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NITROGEN BALANCES AND THEIR EFFECT ON WATER QUALITY IN SMALL AGRICULTURAL CATCHMENTS IN THE NORDIC-BALTIC AREA

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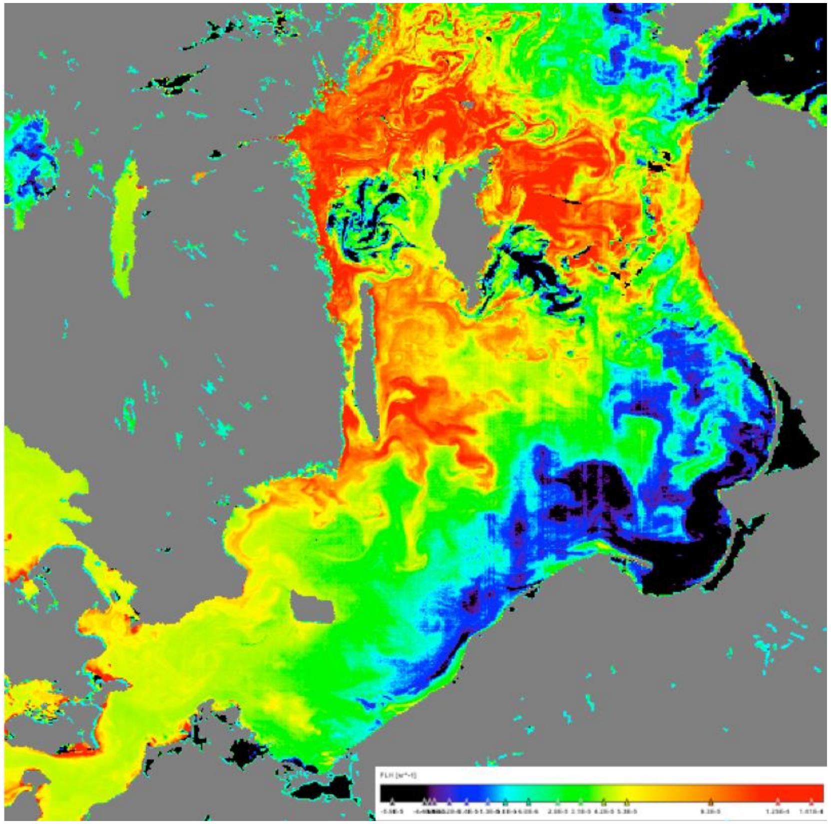
WHAT IS THE PROBLEM?



STRATEGIES TO COMBAT NUTRIENT POLLUTION IN THE DIFFERENT COUNTRIES DURING TWO DECADES

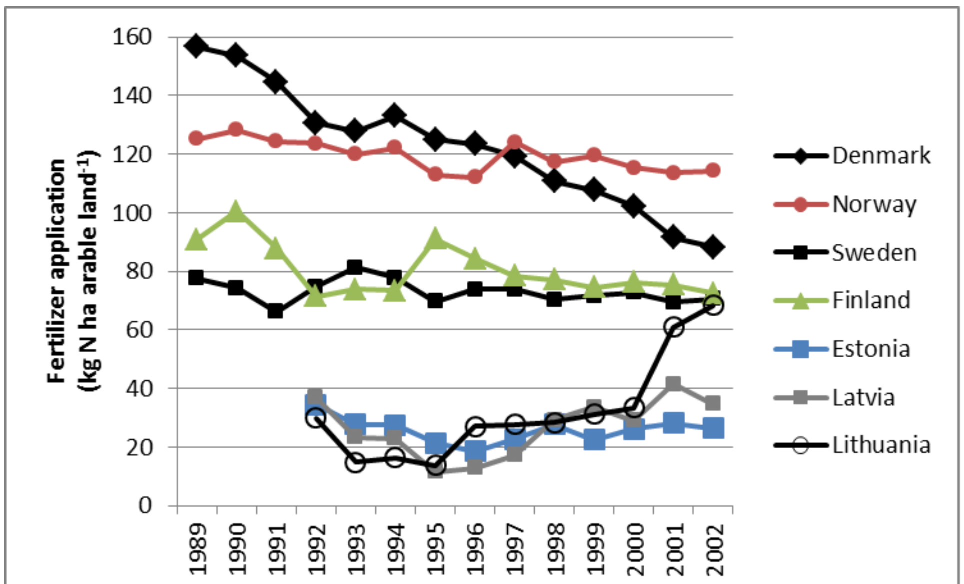
- Common measures for all countries: 1) catch crops, 2) restrictions in fertilizer/manure application, 3) buffer zones

