Evaluation of nutrient retention in four restored Danish riparian wetlands

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Hydrobiologia, 2011

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Grupo III

History, use and function of wetlands

- Demands of the EU for measures to improve ecological quality in surface water bodies
- Regulate the pressures of nutrients on aquatic ecosystems
- Removal of N, retention of P
- Increase biodiversity

Problems?

- Functioning of restored wetland for N and P retention is not well investigated
- Lack of information → problems for planning new restorations projects
- Lack of guidelines → Hydrological and biochemical processes
- Emission of greenhouse gases
- Deterioration of habitat conditions

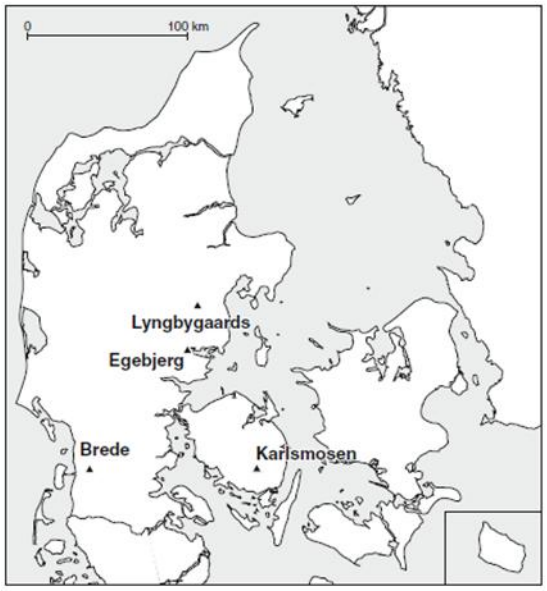
Aims

1. Quantify rates of N and P retention in restored Danish freshwater riparian wetlands and discuss the outcomes as compared to estimations

2. Evaluate and discuss the outcome of different monitoring strategies deployed to quantify the effect of wetland restoration on nutrient retention

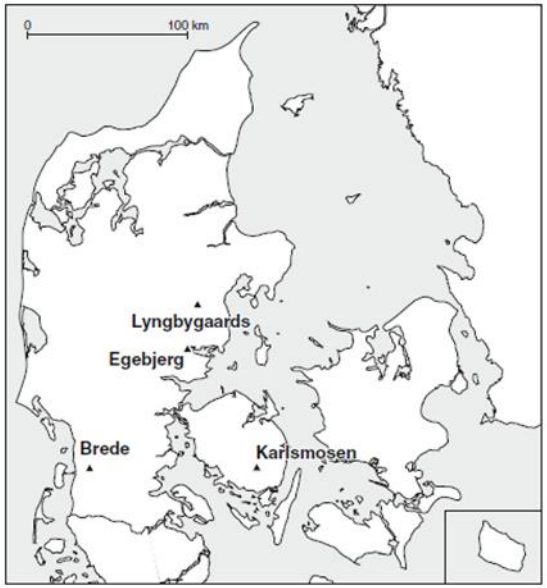
Methods

- Monitoring programme for four restored riparian wetlands in Denmark
- Different monitoring times (arround 1year in most)
- Measurement of nutrients (all N and P forms), Fe, SO_4 and flow pathways in Brede

