Implementation of the European Nitrates Directive via soil N surplus-based application standards

Jaap Schröder, Dico Fraters, Joan Reijs, Frans Aarts & Gerard Velthof

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National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

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- Underpinning of ND-proof N and P application standards
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    - Model
- Some results
- Conversion of outcomes into policies

- Conclusions

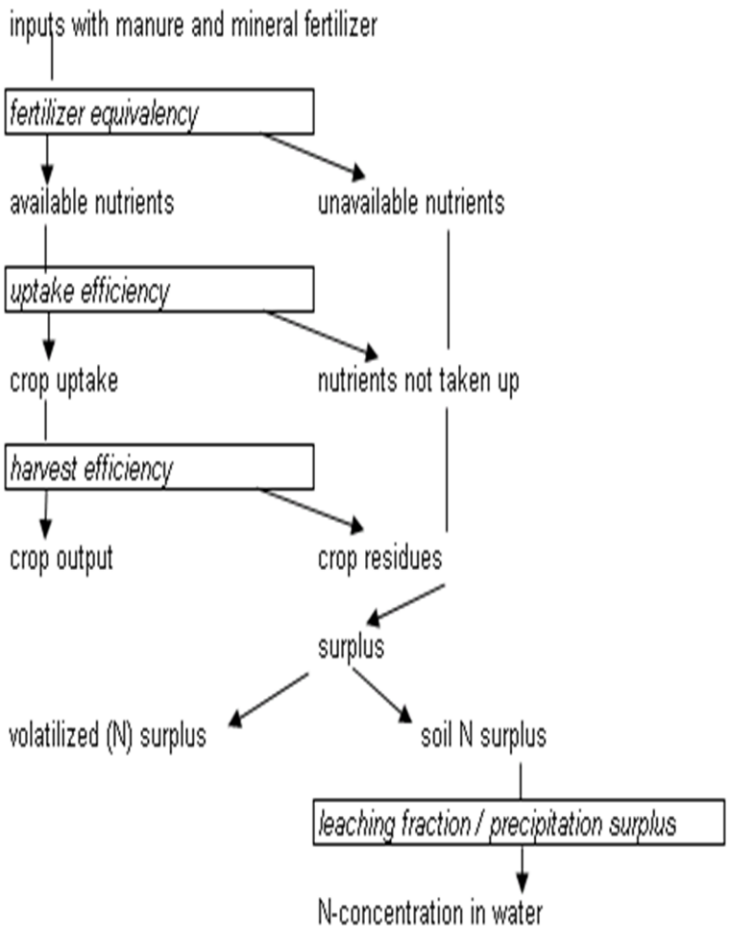
Nitrates Directive in the Netherlands: remaining issues

- Impressive reduction of [NO_3] between 1992-2004, but stagnation afterwards
- Frequent excedance of 50 mg NO_3/l threshold in upper groundwater
    - *particularly: arable land, dry sandy soils, regions with intensive livestock: south eastern part of the Netherlands*

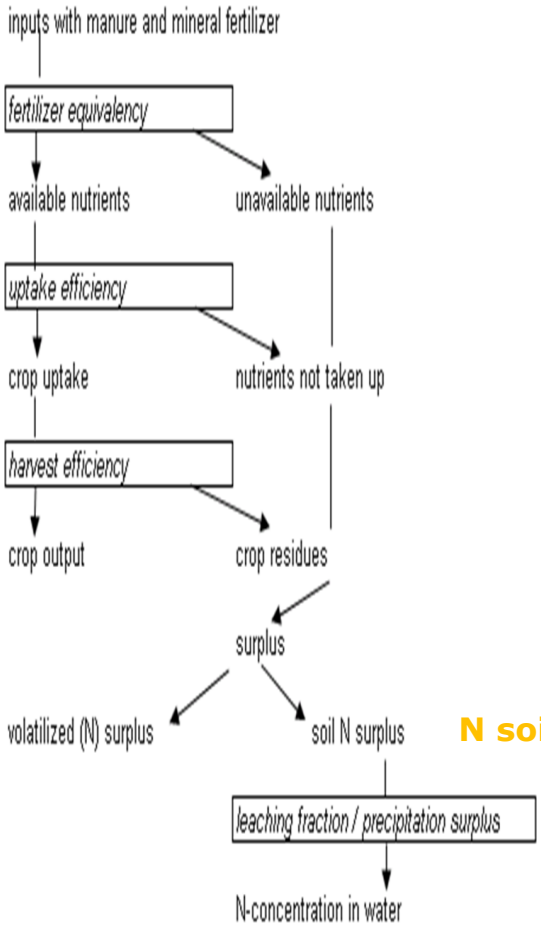
- Fresh water P concentrations still too high
    - *170 kg manure-N >>> crop P offtake!*
- 2014-2017: 5th Action Programme:
    - ***Further reduction of N and P application standards***
- **Preceded by documented underpinning of these reductions**

