Assessment of current and critical nitrogen inputs on European agricultural soils

Wim de Vries

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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 N_2O).
  - Need to include both food security versus harmful effects of over application to avoid misuse

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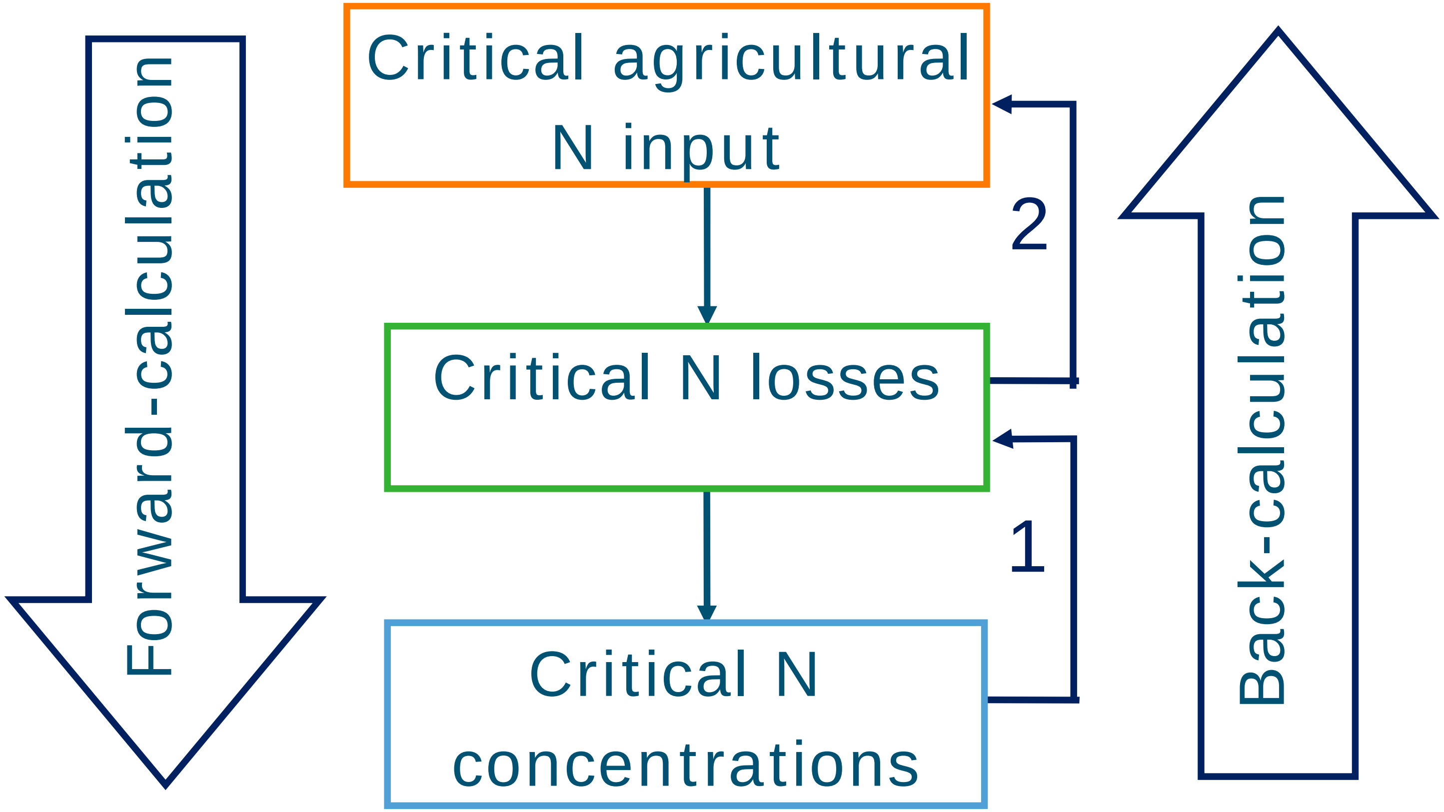
Current Opinion in Environmental Sustainability

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

Wim de Vries[1,2], Johannes Kros[1], Carolien Kroeze[2] and Sybil P Seitzinger[3]

Assessment of critical N loads



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Comparison of current and critical N fluxes