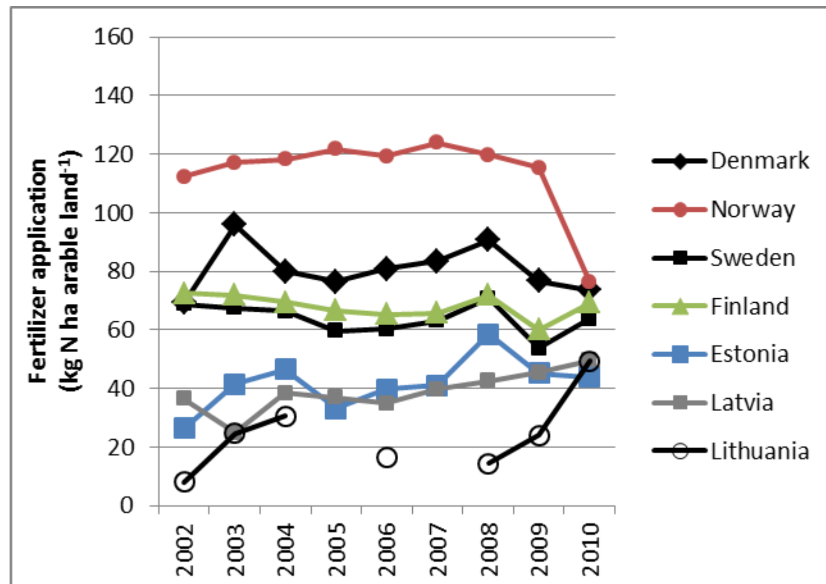
- **Denmark**: Restrictions in the use of fertiliser-N below optimal. Improved utilization of manure. Several nutrient action plans during 25 years.
- **Norway**: Main focus on phosphorus; obligatory nutrient management plan
- **Sweden**: Subsidies for spring ploughing and improved manure management
- **Finland**: Subsidies to reduce N/P applications and nutrient losses
- **Estonia, Latvia, Lithuania**: Political changes. Low use of N in 1990

- Aiming at a 50% reduction in N loss
- A mixture of voluntary, subsidized and mandatory measures

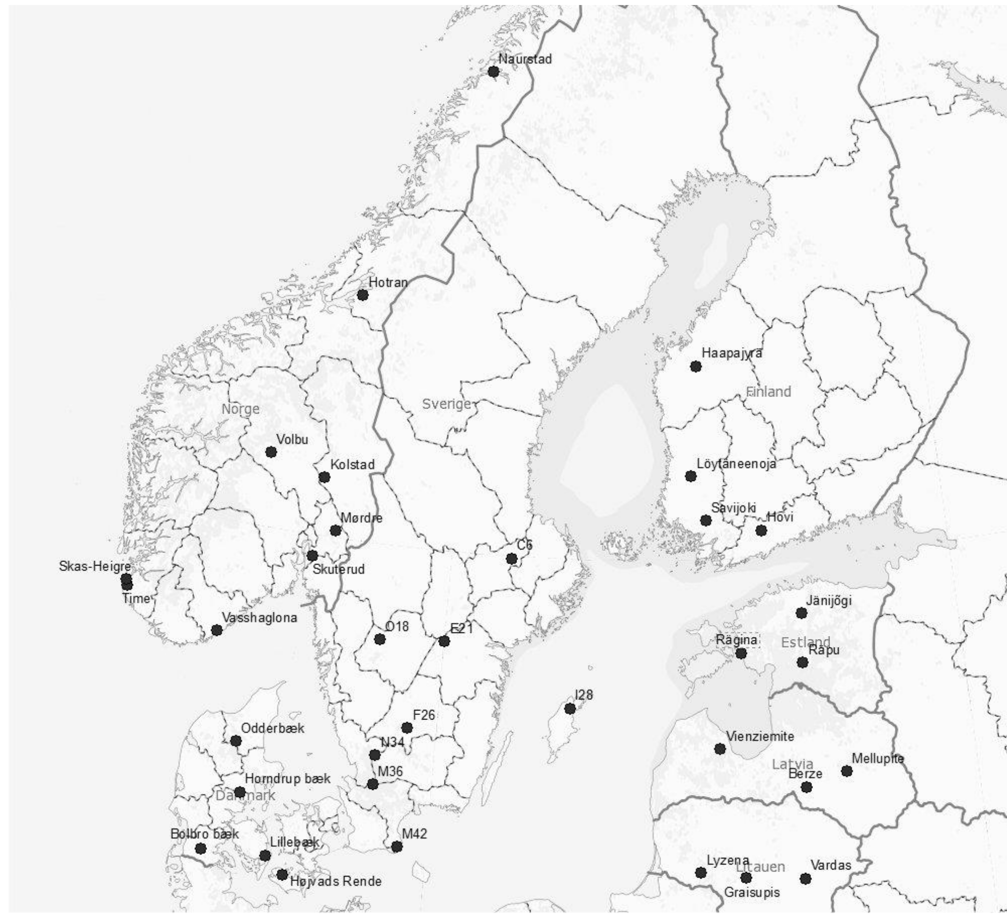
TRENDS IN NITROGEN FERTILIZER CONSUMPTION

- Denmark: Approx. 50% reduction
- Norway: No change until 2009-2010
- Sweden: 9% reduction + increased yields
- Finland: Approx. 20% reduction
- Estonia, Latvia, Lithuania: Increase over two decades from a very low level





MONITORING IN SMALL AGRICULTURAL CATCHMENT IN THE NORDIC-BALTIC COUNTRIES



MONITORING METHODS

- Water discharge
- Flow-proportional watersampling
- Information on agricultural management

