Ecosystem services a key element in protecting biodiversity of wetlands, rivers and estuaries

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Ecosystem management research group

Universiteit Antwerpen

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Introduction

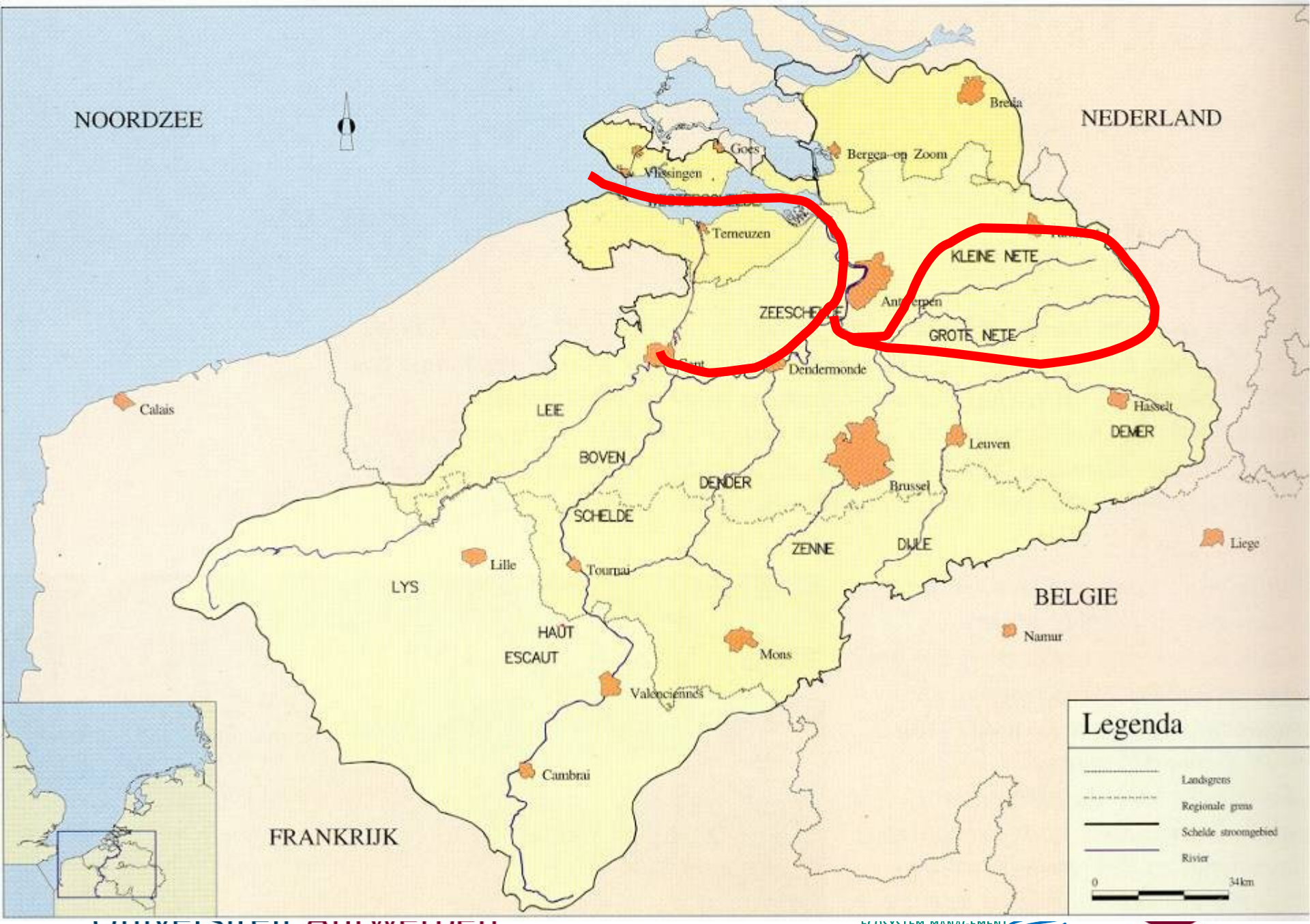
- Detoriation of Wetlands and their biodiversity is a world wide phenomena and this is clearly demonstrated in the Millennium Ecosystem Assessment
- Many actions have been undertaken to stop further losses and to try to restore wetlands, but many of them failed for different reasons.

Aim

- The aim of this presentation is to put foreward some ideas developed and applied in recent years in Flanders concerning wetland restoration and river basin management.

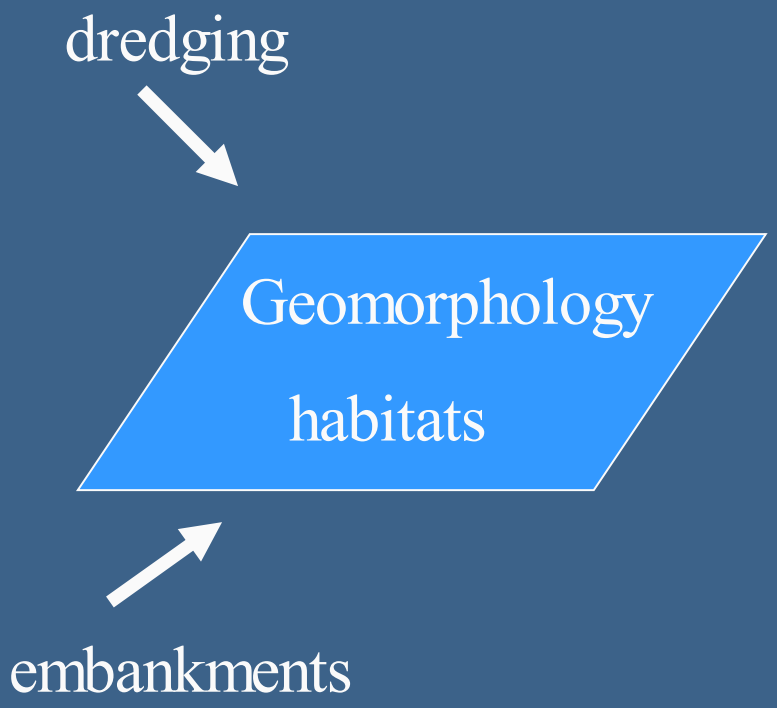
Study area

- The Schelde estuary and the Nete

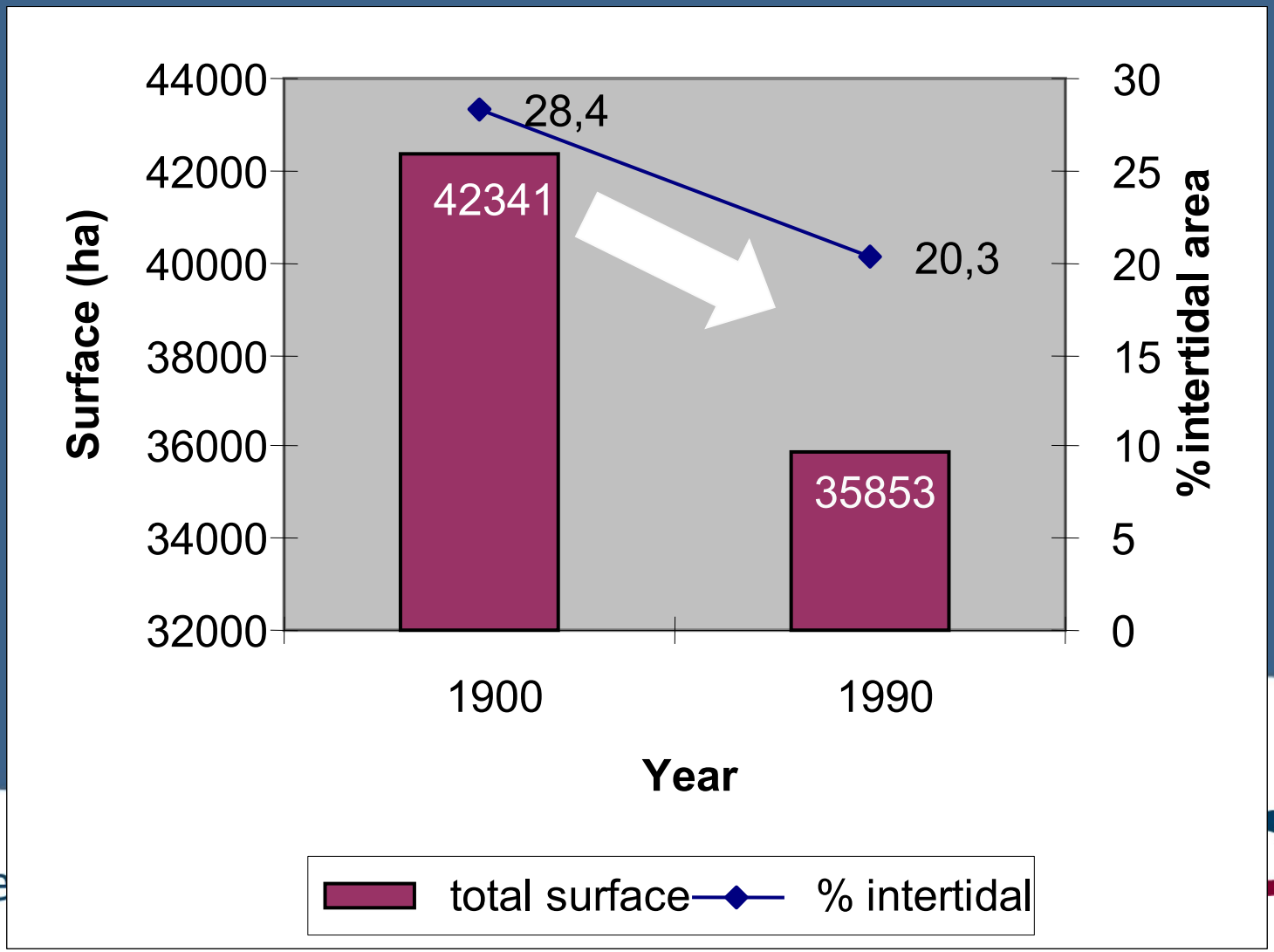

NOORDZEE
NEDERLAND
BELGIE
FRANKRIJK
Breda
Goes
Bergen op Zoom
Vlissingen
Terneuzen
KLEINE NETE
GROTE NETE
ZEESCHELDE
Antwerpen
Dendermonde
Calais
LEIE
BOVEN
DENDER
SCHELDE
Hasselt
DEMER
Leuven
Brussel
ZENNE
DIJLE
Liege
Lille
Tournai
LYS
HAUT
ESCAUT
Mons
Namur
Valenciennes
Cambrai
Legenda
Landsgrens
Regionale grens
Schelde stroomgebied
Rivier
0
34km

How did the Schelde estuary and Nete change from past to present and how did this impact the ecological goods and services or the ecological functioning?

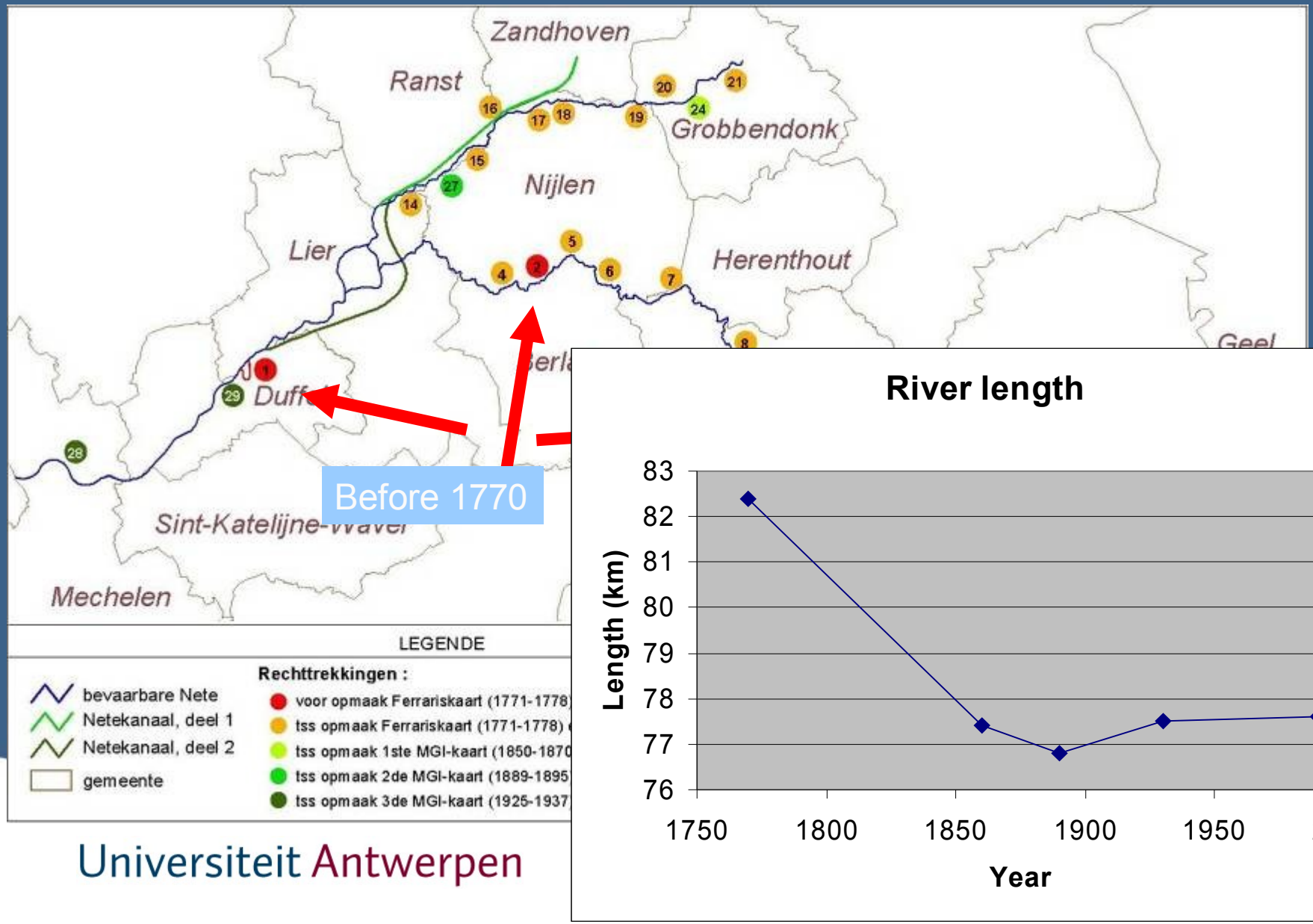
Habitats



Habitat loss



Habitat loss



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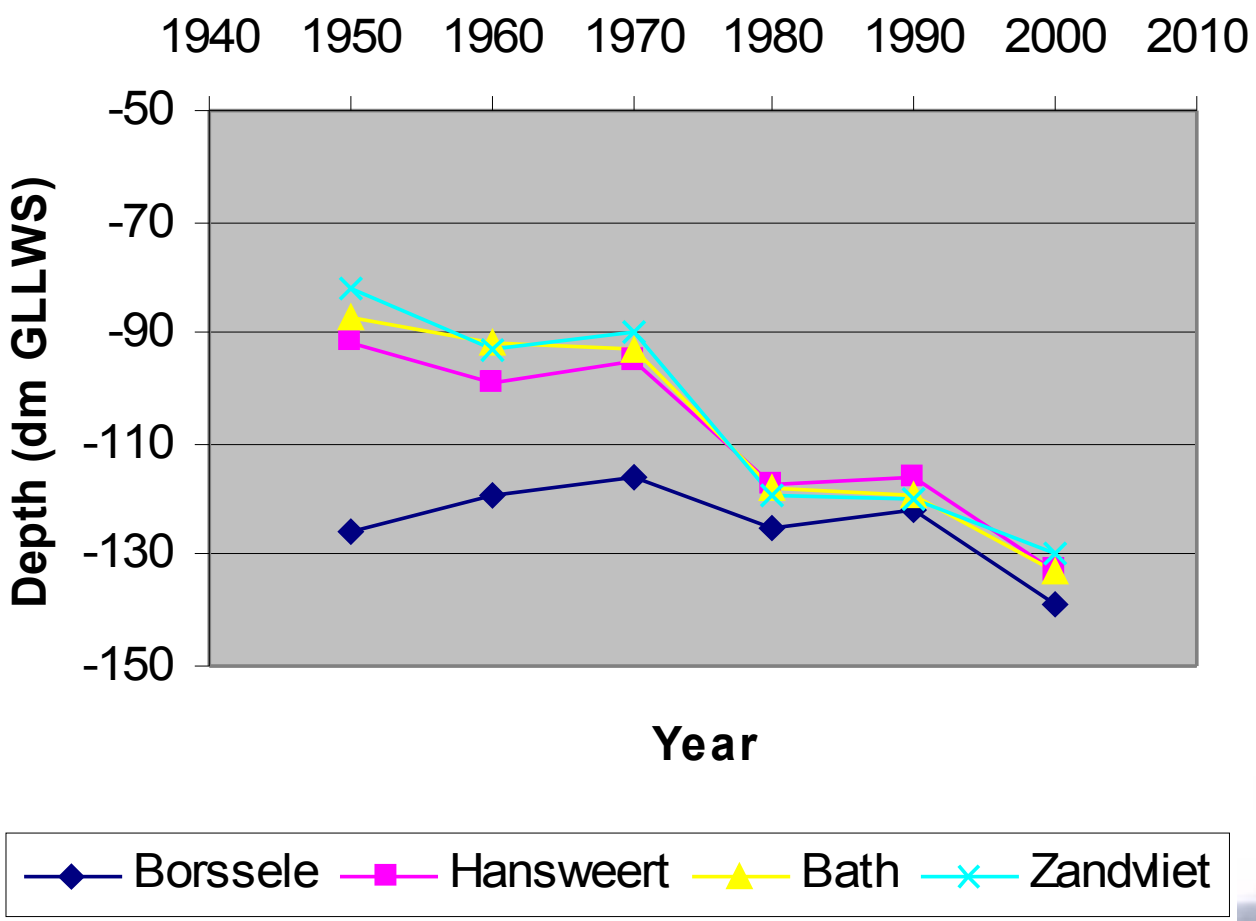
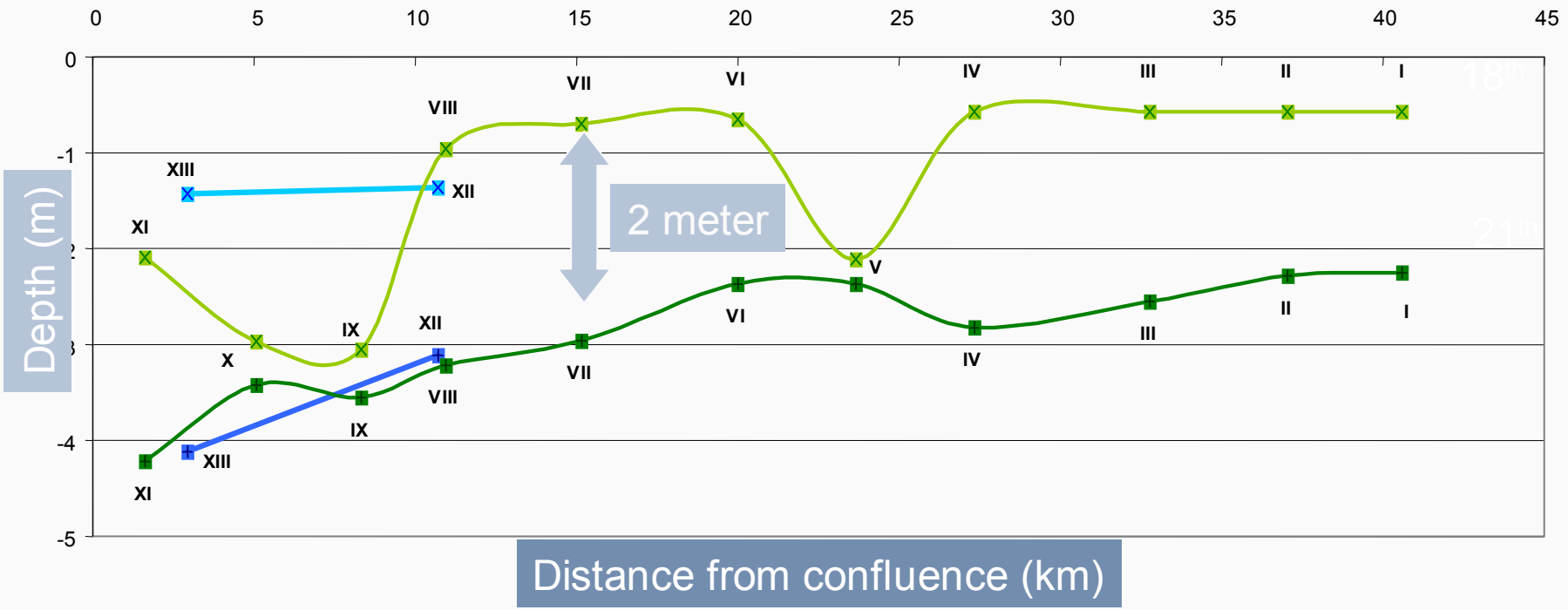
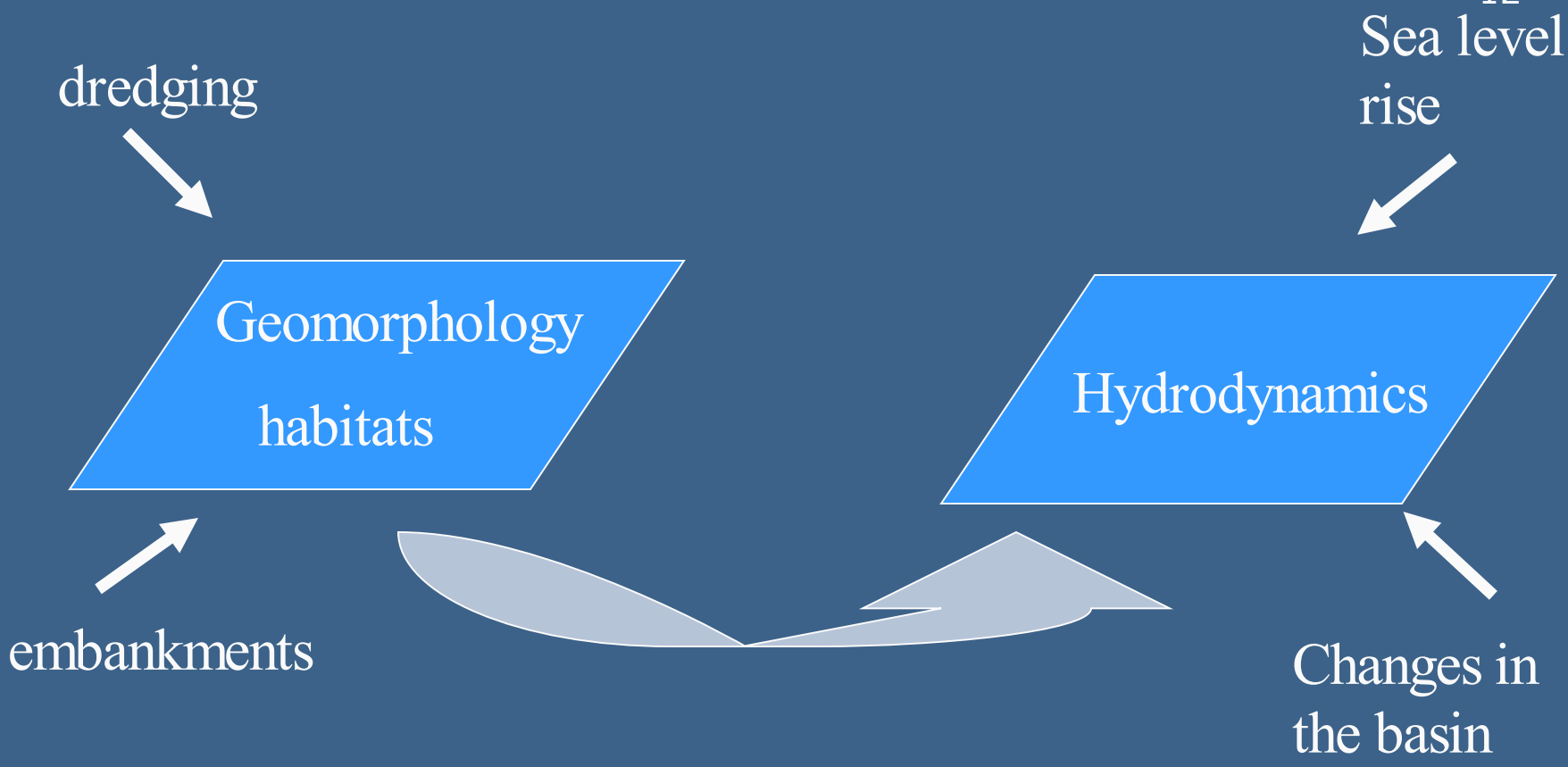
Habitat change



