SLU
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Dep. of Soil and Environment

Design and location of constructed wetlands for optimal phosphorus retention

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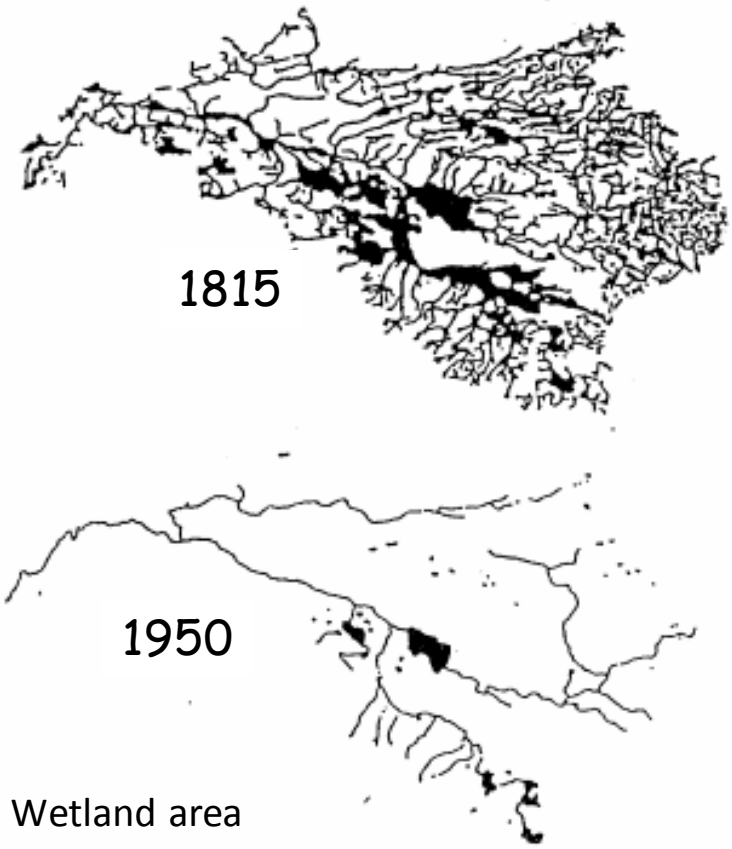
Drainage of natural wetlands

- **Storage capacity decreased**
- **Increased water velocity**

→ Natural retention processes

less time

+ Intensified agriculture & use of fertilizers



Kävlingeån Wetland area

was reduced from 356km^2 to 41km^2

Construction of wetlands

Sweden subsidies

- 90 % of the cost
- P wetlands not for maintenance

Wetlands (1990's):

N removal (denitrification) or Biodiversity

Large open ponds with varying amount of vegetation.

Smaller P wetlands (Jan 2010):

P retention (sedimentation)

Deeper pond followed by a shallow vegetation area.

P retention in wetlands

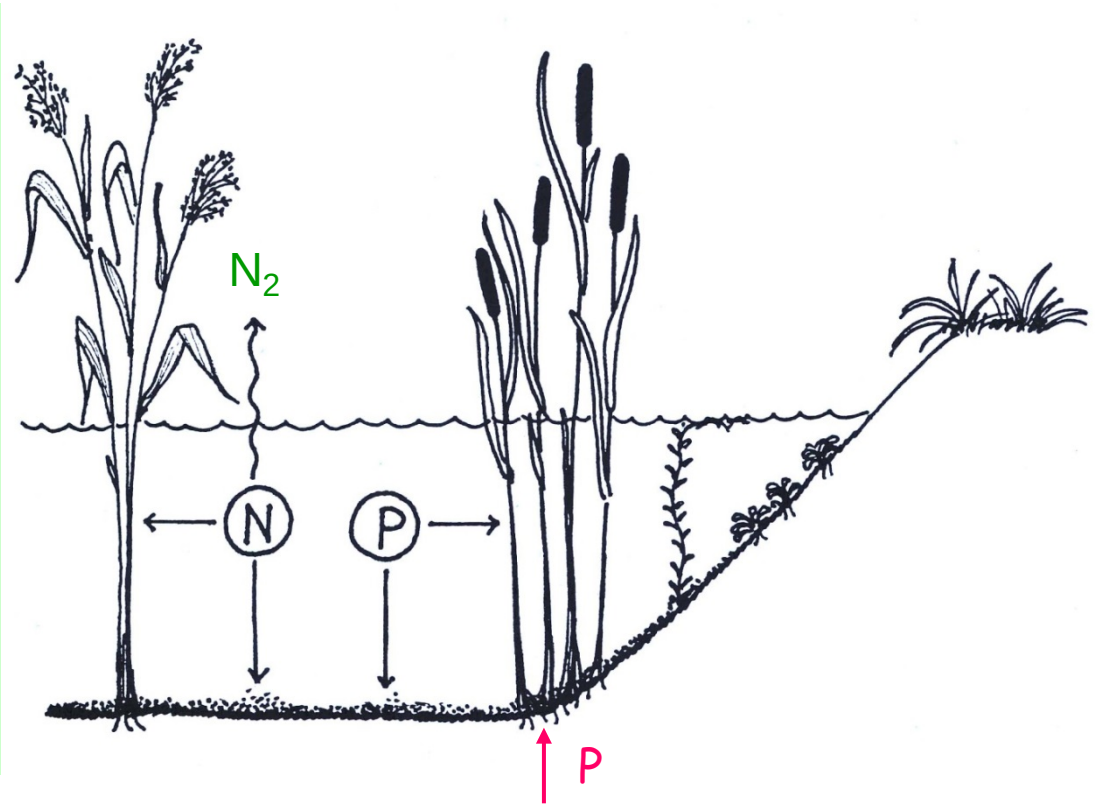
- Physical sedimentation
- Biological uptake in biomass