CHARACTERISTICS OF THE CATCHMENTS

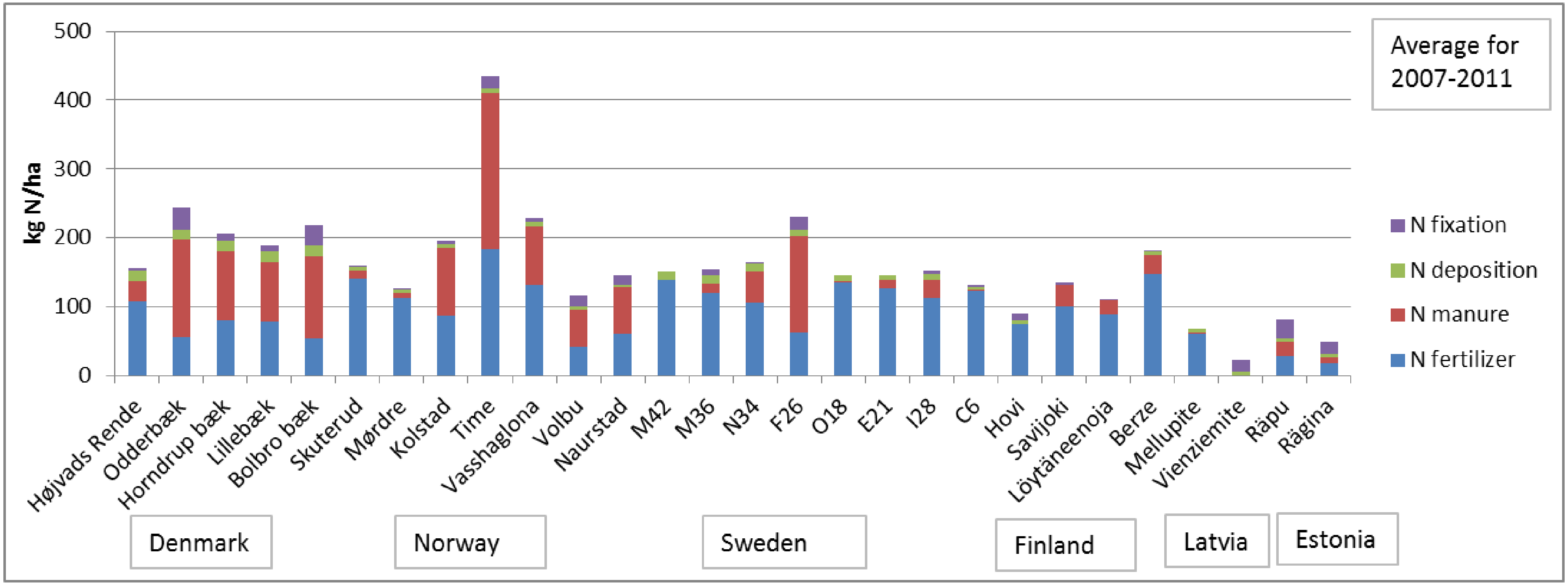
Table 1
General characteristics of the catchments studied, including period for information on N application, catchment size, agricultural area (including grassland and pasture), arable area (sown each year), dominating soil texture according to USDA classification, and cereal yield level (average for all years).

Catchment	Period with available data on N application	Area (ha)	Agricultural area (%)	Arable[a] agricultural area (%)	Soil texture	Cereal yield ($kg\ ha^{-1}$)
Denmark						
Højvads Rende	1991–2011	980	65	84	Loamy sand	7670
Odderbæk	1991–2011	1140	98	54	Sand	5700
Horndrup bæk	1991–2011	550	82	69	Loamy sand	6700
Lillebæk	1991–2011	470	89	67	Loamy sand	6950
Bolbro bæk	1991–2011	820	99	60	Sand	5710
Norway						
Skuterud	1993–2011	[illegible]	[illegible]	[illegible]	[illegible]	5330
Mørdre	1990–2011	[illegible]	[illegible]	[illegible]	[illegible]oam	4340
Kolstad	1990–2011	[illegible]	[illegible]	[illegible]	[illegible]	4365
Time	1992–2001; 20[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	–
Vasshaglona	1990–2011	[illegible]	[illegible]	[illegible]	[illegible]	4443
Volbu	1991–2011	[illegible]	[illegible]	[illegible]	[illegible]	–
Naurstad	1994–2011	[illegible]	[illegible]	[illegible]	[illegible] sand	–
Sweden						
M42	1990–2011	[illegible]	[illegible]	[illegible]	[illegible]am	7280
M36	1993–2011	[illegible]	[illegible]	[illegible]	[illegible]	5240
N34	2002–2011	1393	85	82	Sandy loam and silt loam	5940
F26	2002–2011	182	71	21	Sandy loam	3720
O18	199; 2002–2011	766	92	92	Clay	5560
E21	1995; 1996; 2002–2011	1632	89	87	Sandy loam	6460
I28	1994–2011	477	78	80	Sandy loam	4480
C6	1993; 1997; 2002–2011	3306	59	74	Clay loam	5180
Finland						
Hovi	1997–2009	12	100	100	Heavy clay	3360
Savijoki	2000–2005	1540	39	73	Clay and loamy sand	4050
Löytäneenoja	2000–2005	564	77	90	Clay and sand	3900
Latvia						
Berze	1994–2011	368	98	86	Silty clay loam	4210
Mellupite	1994–2011	960	69	56	Loam	3030
Vienziemite	1998–2004; 2010	592	78	4	Sandy loam	2500
Estonia						
Räpu	1996; 1998; 2007–2011	2490	61	23	Sandy clay loam	3000
Rägina	1999; 2000; 2007–2011	2110	53	50	Sandy clay loam	2800

[a] Arable is where a crop is sown each year.