Conceptual leaching model:

N inputs ↔ N soil surplus ↔ N leaching ↔ NO_3 concentration

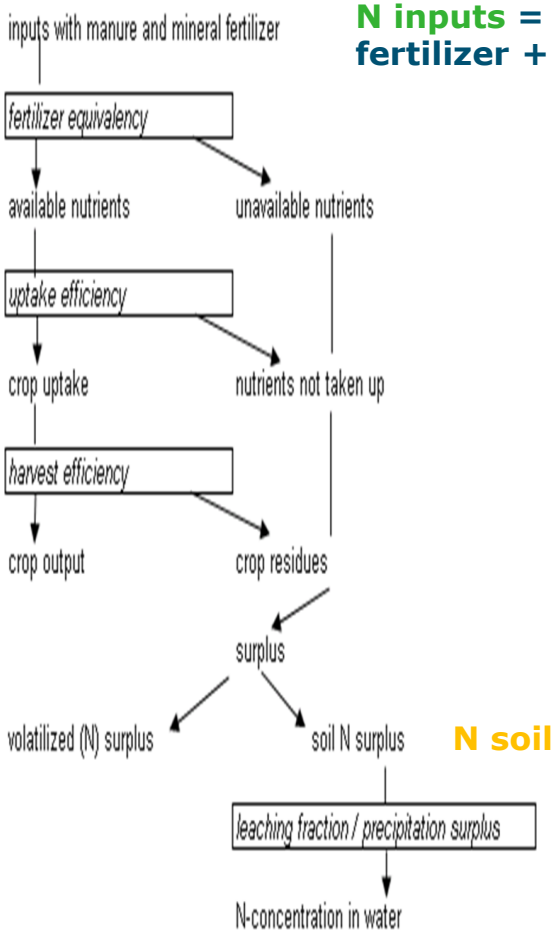


Conceptual leaching model



N soil surplus = N inputs – N outputs

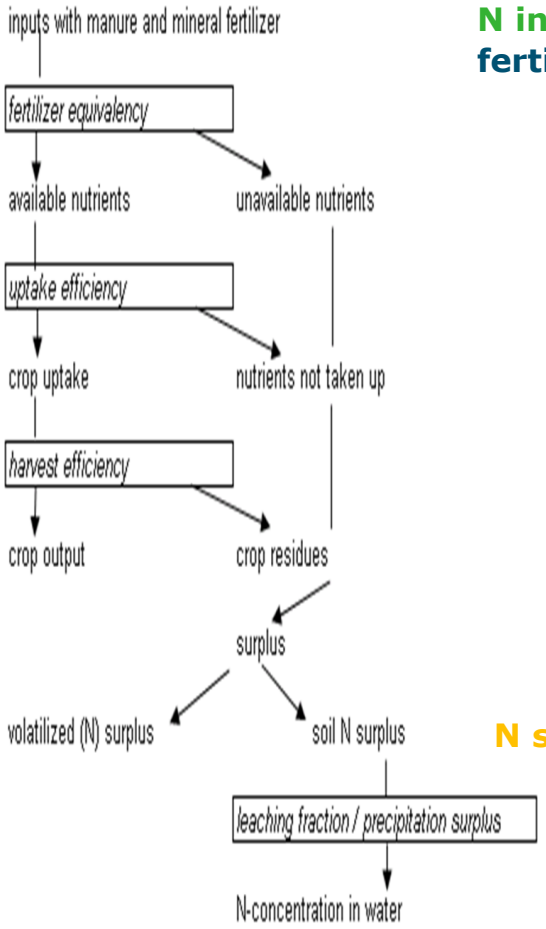
Conceptual leaching model



N inputs = atmospheric N + mineral N fertilizer + manure N *type i*

N soil surplus = N inputs – N outputs

Conceptual leaching model



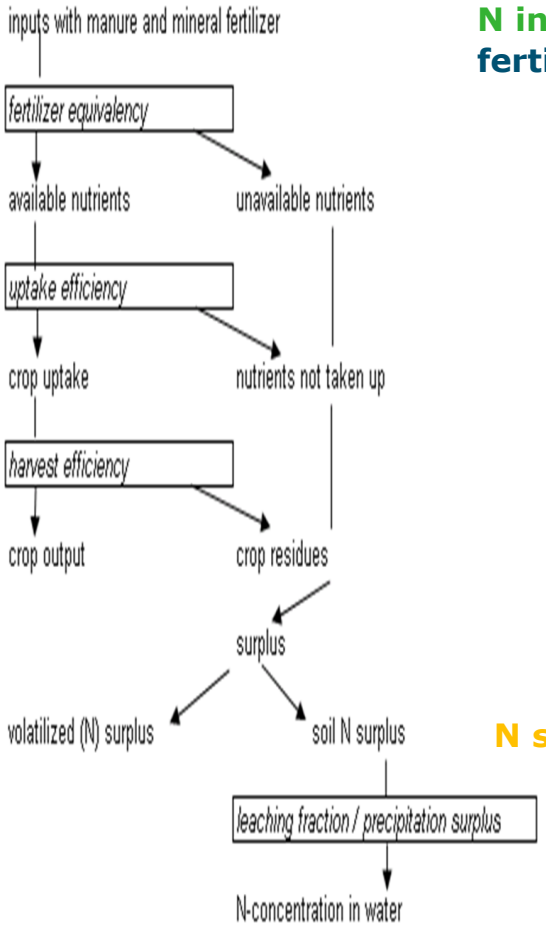
N inputs = atmospheric N + mineral N fertilizer + manure N $_{type\ i}$

N outputs = volatilized NH_3-N from fertilizers and manures + N crop output