Current N sinks

N uptake

NH_3-N emissions to air

N denitrification

NO_3 leaching and runoff

Critical N sinks

N uptake

NH_3-N emissions to air

N denitrification

NO_3 leaching and runoff

The critical N input is exceeded when the current NH_3-N emission rate or N runoff rate input exceeds critical values

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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

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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 NH_3 emission = f critical N deposition) and water (precipitation surplus x critical N concentration)

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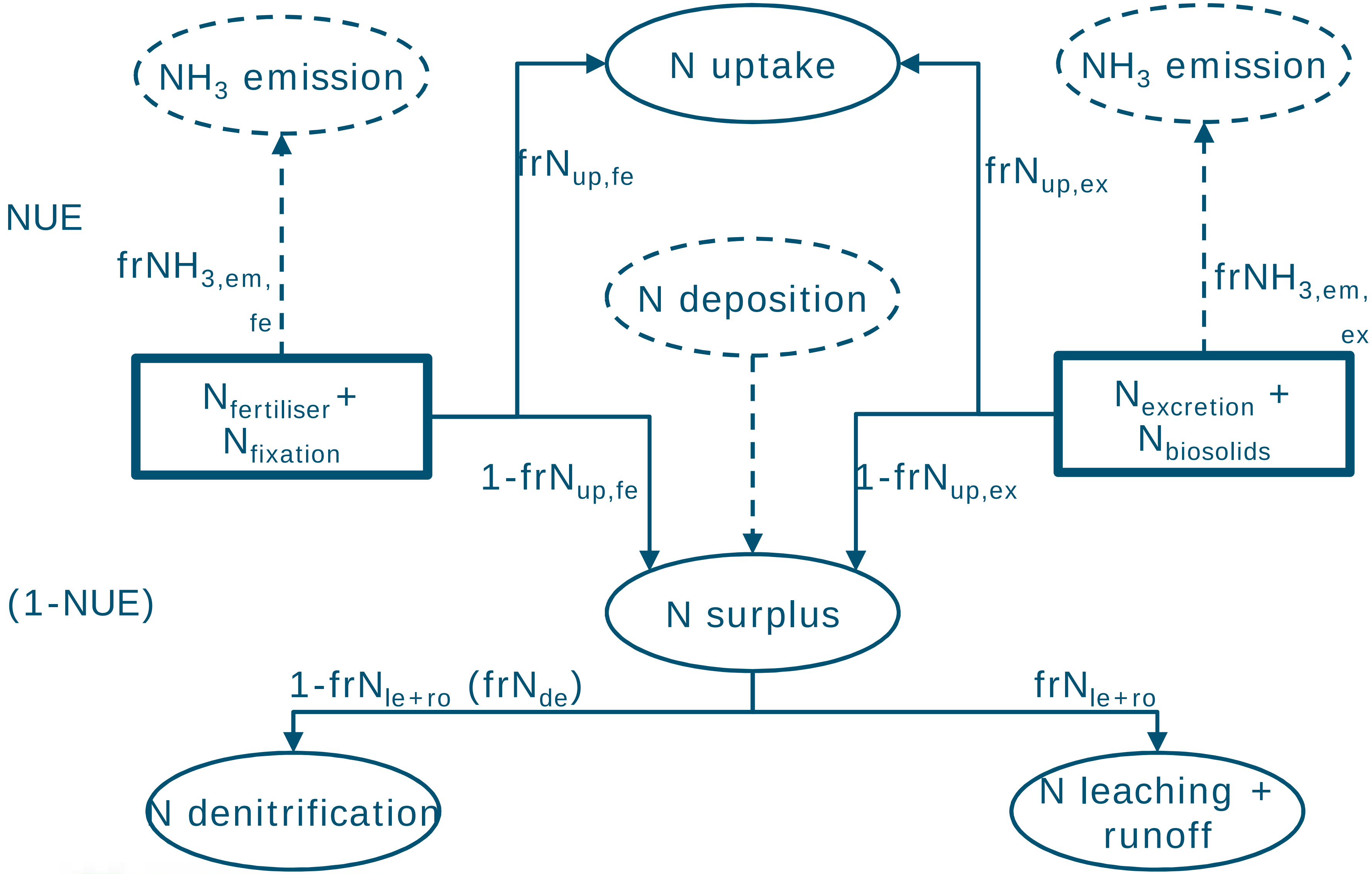