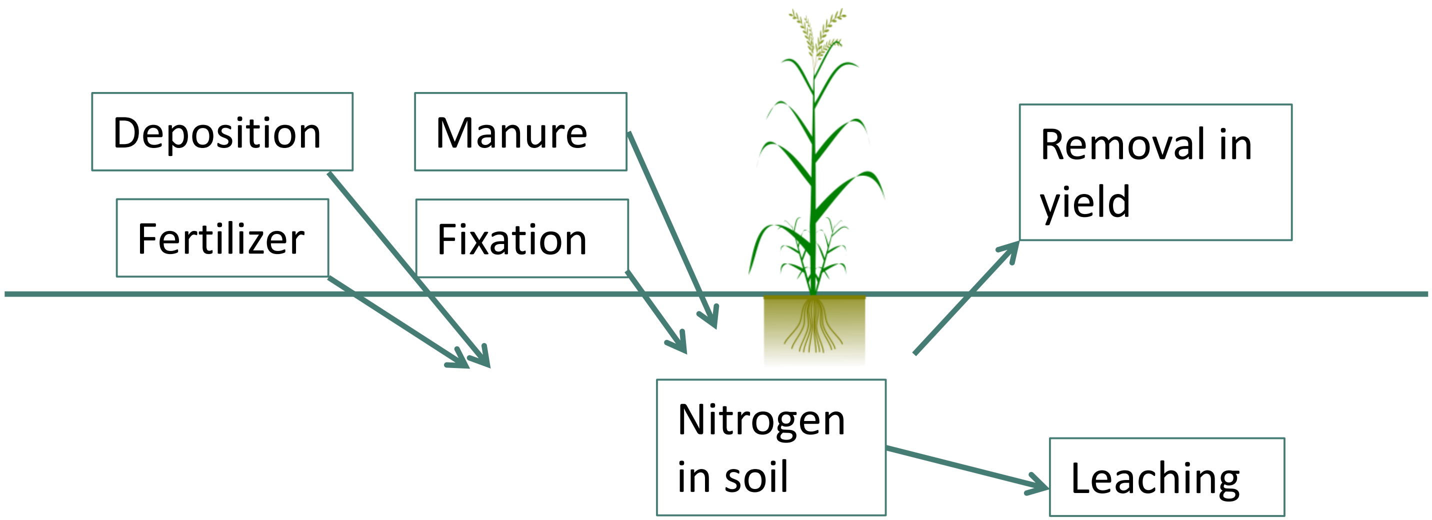
- Size from 12 – 3300 ha
- 35 – 100 % agricultural land
- Arable, grassland and mixture
- Clay, silty clay loam and sand

NITROGEN INPUT TO AGRICULTURAL AREAS IN THE CATCHMENTS (AVERAGE FOR 2007-2011)