N soil surplus = N inputs – N outputs

Conceptual leaching model

N crop output = (Σ^i (**N input**$_i$ x ***fertilizer equivalency***$_i$) x ***uptake efficiency***$_{crop\ type\ j}$ x ***harvest efficiency***$_{crop\ type\ j}$



N inputs = **atmospheric N + mineral N fertilizer + manure N** $_{type\ i}$

N outputs = **volatilized NH_3-N from fertilizers and manures + N crop output**

N soil surplus = **N inputs** – **N outputs**

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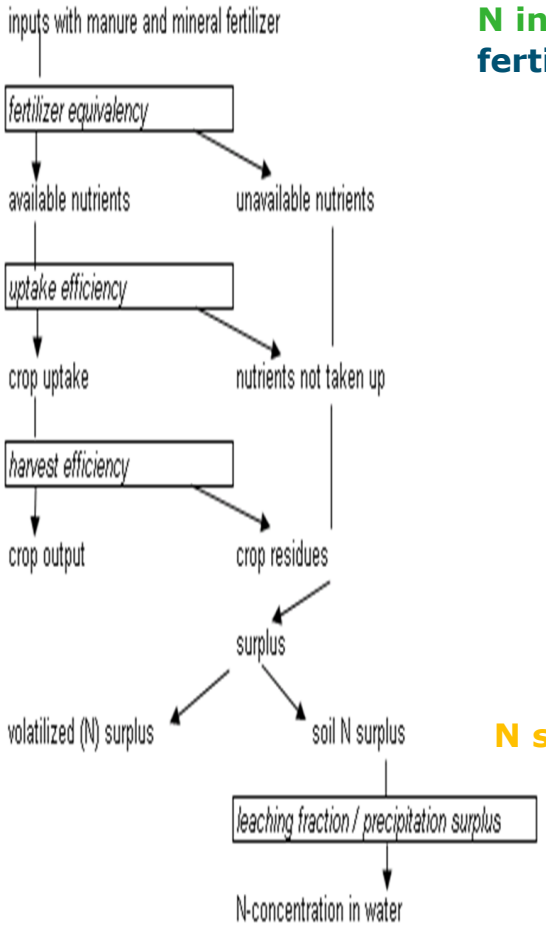
Conceptual leaching model

