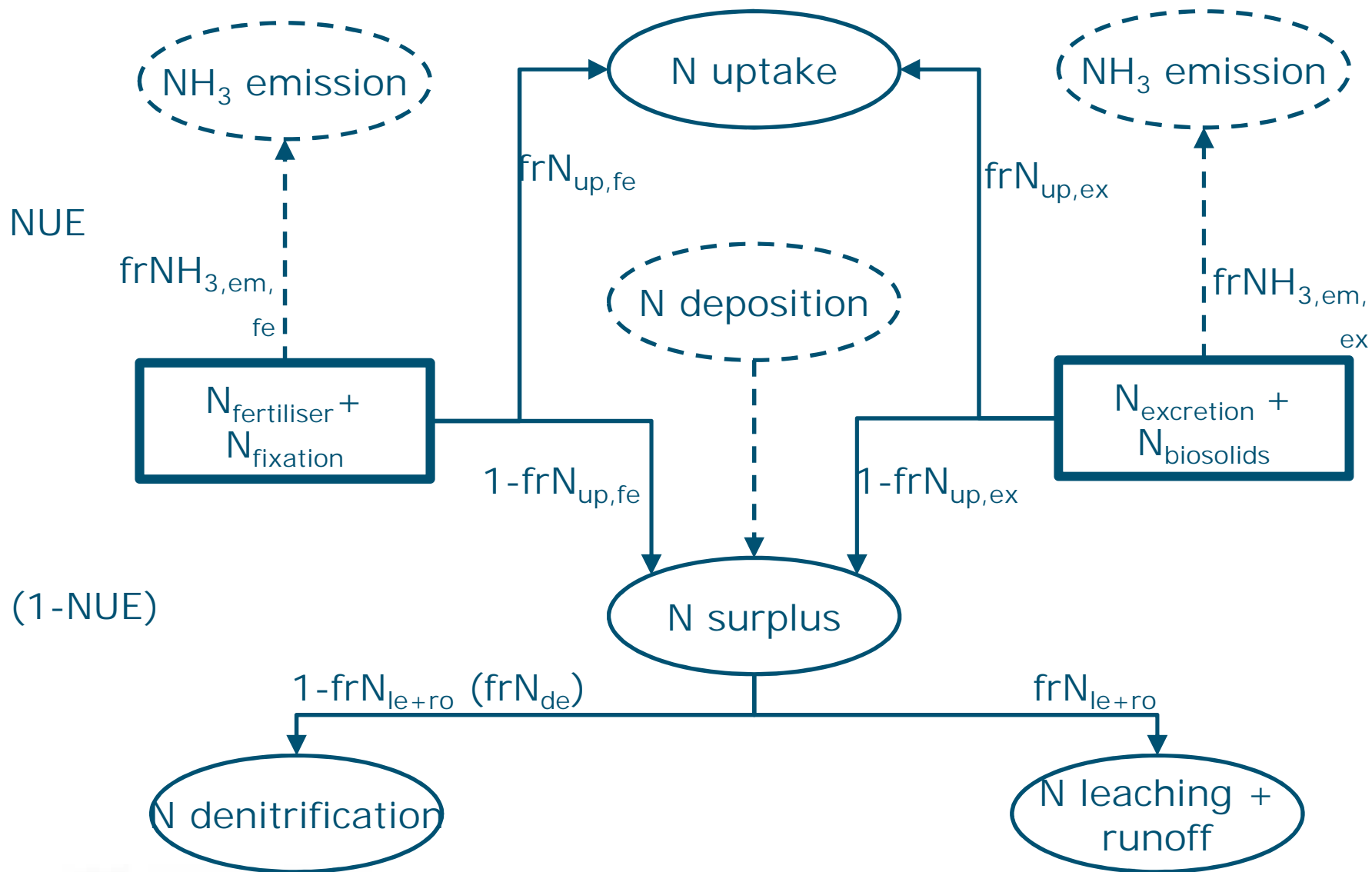
- 1 Assess critical limits for N concentrations in air and water
- 2 Assess PBs for losses of NH_3 to air and N (NO_3) to water
- 3 Assess PBs for agricultural N use in view of critical losses of NH_3 to air and N (NO_3) to water