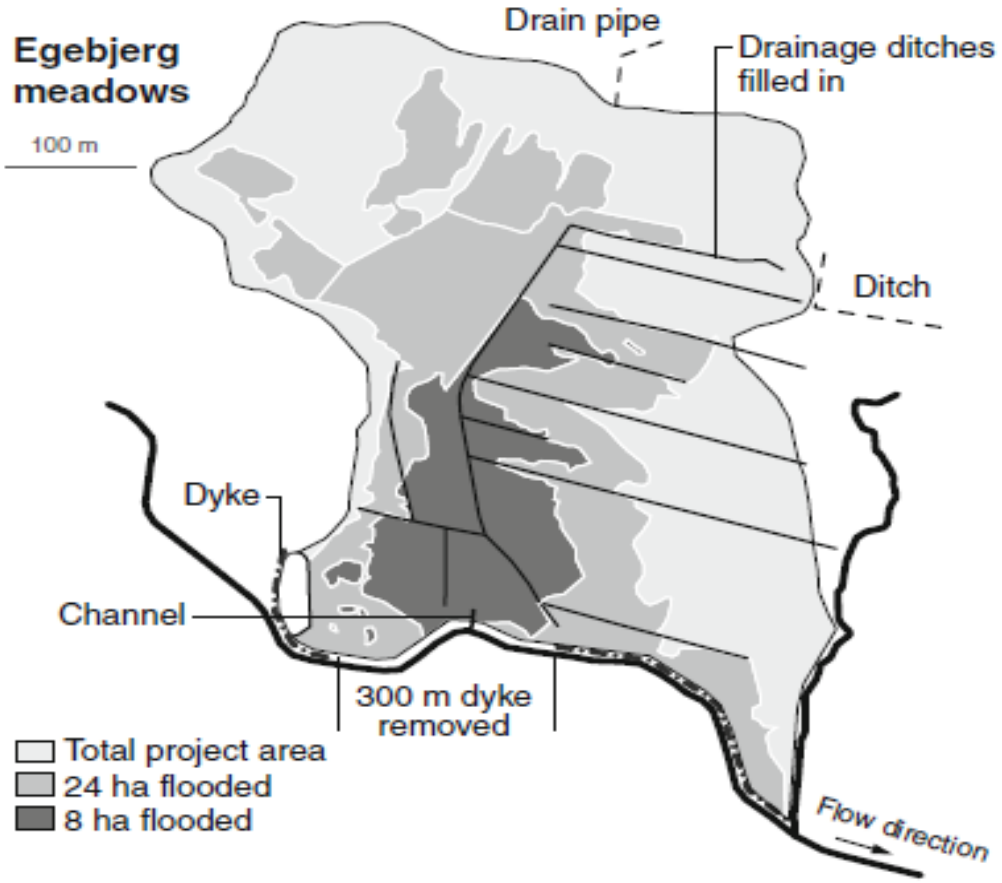


Brede river valley

- Channelized river
- Remeandered channel and artificial wetland

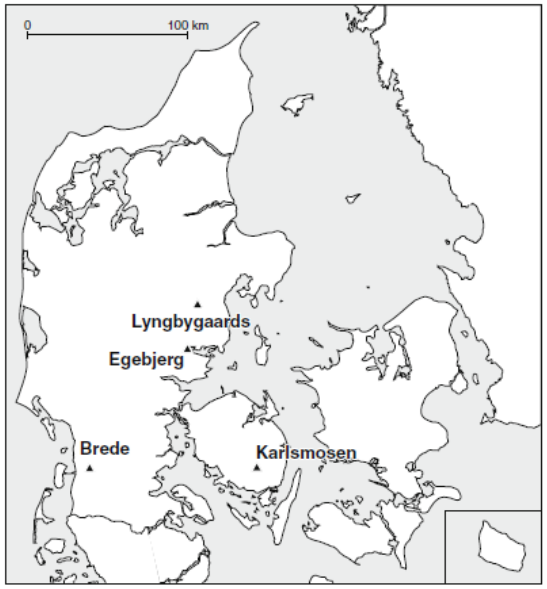


Egebjerg Meadows