  (temporal, released if not harvested)
- Chemical sorption

  Al, Fe or Ca

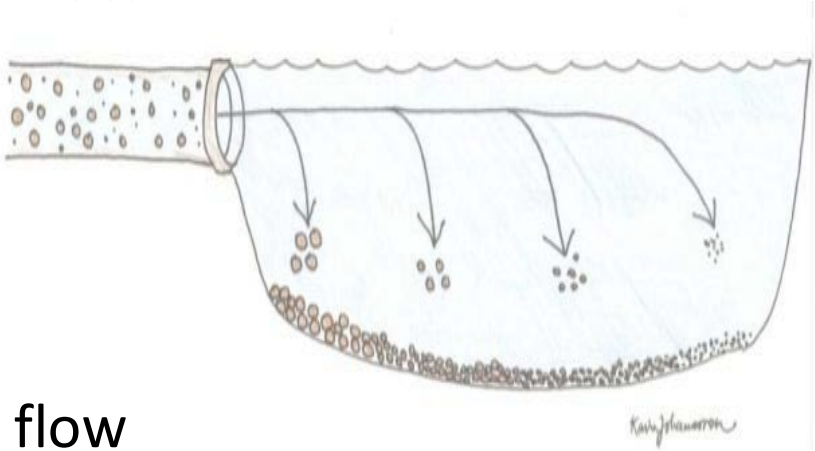
  (dependent of pH & redox pot.)

P is stored in the sediment!



Sedimentation main retention process

Agricultural areas: most P bound to soil particles



Slow down the water

→ particles & P sinks to the bottom

Resusupension: bioturbation and high flow

Sedimentation rate:

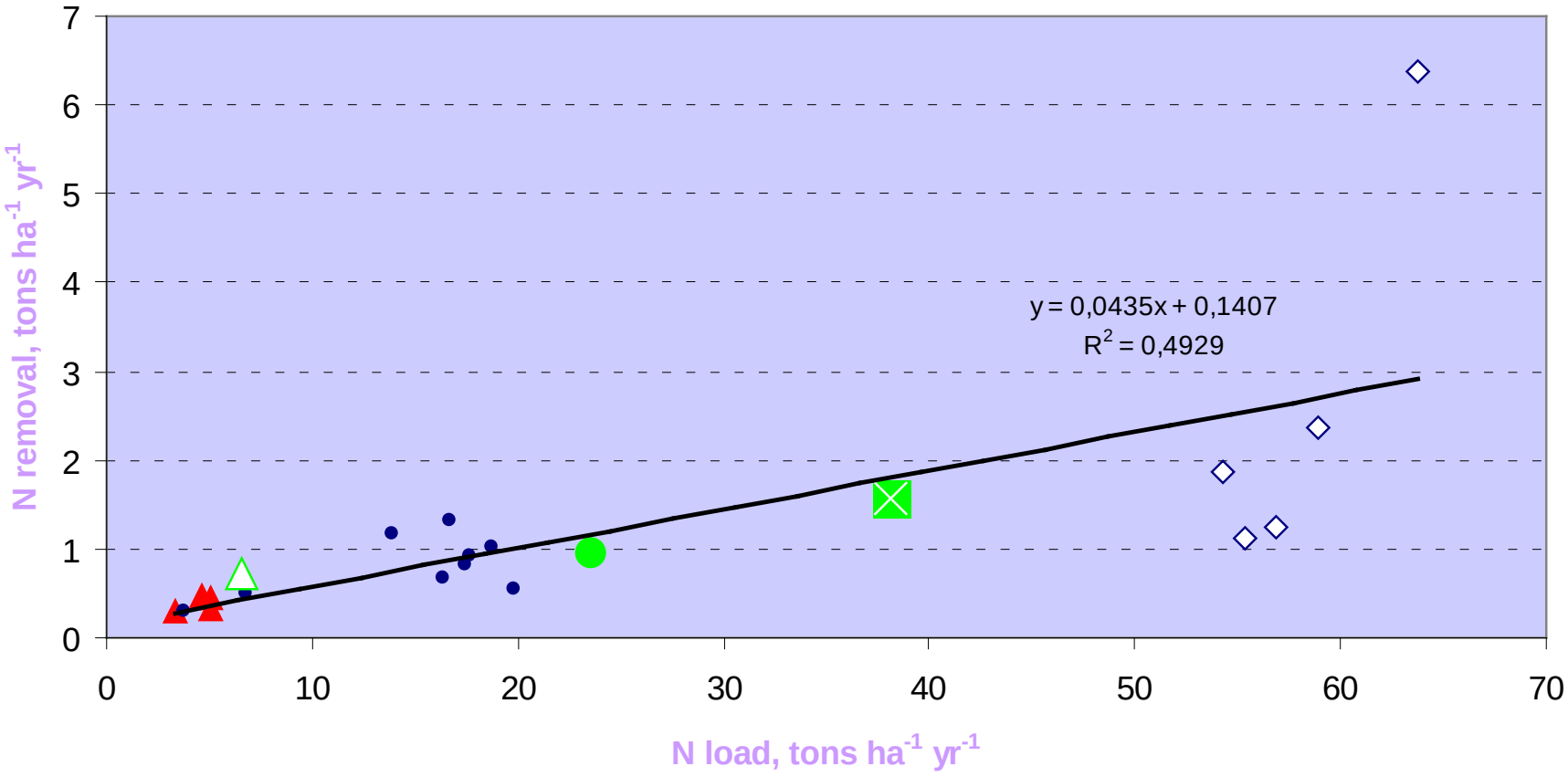
- Particle size, density and shape (flocks etc.)
- Depth
- Water residence time (bigger wetland)

N retention in Wetlands

Area specific N retention increases with increasing load

better cost efficiency in SEK/kg N with higher load

(*Strand & Weisner 2013 Ecological Engineering*)