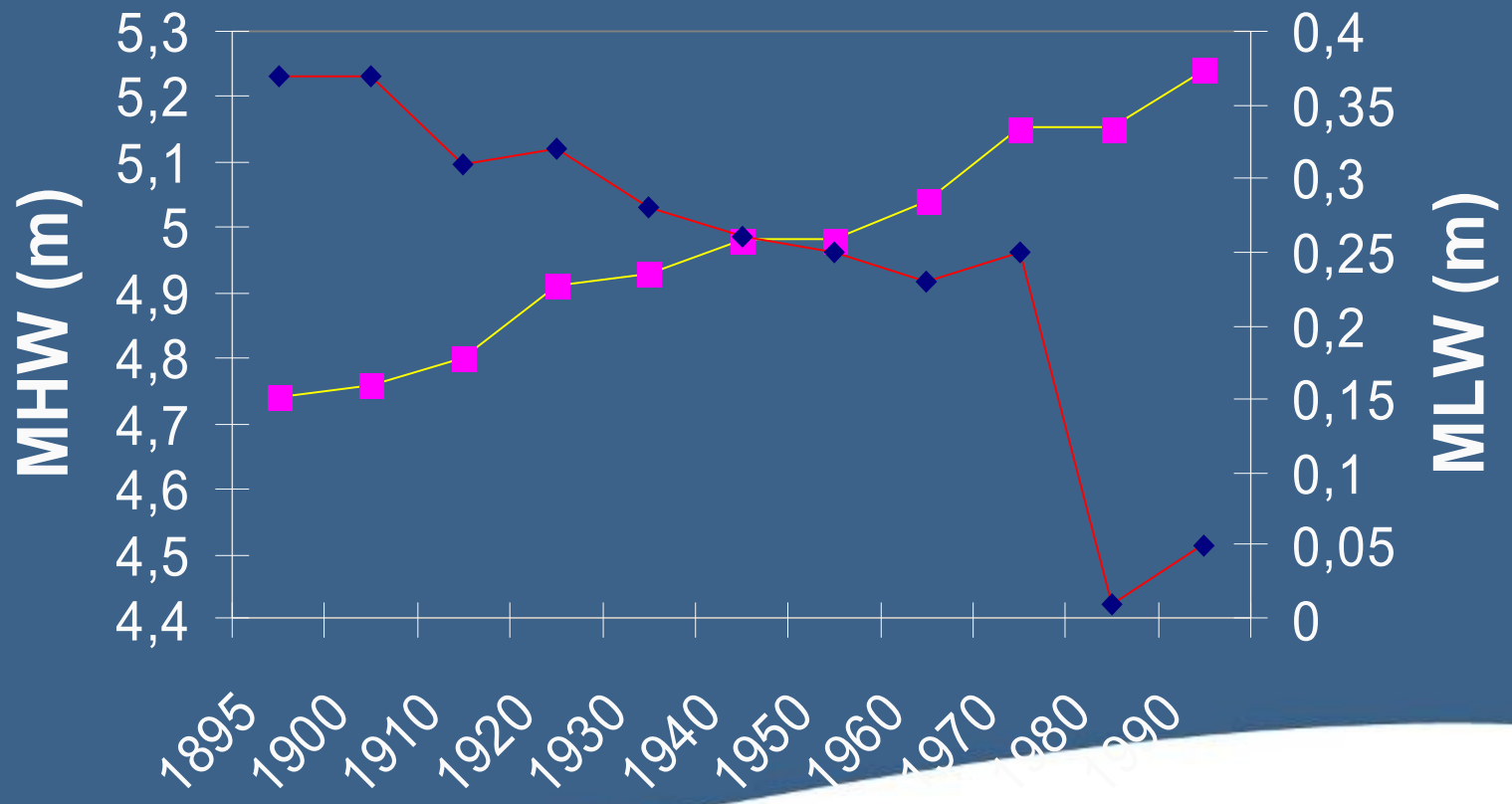
DREDGING

Habitat change




dredging
Sea level rise
Geomorphology habitats
Hydrodynamics
embankments
Changes in the basin

Changes in tidal amplitude



increase MHW 0,5 m

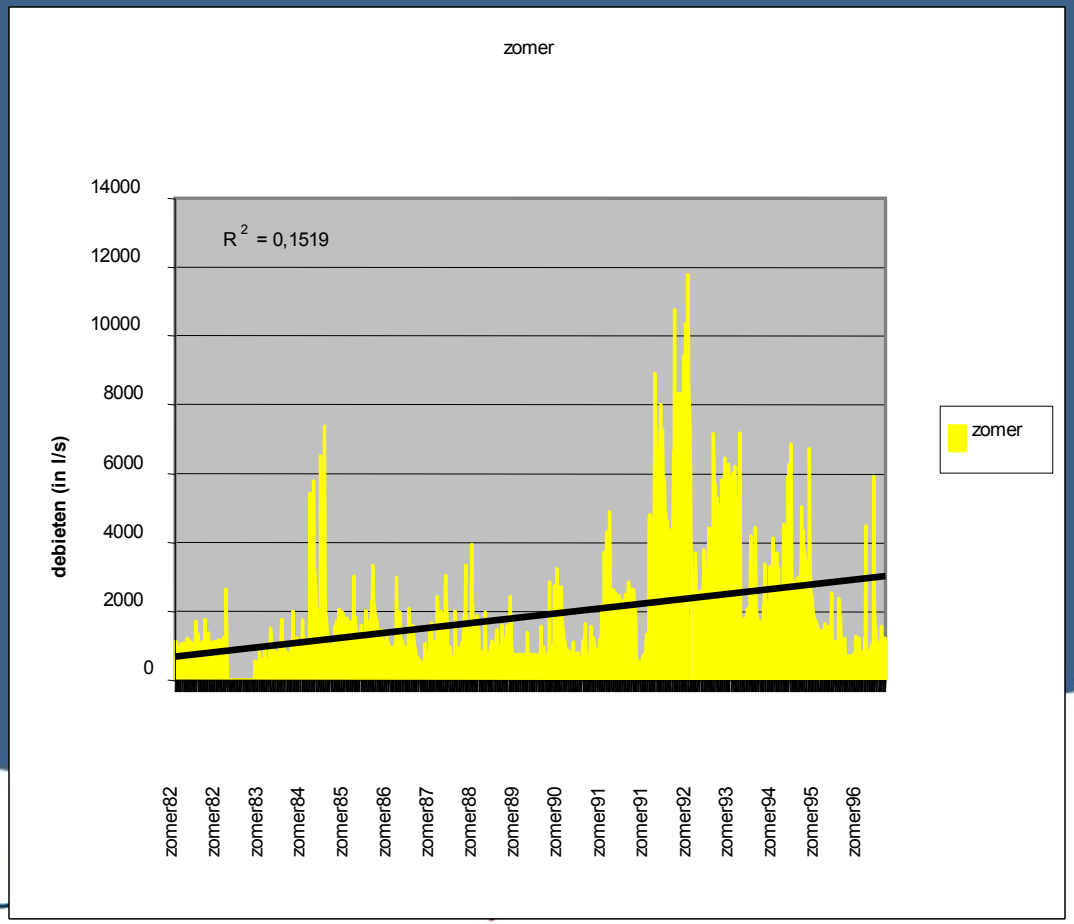
decrease MLW 0,3 m

total increase tidal amplitude 0,8m

	1895	1925	1955	1985
Vlissingen - Hansweert	71	70	63	56
Vlissingen - Antwerpen	144	133	120	104

Time of flood wave (min)

Increased discharges from the catchment



Associated, large inputs from sediments

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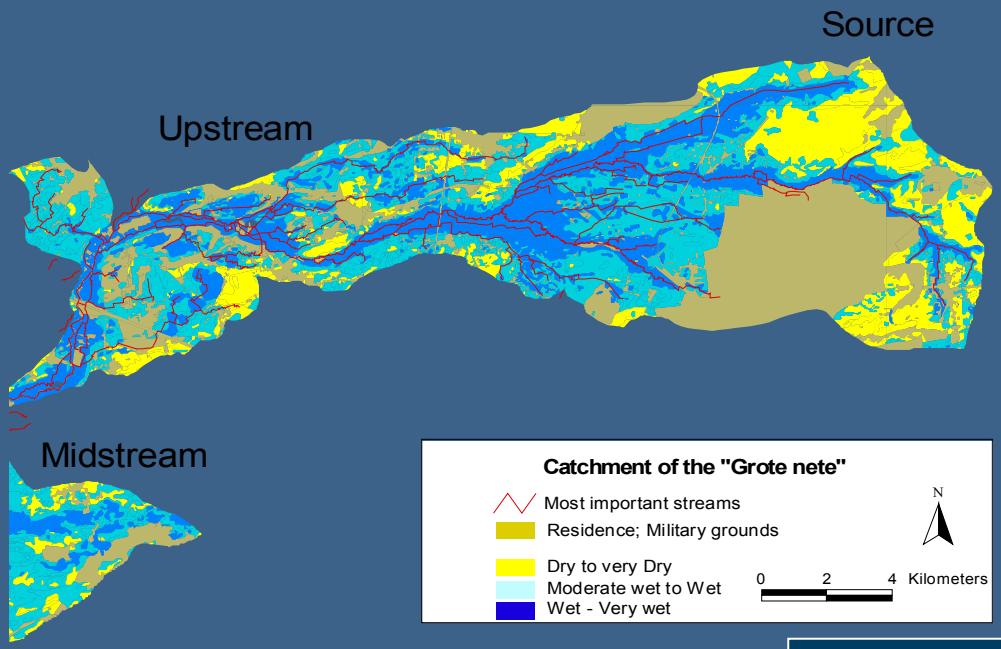
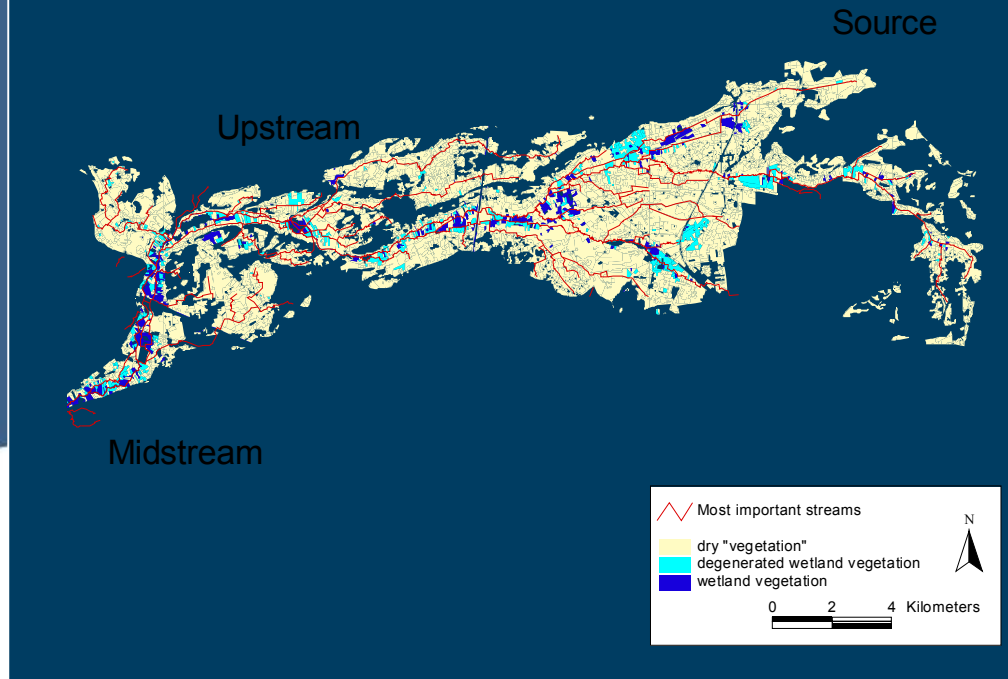
Inundations

Grote Nete 17 september 1998

Photo: AMINAL





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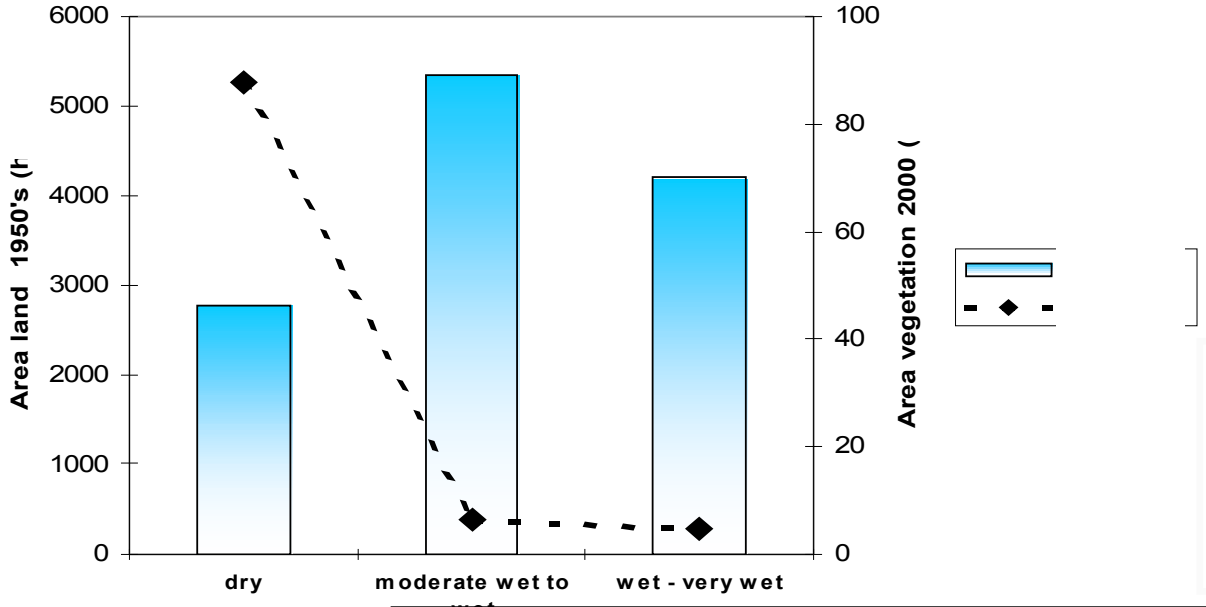
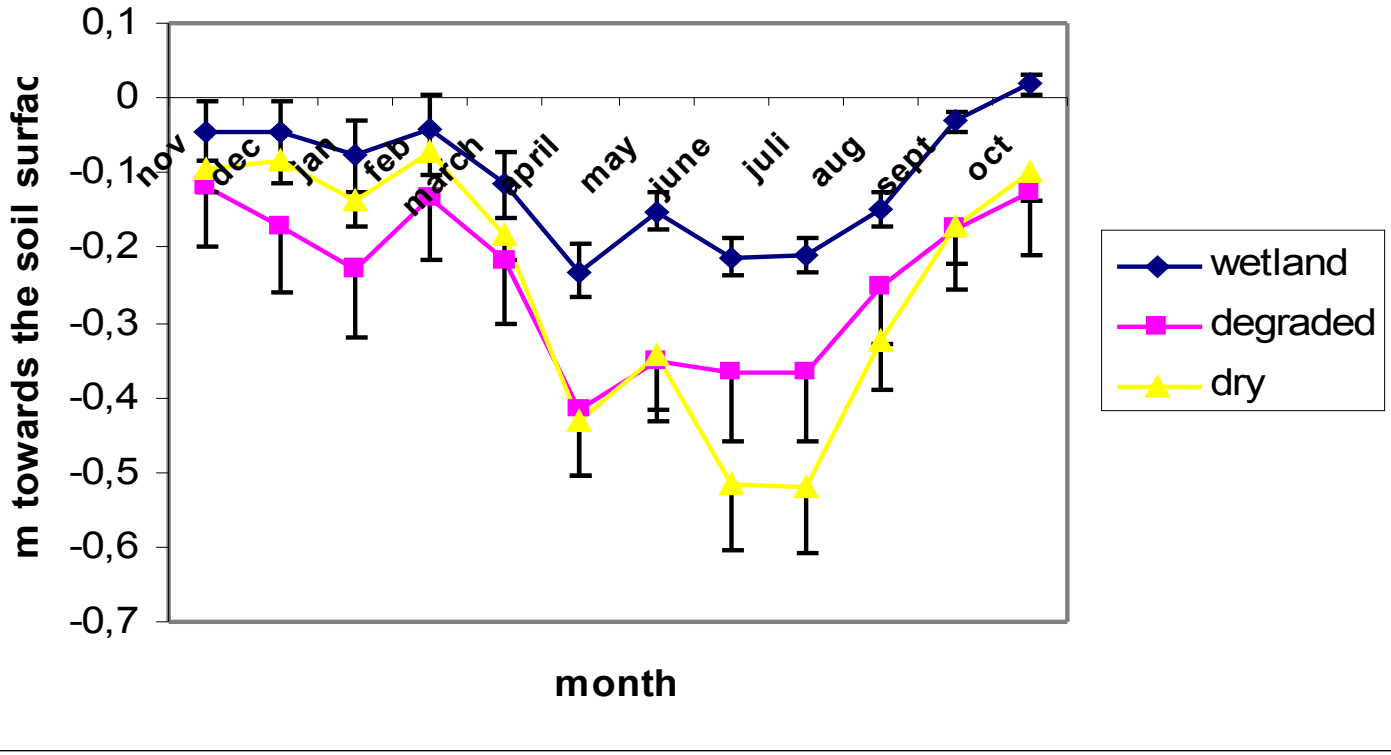


It is concluded that nearly 90 % of the wetland has dissapeared in the valley of the Grote Nete.