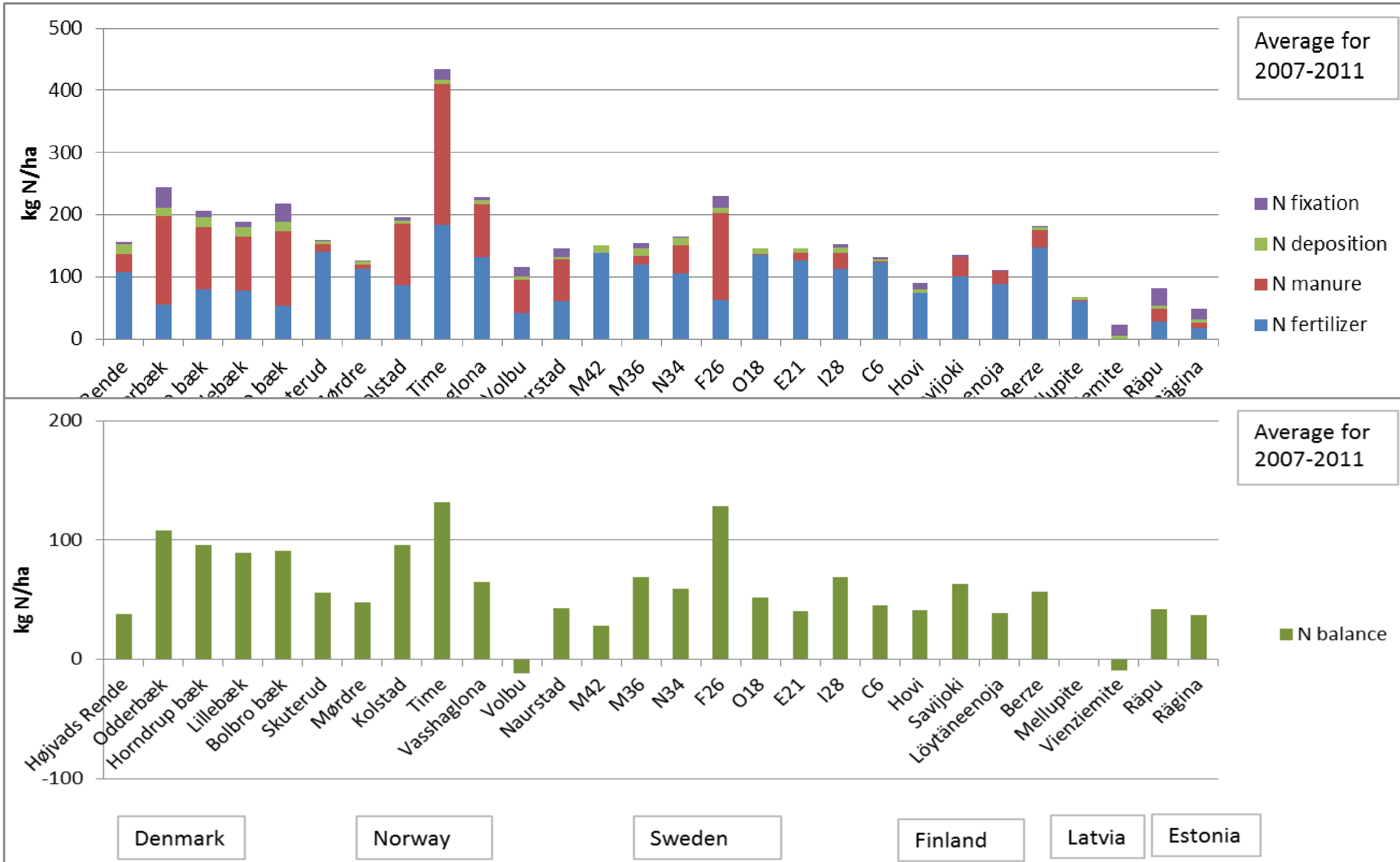
NITROGEN BALANCES

- Nitrogen surplus = N balance = Input – output of nitrogen =
  - Fertilizer-N + Manure-N + Fixation-N + Deposition-N – Yield-N

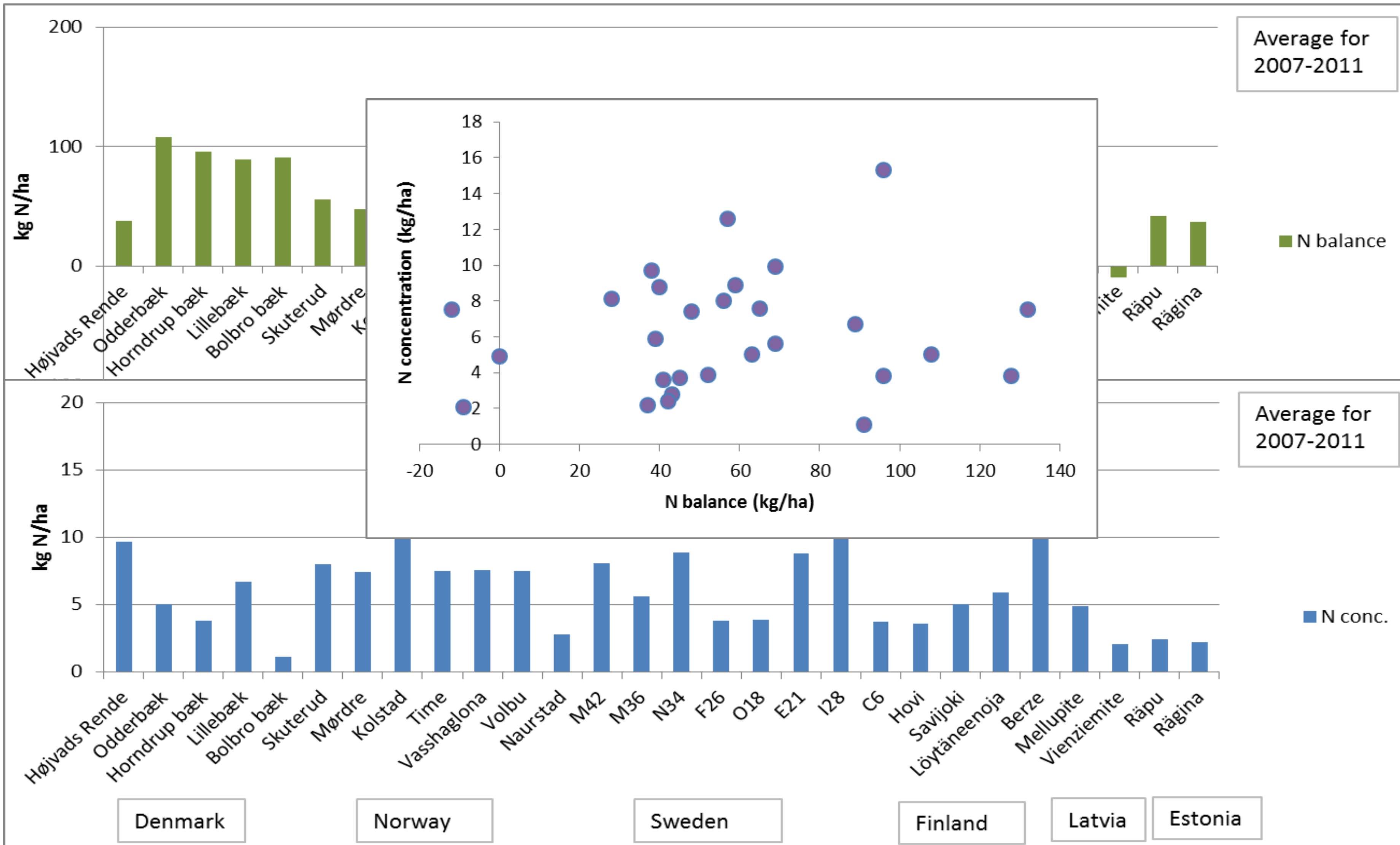


- How does N balance influence nitrogen emissions to small agricultural streams?