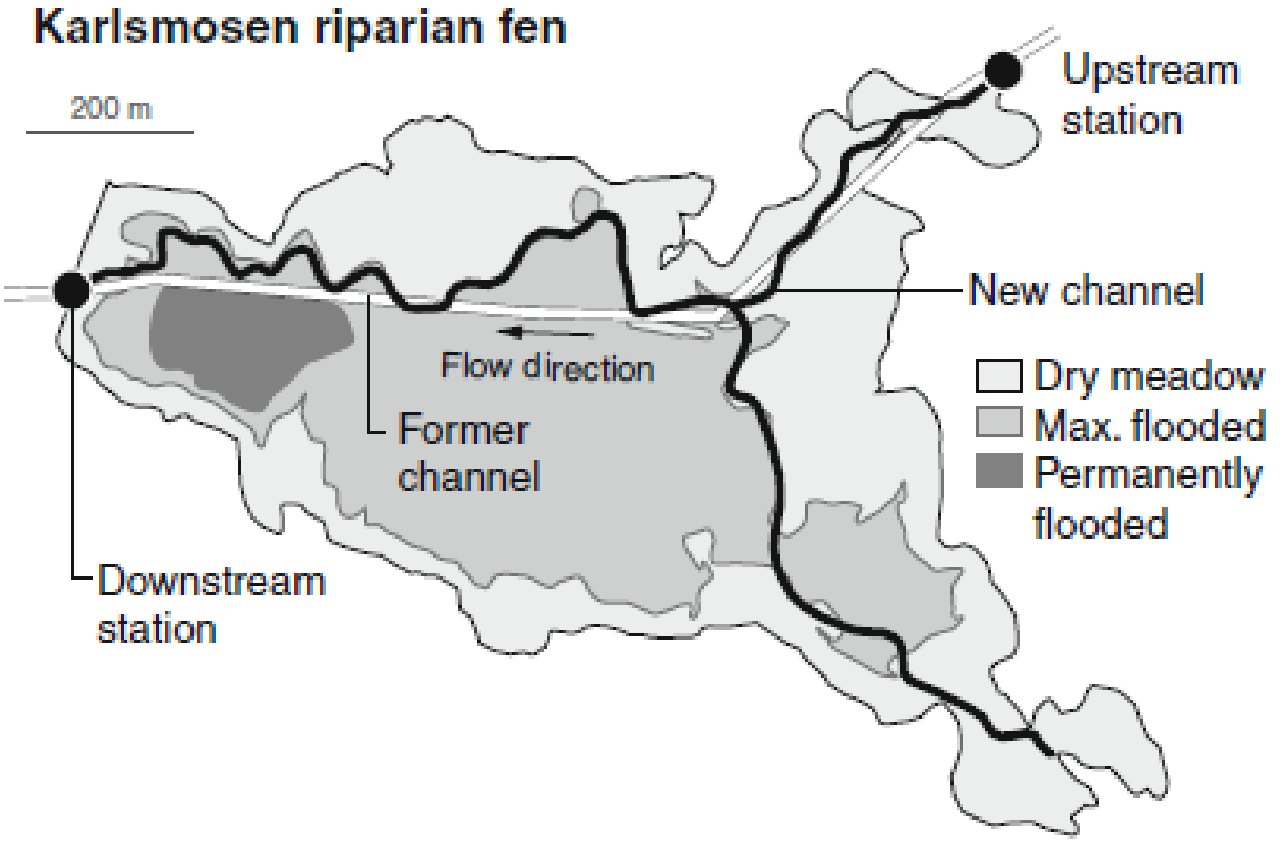


- Before restoration: ditched area and embanked river

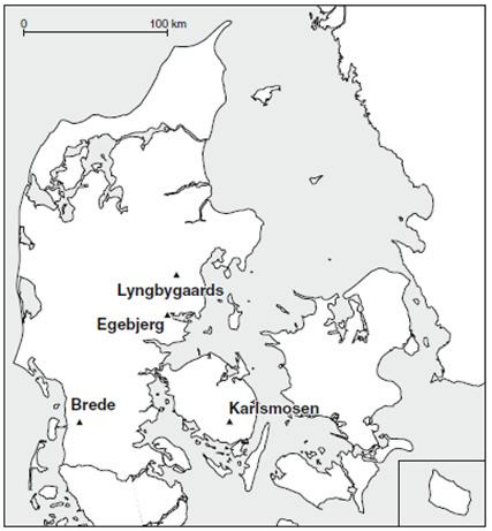
- As part of the restoration: ditches were disconnected