Placement of wetlands

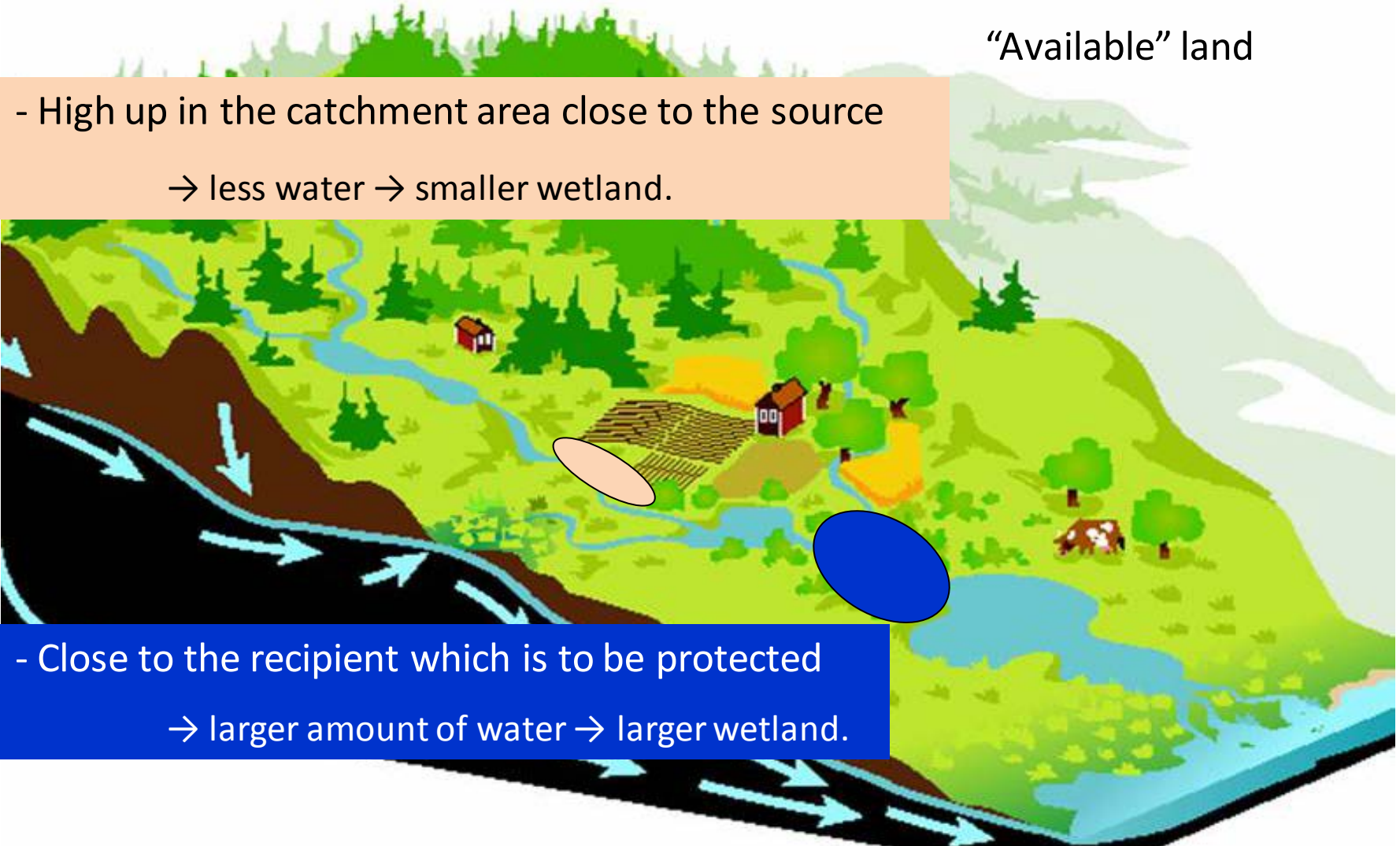
Nutrient content in incoming water is high.

Dimension: With regard to water flow

"Available" land

- High up in the catchment area close to the source

→ less water → smaller wetland.



- Close to the recipient which is to be protected

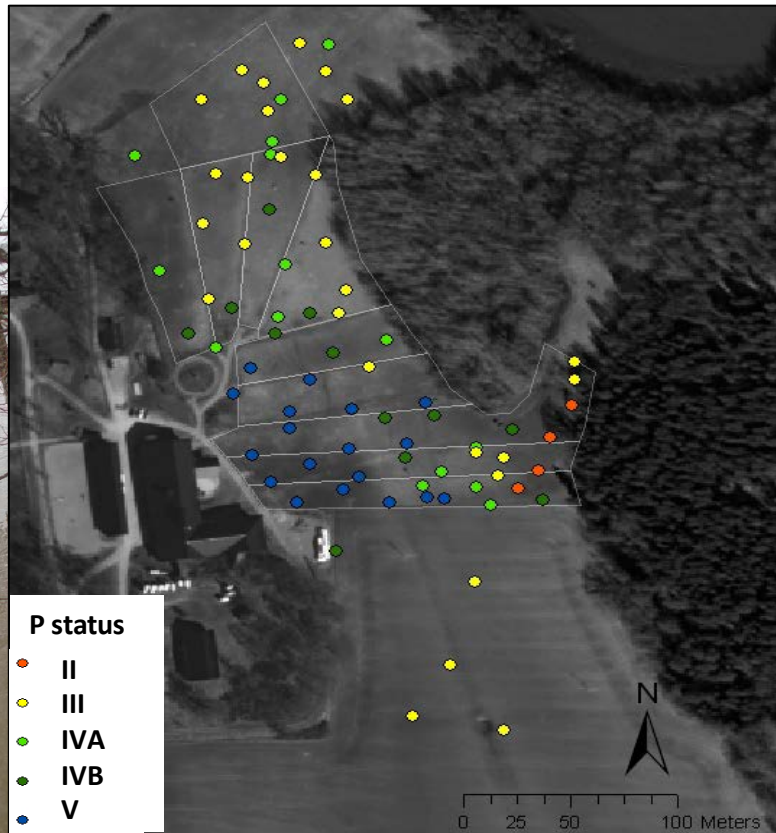
→ larger amount of water → larger wetland.