Assessment of critical N limits and N losses

Step 1 Assess critical limits for N concentrations in air and water

| N compound/ concentration or emission | Range in critical concentrations/loads |
|--|--|
| NH ₃ emission | Area-weighted mean critical N loads |
| NO ₃ ⁻ concentration in leachate to ground water | 25 - 50 mg l ⁻¹ |
| N concentration in runoff to surface water | 1.0 - 2.5 mg N l ⁻¹ |

Step 2 Assess critical losses of N to air (critical NH₃ emission = f critical N deposition) and water (precipitation surplus x critical N concentration)



Critical N fertilizer application rate in view of N leaching or N runoff

The critical N fertilizer application rate can be derived as:

$$\blacksquare N_{\text{in(crit)}} = N_{\text{up(crit)}} + N_{\text{de(crit)}} + N_{\text{le+ro(crit)}} \quad (1)$$

Note that

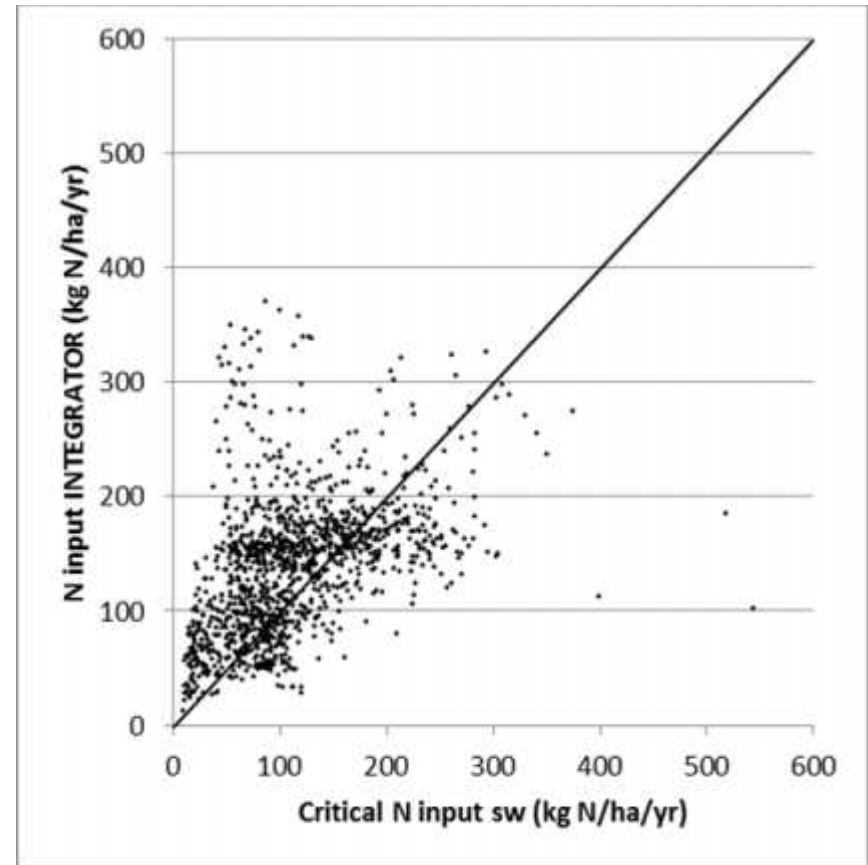
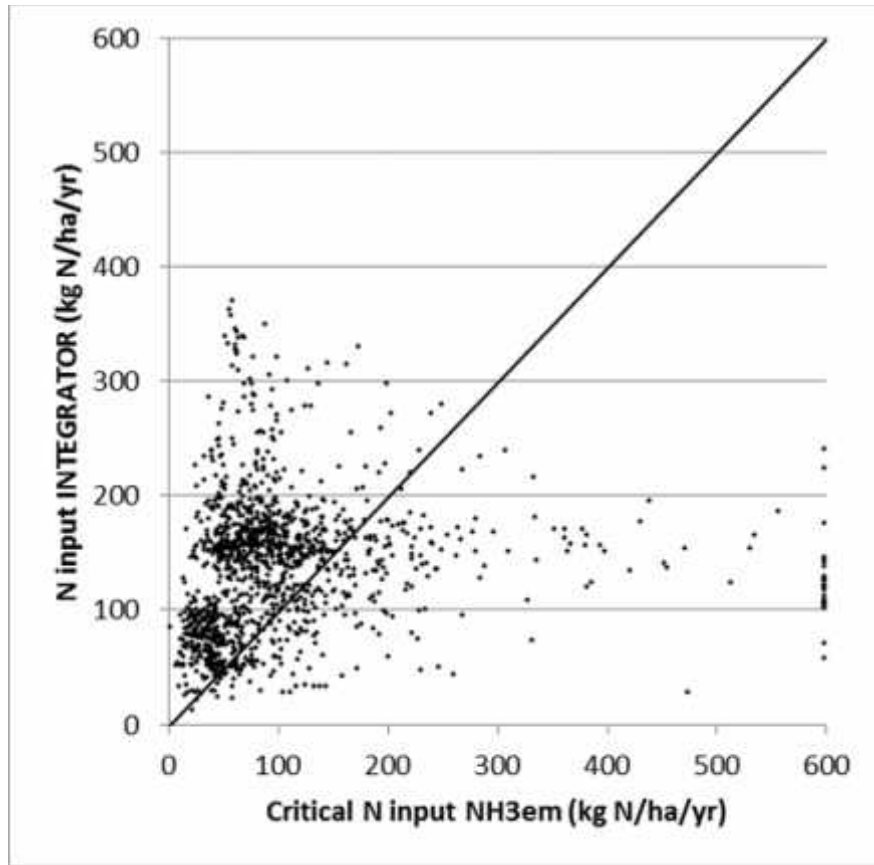
$$\blacksquare N_{\text{in(crit)}} = N_{\text{fe+fix(crit)}} + N_{\text{ex+bio(crit)}} \quad (2)$$

