

Farmer driven national monitoring of nitrogen concentrations in Denmark

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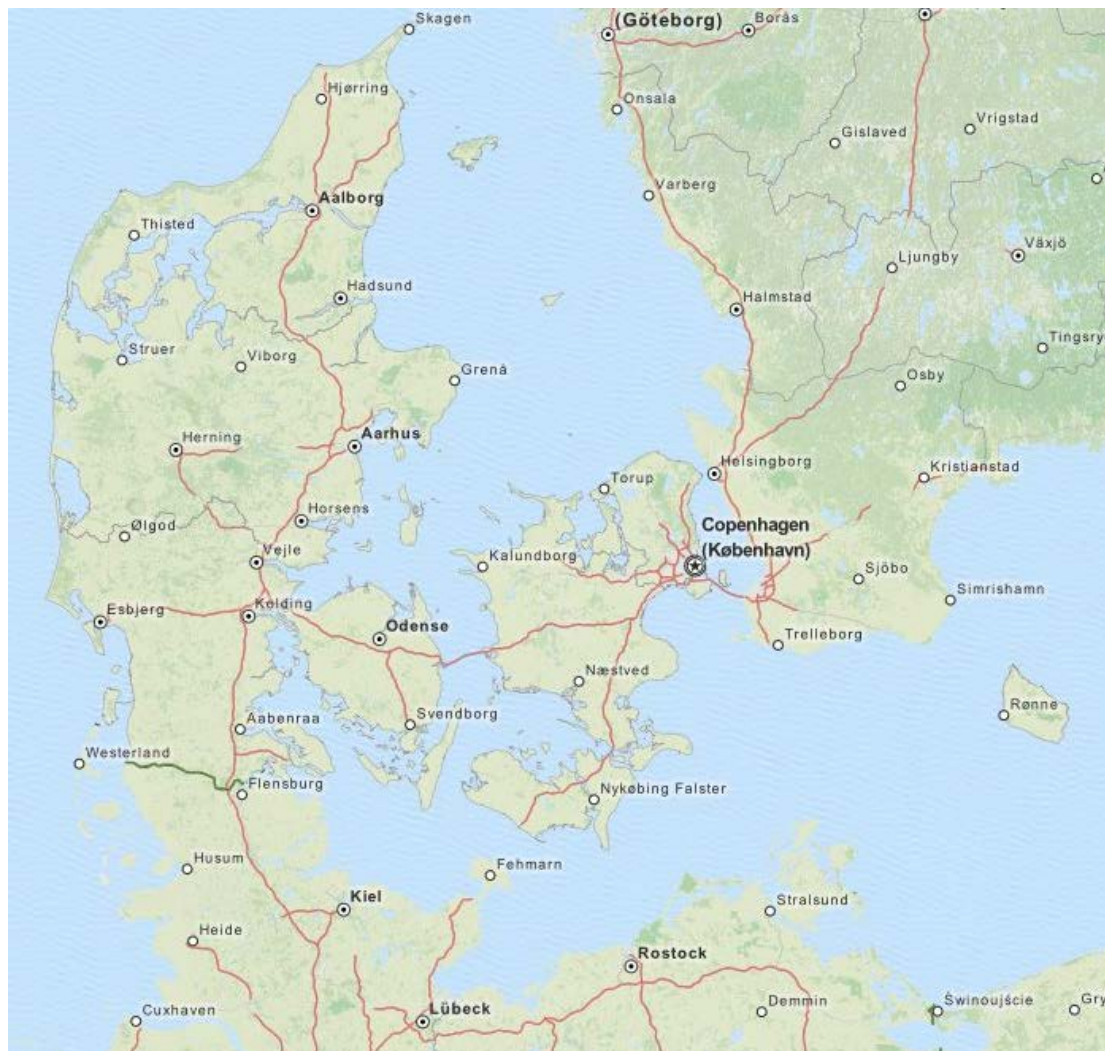
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Background

Agriculture in Denmark

- Area: 42900 km²
- Coast line: 7300 km
- Intensive agricultural production
 - Land use: 62% agricultural land
 - Livestock: 1.6 million cattle and 12 milion pigs
- Oxygen deficits in fjords and inner water bodies