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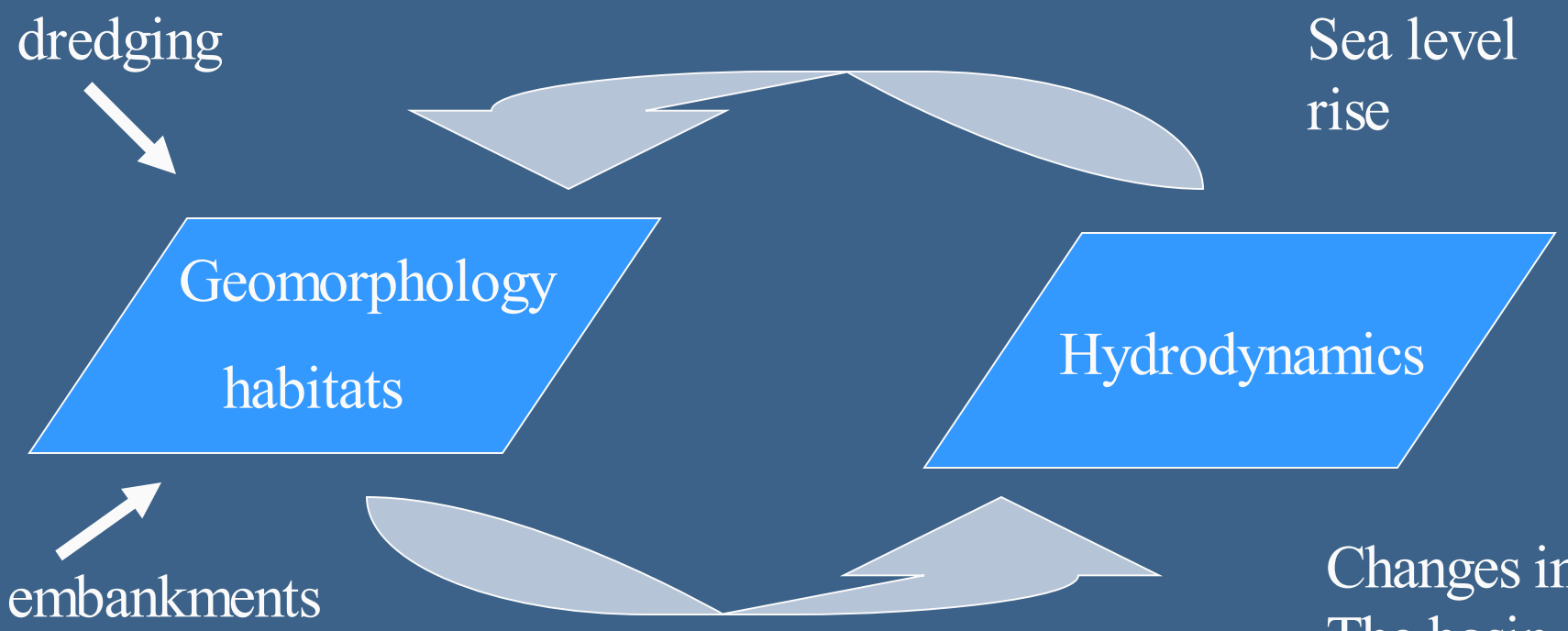
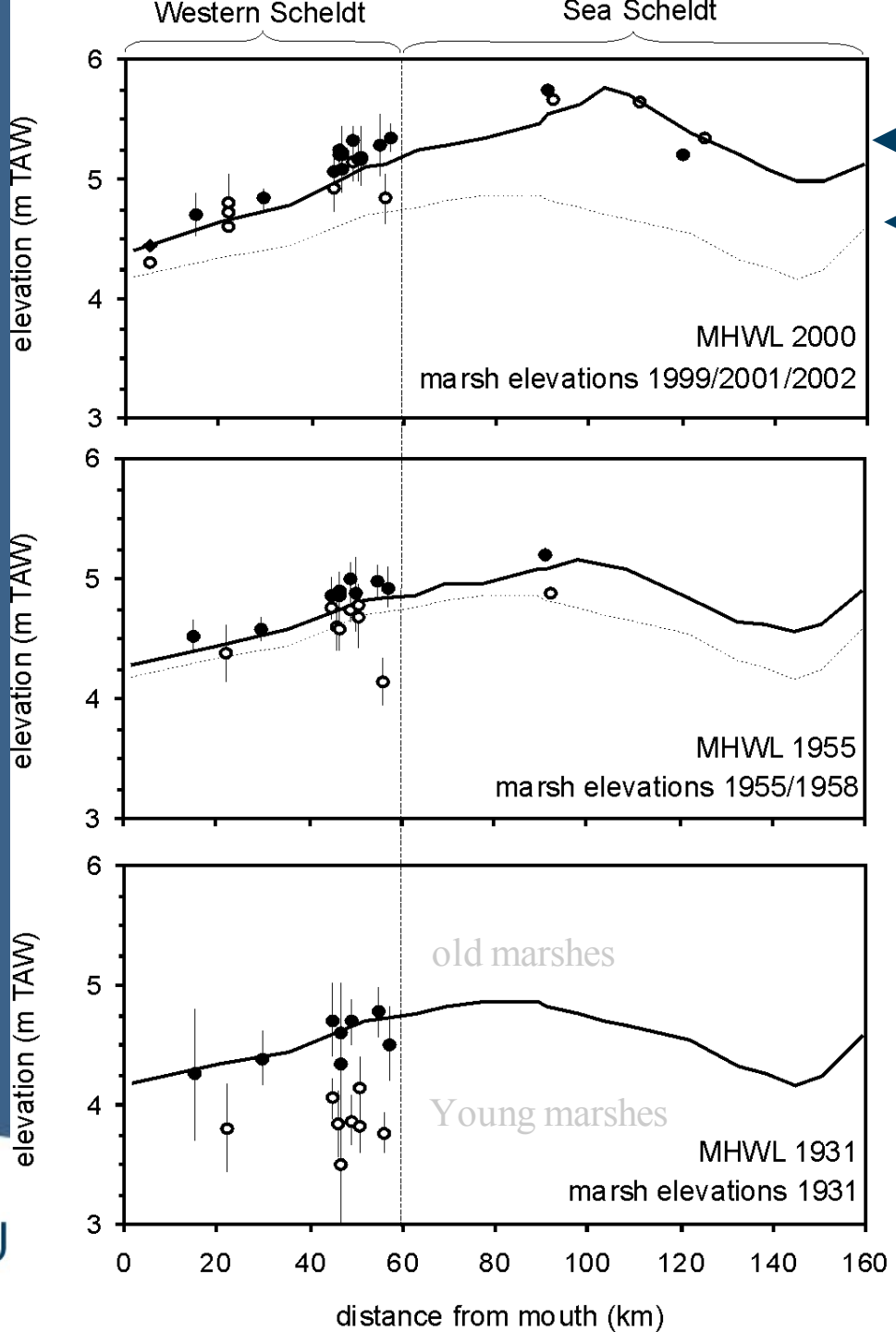

dredging
Sea level rise
Geomorphology habitats
Hydrodynamics
embankments
Changes in The basin