N crop output = (Σ^i (N input$_i$ x *fertilizer equivalency*$_i$) x *uptake efficiency*$_{crop\ type\ j}$ x *harvest efficiency*$_{crop\ type\ j}$



N inputs = atmospheric N + mineral N fertilizer + manure N $_{type\ i}$

N outputs = volatilized NH_3-N from fertilizers and manures + N crop output

N soil surplus = **N inputs** – **N outputs**

P surplus =

(manure N x *P/N*$_{manure\ type\ i}$) –

(N in crop output x *P/N*$_{crop\ type\ j}$)

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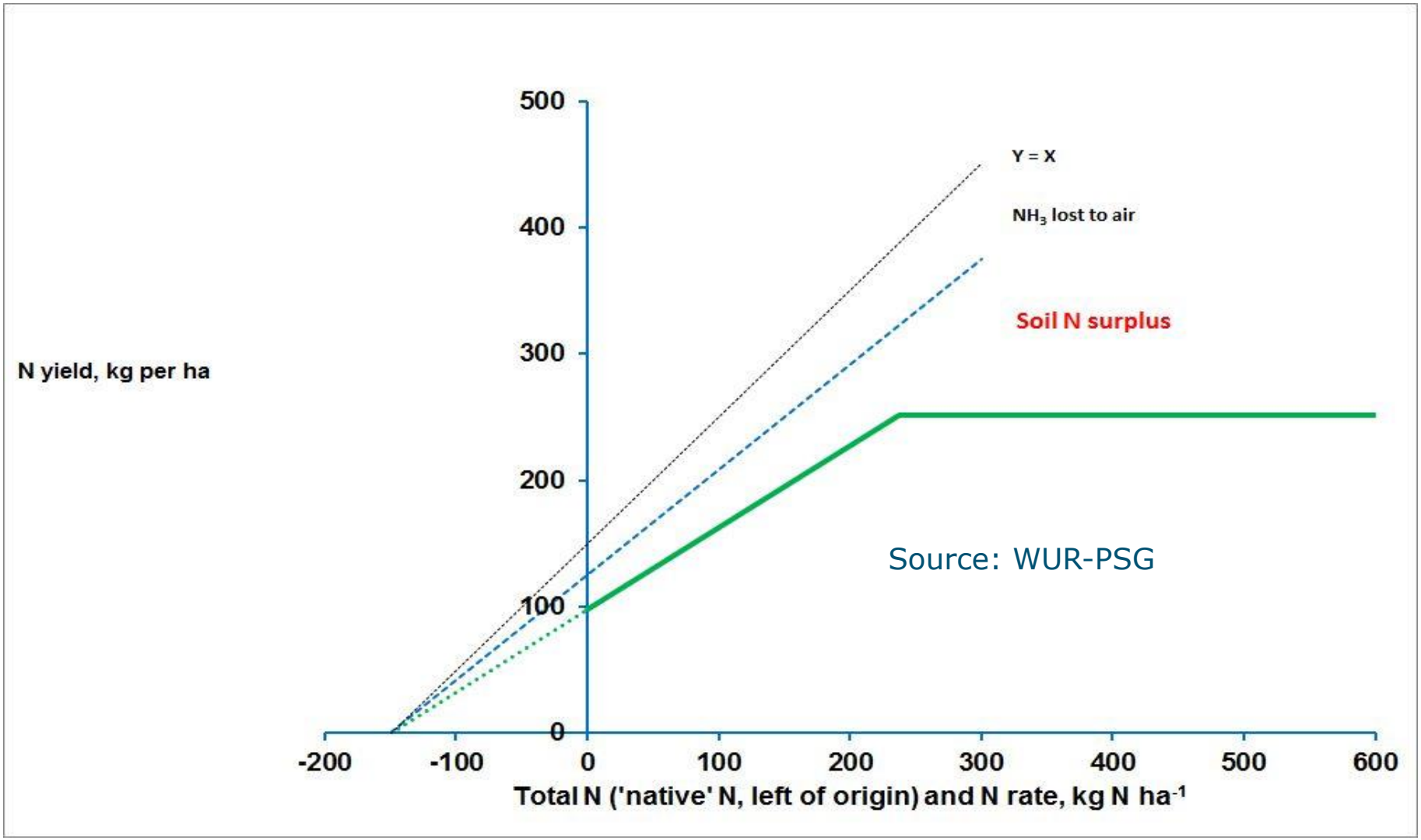
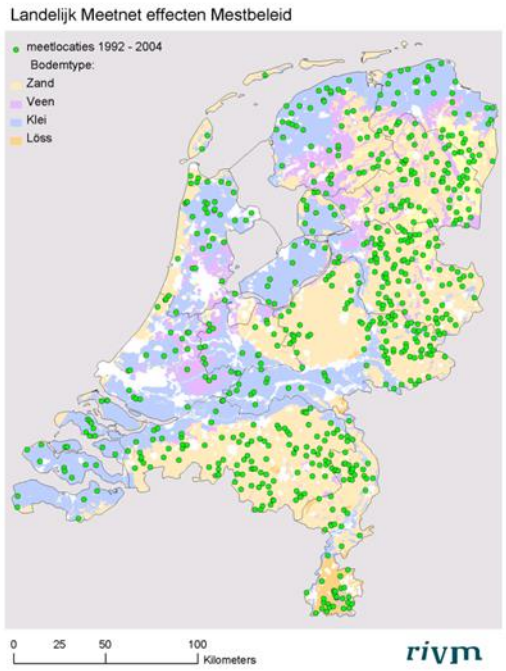
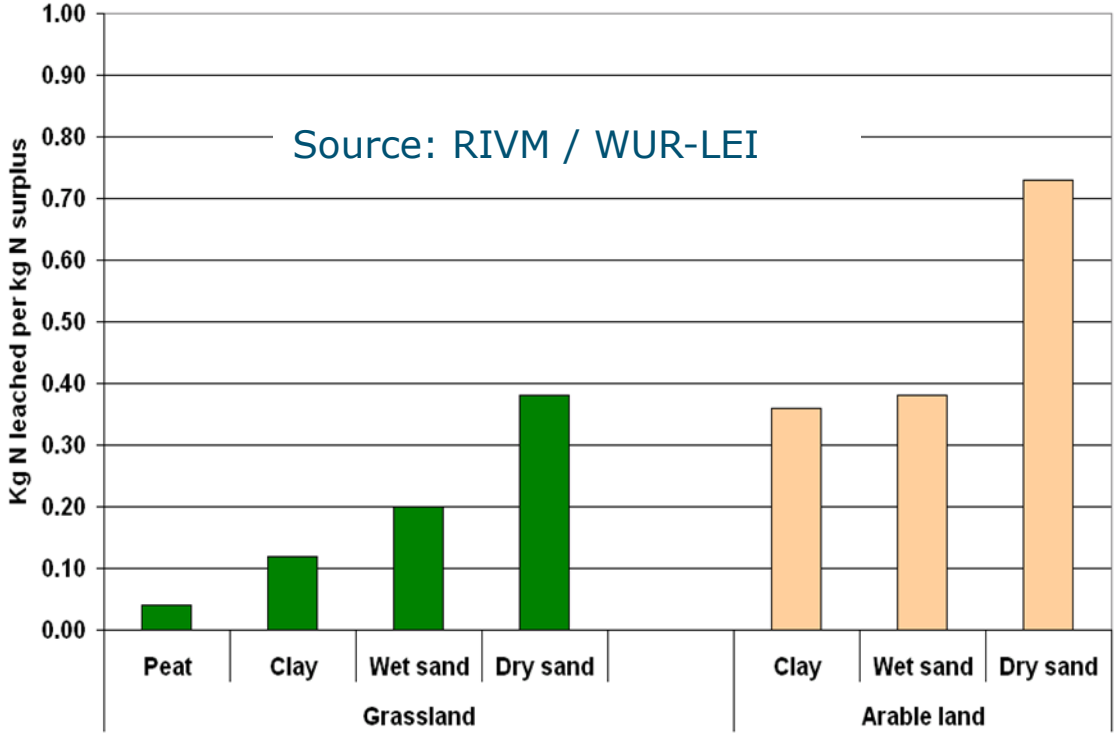
Crop type-specific relationships between N input, crop N uptake, soil N surplus