Where are P wetlands most effective?

Large P losses → High P concentration in the water

- Arable land (Not much forest)
- Soils sensitive for erosion (Clay and silt)
- Higher up in the catchment area (Close to the fields with high P losses)
- High P status in the soil (Manure long time & paddocks for grazing animals)

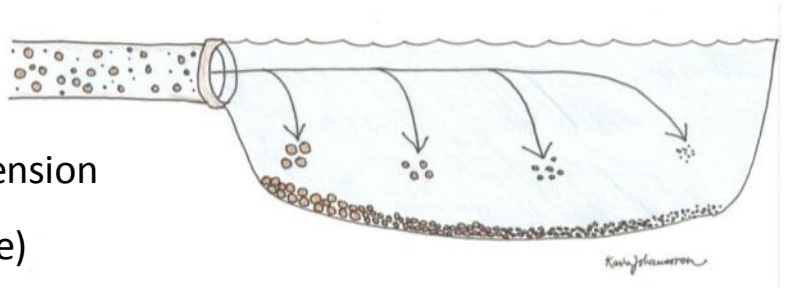
Drainage conditions (Standing water on the field)



Wetlands designed for P removal

Deep pond

- Decreases the water velocity (pipe or ditch) → Particles & P sinks to the bottom
- Most of the sediment accumulates closest to inlet → Rest of the wetland is not filled up

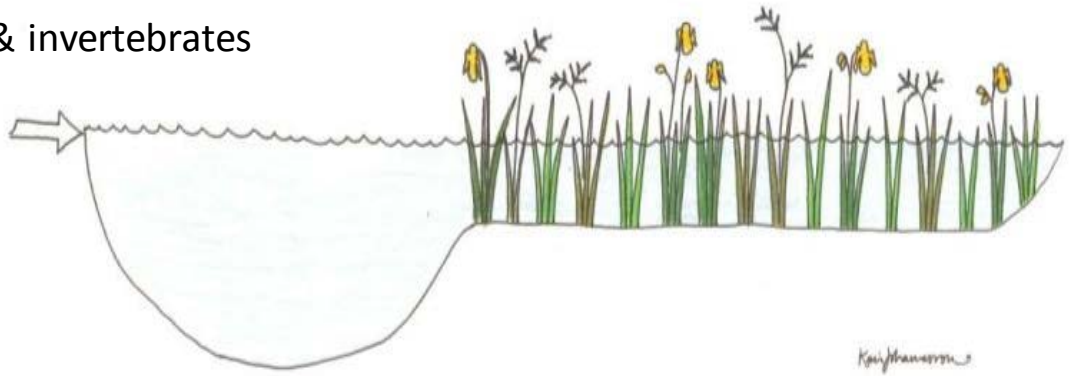


Shallow vegetation area

- Roots stabilising sediment → decreased resuspension
- Filter for particles and P (shorter settling distance)
- Nitrogen removal