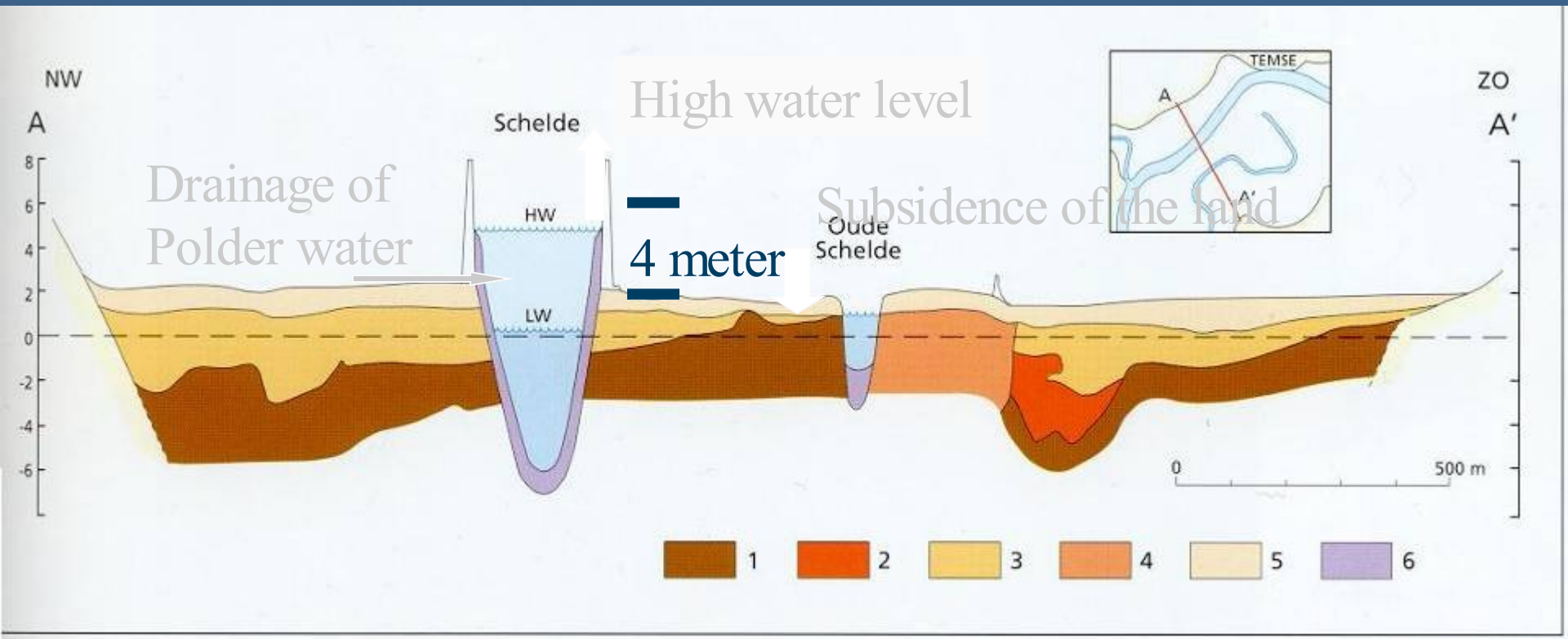


MHWL 2000

MHWL 1931

Data: S. Temmerman


Slope ↑, current speed ↑ ➔ marsh erosion ↑



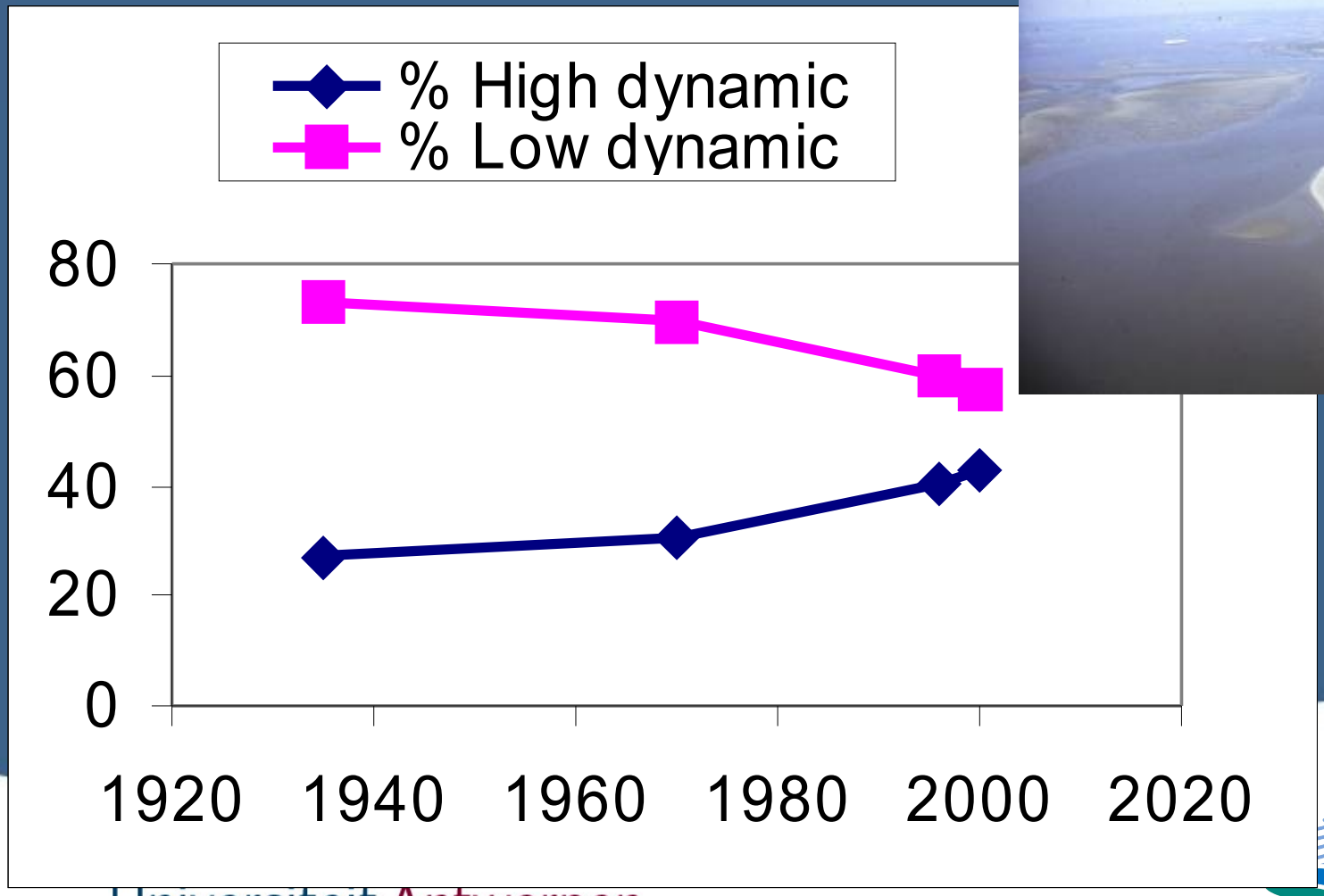
Drainage of
Polder water

High water level

Subsidence of the land

Increasing risks of inudation
now risk is 1 in 70 years

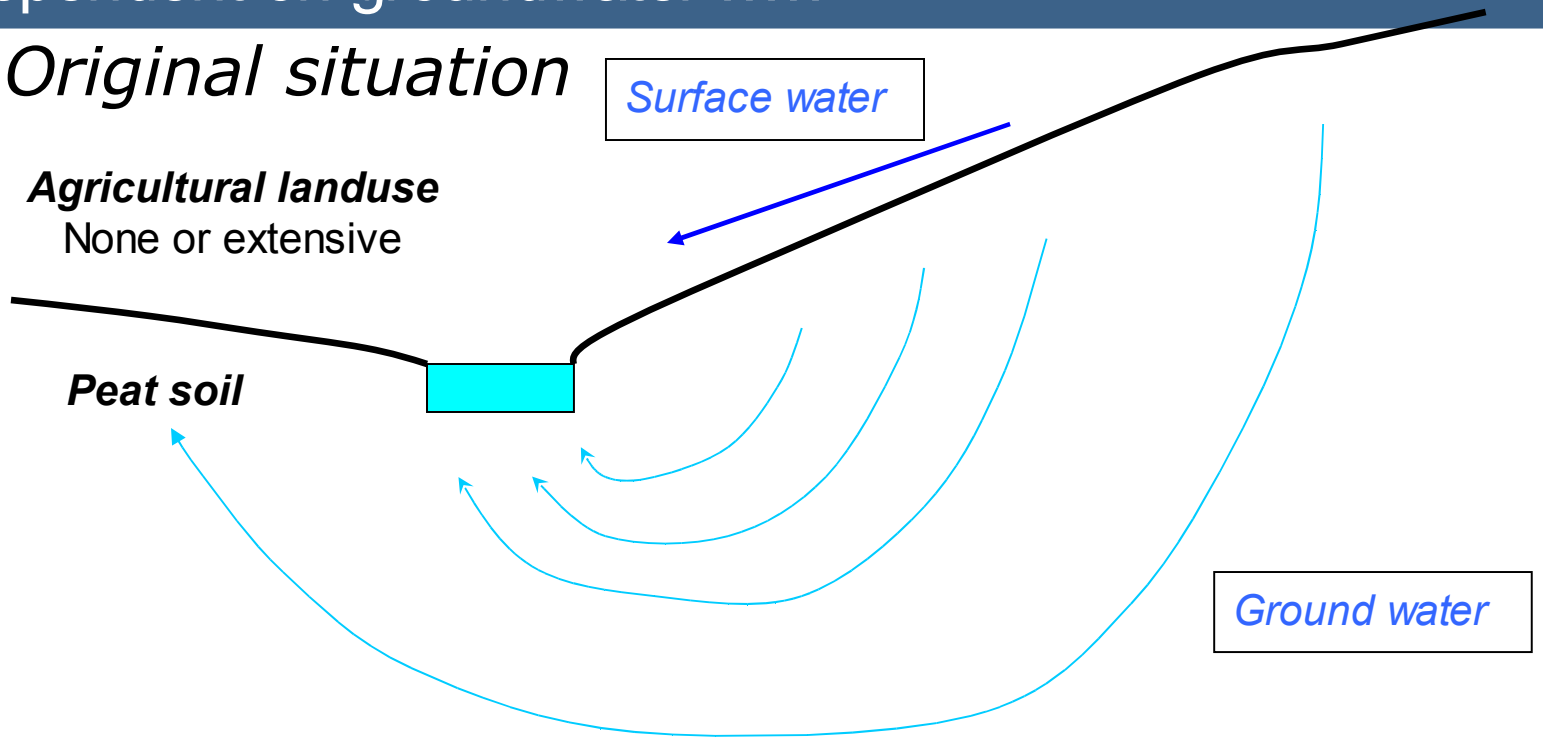
Increase high dynamic flats

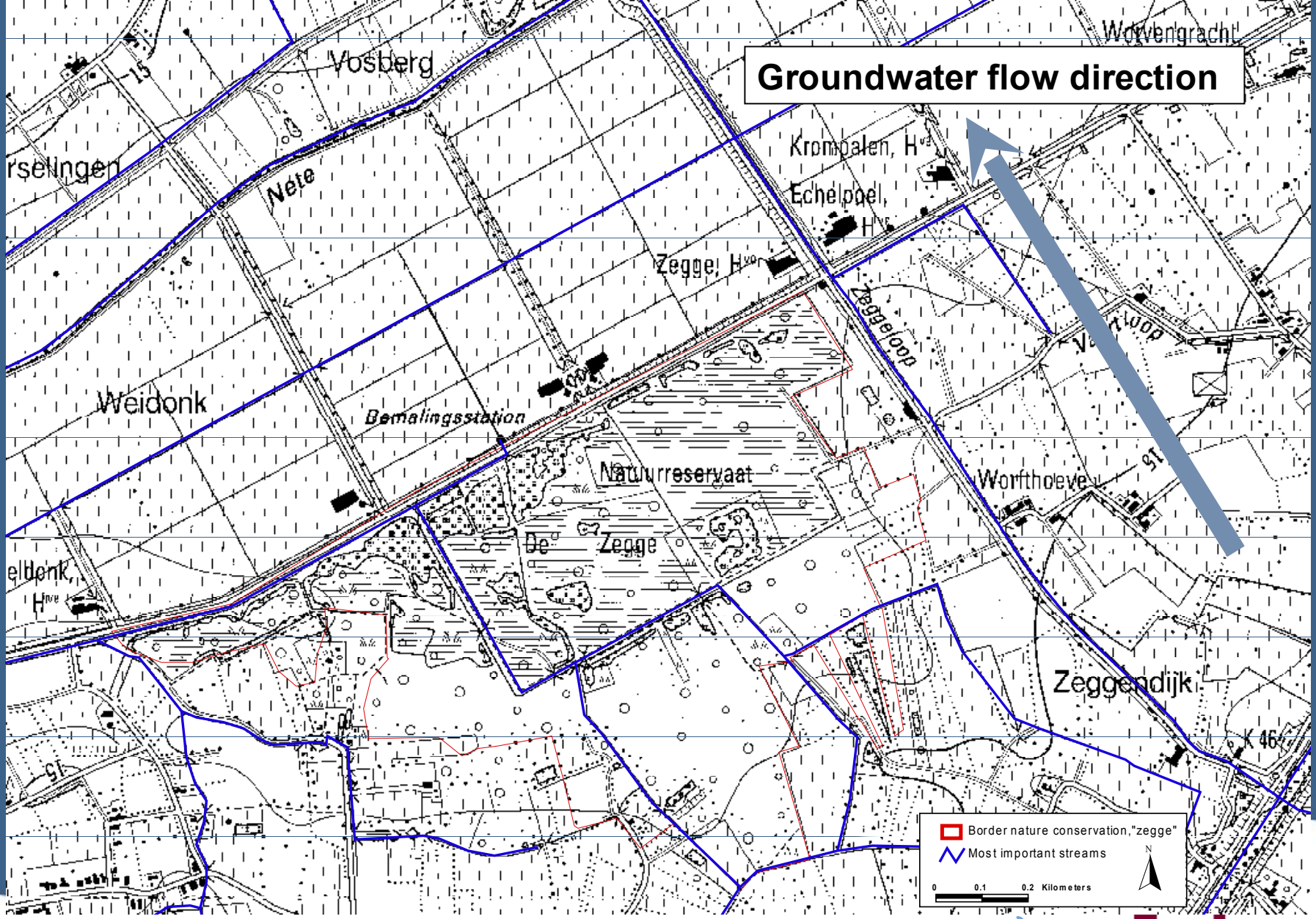


Courtesy Dick de Jong, RIKZ

"De Zegge" (106.7 ha), is a nature reserve, and harbors many rare plant-, bird and reptile species, for several of them is the last population in Flanders.
dependent on groundwater !!!!!

- *Original situation*





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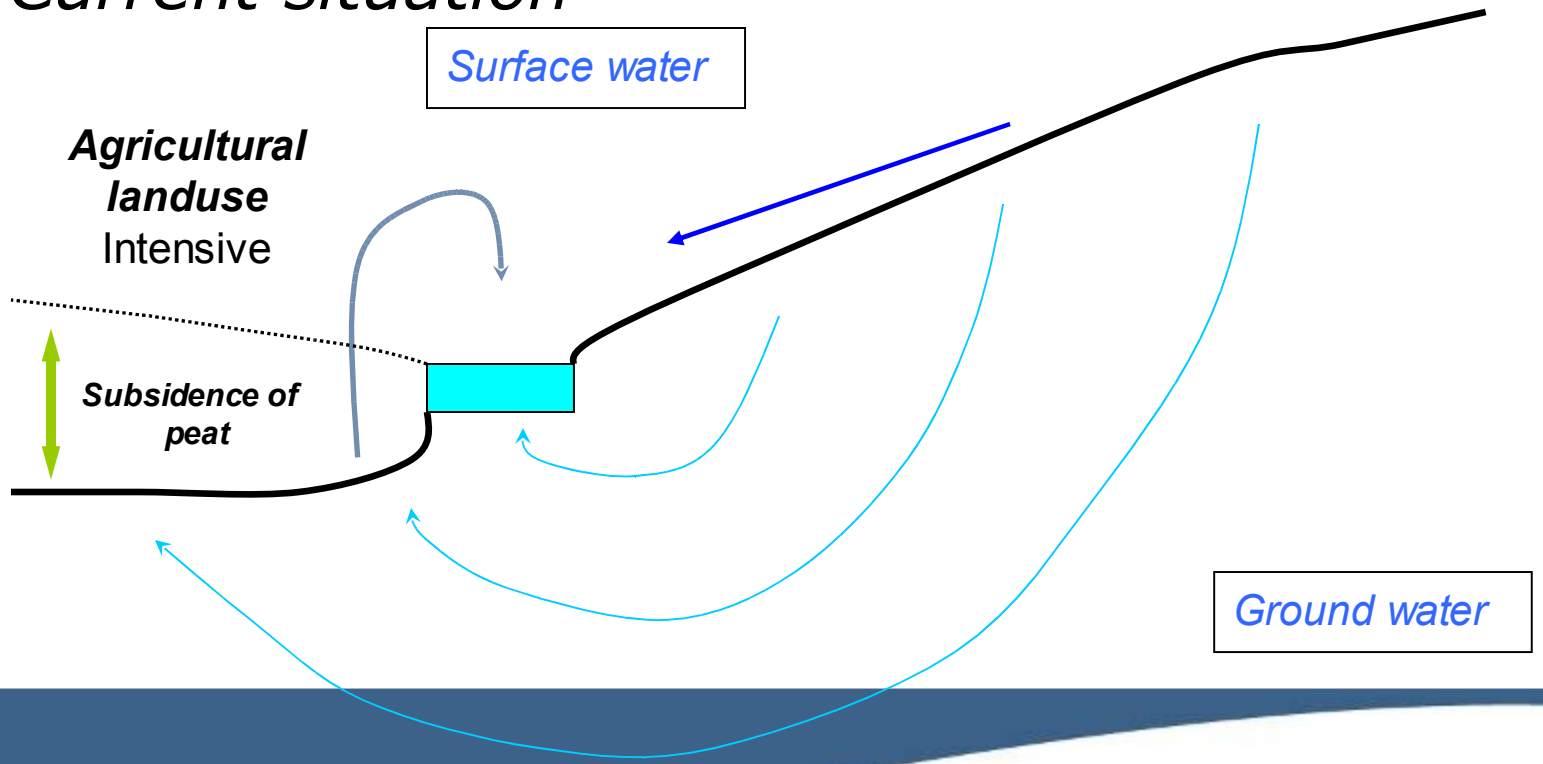
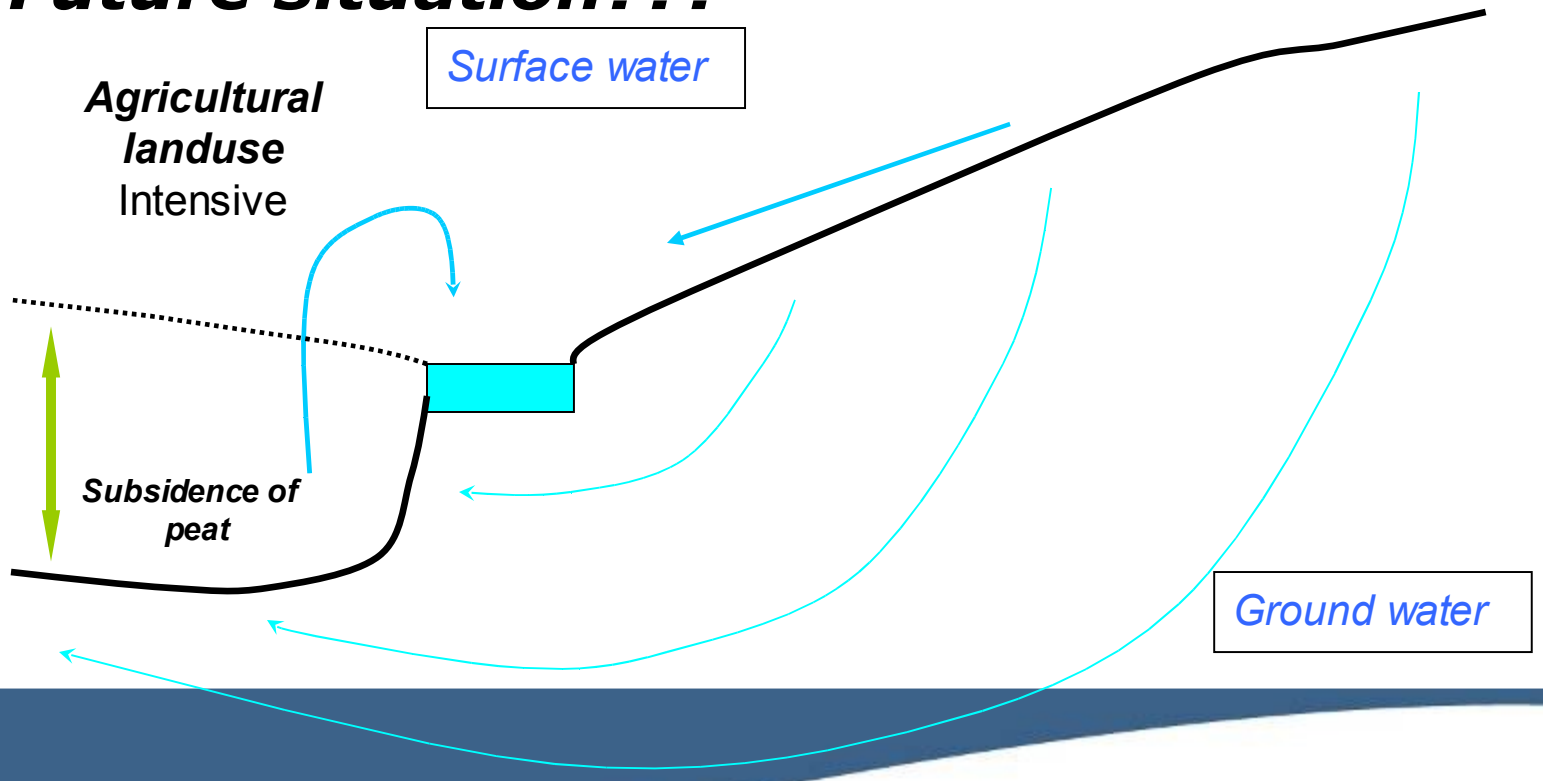
- *Current situation*



- ***Future situation???***



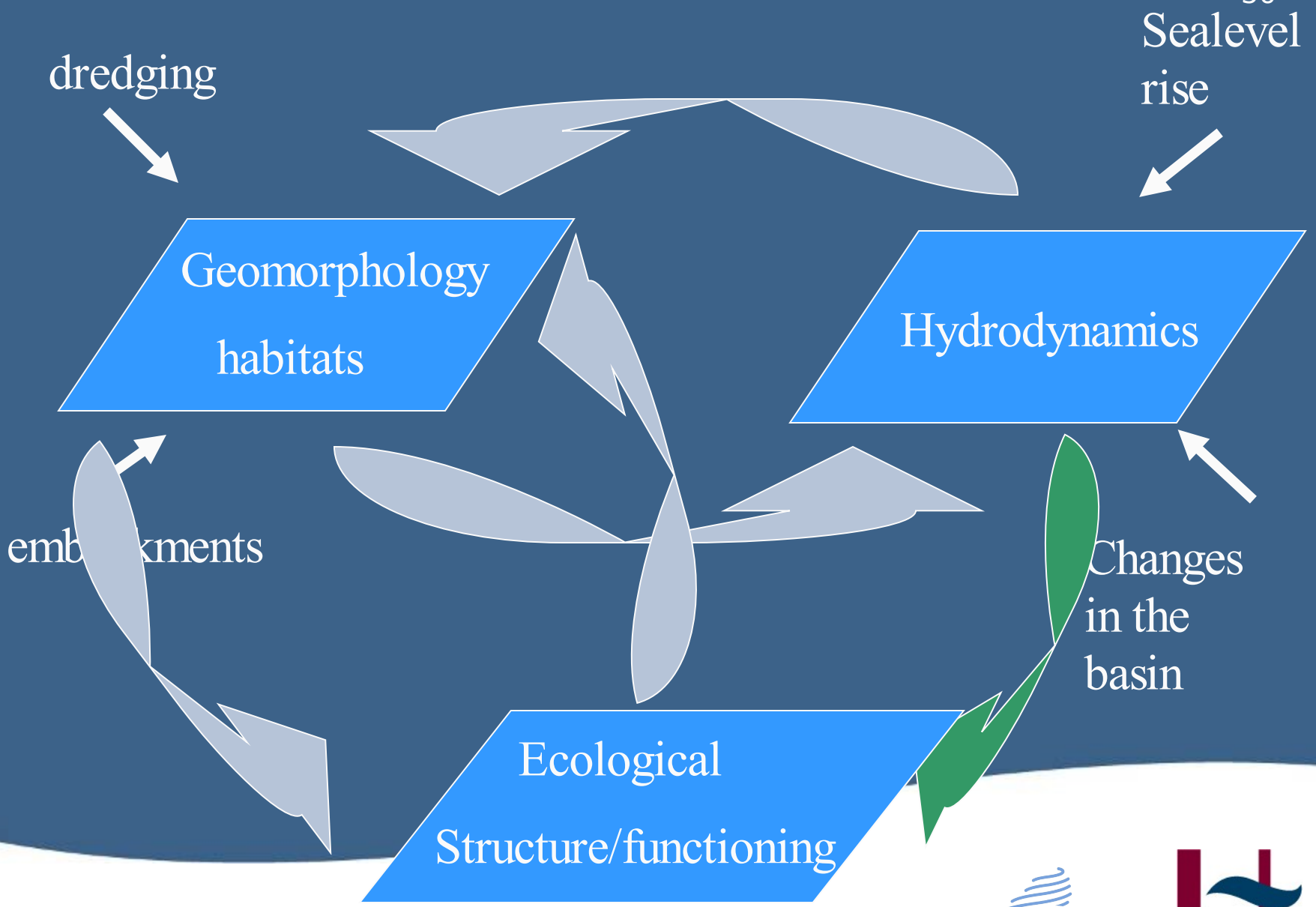
Ecosystem services ?

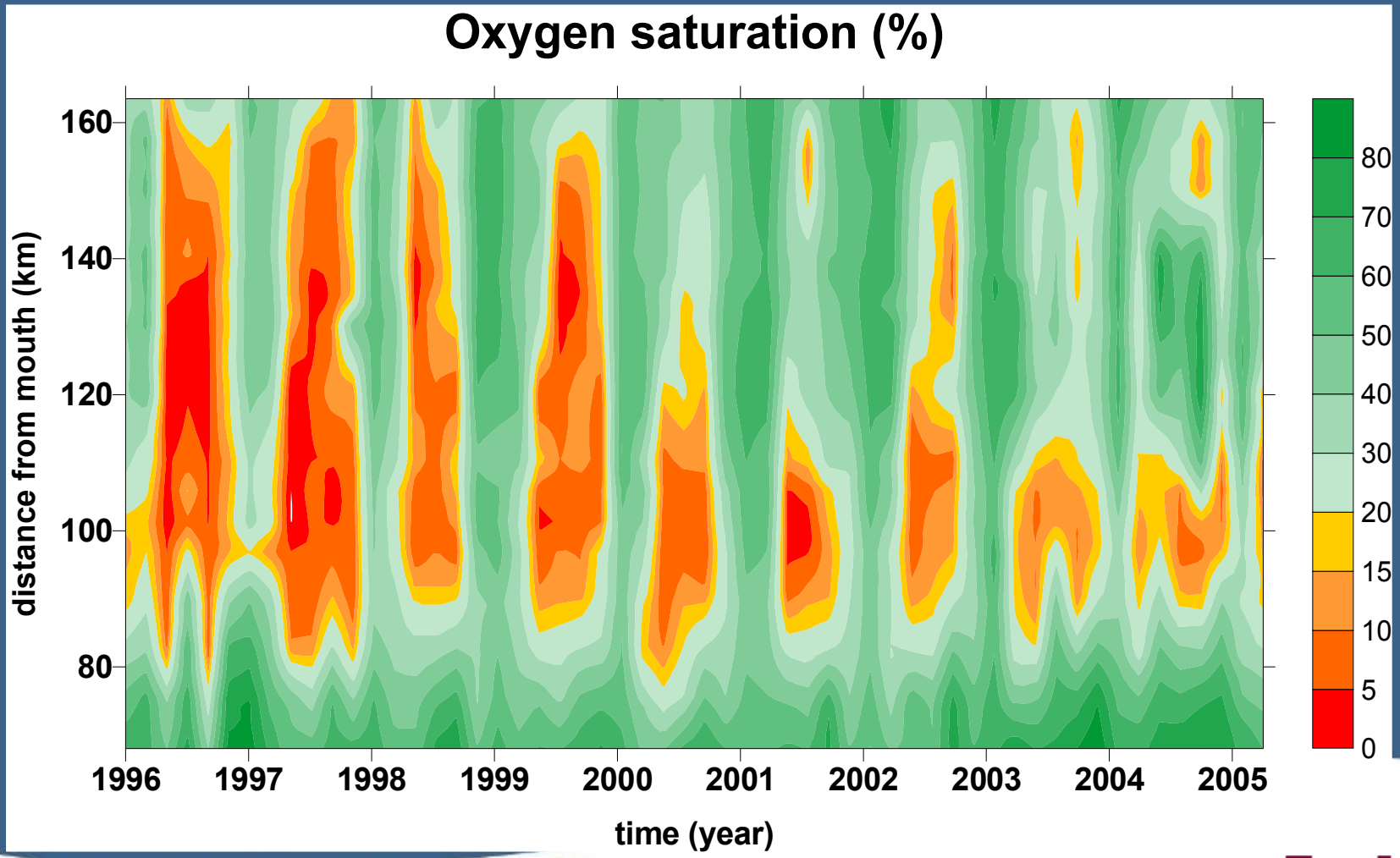
- water regulation and protection against flooding
  - Risks of flooding has increased significantly
  - ➔ present management:
    - Sigmaplan / Deltaplan
      - Heightening of dikes
      - Controlled inundation areas
      - Storm surge barrier

Ecosystem services ?