Karlsmosen riparian fen

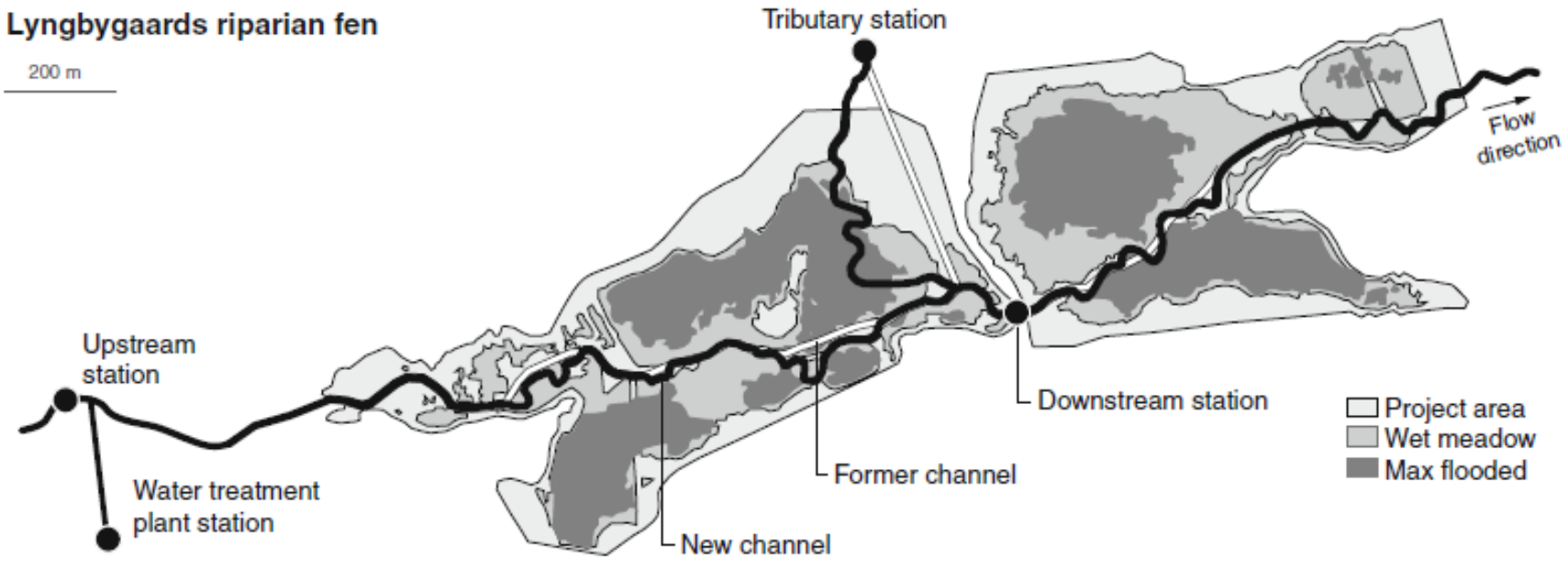


- Remeandered watercourse



Lyngbygaards riparian fen

- Remeandered segment of the river



Transect and area (ha)	First year after restoration (1995)			%	Five years after restoration[a] (1999–2000)			%
	Input (kg year^{-1})	Total retention (kg year^{-1})	Retention (kg ha^{-1} year^{-1})		Input (kg year^{-1})	Total retention (kg year^{-1})	Retention (kg ha^{-1} year^{-1})	
Nitrate-N								
1 (24.9)	2,236	1,087	44	49	2,795	2,403	97	86
3 (30.0)	5,793	4,812	160	83	6,592	6,556	171	99
4 (8.4)	243	−51	−6	−21	–	–	–	
Σ (63.4)	8,272	5,847	92	71	9,387	8,959	141	95
Ammonium-N								
1 (24.9)	21	−208	−8.4	−990	40	−662	−27	−1,655
3 (30.0)	23	−138	−4.6	−600	63	−1,305	−34	−2,071
4 (8.4)	123	18	2.1	15	–	–	–	
Σ (63.4)	167	−328	−5.8	−196	103	−1,967	−31	−1,910
Ferrous iron								
1 (24.9)	97	27	1	28	14	−26	−1	−186
3 (30.0)	156	−17,386	−578	−11,145	235	−62,450	−1,620	−26,574
4 (8.4)	614	−149	−18	−24	–	–	–	
Σ (63.4)	866	−17,508	−276	−2,022	249	−62,476	−985	−25,091
Sulphate								
1 (24.9)	19,100	−14,200	−575	−74	18,200	−58,600	−2,352	−322
3 (30.0)	29,800	−32,800	−1,092	−110	37,000	−95,000	−2,473	−257
4 (8.4)	11,200	2,900	349	26	–	–	–	
Σ (63.4)	60,100	−44,100	−696	−73	55,200	−153,600	−2,423	−278