Background

Nitrogen regulation in Denmark

Eutrophication problems in the 80ties and 90ties tackled through a series of water management plans

Likely the strictest regulation of agricultural practice in Europe

- Fixed norms for N application (>15% below financial optimum)
- Mandatory catch crops on 14% of arable land
- Mandatory nutrient management plans
- Mandatory 10 m buffer zones around streams and rivers
- Detailed regulation regarding timing of tillage, manure application etc.
- Environmental assessment of expanding animal husbandry

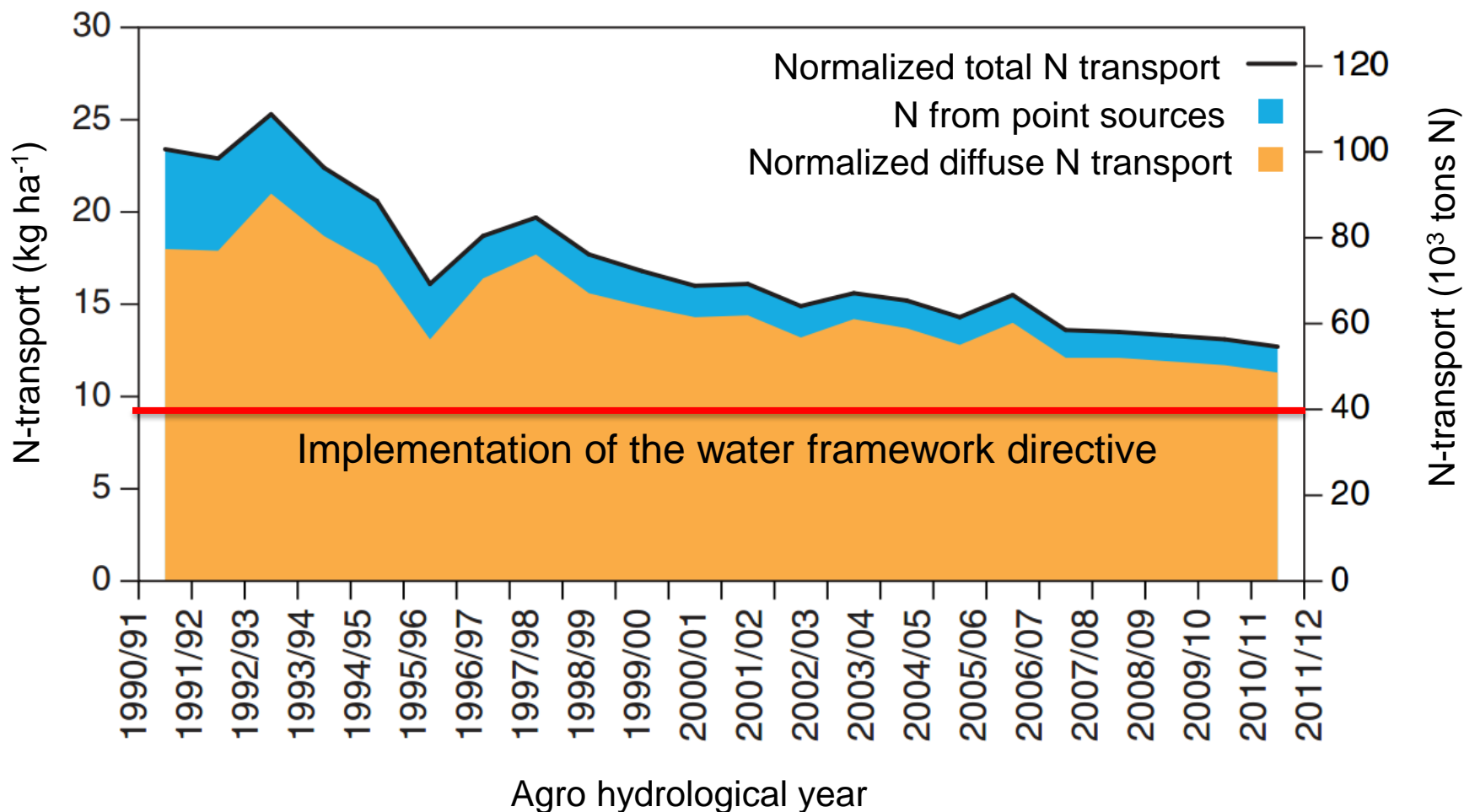
Substantial bureaucracy to check that these rules are obeyed

Economic loss for the agricultural sector estimated at 270 mill. euros



The national drainage water survey

Why?