Relationship between soil N surplus and N leaching:

Leaching Fractions





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Modelling: task

- **Find**: the combination of manure N and mineral fertilizer N that maximizes yield whilst fulfilling P surplus = 0 and [NO_3] = < 50 (and assuming that [soil organic N] does not change)

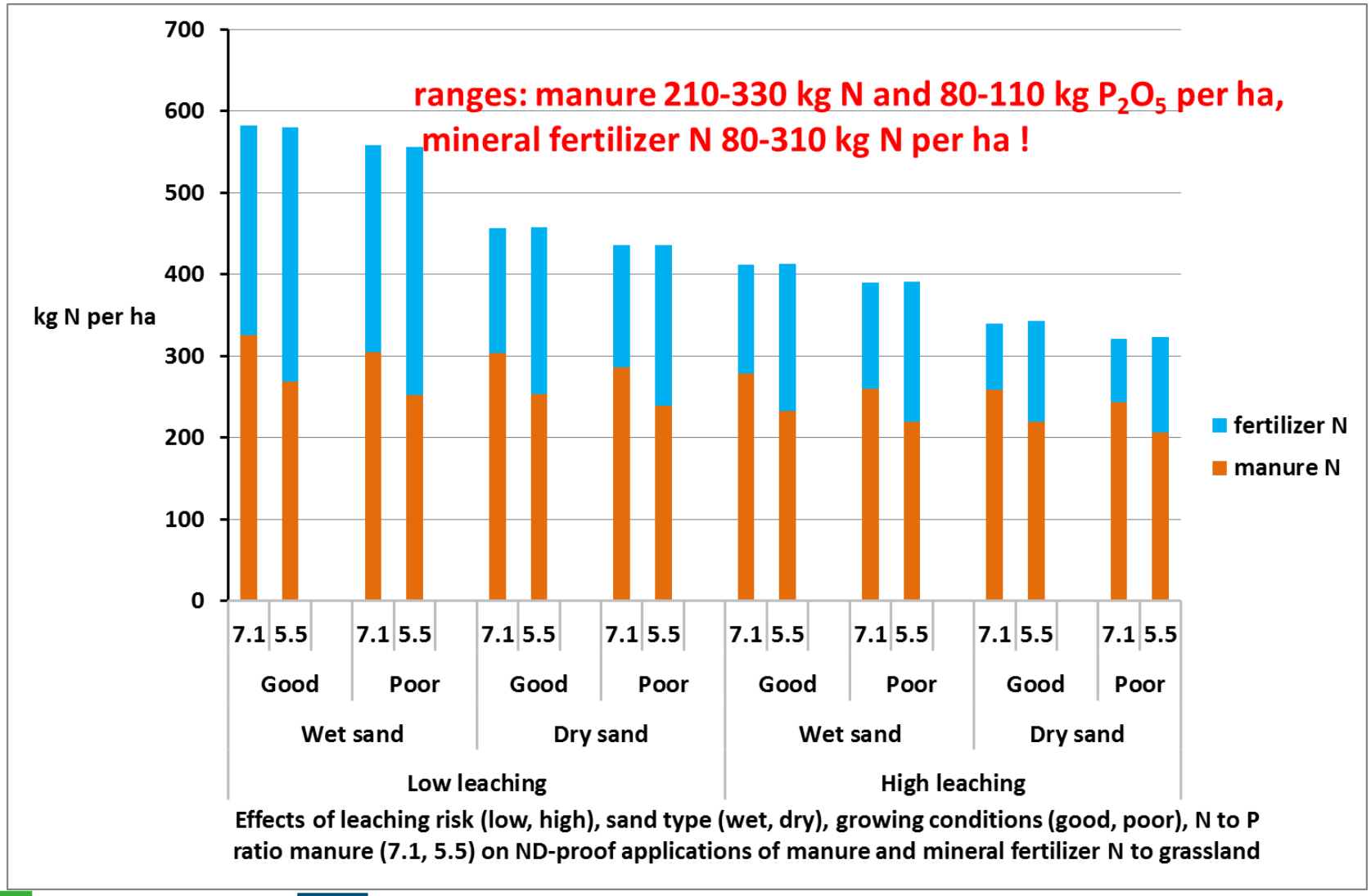
- Spatial and temporal scale of realization of 50 mg nitrate/l unclear in Nitrates Directive !