- sediment trap
  - Due to a lack of sedimentation areas, extremely high rates

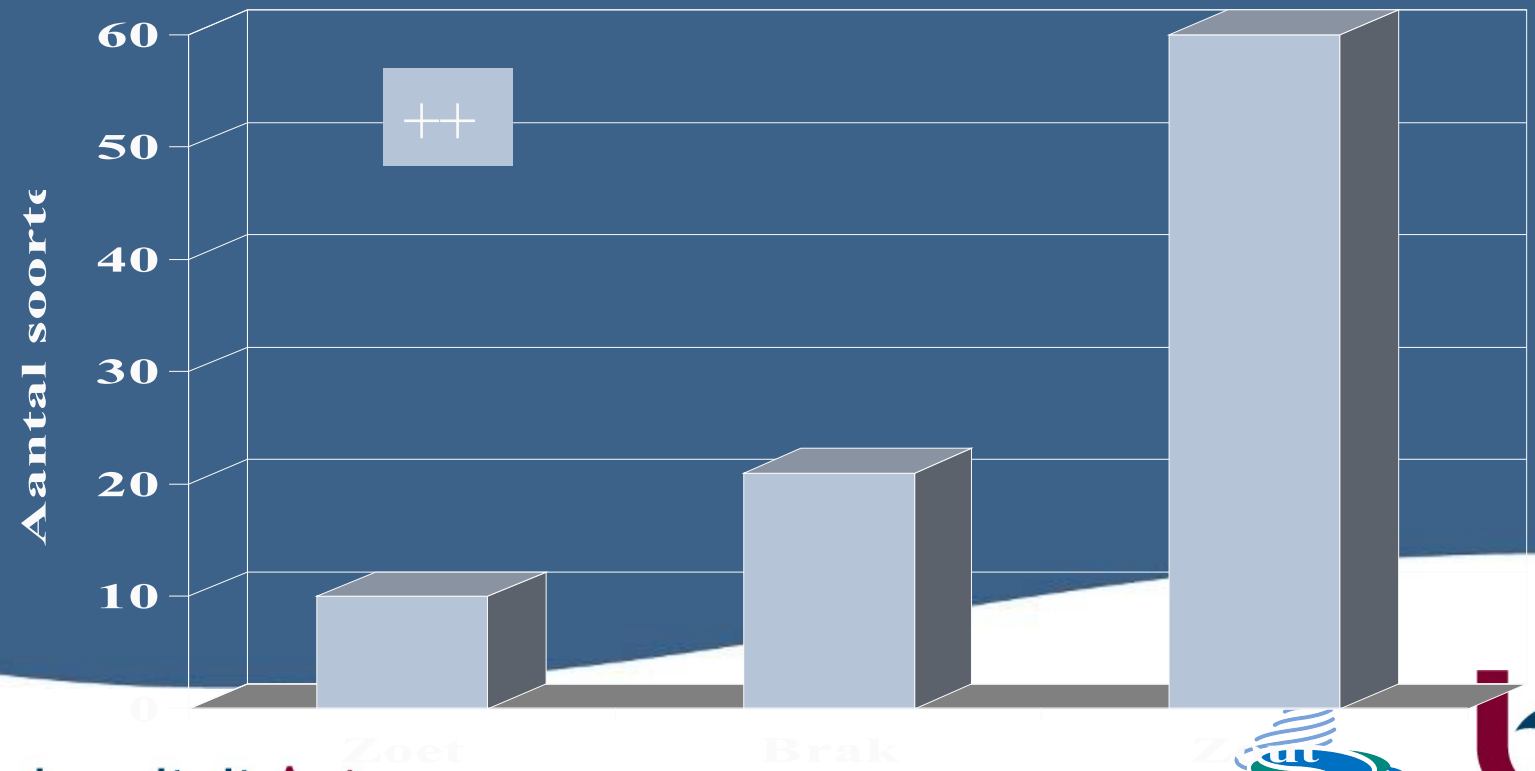
  ➔ present managament:
    - Dredging (up to 500.000 ton DW.y^{-1} removed from the area)
    - NO link to sediment management in basin
- protection against erosion
  - Many dikes are not protected by marshes, this is solved by hard engineering

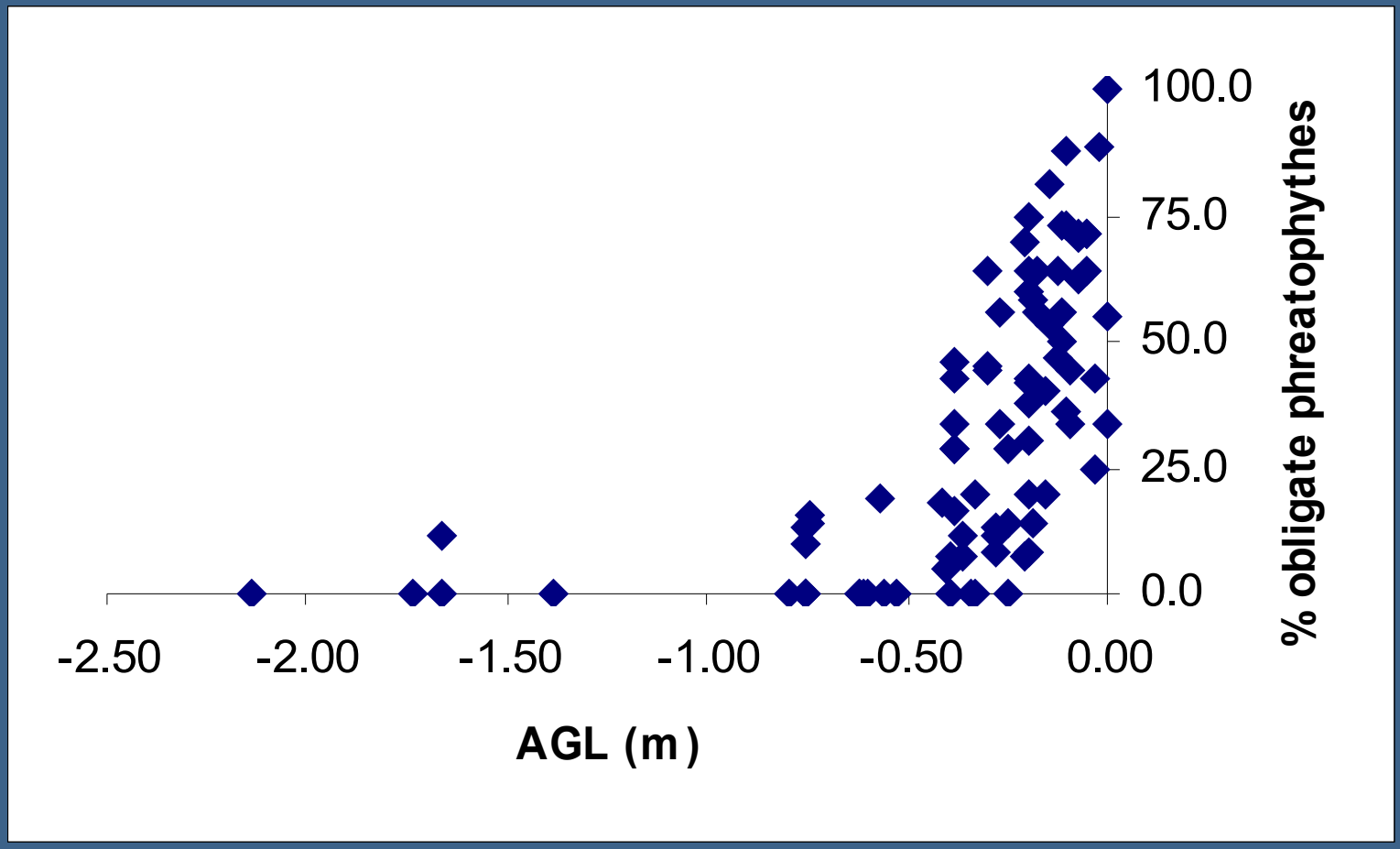

dredging
Sealevel rise
Geomorphology habitats
Hydrodynamics
emb kments
Changes in the basin
Ecological Structure/functioning


Oxygen saturation (%)
distance from mouth (km)
160
140
120
100
80
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
time (year)
80
70
60
50
40
30
20
15
10
5
0

Structural biodiversity under pressure

Macrobenthos: effect of water/sediment quality



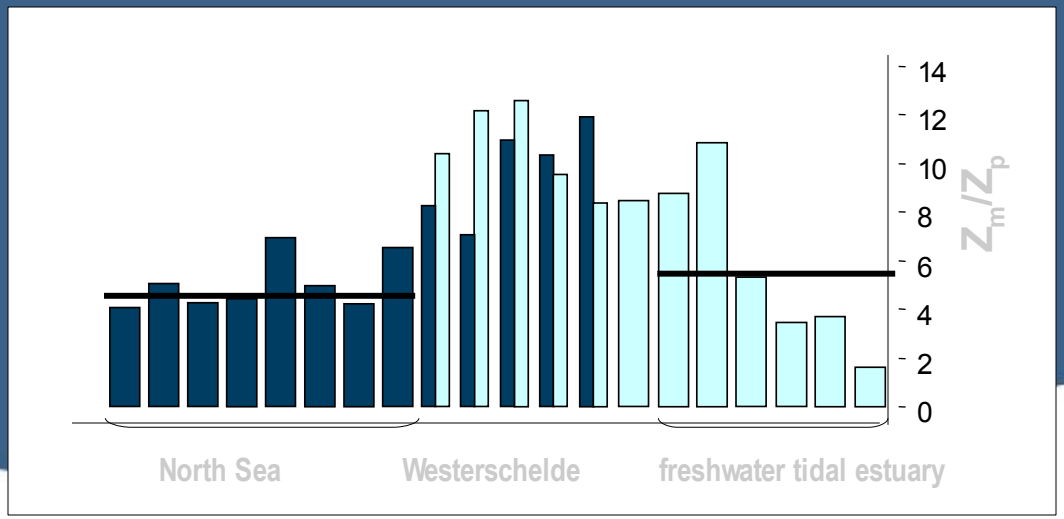

100.0
75.0
50.0
25.0
0.0
% obligate phreatophythes
-2.50
-2.00
-1.50
-1.00
-0.50
0.00
AGL (m)

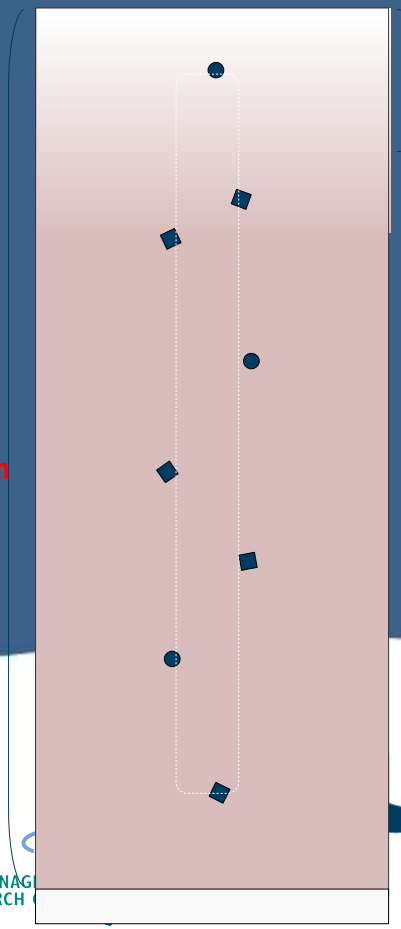
Ecosystem functions ?

- trophic-dynamic regulations of populations
- habitat for resident and transient populations
- important habitat for global population
- nursery
- migration route
  - ➔ severely impacted
  - ➔ present management:
    - "classical nature management"
      - Juridical measures
      - Species oriented measures
      - Vegetation management
  - ➔ no impact at all on major problems like water quality

Benthos biomass depends on sediment characteristics

North Sea	Schelde estuary	
	Westerschelde	freshwater tidal estuary
(Reid *et al*. 1990) (this study)	(Soetaert *et al*. 1994)	
200 g C m^{-2} $year^{-1}$	41 g C m^{-2} $year^{-1}$	260 g C m^{-2} $year^{-1}$





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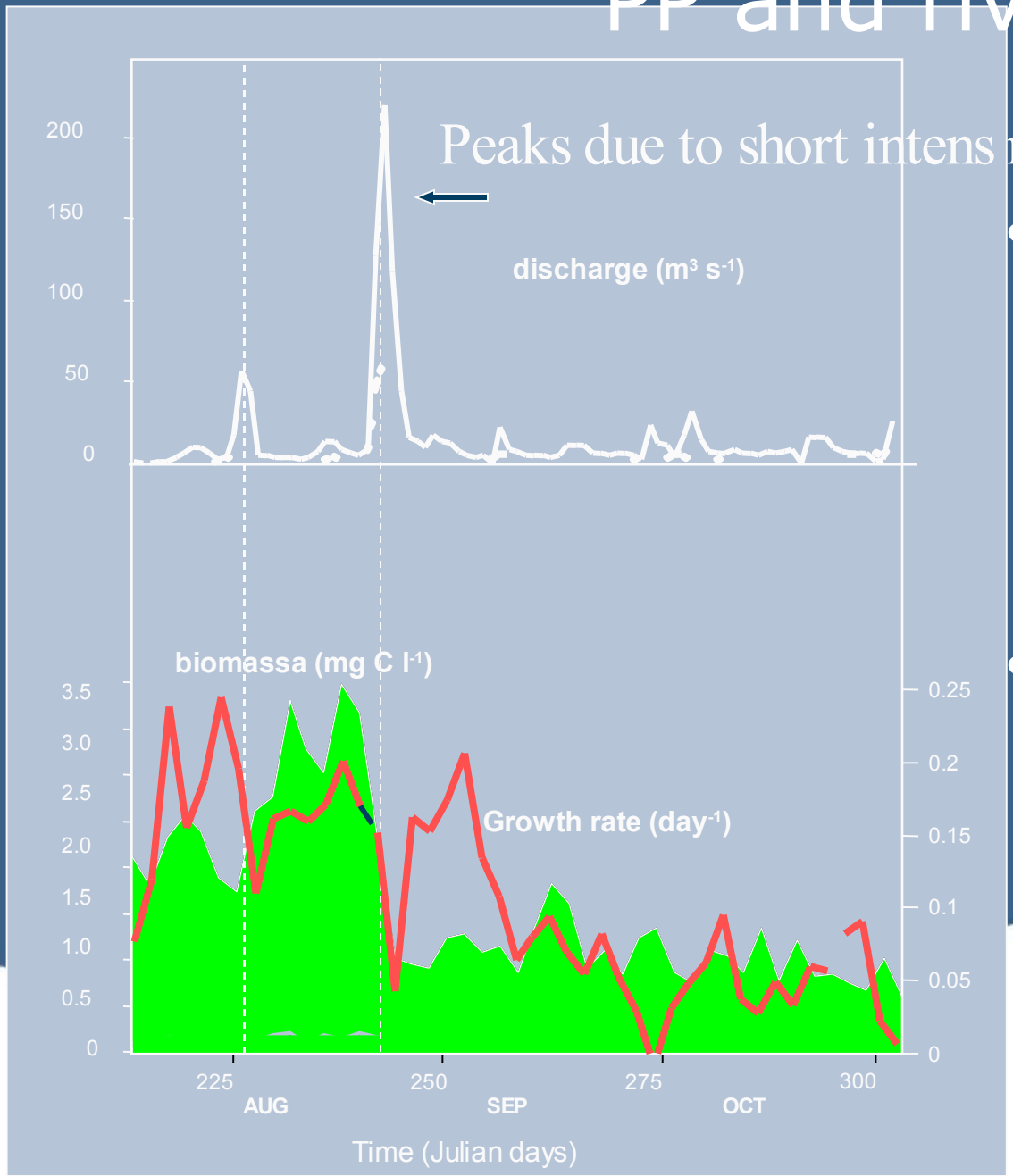
RESEARCH

PP and river discharge



- Primary porduction is influenced to a large extend by retention time, which depends on discharge characteristics
- Data: K. Muylaert

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Percentage of the load that reaches the North Sea

1974 Billen et al. 1985	1985 Soetaert & Herman, 1995	2002 Cox et al. in prep.
48% 55.000 t	77% 66.000	74% 70.000

27.500 49.500 51.800

RISK OF EUTROFICATION, POLLUTION

Ecosystem functions?

- regulation net transport of nutrients to North Sea
- regulation net transport contaminants to North Sea

✂➔ Yes but the overall effect is still small since the available surface of marshes decreased significantly and pelagical processes are limited by pollution and turbidity

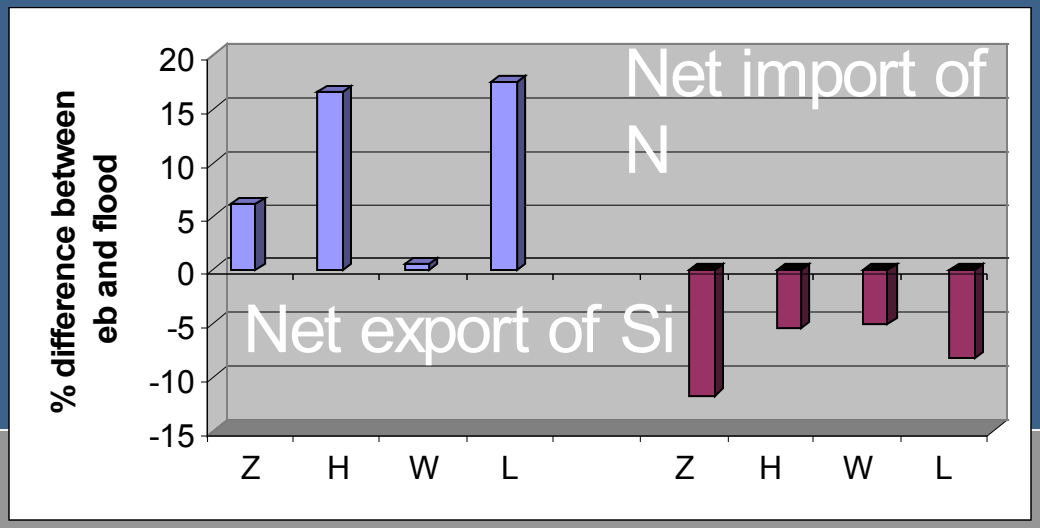
- water treatment
- regulation gas exchange with the atmosphere
- climate regulation

Conclusion 1

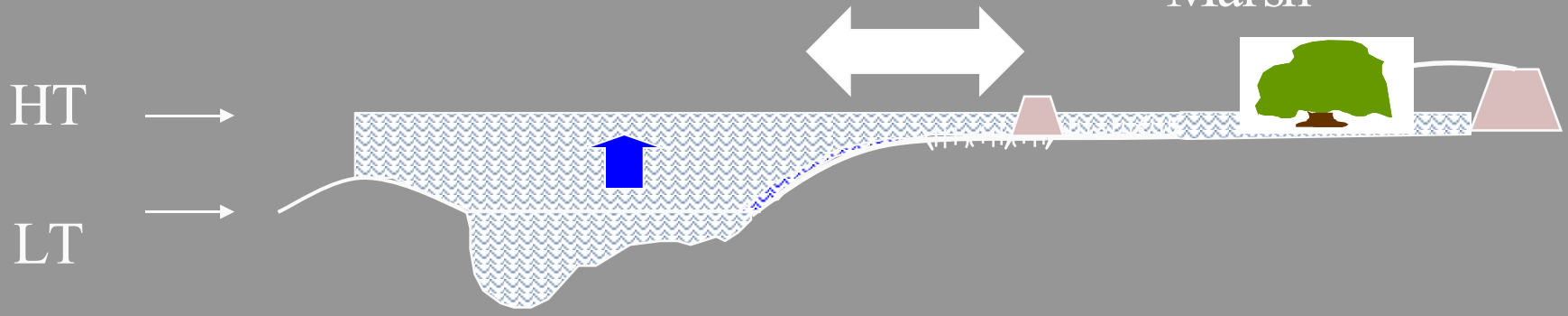
- Major changes occurred in the river system over the last decades, centuries
- These affected to a very large extend the ecosystem services of these habitats which has a negative impact on both biodiversity and human activities