[a] Area 3 was covering an area of 38.4 ha in the 1999–2000 investigation

Flow: underground wetland and deep underground

Total N retention (92 and 141Kg/Ha, increasing with time)

P, NH_4, Fe, So_4 Source (P and Fe due to machinery erosion)

Ratio decrease for N and Iron and increase for P

Results: Egebjerg Meadows

Table 8 Mass balance of ammonium, organic nitrogen (N), total N, soluble reactive phosphorus (SRP) and total P for the restored wetland Egebjerg Meadows

	Ammonium-N (kg year^{-1})	Nitrate-N (kg year^{-1})	Total N (kg year^{-1})	SRP (kg year^{-1})	Total P (kg year^{-1})
Inflow drainage ditch	6.4	435.2	511.3	3.86	11.66
Inflow drain pipe	11.2	706.8	718	8.61	11.94
Inflow from river	30.2	741.3	1,442	15.88	47.26
Total inflow	47.8	1,883.3	2,671	28.35	70.86
Outflow to river	39.7	102.4	781	13.1	66.28
Total retention	8.1	1,780.9	1,890	15.3	4.58
Retention of input (%)	17	95	71	54	6
Total retention (kg ha^{-1} year^{-1})	0.23	52.4	55.6	0.45	0.13

Input from the drainage ditch, the drain pipe and inflow from the river during inundation periods. Outflow from the wetland only to the river

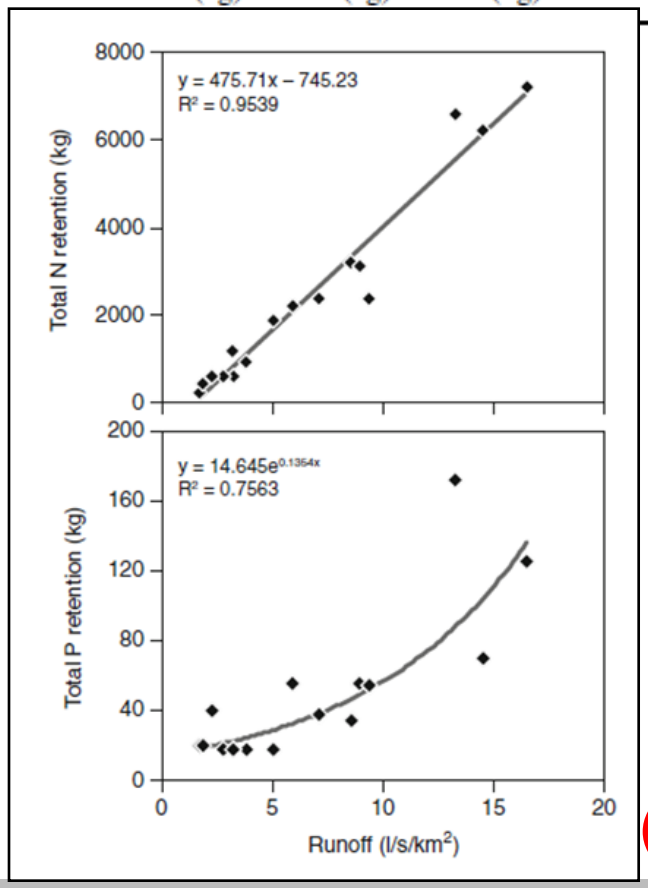
Constant income from drain and ditch, flooding events

Net retention of N (NO_3, NH_4 and total), and P (SRP and Total)

Inflow :**15** % Organic N, **40-69**% organic P → Outflow: **84%** Organic N and **93%** Organic P.