Wiberg Larsen et al. (2012)



The national drainage water survey

Why?

More regulation, increased catch crop area etc. threatened to make financially viable farming impossible in certain areas

Frustrated farmers wanted to see for themselves if they were to blame!

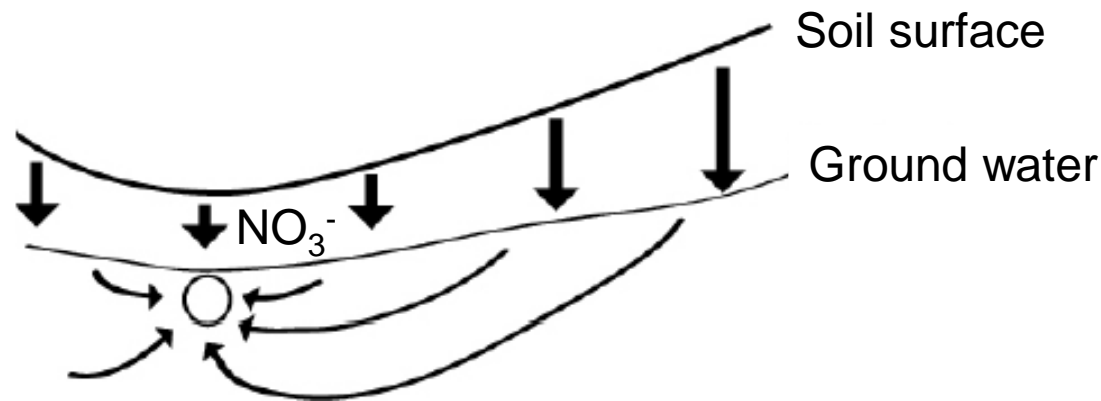
The national drainage water survey



The national drainage water survey

Why drains?

- Only seven drains are monitored in the official national agricultural monitoring program – are these representative?
- Drains are considered to short circuit the hydrological cycle → provides a path for unreduced nitrate from the root zone to surface water
- Drainage water is a complex mixture



The national drainage water survey

Design

- Sites are chosen by the farmers and they pay for the monitoring themselves
- No measurement of discharge

Total nitrogen (TN)
Nitrate (NO_3^-)
Ortho-P



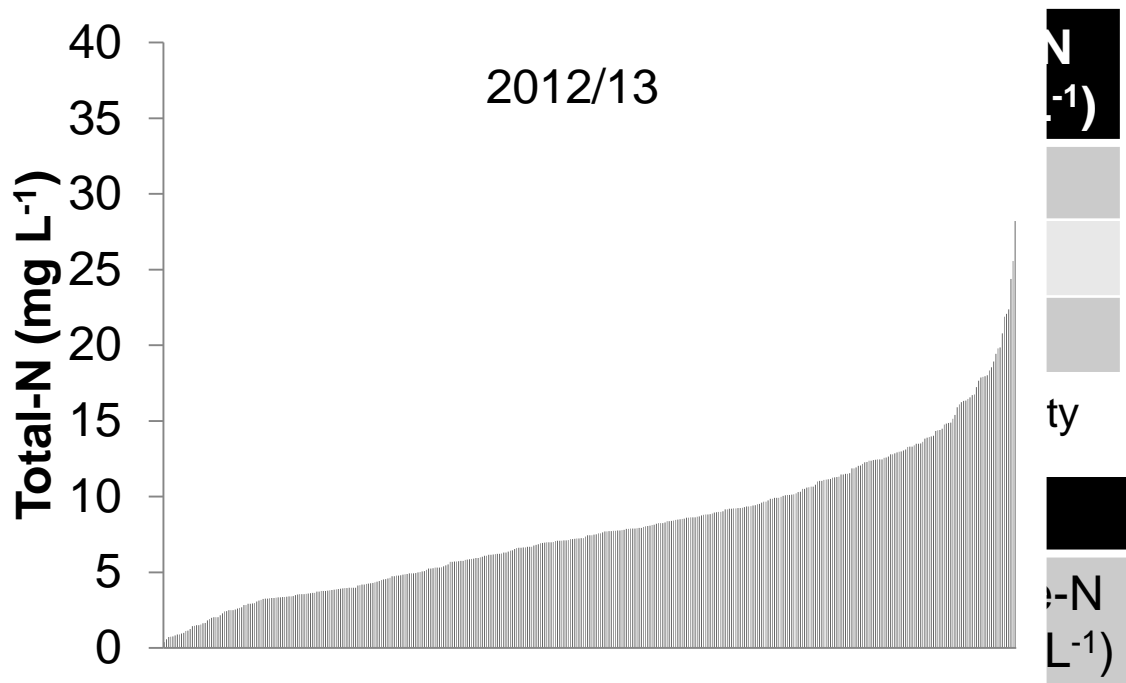
Year	Number of sites
2011/12	254
2012/13	503
2013/14	421