Quantification of services

Role of marshes



Marsh



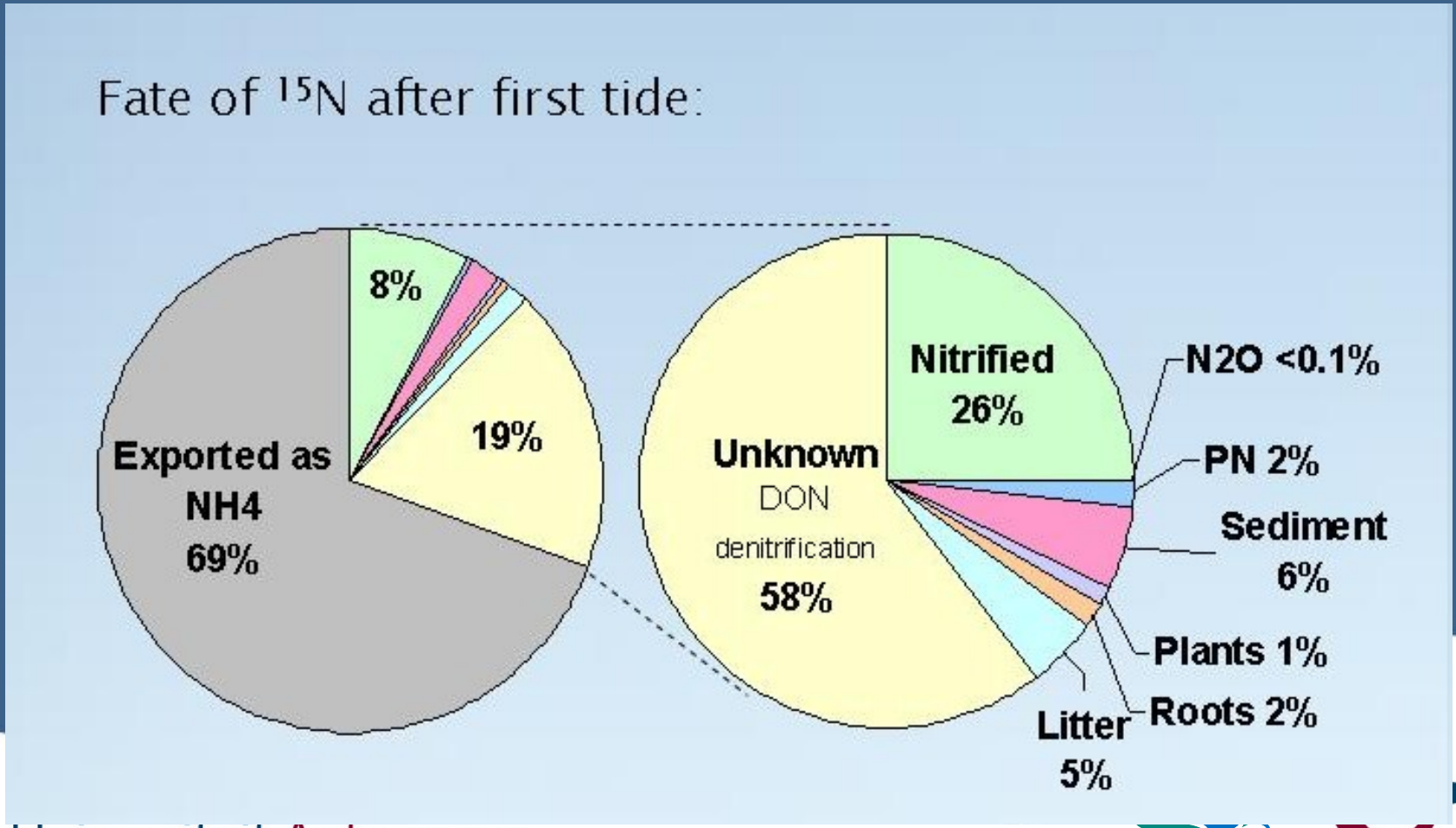
Marshes and nitrogen

Labeling – experiments: stable isotope ^{15}N

→ **Small amount added to floodwater**

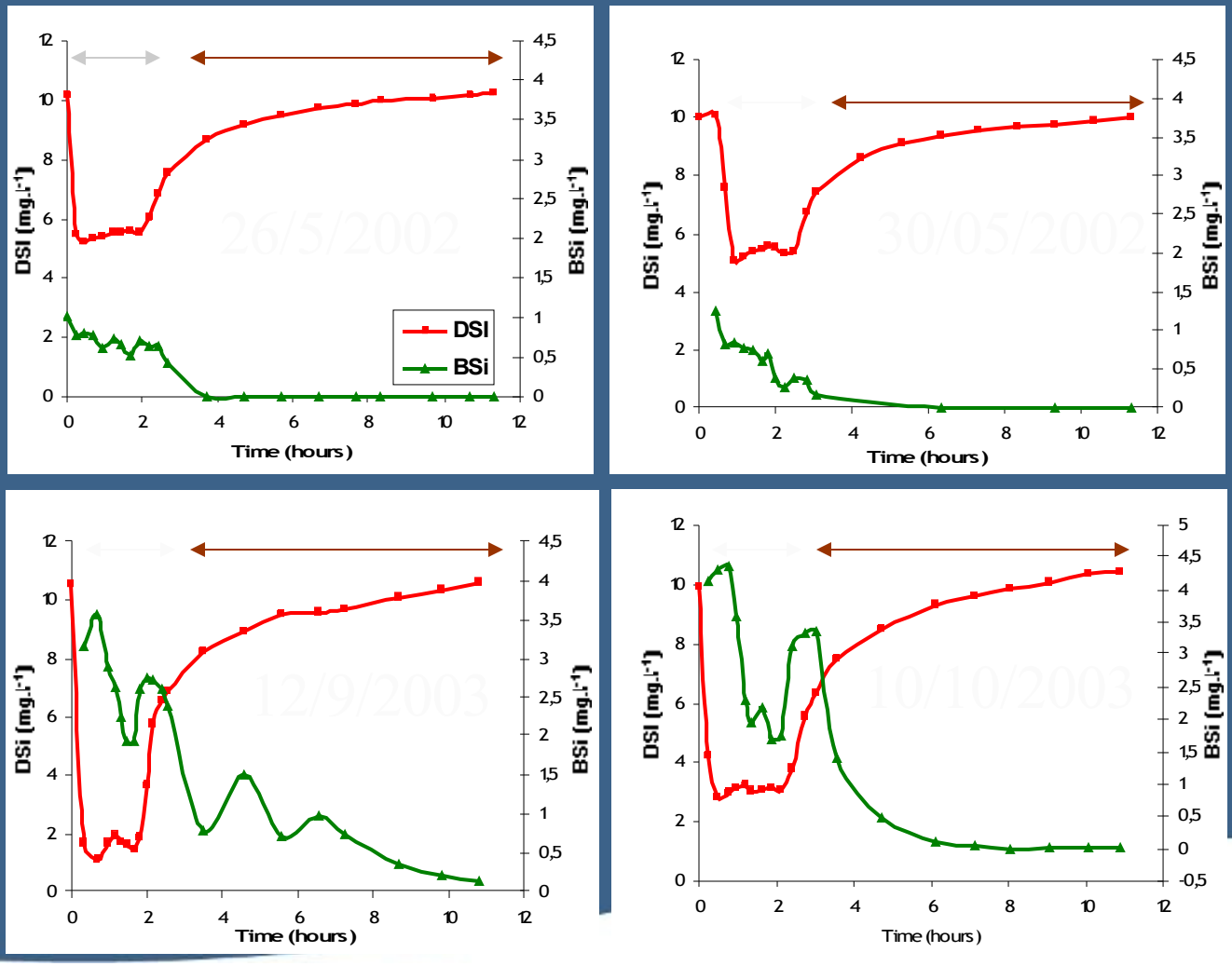
→ **Tracing of uptake and transformation**

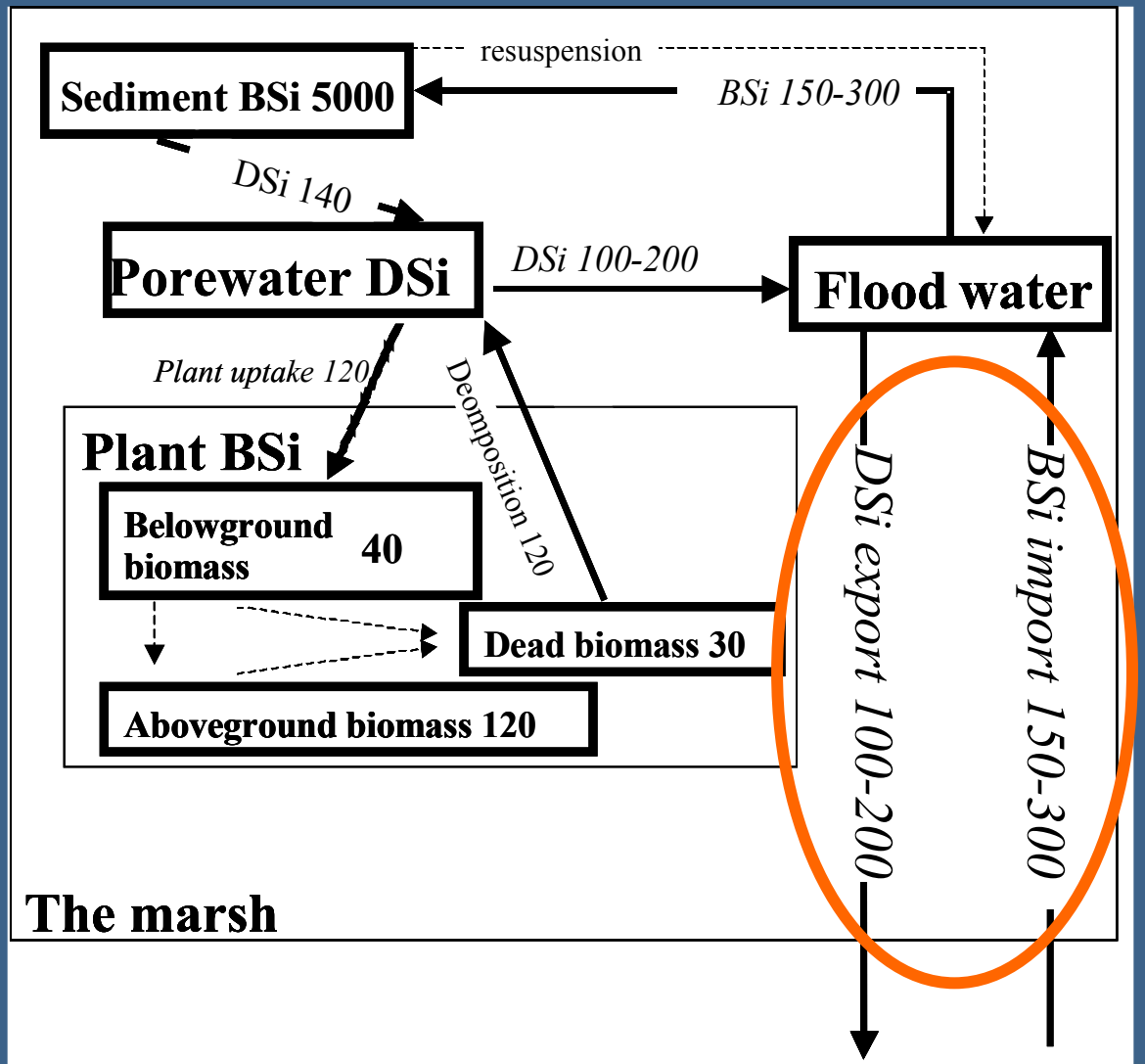
Intense N processing and storage

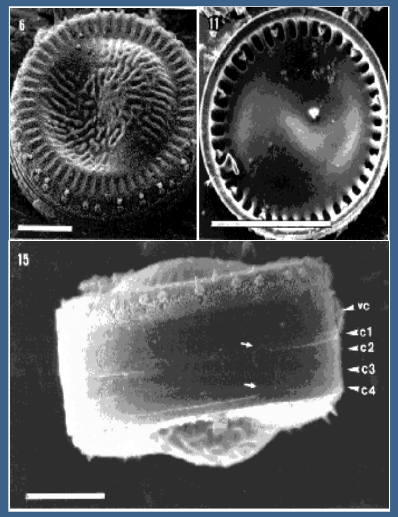


- Based on a whole ecosystem labeling experiment (N^{15}) we were able to show that about 15% of DIN is retained in the tidal marshes each tide!

Tidal concentration patterns







Estuarine channel/mud flat Si cycle

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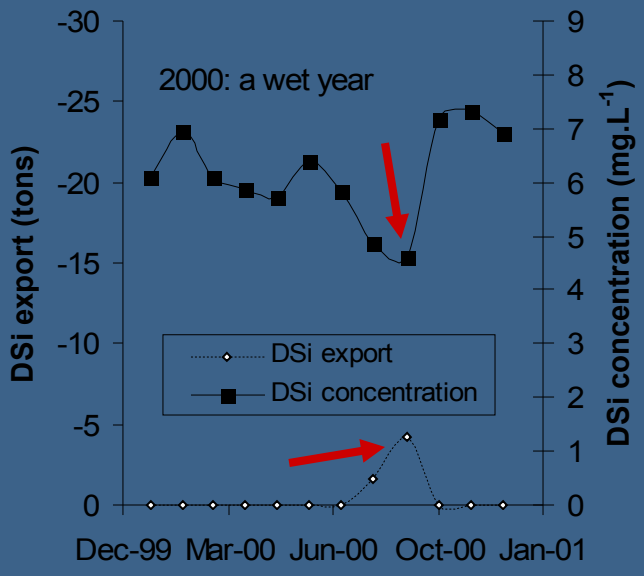
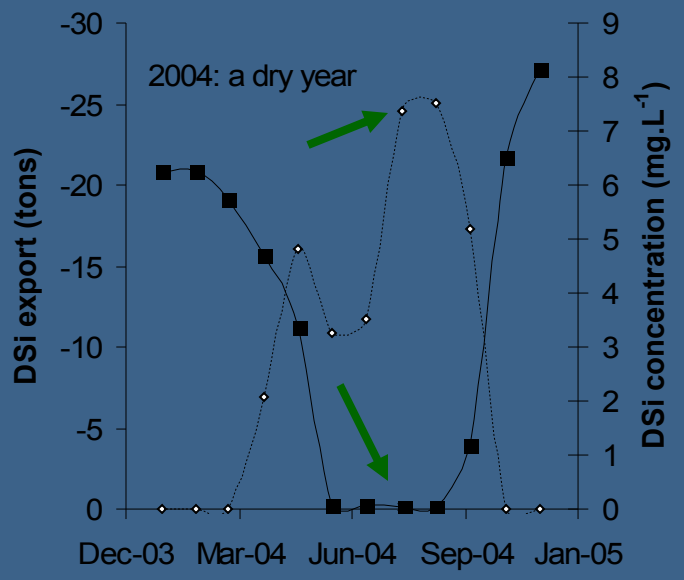
Does marsh DSi recycling matter?

Export in the freshwater zone of the estuary





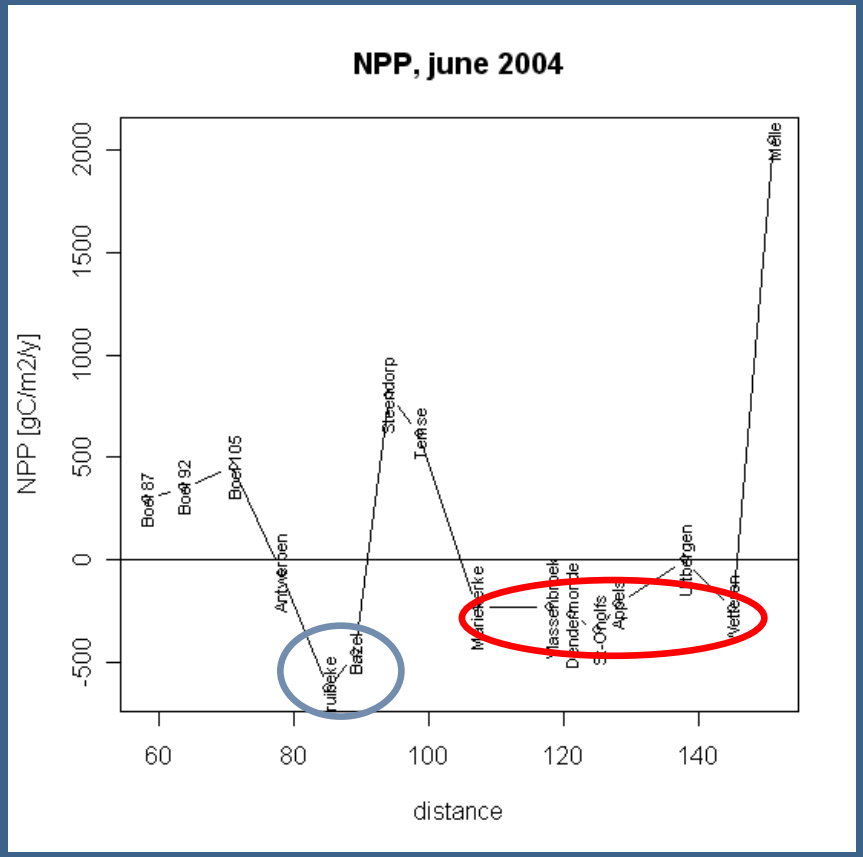
In a wet year, DSi concentrations are high, export is low

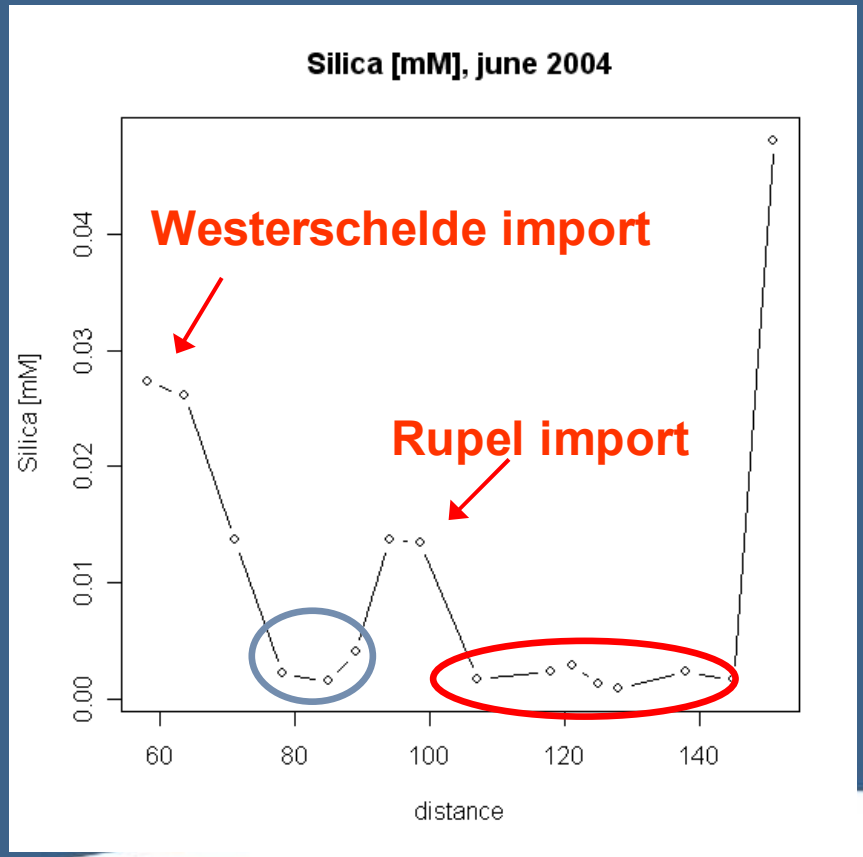
In a dry year, DSi concentrations depleted, export is much higher

Does marsh Si recycling matter?