$\text{NH}_{3,\text{em}} = N_{\text{dep}}$ and thus $\text{NH}_{3,\text{em(crit)}}$ is excluded in (1) and $N_{\text{dep(crit)}}$ is excluded in (2)

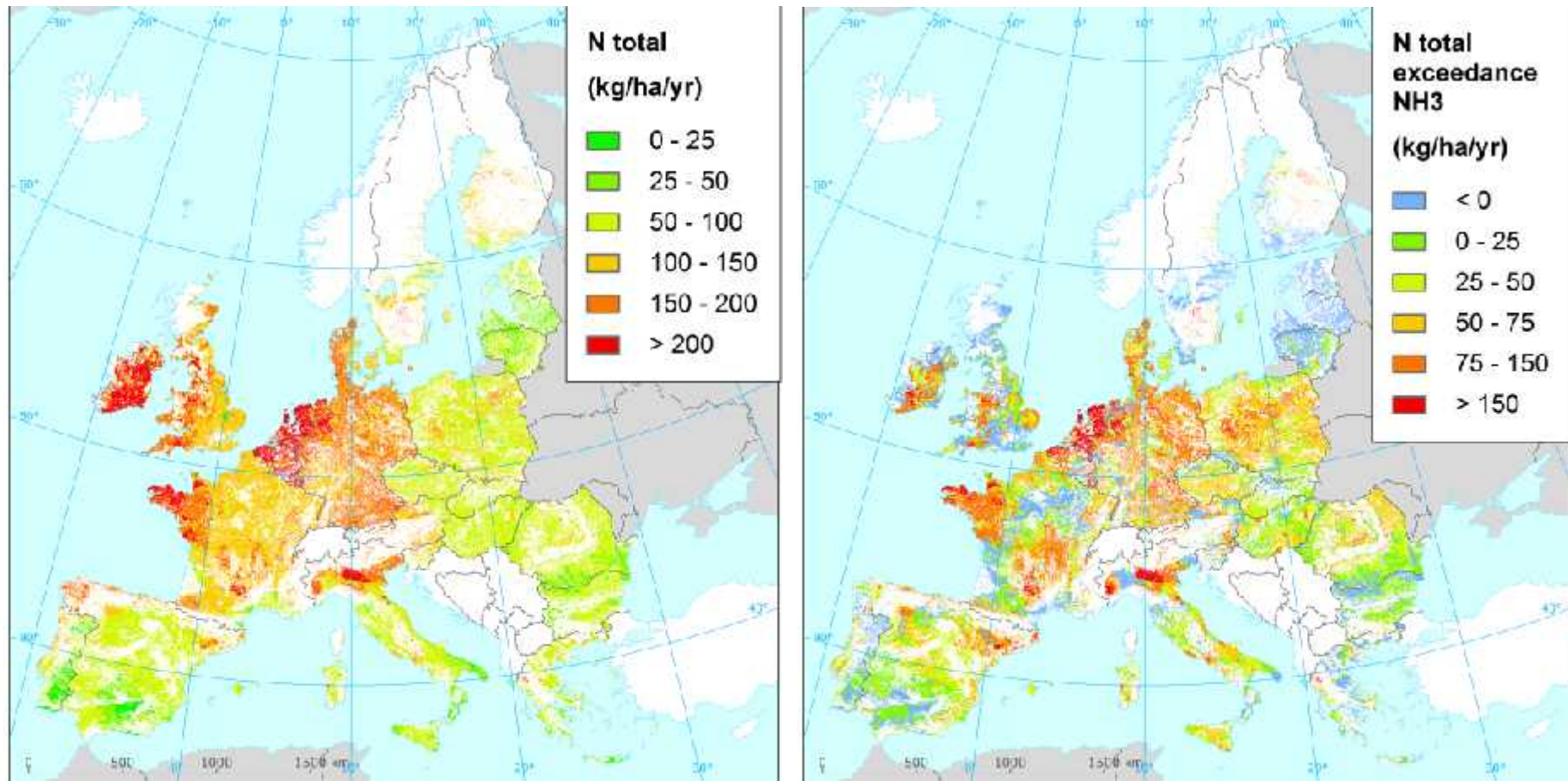
Current and critical N loads at EU27 level

| Source | N budget EU-27 (kg N ha ⁻¹ yr ⁻¹) | | |
|-------------------------|--|-------------------|-----------------------------------|
| | Current | Critical N runoff | Critical NH ₃ emission |
| Input to land | | | |
| Fertilizer +fixation | 63.0 | 56.7 | 63.5 |
| Excretion+ biosolids | 47.3 | 34.8 | 24.7 |
| Total input | 110.3 | 91.5 | 88.3 |
| Output from land | | | |
| Crop uptake | 76.8 | 65.2 | 53.3 |
| Total surplus | 33.5 | 26.3 | 35.0 |
| Denitrification | 23.6 | 20.5 | 24.7 |
| Leaching + runoff | 13.9 | 5.8 | 10.3 |
| Accumulation | -3.9 | 0 | 0 |
| Total output | 110.3 | 91.5 | 88.3 |