  - Each individual crop?
  - Each crop type, assuming average yield level?
  - Each individual farm?
  - Sectors (dairy, arable, horticulture) as a whole?
  - **Regions as a whole?**

Modelling: results

- Outcomes strongly depending on factors that differ from one farm to another, e.g.:
  - Soil type and weather
  - Composition of rotation
  - N/P ratio of manure
  - Operational management skills

No such thing as one unique solution



Effects of leaching risk (low, high), sand type (wet, dry), growing conditions (good, poor), N to P ratio manure (7.1, 5.5) on ND-proof applications of manure and mineral fertilizer N to grassland

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Conversion of outcomes into policies (1)

- Considerations against differentiation:
  - not always needed from an environmental point of view due to temporal and spatial mixing
  - much larger farm data requirement
  - much larger enforcement effort for authorities
  - creation of an unlevel playing field for farmers
  - draconic interventions needed in specific situations

- Reduction of N rates by -20% for 'leaky crop types' yet deemed inevitable in south eastern sandy regions

Conversion of outcomes into policies (2)

- reductions of N rates beyond economical optimum in south eastern sandy regions

Effective N (kg/(ha.y)) from mineral and/or organic fertilizers (2014-2017)

crop	region:			
	Sand:		Peat	Clay
	south eastern	elsewhere		
	(dry < ⟵ ⟶ < wet)			
Grassland, partly grazed	250	250	265	345
Grassland, cut only	320	320	300	385
Silage maize	↓ 112	140	150	160-185
Winter wheat	160	160	160	245
Ware potatoes	↓ 188	235	245	250
Sugar beets	↓ 116	145	145	150
Onions	120	120	120	120
Leek	↓ 180	225	235	245
White cabbage	↓ 232	290	305	320
Lettuce, per crop	↓ 116-132	105-165	105-170	105-180
Spinach, per crop	↓ 116-152	145-190	150-200	185-260

Conversion of outcomes into policies (3)

*Permitted **manure N** application rates (kg N/ha) and stipulated fertilizer equivalency of manure*

Farm type	Region	Rate	Fertilizer equivalency
Dairy farm with >80% grassland, including grazing	South-east	230	45%
Dairy farm with >80% grassland, no grazing	South-east	230	60%
Dairy farm with >80% grassland, including grazing	Elsewhere	250	45%
Dairy farm with >80% grassland, no grazing	Elsewhere	250	60%
Dairy farm with <80% grassland, including grazing	Anywhere	170	45%
Dairy farm with <80% grassland, no grazing	Anywhere	170	60%
Arable farm using cattle slurry (N/P = 6.3)	Anywhere	140-170	60%
Arable farm using pig slurry (N/P=3.5)	Anywhere	80-120	80%

Conclusions

- Nitrate in the Netherlands not yet under control, so
- **Reduction of N applications needed**, underpinned via a
- Relatively simple model: transparent for all stakeholders
- Model relationships:
    - Derived from experiments and commercial farms, however
    - Strongly based on average situations and performances
- Reduced N rates in south eastern NL: **yield reduction 5-10%**
- Increasing call for more differentiation from farmers stating that they act 'better than their neighbours'
    - Required evidence not always easy to collect...
    - **Differentiation** must work in **two directions** to arrive at a comparable water quality...