o Increased water storage → decrease flooding

o Biodiversity increases: water plants & invertebrates

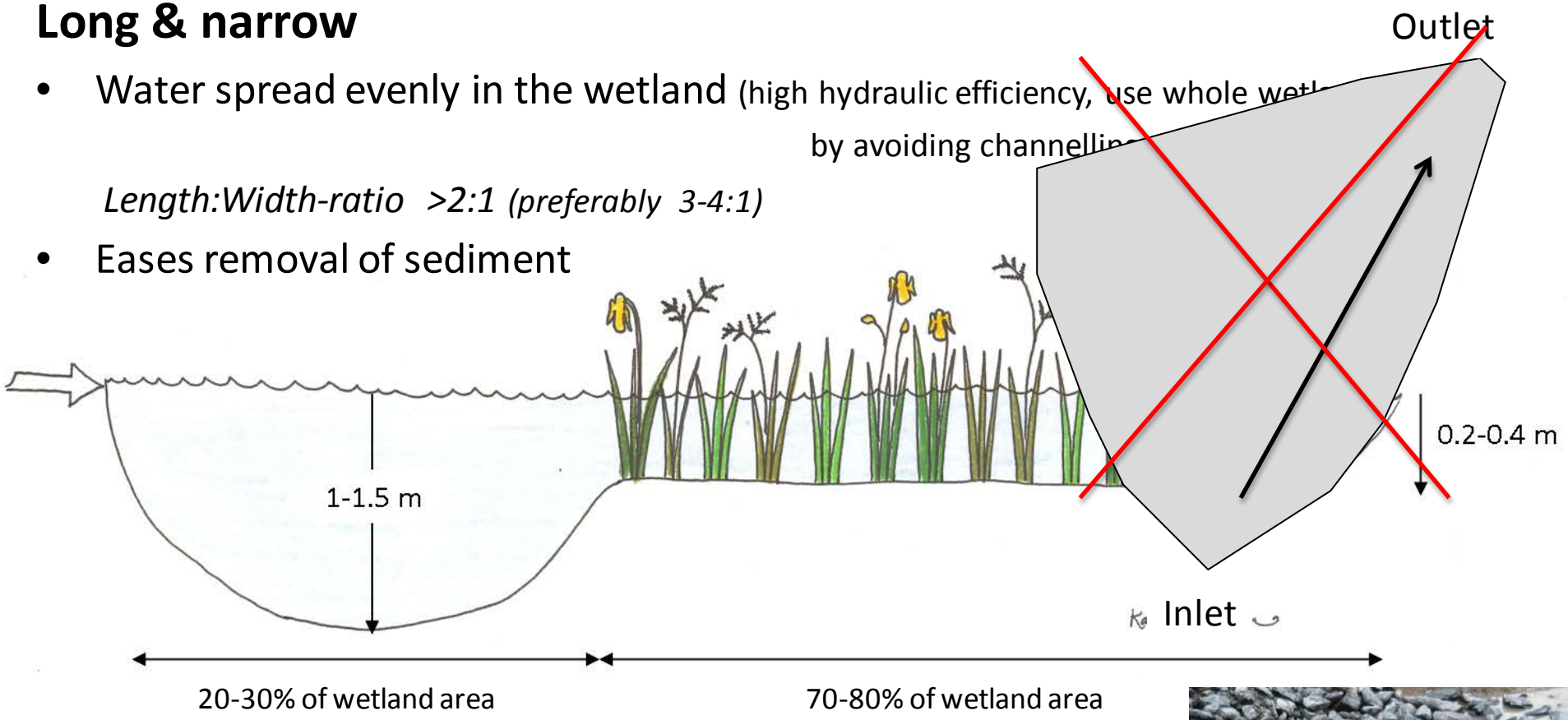


Wetland shape

Long & narrow

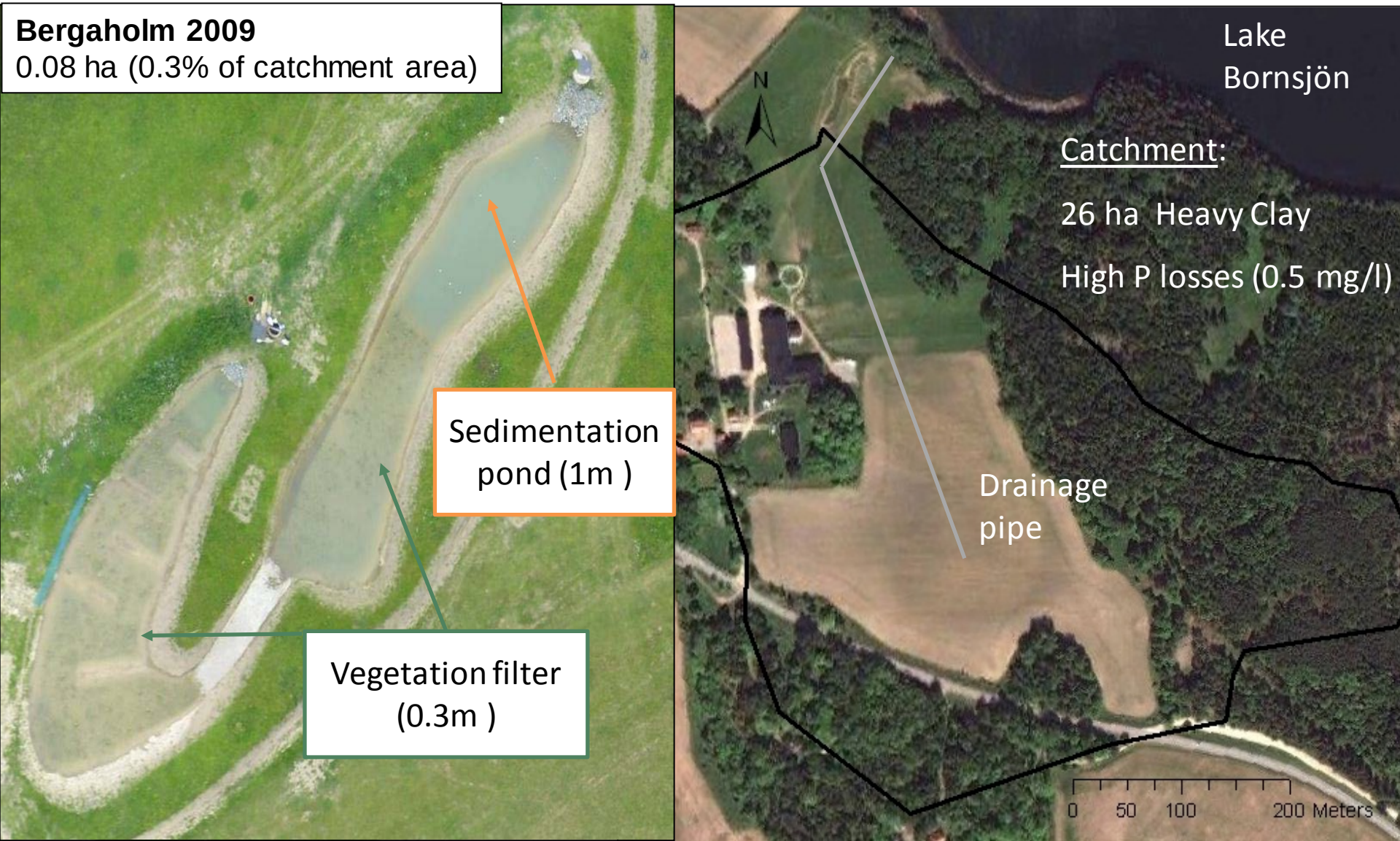
- Water spread evenly in the wetland (high hydraulic efficiency, use whole wetl
  by avoiding channellin