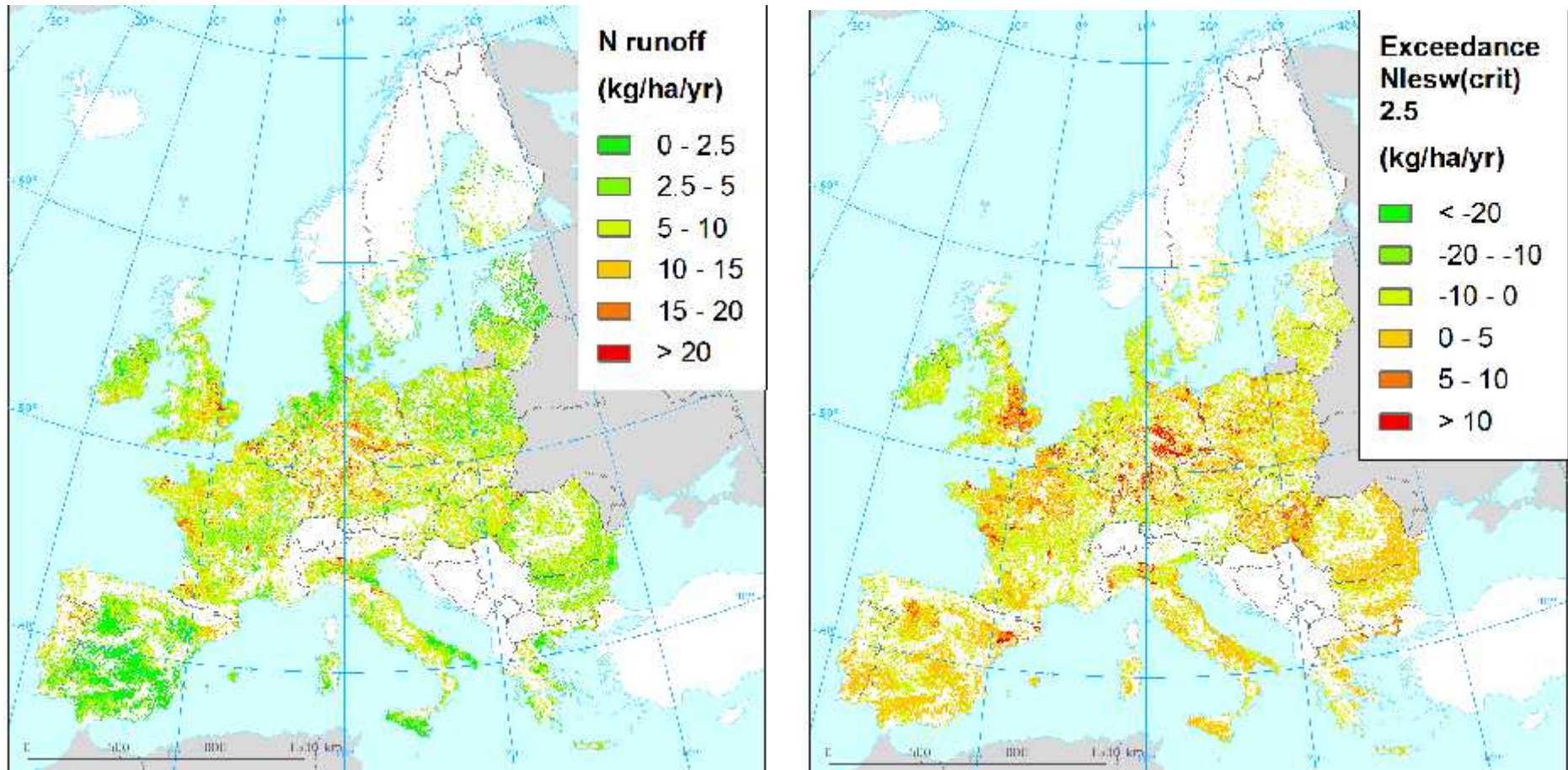
Current N loads vs critical N loads for impacts on ecosystems and surface waters