The national drainage water survey

Expectations and results

Site	n	Soil type	Land
LOOP 1	4	Clay	Mo
LOOP 3	2	Clay	Mo
LOOP 2	1	Sand	Low



	2011/12		2012/13			
	Total-N (mg N L ⁻¹)	Nitrate-N (mg N L ⁻¹)	Total-N (mg N L ⁻¹)	Nitrate-N (mg N L ⁻¹)	Total-N (mg N L ⁻¹)	Nitrate-N (mg N L ⁻¹)
Average	6.5	5.7	8.0	6.7	7.8	6.3
Standard deviation	4.6	4.6	4.7	4.5	5.0	4.7
n	217	217	396	396	290	290



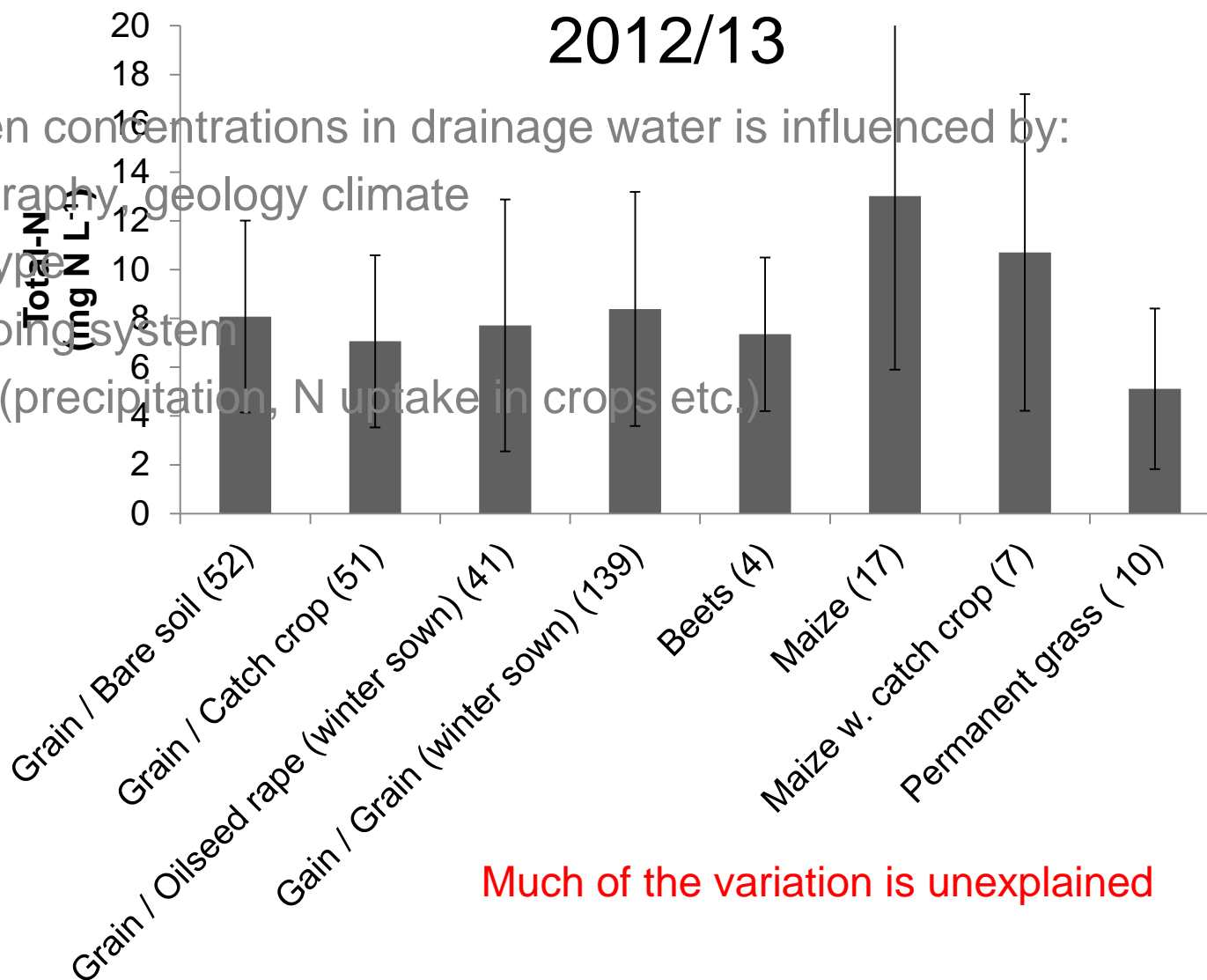
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Variation