NH3 emission
N uptake
NH3 emission
frNup,fe
frNup,ex
NUE
frNH3,em,fe
N deposition
frNH3,em,ex
Nfertiliser + Nfixation
Nexcretion + Nbiosolids
1-frNup,fe
1-frNup,ex
(1-NUE)
N surplus
1-frNle+ro (frNde)
frNle+ro
N denitrification
N leaching + runoff

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

The critical N fertilizer application rate can be derived as:

- $N_{in(crit)} = N_{up(crit)} + N_{de(crit)} + N_{le+ro(crit)}$ (1)

Note that

- $N_{in(crit)} = N_{fe+fix(crit)} + N_{ex+bio(crit)}$ (2)

$NH_{3,em} = N_{dep}$ and thus $NH_{3,em(crit)}$ is excluded in (1) and $N_{dep(crit)}$ 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**

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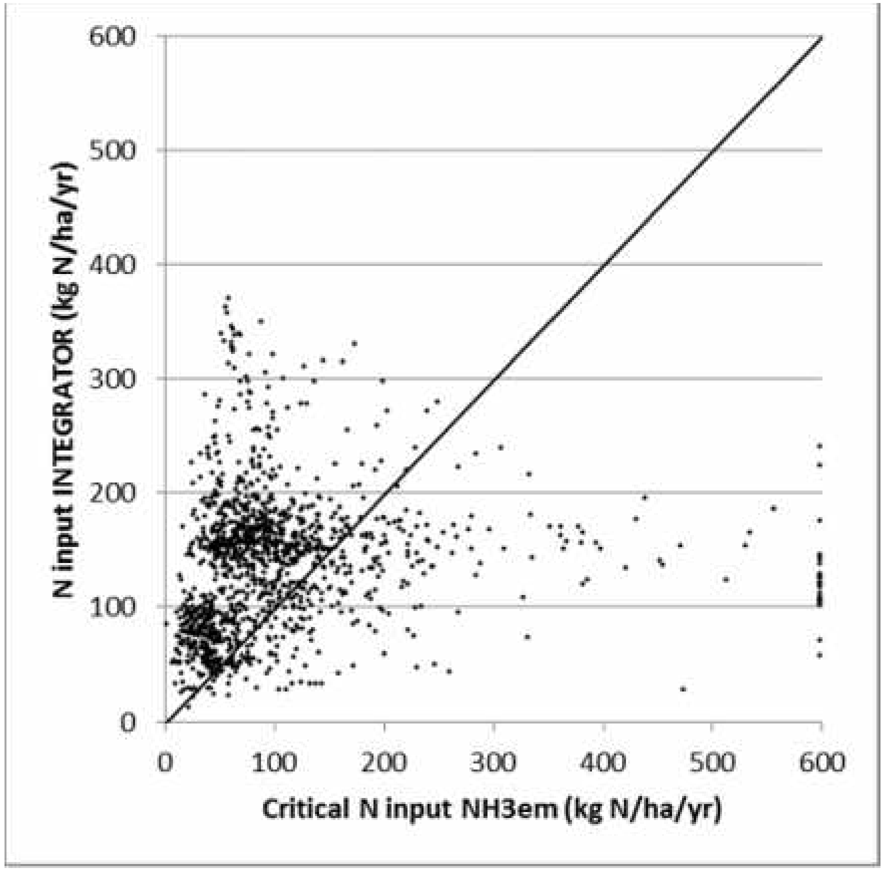
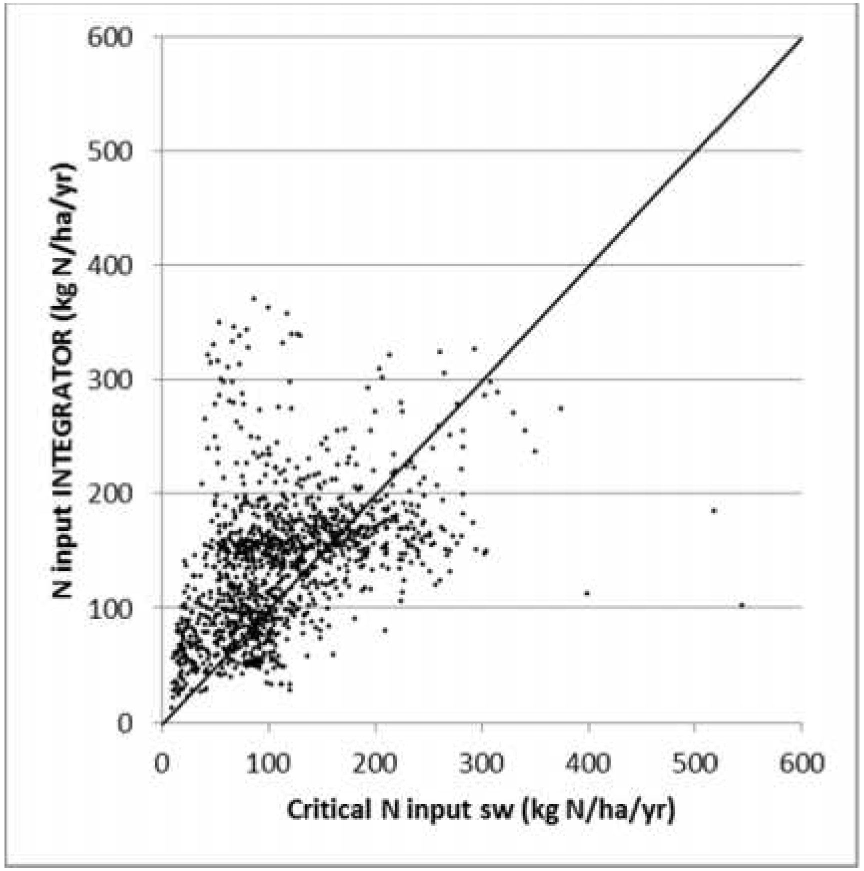
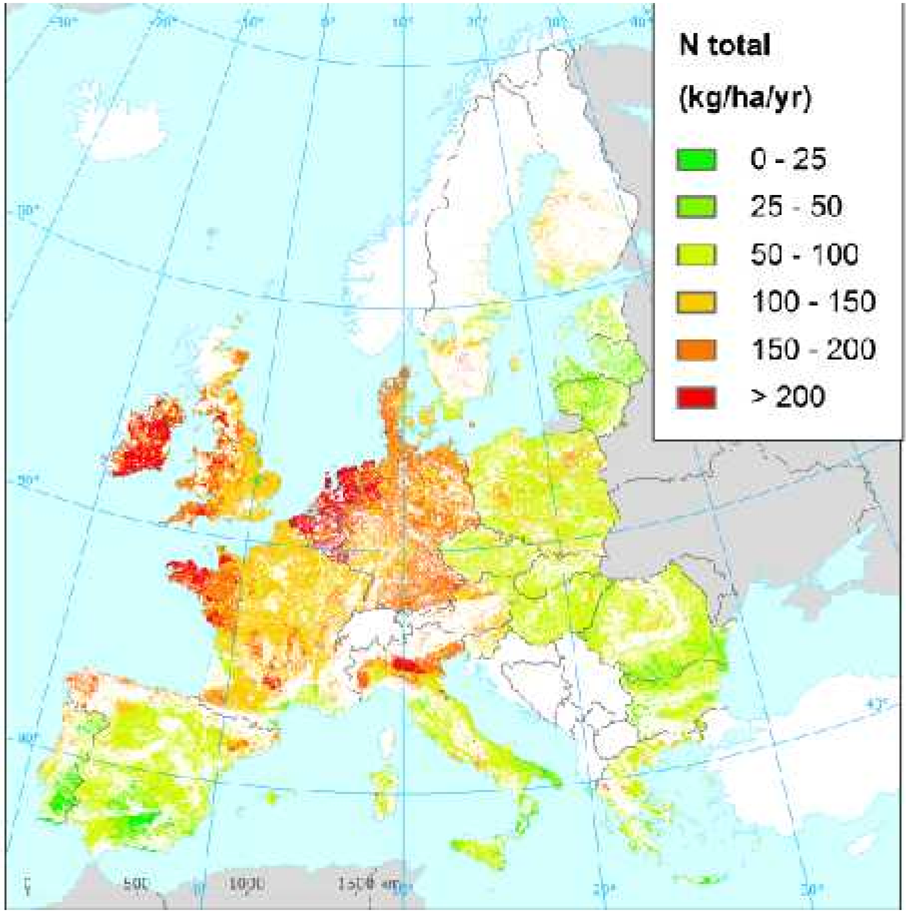
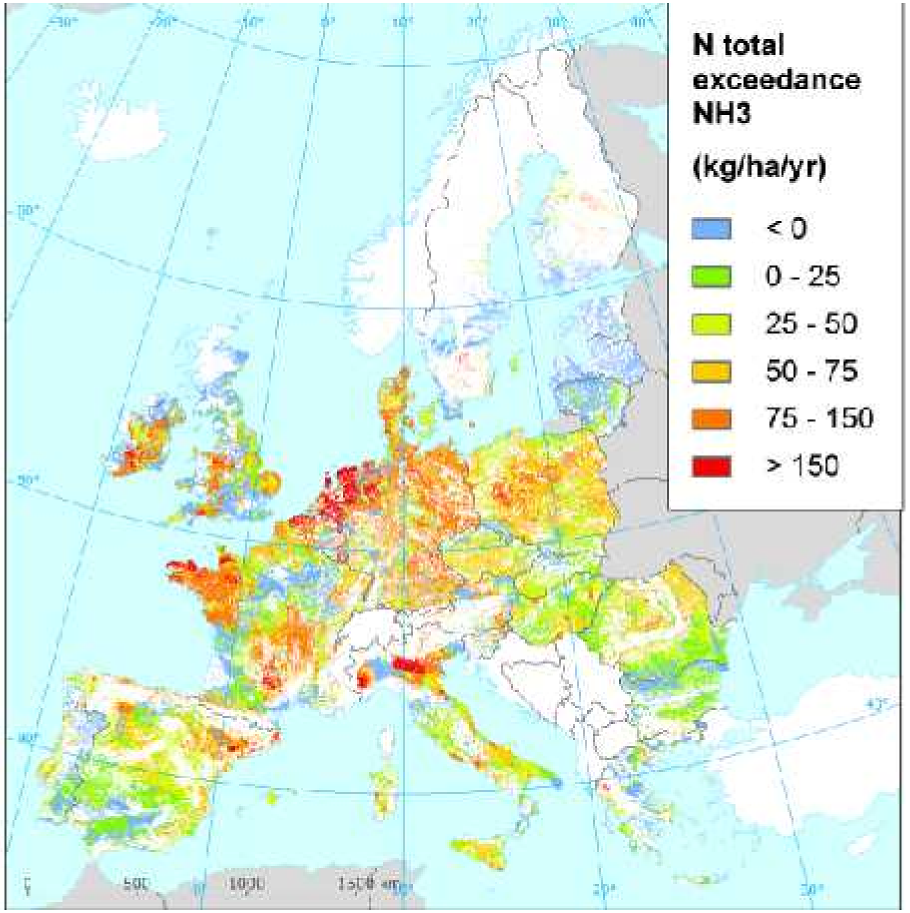
Current N loads vs critical N loads for impacts on ecosystems and surface waters