Current N loads and exceedance critical N load in view of N deposition on nature



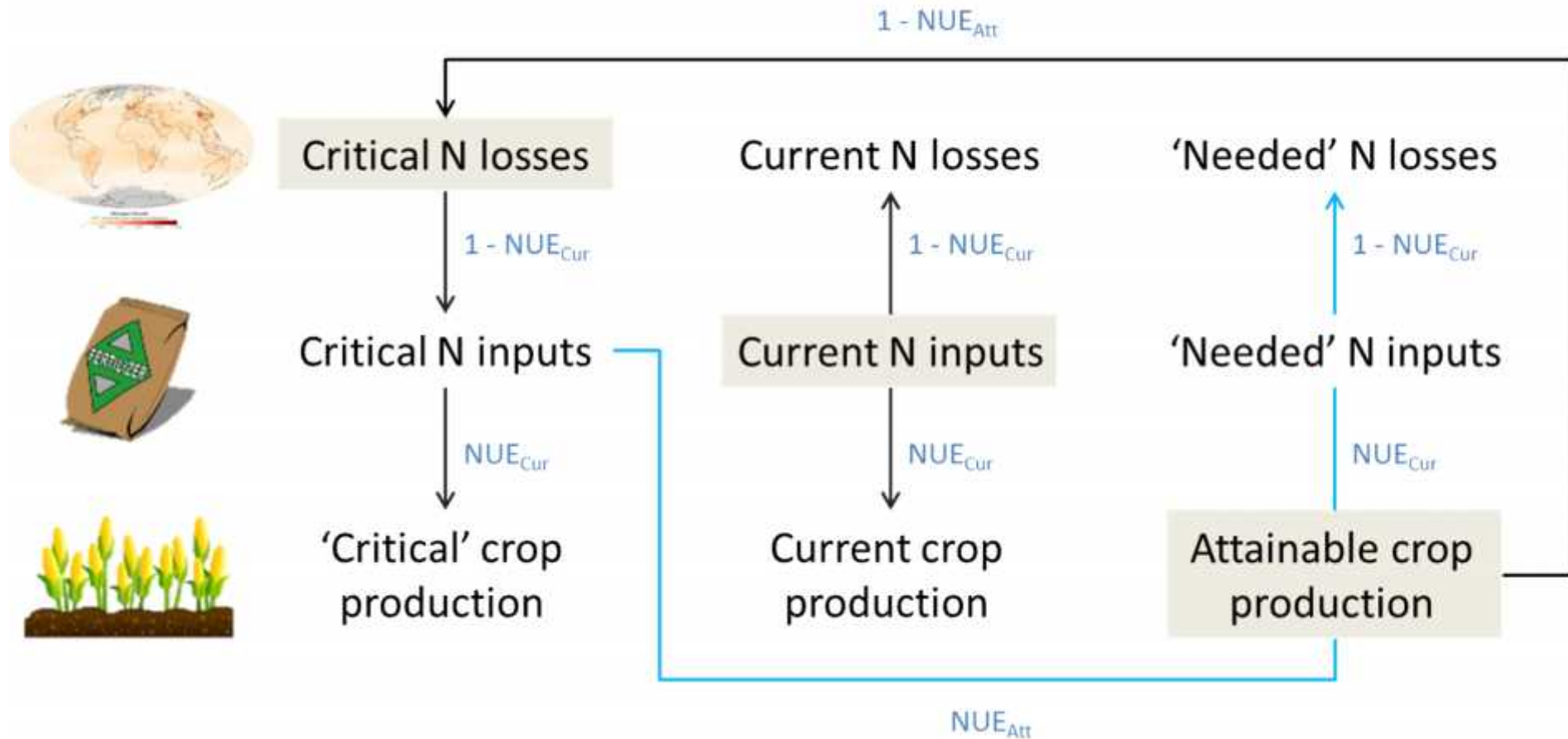
Current and critical N runoff to surface water in EU27



Conclusions

- At EU 27 level, current N inputs exceed critical N loads in view of eutrophication by 15% for aquatic ecosystems and 25% for terrestrial ecosystems.
- Large critical N input exceedances occur in intensive animal husbandry areas
- Critical N inputs are larger than current loads in areas with lower current NH_3 emission (e.g. low livestock) or lower current N leaching (e.g. peat soils) than acceptable losses.
- In areas exceeding critical N loads the needed NUE increase can (will) be calculated to avoid environmental impacts

Assessing needed increases in NUE



Questions?



INMS Towards the Establishment of an
International Nitrogen Management System