NITROGEN INPUT TO AGRICULTURAL AREAS IN THE CATCHMENTS (AVERAGE FOR 2007-2011)



N BALANCES AND N CONCENTRATIONS IN STREAMS



TRENDS IN CONCENTR[A]

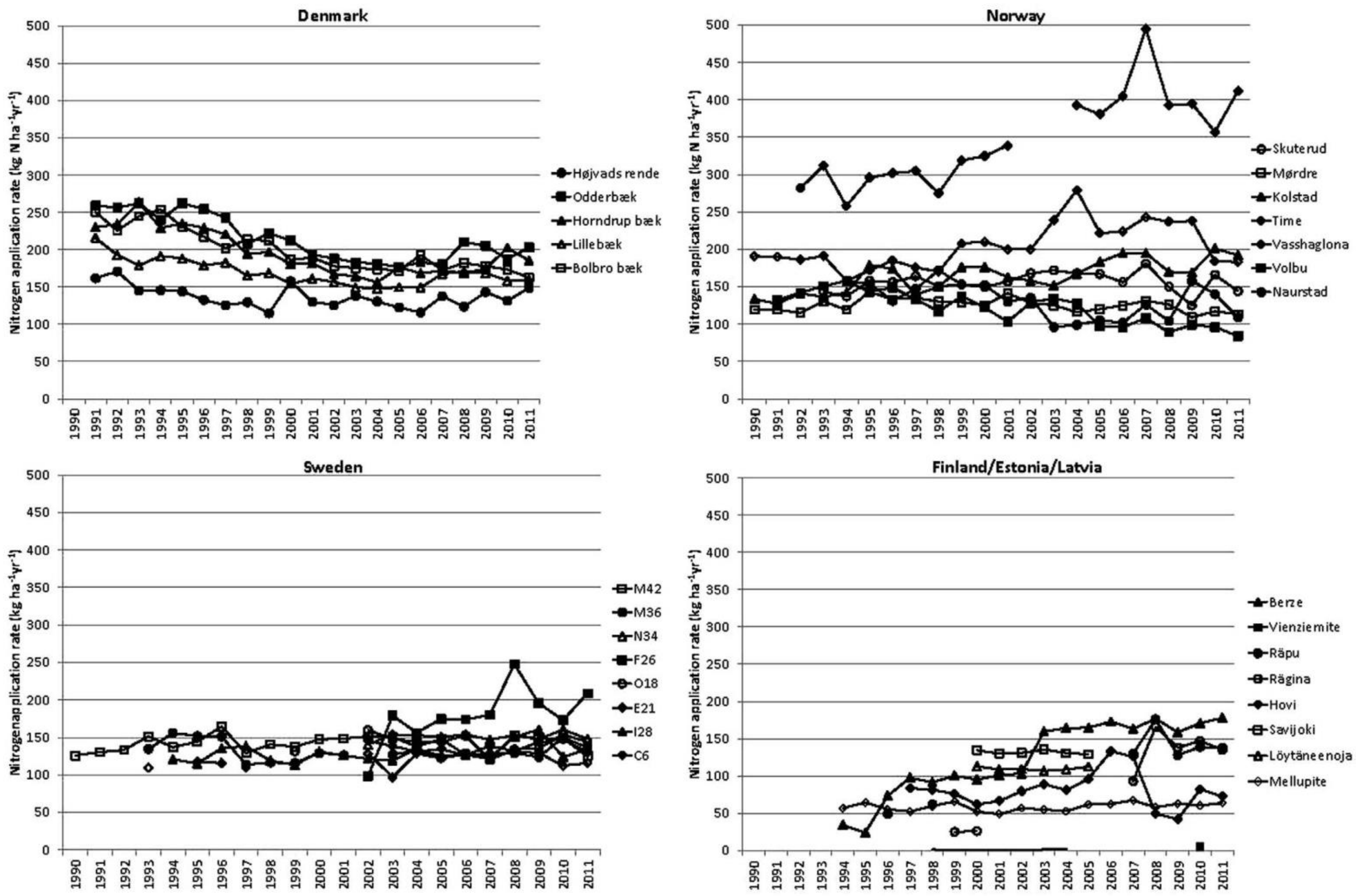
LOSSES

(STÅLNACKE ET AL.