  Length:Width-ratio >2:1 (preferably 3-4:1)
- Eases removal of sediment



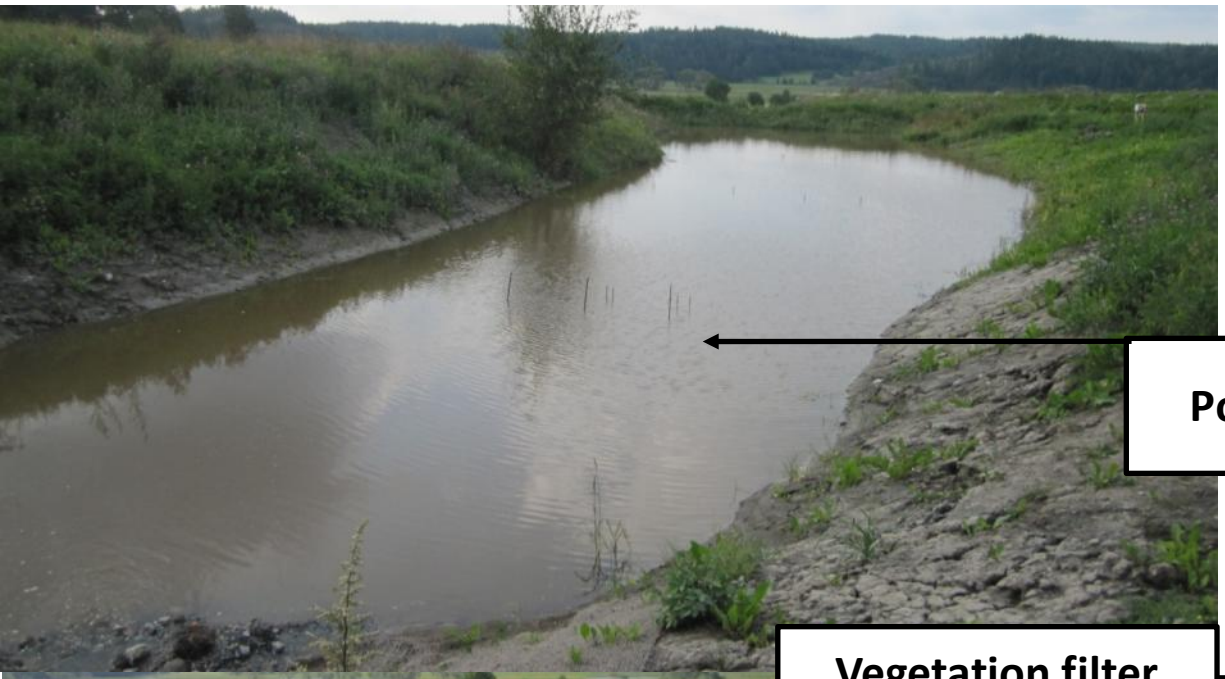
Erosion protection where water velocity can be high (inlet)

P wetland Bergaholm opening a drainage pipe



P wetland Bergaholm opening a drainage pipe

P Wetland Nybble in an open ditch



Nybble 2011
0.12 ha (0.3 %)

Open ditch

Pond (1m)

Vegetation filter (0.3m)