2012/13

Nitrogen concentrations in drainage water is influenced by:

- Geography, geology climate
- Soil type
- Cropping system
- Year (precipitation, N uptake in crops etc.)

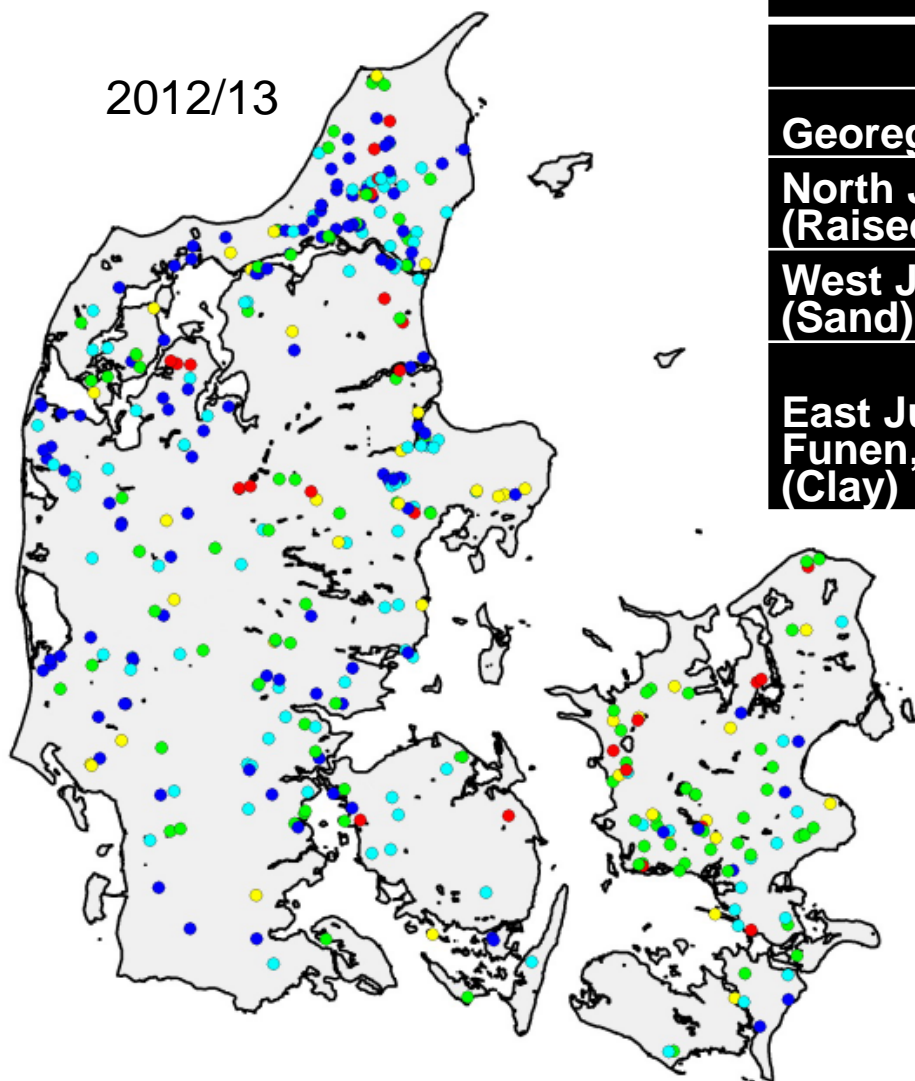


Much of the variation is unexplained



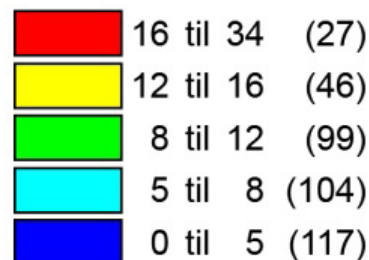