- Significant downward trends in Denmark and Sweden
- Significant increasing trends in the Baltic states

	Vasshaglona	**1998-2011**	(-) 1.424	(-) 0.001	(-) 0.094
Sweden	**M42**	**1992-2010**	(+) 0.007	(-) 0.177*	(-) 0.003*
	M36	**1990-2010**	(+) 0.061	(-) 0.201***	(-) 0.005**
	N34	**1996-2010**	(+) 0.039	(-) 0.332***	(-) 0.060***
	F26	**1994-2010**	(+) 0.218	(-) 0.196***	(-) 0.018***
	O18	**1988-2010**	(+) 0.041	(-) 0.081*	(-) 0.002
	E21	**1988-2010**	(+) 0.127	(-) 0.047*	(+) 0.003
	I28	**1989-2010**	(-) 0.032	(-) 0.092	(-) 0.002
	C6	**1994-2010**	(-) 0.003	(-) 0.069*	(-) 0.001
Denmark	**Højvads Rende**	**1990-2011**	(-) 0.556	(-) 0.033	(-) 0.002
	Odderbæk	**1990-2011**	(+) 1.671	(-) 0.058***	(-) 0.002***
	Horndrup bæk	**1990-2011**	(+) 0.519	(-) 0.178***	(-) 0.016***
	Lillebæk	**1990-2011**	(+) 0.266	(-) 0.227***	(-) 0.013***
	Bolbro bæk	**1990-2011**	(+) 1.584	(-) 0.011	(-) 0.001*
Finland	**Löytäneenoja**	**1998-2009**	(-) 0.062	(-) 0.032	(-) 0.005
	Hovi	**1998-2009**	(-) 0.101	(-) 0.070	(-) 0.010*
	Savijoki	**1998-2009**	(-) 0.111	(-) 0.040	(-) 0.001
	Haapajyrä	**1998-2009**	0,000	(+) 0.038	(-) 0.000
Baltic states	**Jänijõgi**	**2002-2011**	(+) 1.390	(+) 1.138*	(+) 0.259
	Rägina	**2000-2011**	(+) 0.070	(-) 0.080	(+) 0.007
	Räpu	**1995-2011**	(+) 0.801*	(+) 0.457**	(+) 0.106*
	Berze	**1993-2012**	(-) 0.001	(+) 0.247**	(+) 0.002**
	Mellupite	**1994-2012**	(+) 0.017	(+) 0.042	(+) 0.001
	Vienziemite	**1993-2012**	(+) 0.079	(+) 0.021	(+) 0.002

TRENDS IN NITROGEN APPLICATION IN THE CATCHMENTS (FERTILISER AND MANURE)



TRENDS IN NITROGEN BALANCES AND NITROGEN CONCENTRATIONS

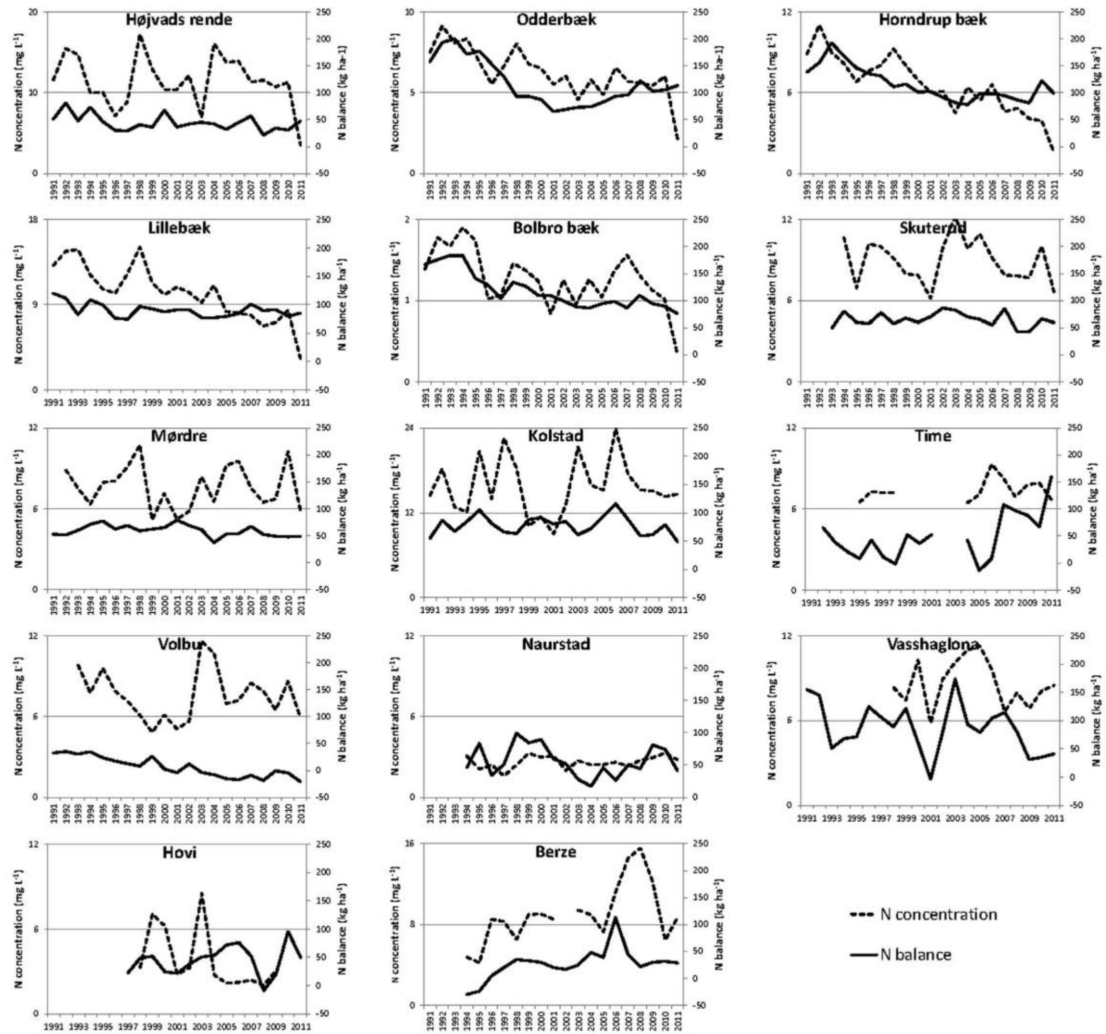


Fig. 5. Annual nitrogen balances (kg ha^{-1} yr^{-1}) and annual nitrogen concentrations in runoff water (mg L^{-1}) from the 14 catchments with long-term time series. Differences in scale on the first *y*-axis.