- In summer months, Si **discharges can drop to 280 ton DSi/month**, while **marsh recycling can rise to 120 ton DSi/month = 43 % from marsh recycling**
- **In summer months, marshes are essential DSi suppliers to estuarine ecosystem**

Silica importance





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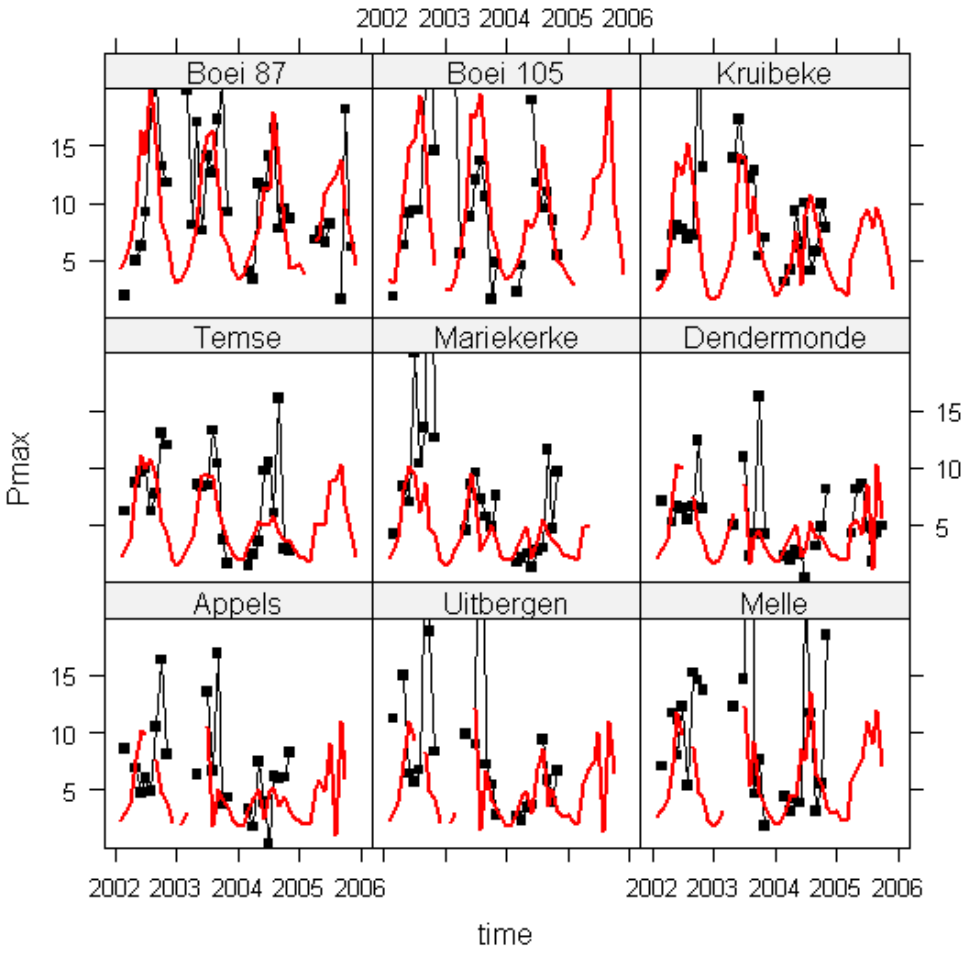
Modeling services



Conclusion 2

- Quantification of services and modeling the ecosystem characteristics is crucial to improve our understanding

Can we use ecosystem services as a basis for ecolological restoration or ecosystem management?

Zone of estuary

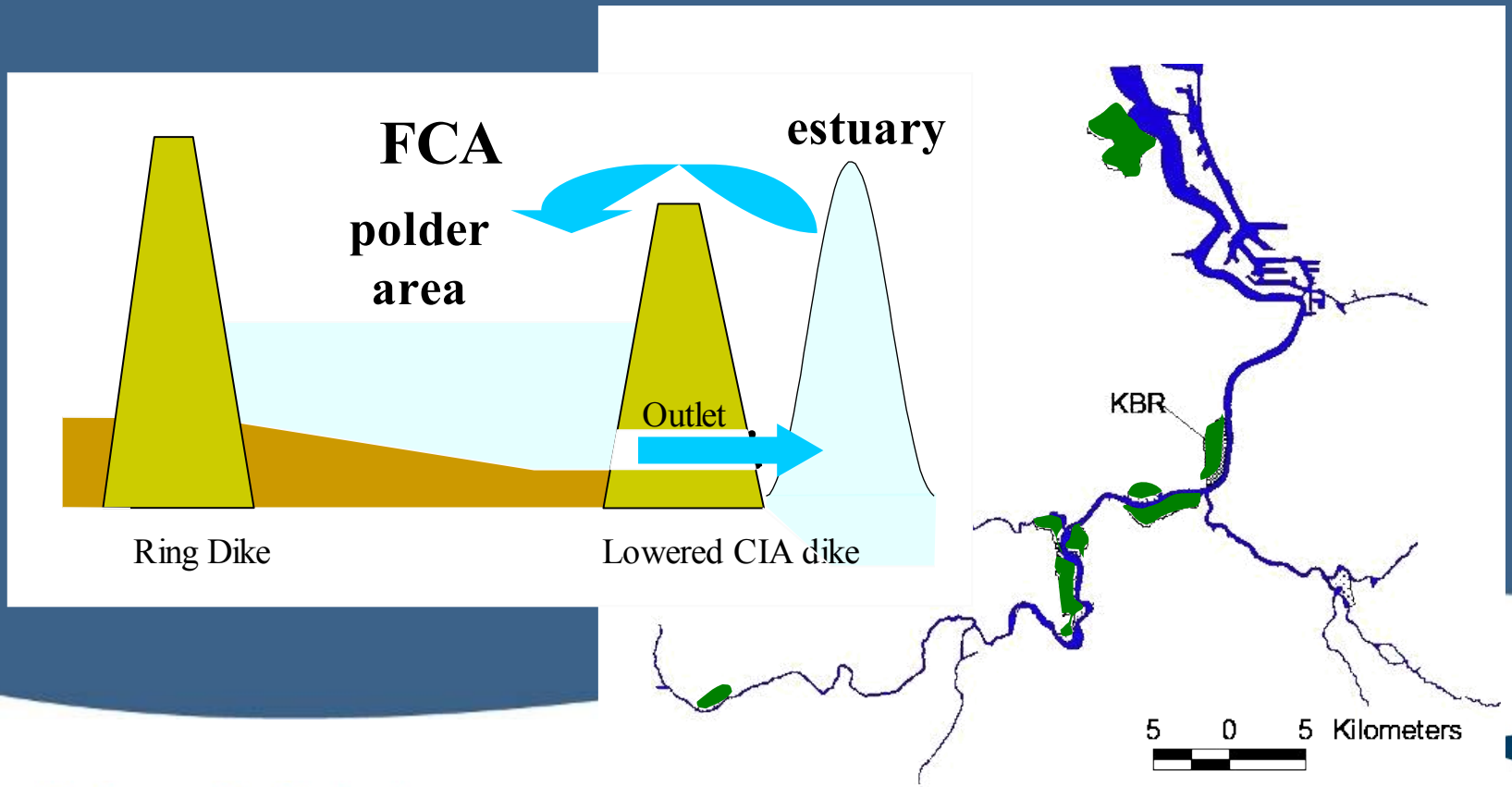
Services doelstelling	01 VlRaa	02 VlHan	03 HanGr	04 GrBur	05 BurTm	06 TmDem	07 DemGt	08 Durme	09 ZeDNe	10 strSc
maximaliseren buffer bovenstroomse afvoer	0	0	0	0	+	+	++	++	++	++
maximaliseren tidale energiedissipatie	+	++	++	++	++	+	+	+	+	0
uitbreiden meergeulenstelsel	0	++	++	0	0	0	0	0	0	0
optimaliseren natuurlijk habitatprocessen	++	++	++	++	++	++	++	++	++	0
minimaliseren turbiditeit	0	+	+	++	++	++	+	++	+	0
optimaliseren koolstofhuishouding	0	0	0	0	0	0	0	0	0	++
optimaliseren stikstofhuishouding	0	0	+	+	+	++	++	++	++	++
optimaliseren zuurstofhuishouding	0	0	0	+	++	++	+	++	+	++
optimaliseren fosforhuishouding	0	0	0	0	0	0	+	+	+	++
optimaliseren siliciumhuishouding	+					++	++	++		0
optimaliseren primaire productie	0	+	+	++	++	++	+	++	+	0
optimaliseren condities voor zoöplankton	0	+	+	+	++	++	++	++	++	0
optimaliseren condities voor benthos	+	++	++	++	++	++	++	++	++	0
optimaliseren vismigratie	0	+	+	+	+	+	++	++	++	++
uitbreiden areaal ondiep laagdynamisch water	+	++	++	++	++	++	++	++	++	0
uitbreiden areaal slik	+	++	++	++	++	++	++	++	++	0
verlagen dynamiek slik	0	++	++	0	0	0	0	0	0	0
uitbreiden areaal schor	+	++	+	+	++	+	++	+	++	0
verjongen schor	+	++	++	++	++	++	++	0	0	0
uitbreiden areaal wetland	0	0	0	+	+	+	++	+	++	0

How to quantify measures?

- Quantify ecosystem goods and services which we want to obtain from the system, e.g. maximum load of nutrients allowed towards North Sea, flood volume etc.

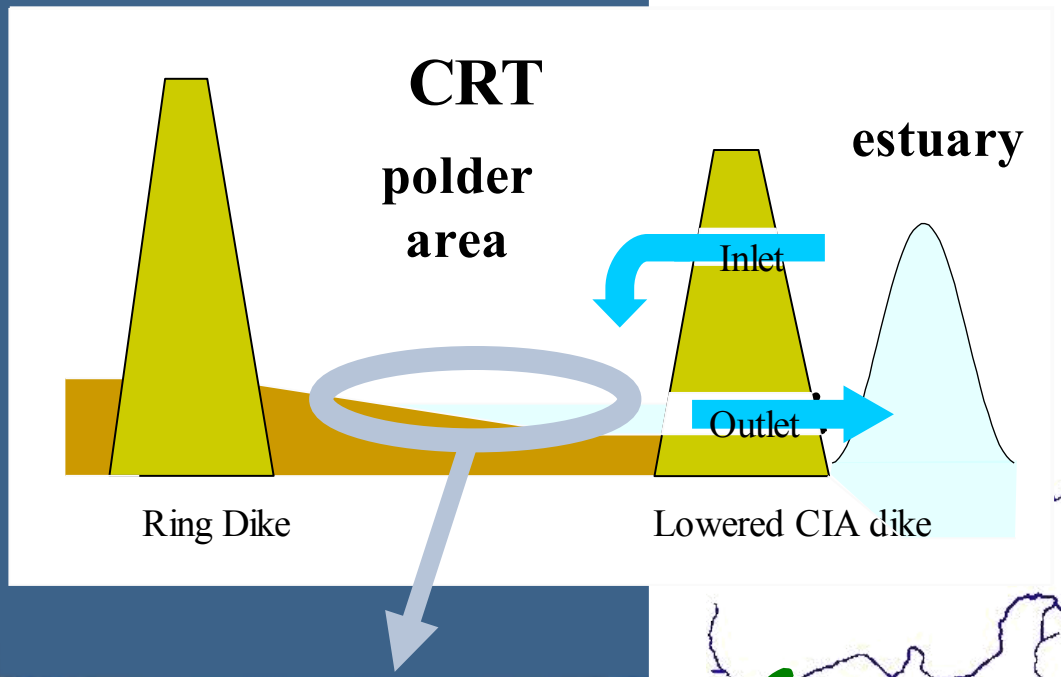
- Translate goals for different functions in area of needed habitat, its spatial distribution, or other measures, based on modelling

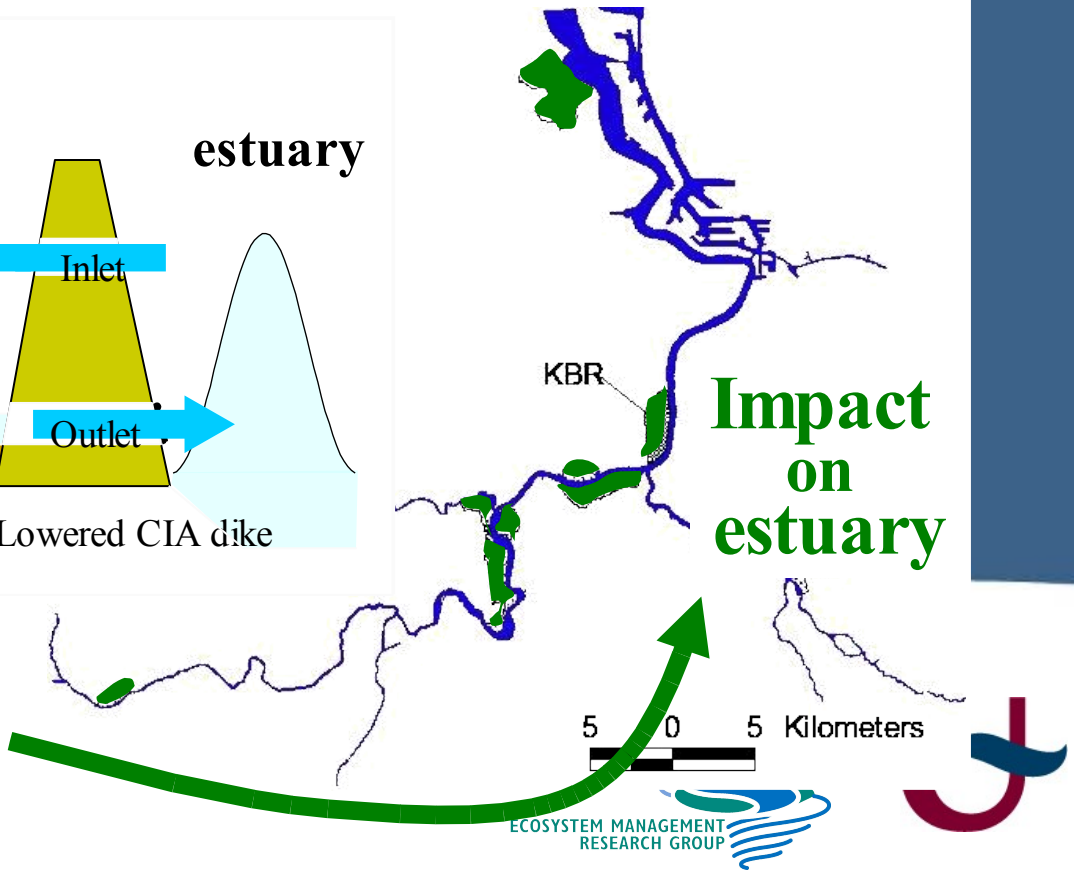
Flood Control Areas (FCA)
Controlled Reduced Tide (CRT)



- Based on optimization (minimizing the damage of flooding)
- 1800 ha of flood control area needed

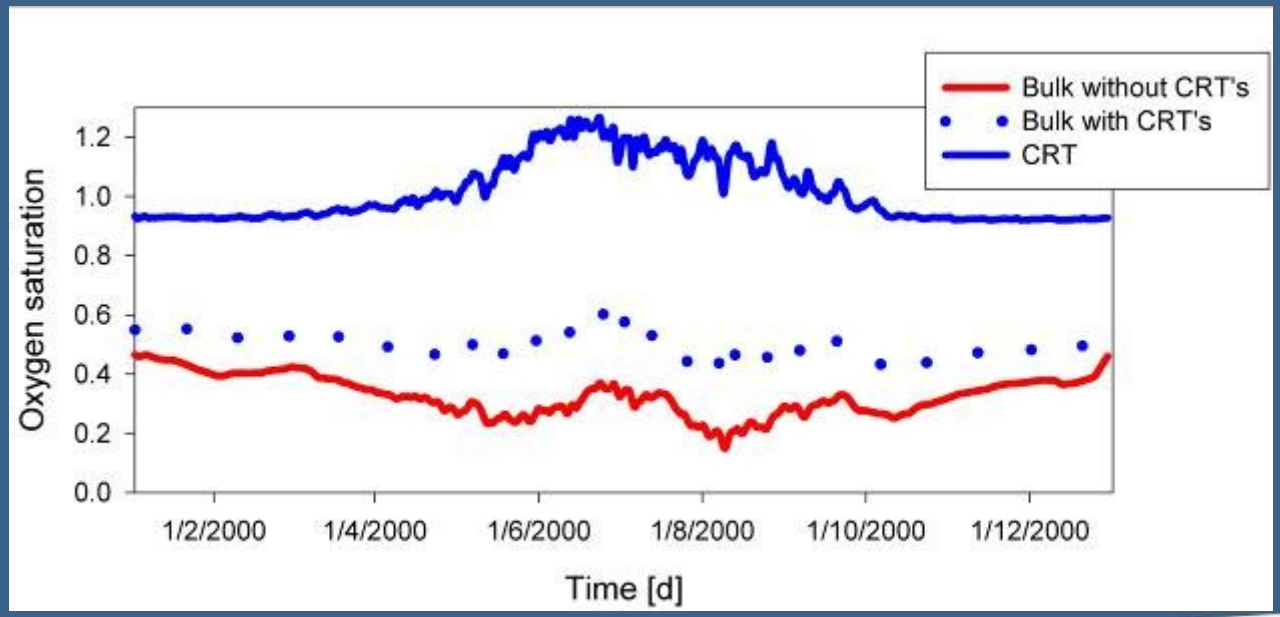
Flood Control Areas (FCA)
Controlled Reduced Tide (CRT)