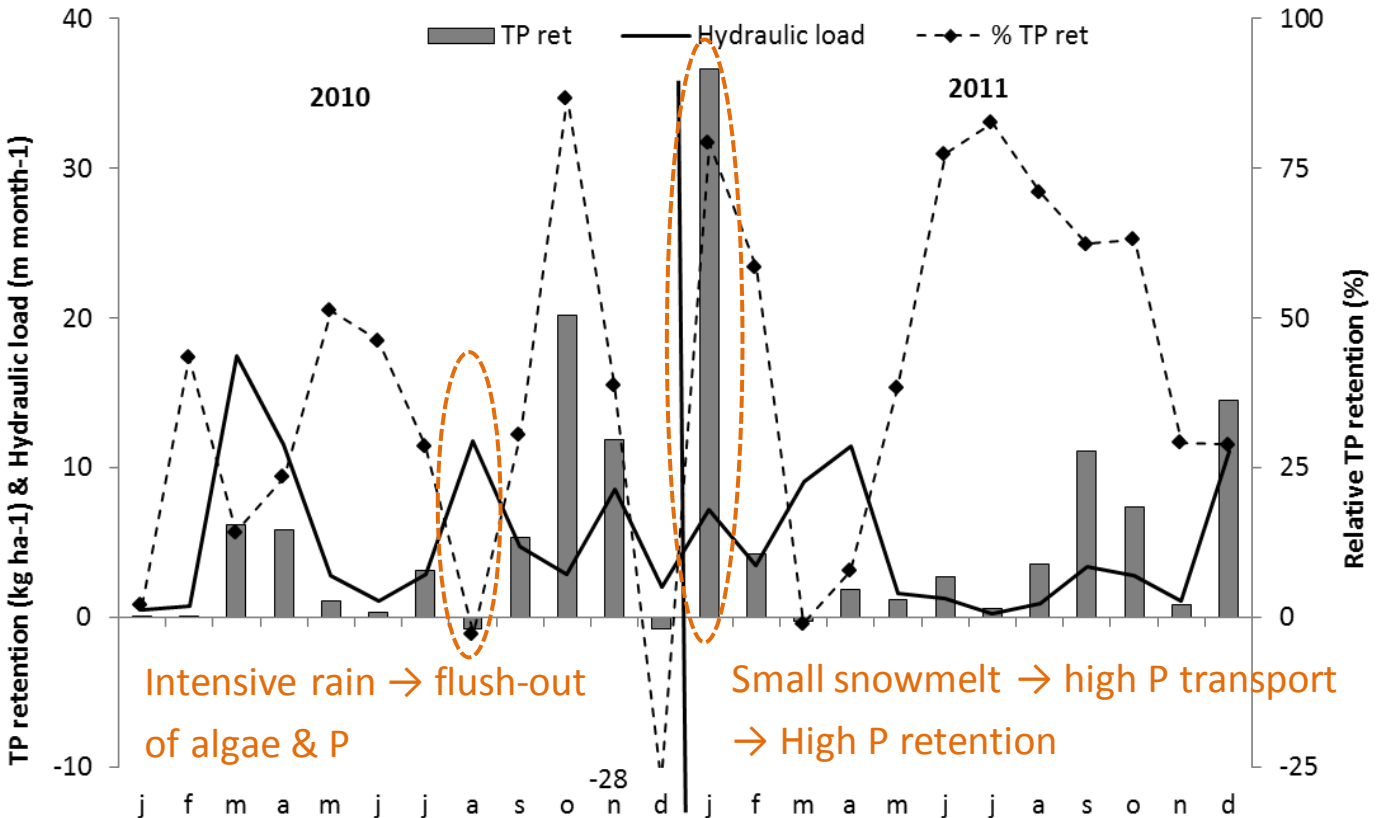
P filter

Foto: Pia Kynkäänniemi 2011

P retention in Bergaholm

Kynkäänniemi et al. 2013 JEQ	TP			DP	PP	TSS	TN
	Year 1	Year 2	Mean				
Load (kg/ha, yr)	192	194	193			83 036	1 281
Retention (kg/ha, yr)	54	84	69	17	46	29 663	322
% of the load	**28%**	**43%**	**36%**	**9%**	**24%**	**36%**	**25%**

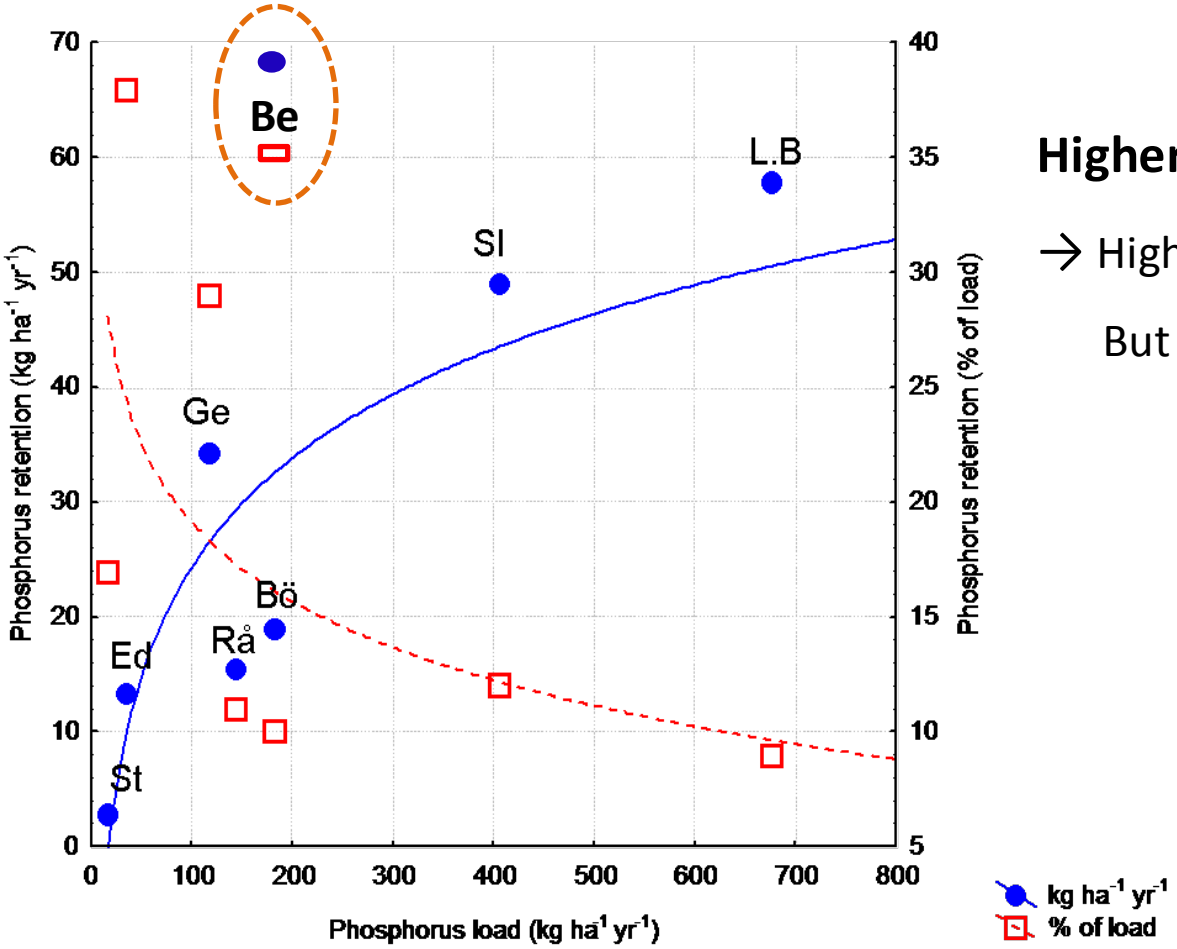
Relation P load and retention. **Annual net sink of P (better retention of particulate bound P)**



P retention in Swedish wetlands

Bergaholm higher P retention than other Swedish wetlands

Both specific and relative!



Higher P load

→ Higher specific retention (kg/ha)