14 long term time series with N balances and N concentrations

TRENDS IN NITROGEN BALANCES AND NITROGEN CONCENTRATIONS

Significant trend in N balance

Significant trend in N concentration

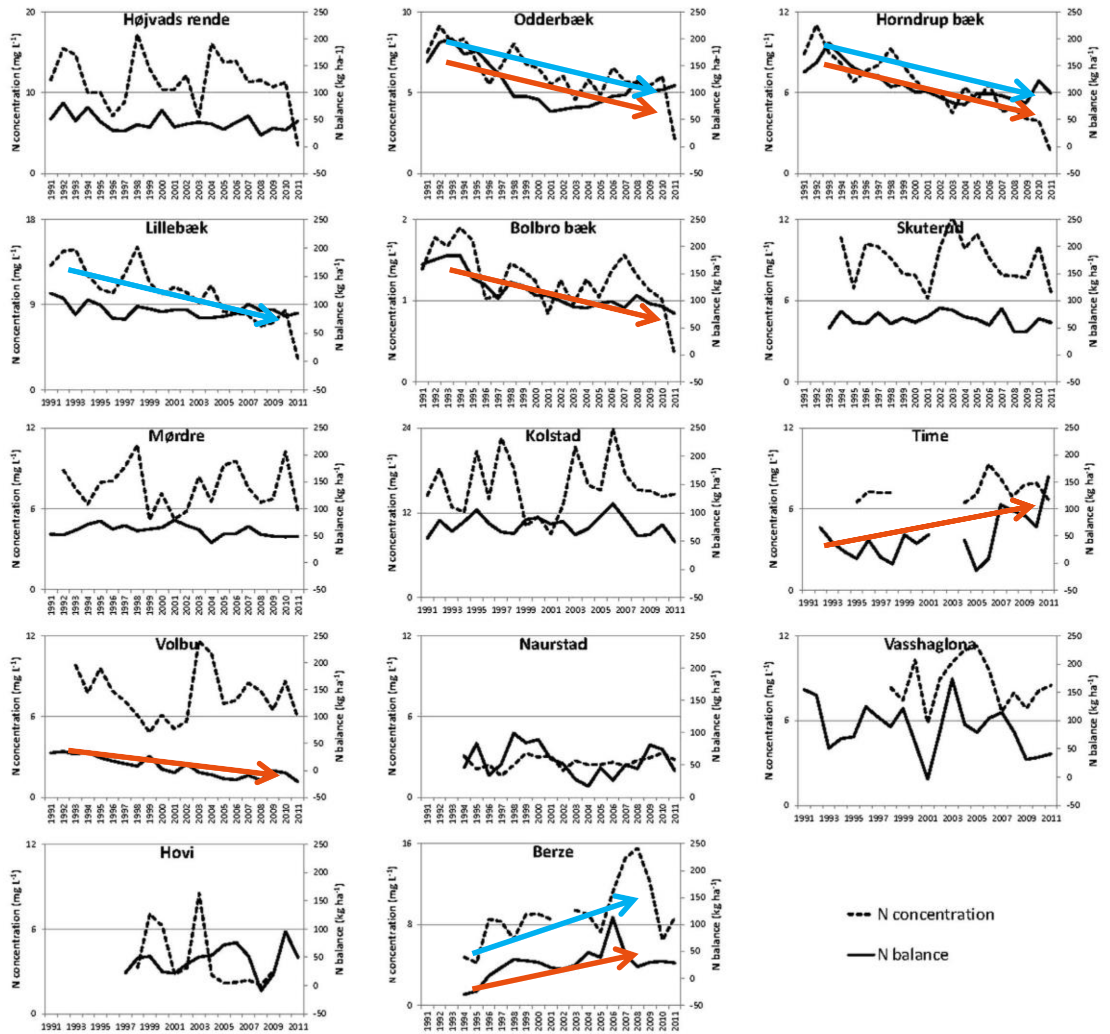


Fig. 5. Annual nitrogen balances (kg ha^{-1} yr^{-1}) and annual nitrogen concentrations in runoff water (mg L^{-1}) from the 14 catchments with long-term time series. Differences in scale on the first *y*-axis.

CONCLUSIONS

We have detected

- Decrease in N application and N balances due to
  - Restrictions in use of fertilizer (Denmark)
  - Decreased number of livestock (extensive areas in Norway)
- Increase in N balances due to
  - increased use of fertilizer (Baltic countries)
  - increased number of livestock (Sourthern Norway)

To be able to detect corresponding changes in nitrogen balance and nitrogen concentration, the changes in N application rates need to be large and constant over long time, like for some of the Danish catchments.

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