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





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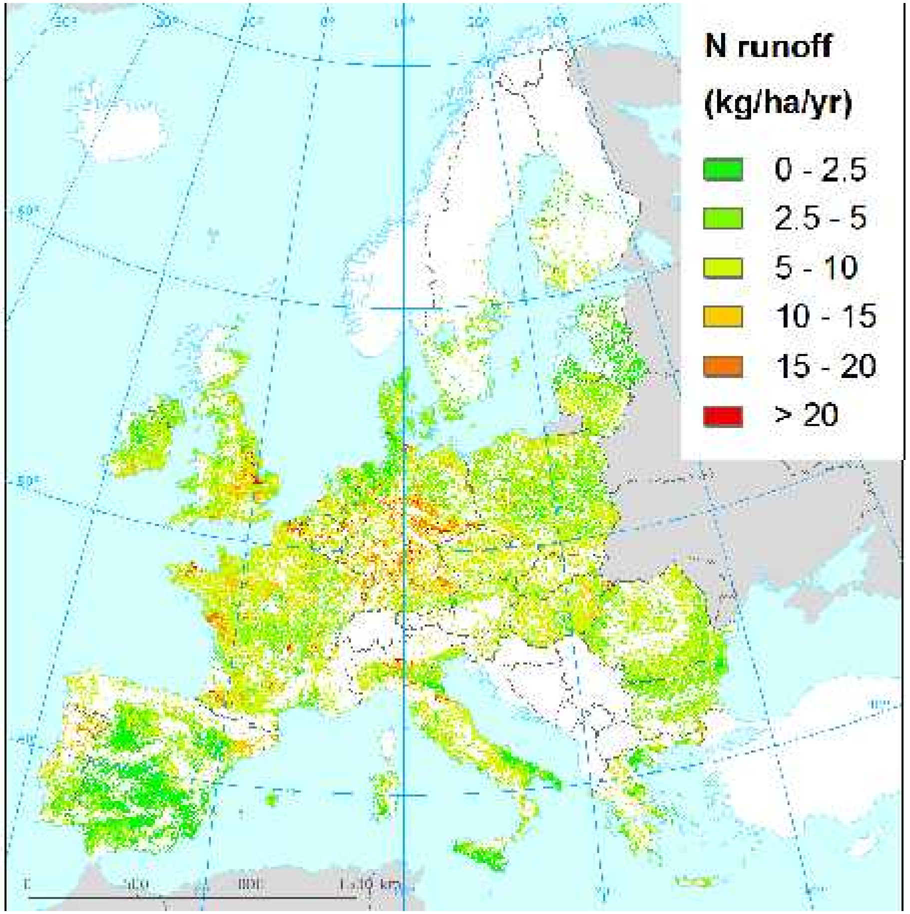
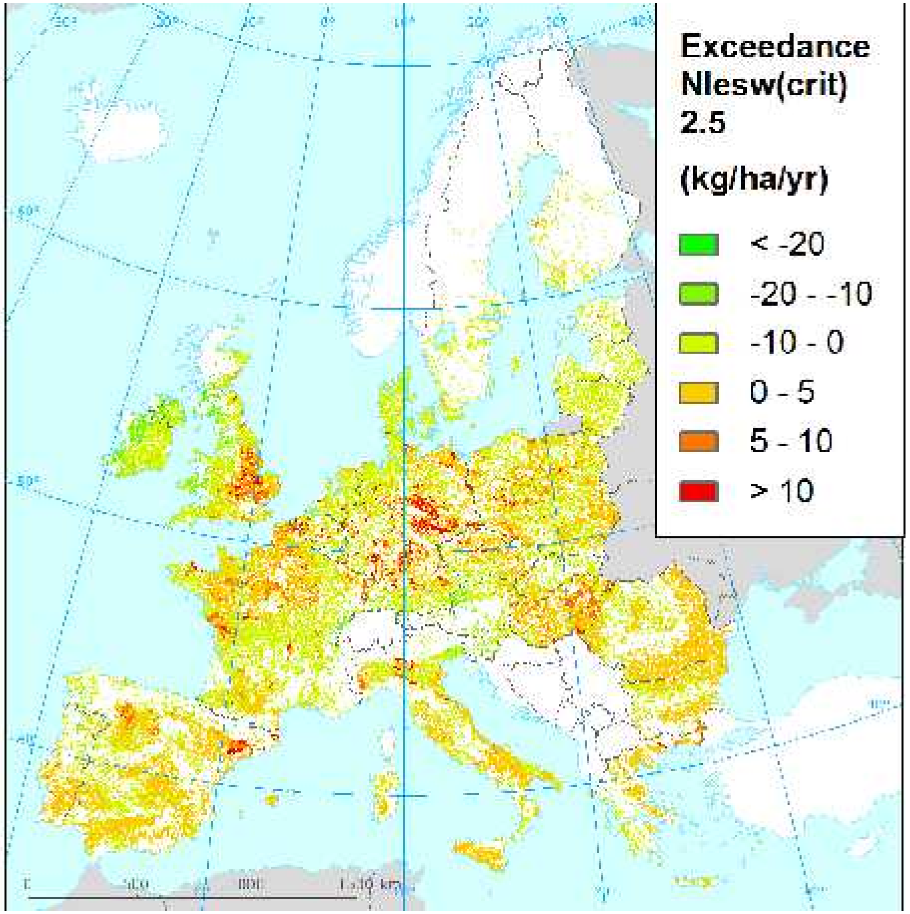
Current and critical N runoff to surface water in EU27