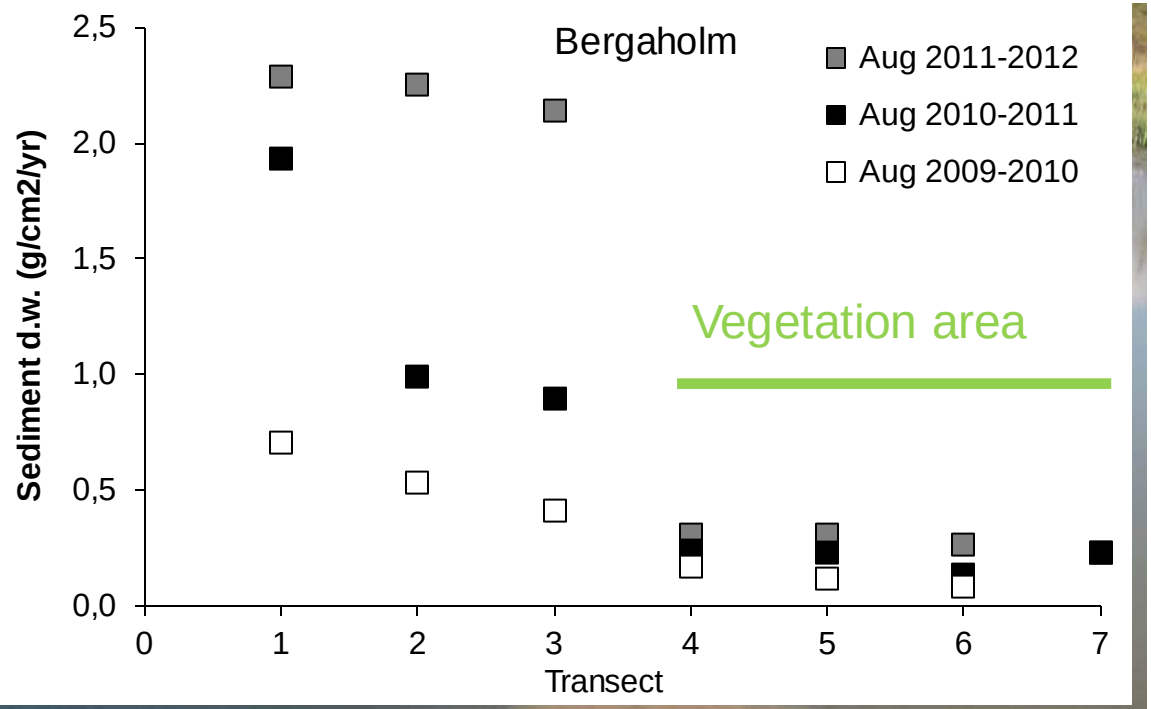
But lower relative retention (%)

From Johannesson *et al.* (in prep)

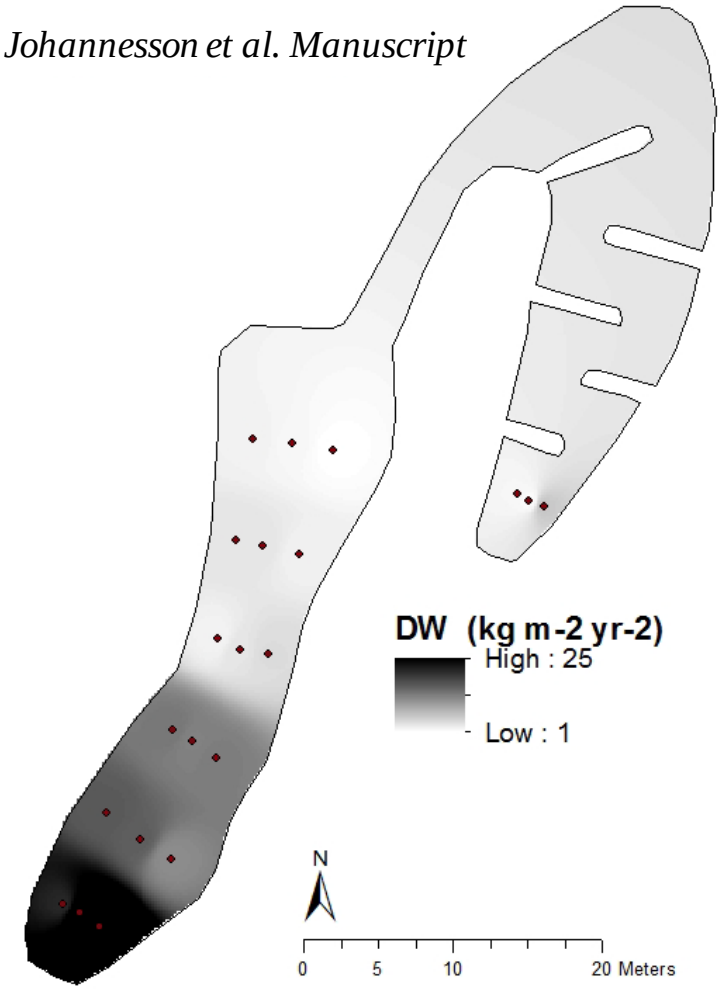
Estimation of sediment accumulation

Foto: Pia Kynkäänniemi August 2012

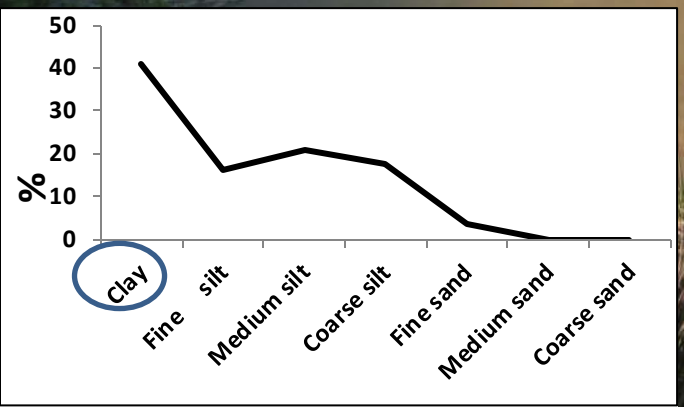
Estimation of sediment accumulation



Johannesson et al. Manuscript



Gradient Inlet → Outlet more accumulates every year



Maintenance

Sediment built up

→ need to be removed to prevent P released

→ Recycling soil and P to the fields

Need subsidies for maintenance!

Photo: Bent Braskerud

Recommendations P wetlands

Farmers

1. Demands less land
   - in an open ditch
   - higher up in catchment
2. Planning to reconstruct drainage network
3. Recycle soil and P

Policy decision maker

1. Higher subsidy to farmers & for the total cost
2. Subsidy for maintenance (recycling soil & P)
3. Divide payment of subsidy (long time for farmers to put out money)