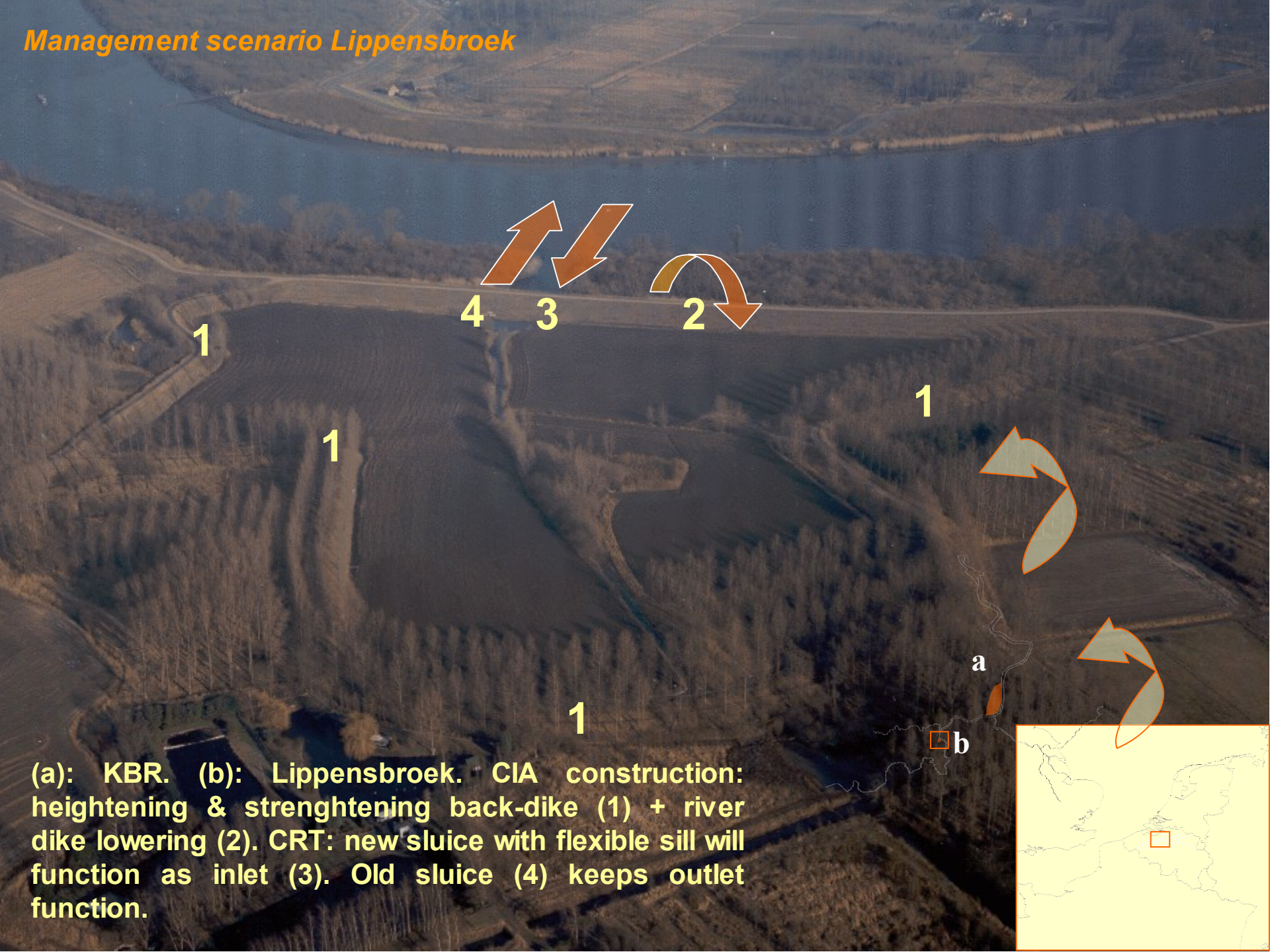
Results

Oxygen Saturation



averaged oxygen saturation (data 2000) in compartment 15

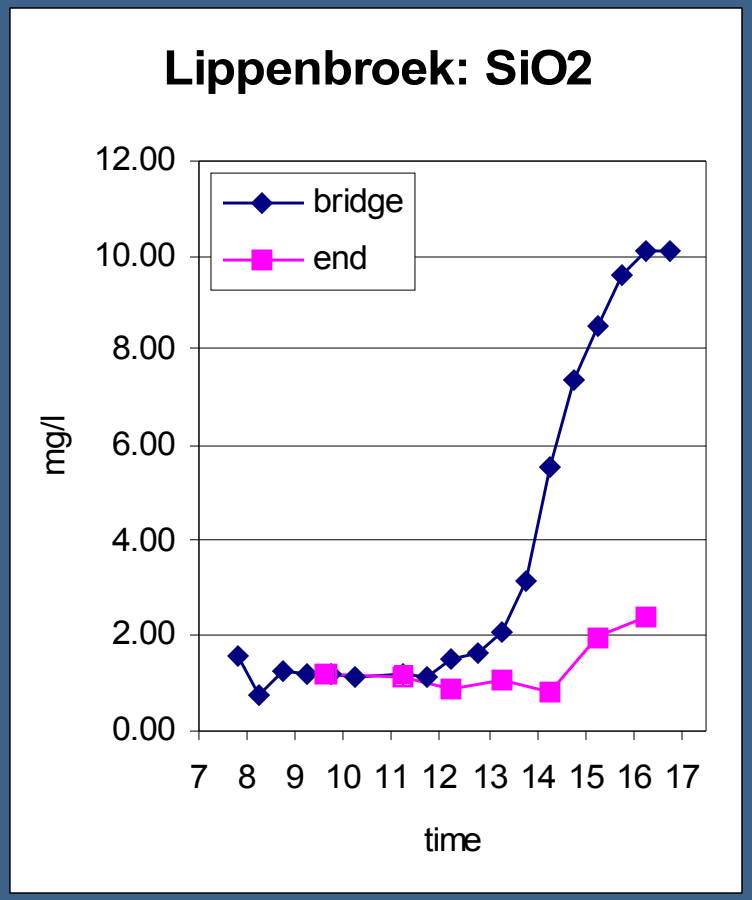
Management scenario Lippensbroek

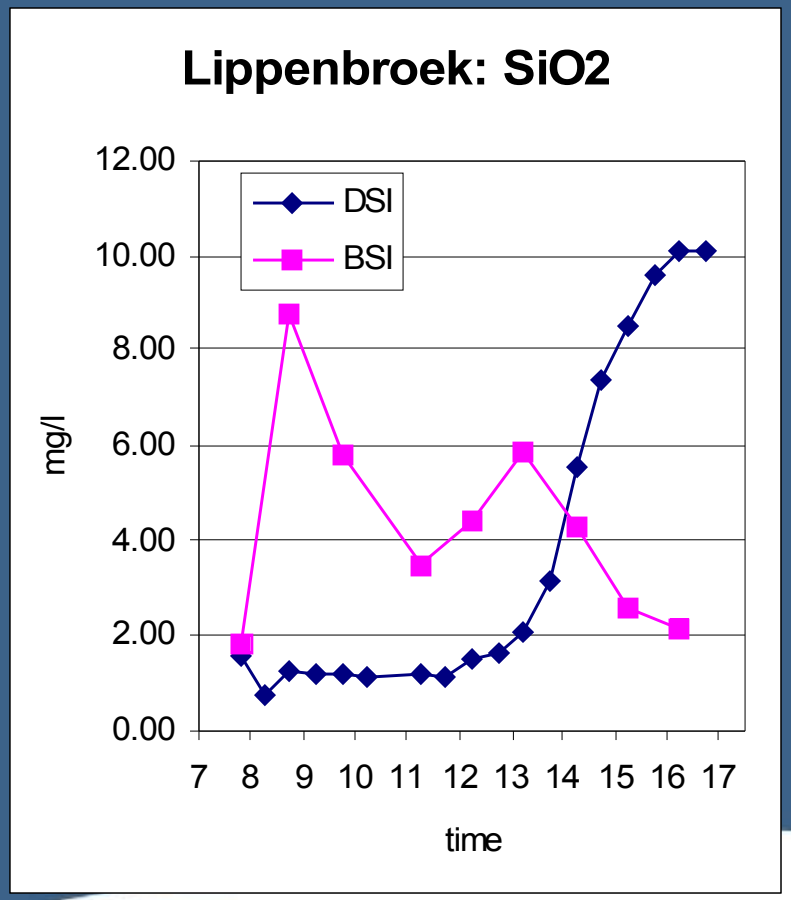


(a): KBR. (b): Lippensbroek. CIA construction: heightening & strenghtening back-dike (1) + river dike lowering (2). CRT: new sluice with flexible sill will function as inlet (3). Old sluice (4) keeps outlet function.

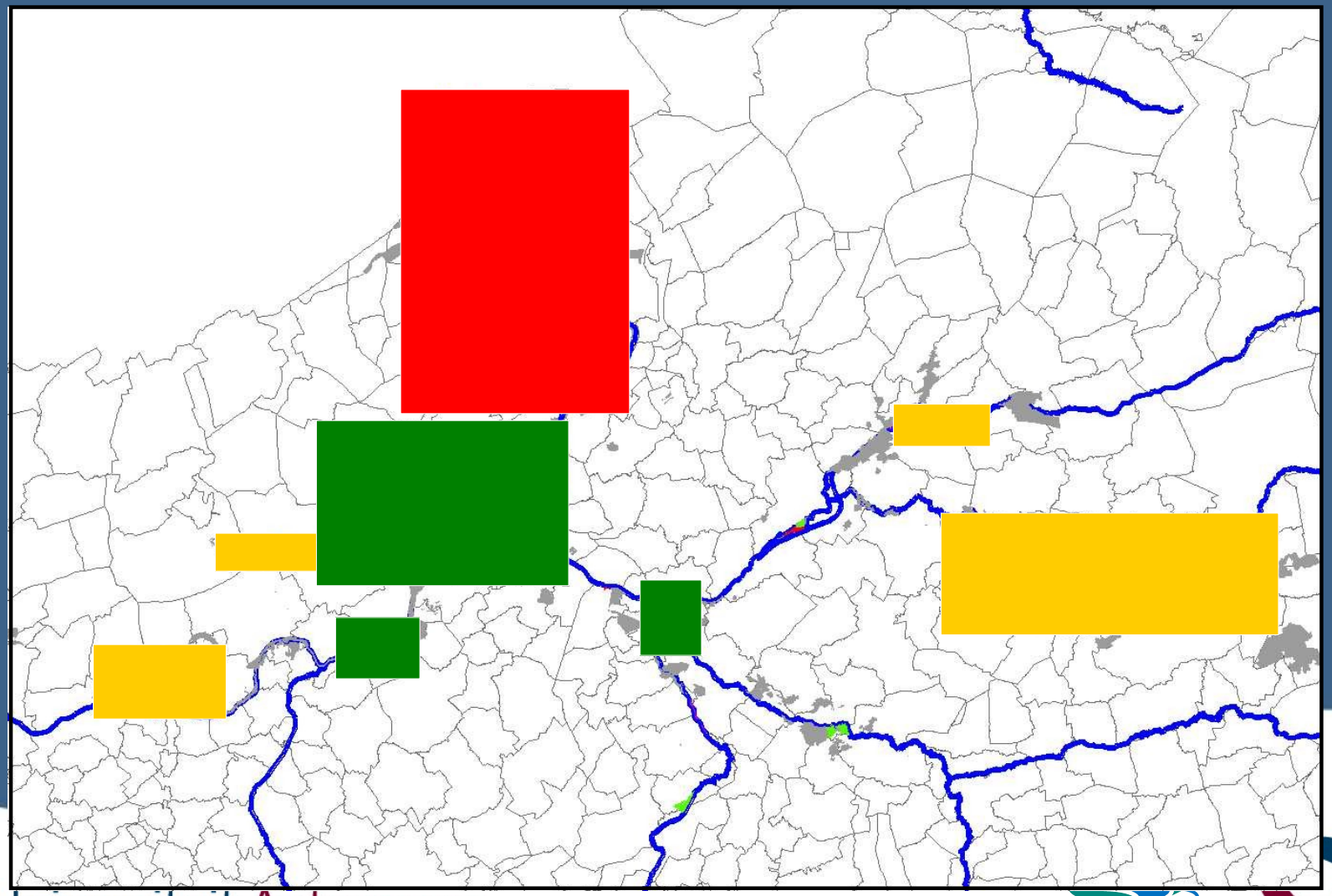
Modelling FCA-CRT

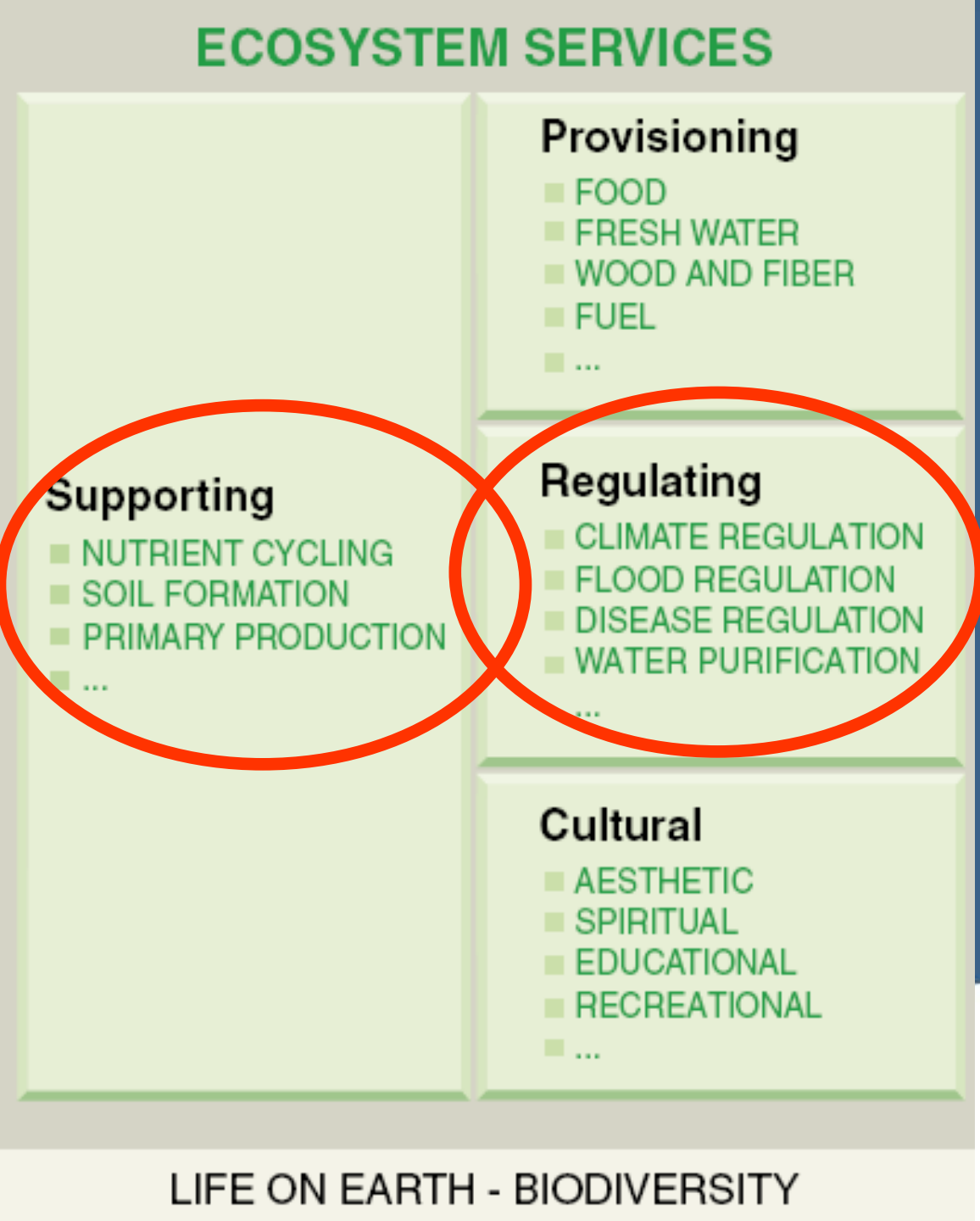
Pionneer controlled inundation with reduced tide


Lippenbroek: SiO2
12.00
10.00
8.00
6.00
4.00
2.00
0.00
mg/l
bridge
end
7 8 9 10 11 12 13 14 15 16 17
time


Lippenbroek: SiO2
12.00
10.00
8.00
6.00
4.00
2.00
0.00
mg/l
DSI
BSI
7 8 9 10 11 12 13 14 15 16 17
time

- Flemish government decided to restore about 4000 ha of wetlands to restore ES





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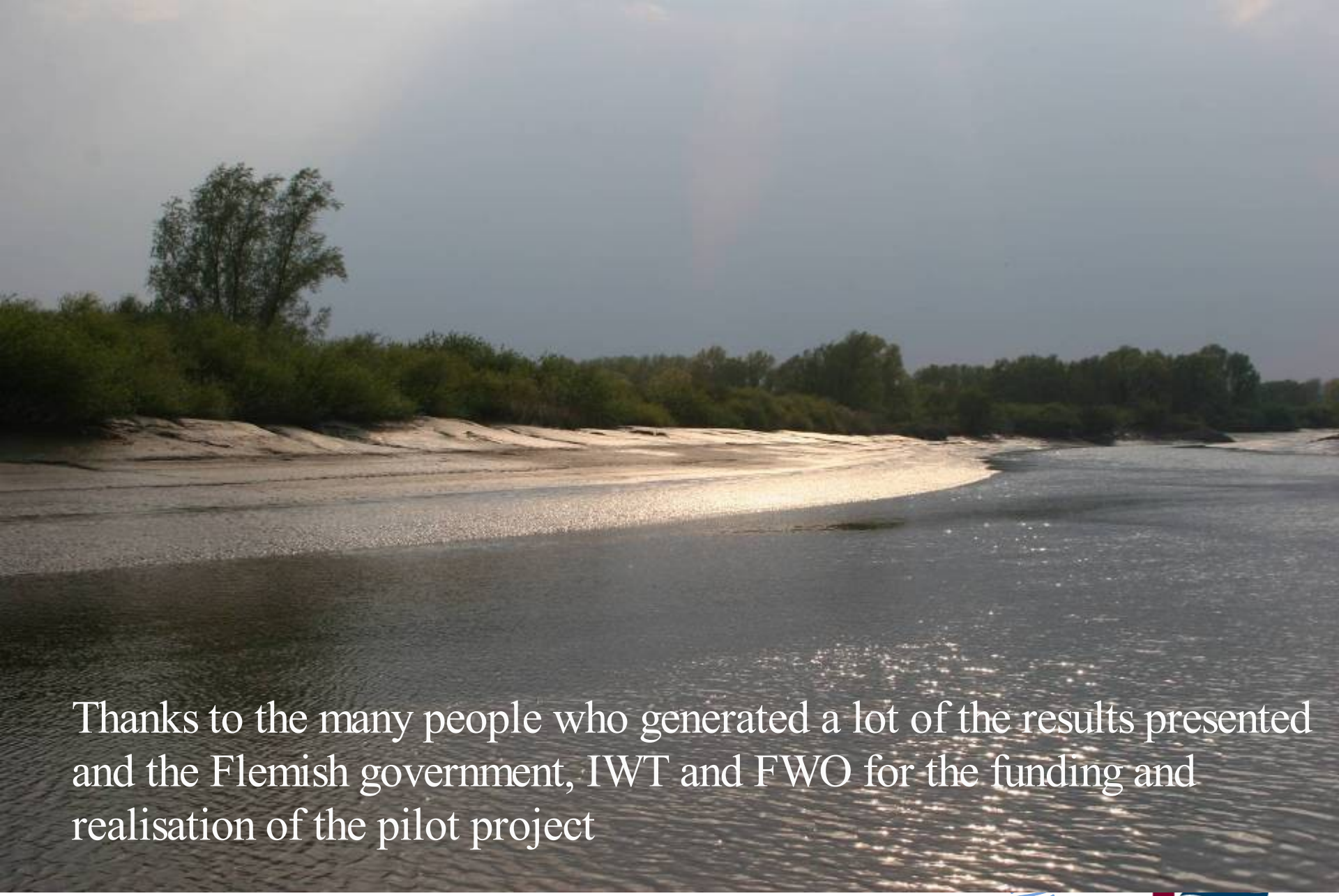
Conclusions

- Optimalisation of ecosystem goods and services is an important possibility for ecological restoration
- In the Schelde, it proved even to be the key factor in the decision making
- Much more work is needed however to identify and quantify ecosystem services
- Also a better understanding between functional and structural biodiversity is crucial

Conclusions

- Better quantification of losses and desired levels of ecosystem services is needed
- Modeling ecosystem services is crucial to be able to work restoration plans, especially as the area needed has to be estimated as accurate as possible
- Field experiments are essential to increase our understanding
- MEA can be seen as milestone and applying the approach to a more regional level would be very important
- An ecosystem approach is essential to restore services as the abiotic conditions changed so profoundly that small scale nature conservation will not be able to stop biodiversity loss



Thanks to the many people who generated a lot of the results presented and the Flemish government, IWT and FWO for the funding and realisation of the pilot project

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That’s all folks
Let discuss it