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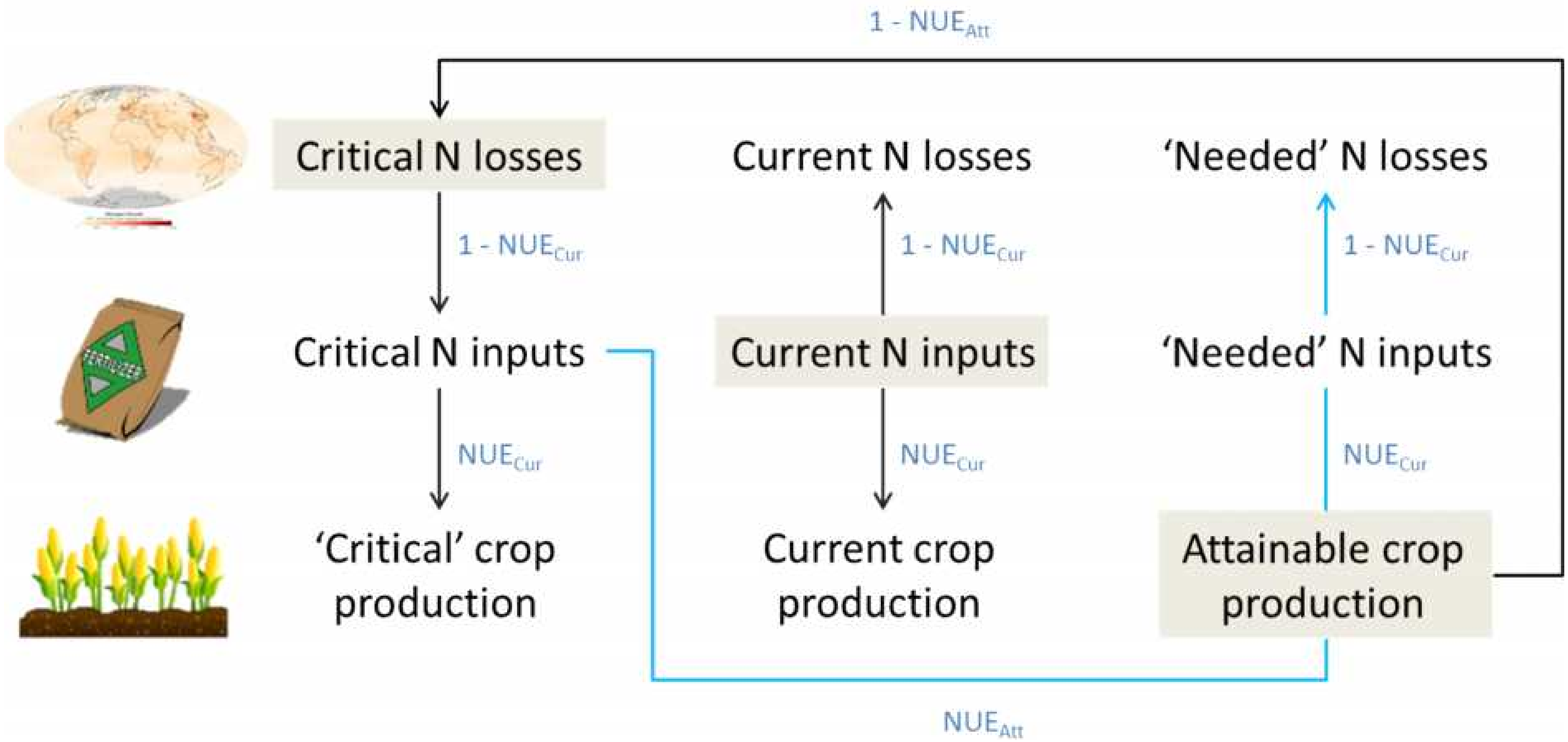
Conclusions

- 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



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Questions?


INMS
Towards the Establishment of an
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