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Results




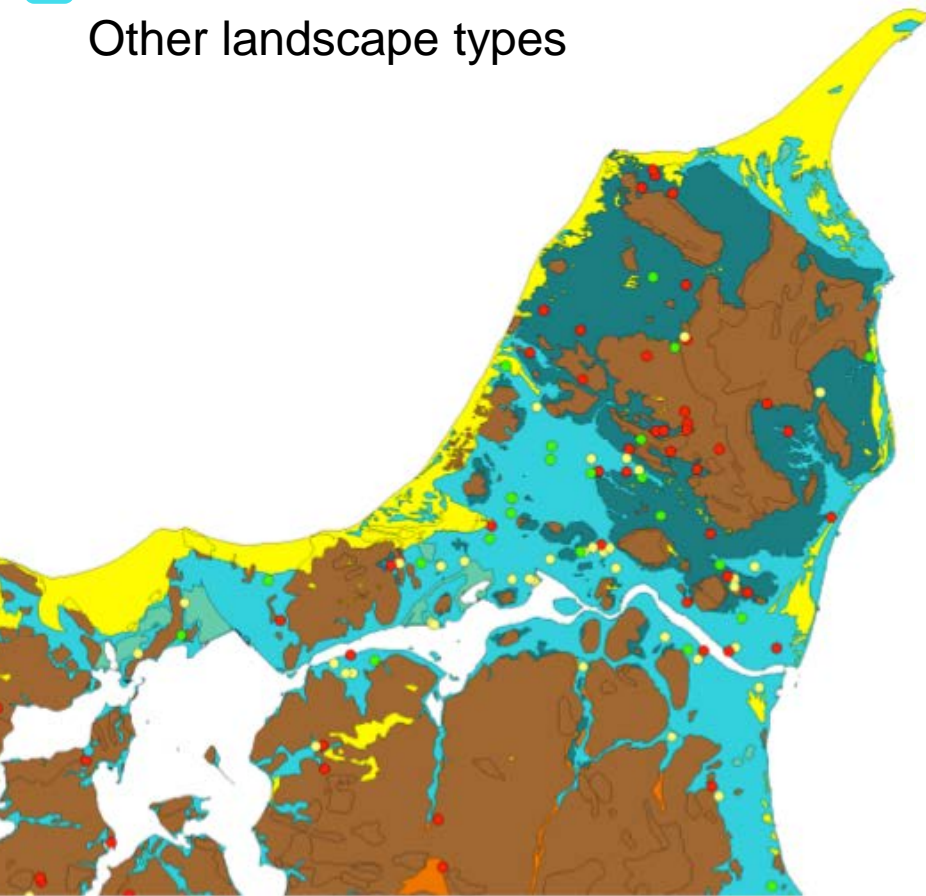
	2012/13		
	N	Total-N	Nitrate-N
Georegion	mg N L ⁻¹		
North Jutland (Raised seabed)	84	6.8	5.2
West Jutland (Sand)	53	6.4	5.3
East Jutland, Funen, Zealand (Clay)	124	9.4	8.4