Table 9 Mass balance results from monitoring of total nitrogen and total phosphorus retention in the Karlsmosen Fen during October 2002 to January 2004

Month	Total Nitrogen					Total phosphorus				
	Input (kg)	Output (kg)	Retention (kg)	Retention (kg ha^{-1})	%	Input (kg)	Output (kg)	Retention (kg)	Retention (kg ha^{-1})	%
				14.2	51	40	22	18	0.28	45
				95.8	41	180	110	70	1.08	39
				49.1	41	100	66	34	0.52	34
				101.5	49	260	88	172	2.65	66
				47.5	47	100	44	56	0.86	56
				36.1	45	60	22	38	0.58	63
				28.7	55	40	22	18	0.28	45
				36.1	45	120	66	54	0.83	45
				8.6	56	40	22	18	0.28	45
				8.9	73	40	22	18	0.28	45
				3.1	100	20	0	20	0.31	100
				6.2	100	20	0	20	0.31	100
				8.9	73	40	0	40	0.62	100
				17.6	63	40	22	18	0.28	45
				33.6	48	100	44	56	0.86	56
				111.1	45	280	154	126	1.94	45
					47	1,481	703	778		53
				337	50	880	351	529	8.14	60



Removing of N and P Permanently, retention efficiency of 50% for N and 60% for P

Positive relation of nutrient removing and runoff volume! (linear and exponential)

Results: Lyngbygaards riparian fen

Table 10 Input and retention of nitrate-N (N) and total phosphorus (P) in the 40-ha restored riparian fen Lyngbygaards

Month	N input (kg)	N retention		P input (kg)	P retention	
		(kg)	(%)		(kg)	(%)
Dec-07	18,765	1,450	7.7	257	−3	−1.3
Jan-08	26,784	1,409	5.3	369	5	1.3
Feb-08	13,244	955	7.2	220	18	8.0
Mar-08	17,093	1,054	6.2	262	9	3.5
Apr-08	6,300	518	8.2	121	−192	−159.1
May-08	1,836	339	18.5	53	17	31.6
Jun-08	1,295	463	35.8	38	17	45.3
Jul-08	675	298	44.1	33	14	43.4
Aug-08	1,269	380	29.9	67	12	17.3
Sep-08	1,090	289	26.5	41	10	24.8
Oct-08	1,539	76	4.9	56	3	4.5
Nov-08	10,187	591	5.8	167	28	16.6
Total	100,076	7,822	7.8	1,685	−63.4	−3.8

NO_3, removal continuously : 7,5 % efficiency, 195,6 kg/Ha year.

Total P removal almost all months, effect of machinery work (great release from sediments), overall 7,7% efficiency, 1,58 Kg/Ha year (without april).

DISCUSSION

Nitrogen

4 rivers: high efficiency in N removal

- Brede
  - -Similar results of monitoring methods
  - -Climatic conditions
  - -nitrate leaching to deeper groundwater → low removal rate
  - -Groundwater discharge→ better to have 2 methods
- Karlmosen
  - -Up/downstream mass balance→ min estimate
  - -Water directed to wetland →high removal capacity
- Egebjer
  - -lowest N removal→ dike partly removed
  - -high denitrification rates
- Lynbyagaards
  - -N removal rate similar to expected

DISCUSSION

Phosphorus

Variable retention rates

- Net sink in Egebjerg & Karlmosen → high efficiency → biological uptake and sedimentation
- Net source in Brede & Lyngbyagaars → 1 post-restoration year !!!
- Erosive phase after restoration
- Sedimentation of particulate P +++ inundation periods
- SRP → Org. P (algal biomass)

DISCUSSION

Monitoring strategies for wetland restoration

1 strategy → not for all systems

•E.g. Brede & groundwater, other strategies could help (more expensive)

•Ratio method→ valuable when mass balance difficult, needs pre-monitoring

•Mass balance - (fortnightly) → high uncertainty (P dynamics)
- measurements in wetland→ to be used in post-restoration period
-daily sampling→ ++ geochemical processes

Post-restoration monitoring for more than 1 year

CONCLUSIONS

- Nutrient retention and removal assessed in 4 restored systems
- Variability in efficiency among wetlands +N +o- P
- Longer-term post-restoration monitoring is needed


In Uruguay?

Native wetland areas as national parks.
Some artificial wetland experiences for sewage treatment


Thank you!!!