Total N, mg N L⁻¹
() no. of observations



Raised seabed





 Raised seabed
Other landscape types



- Low concentrations on raised seabed
- Little N present as nitrate
- Denitrification
- High nitrogen retention on raised sea bed, despite intense drainage

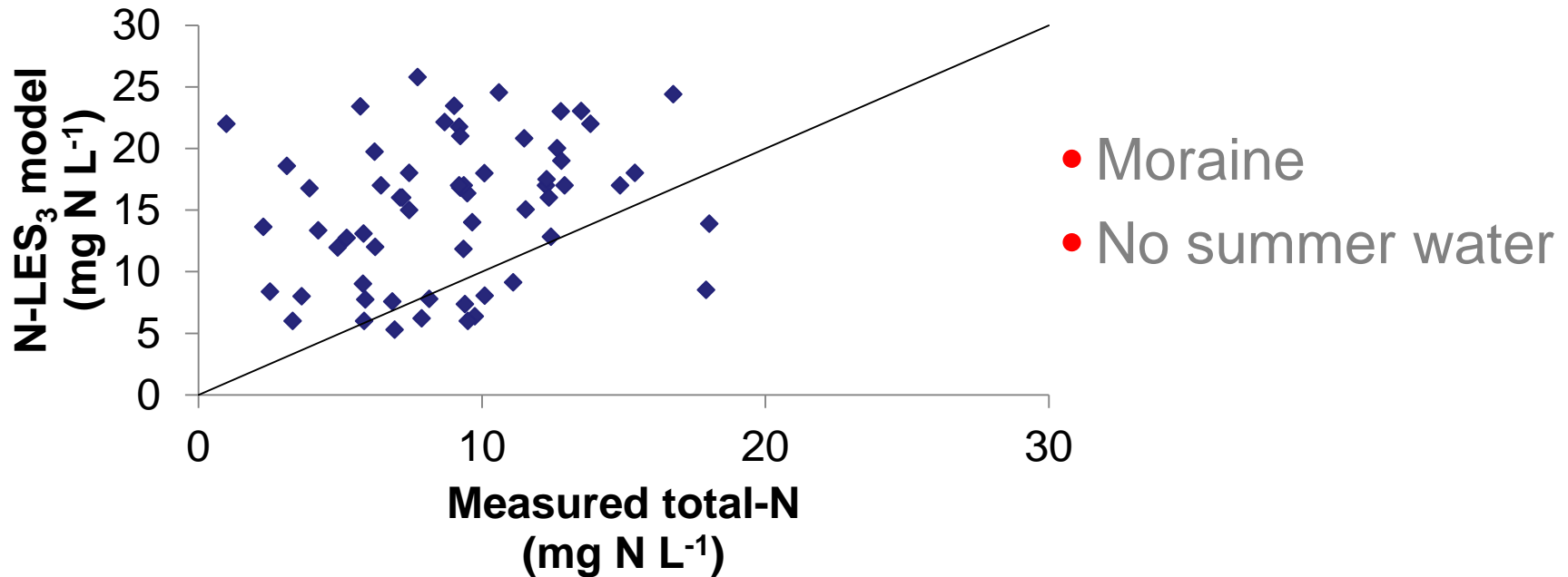
Total N, mg N L⁻¹

Fraction of total-N as nitrate-N (%)

	> 80	(255) 6)
	50 til 80	(102) 9)
	0 til 50	(36) 4)
	0 til 5	(117)



The national drainage water survey Comparison with N-LES₃ leaching model – moraine sites



Either drainage water not un-reduced root zone water or
the model prediction is too high



Conclusions

- N concentrations in drainage water are variable, but generally lower than expected
- Substantial nitrogen retention on raised sea bed lowlands, but also on clay soils
- N-LES₃ cannot predict drainage water concentrations, nor on raised sea bed
 - N retention before draining off or the model is not systematically predicting too high values
- Increased farmer awareness of N loss



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