GROUNDWATER dependent VEGETATION and INTERACTIONS with stream hydro-morphological PROCESSES

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THIS TALK FOCUS ON HOW TO PROTECT AND IMPROVE PLANT diversityin RIPARIAN AREAS

- The Convention on Biological Diversity: include measures and incentives for the conservation and sustainable use of biological diversity
- Habitats Directive: aims to protect some 220 habitats and approximately 1,000 species listed in the directive's Annexes
- Water Framework Directive: protect and enhance the quality of surface freshwater (including lakes, streams and rivers), groundwaters and groundwater dependant ecosystems e.g. fens and meadows

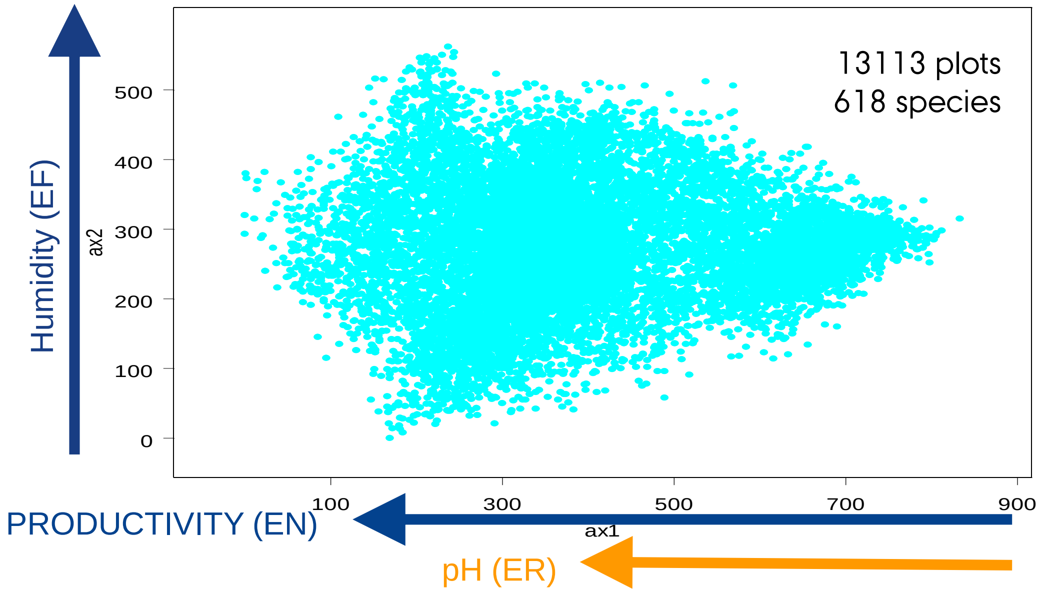
OVERVIEW of my talk

- Characterization of groundwater-dependent vegetation – predictive model development
- Groundwater dependent-vegetation in Danish riparian areas
- Stream hydro-morphological characteristics and how it affects groundwater-dependent vegetation
- Modelling groundwater-dependent vegetation from catchment characteristics

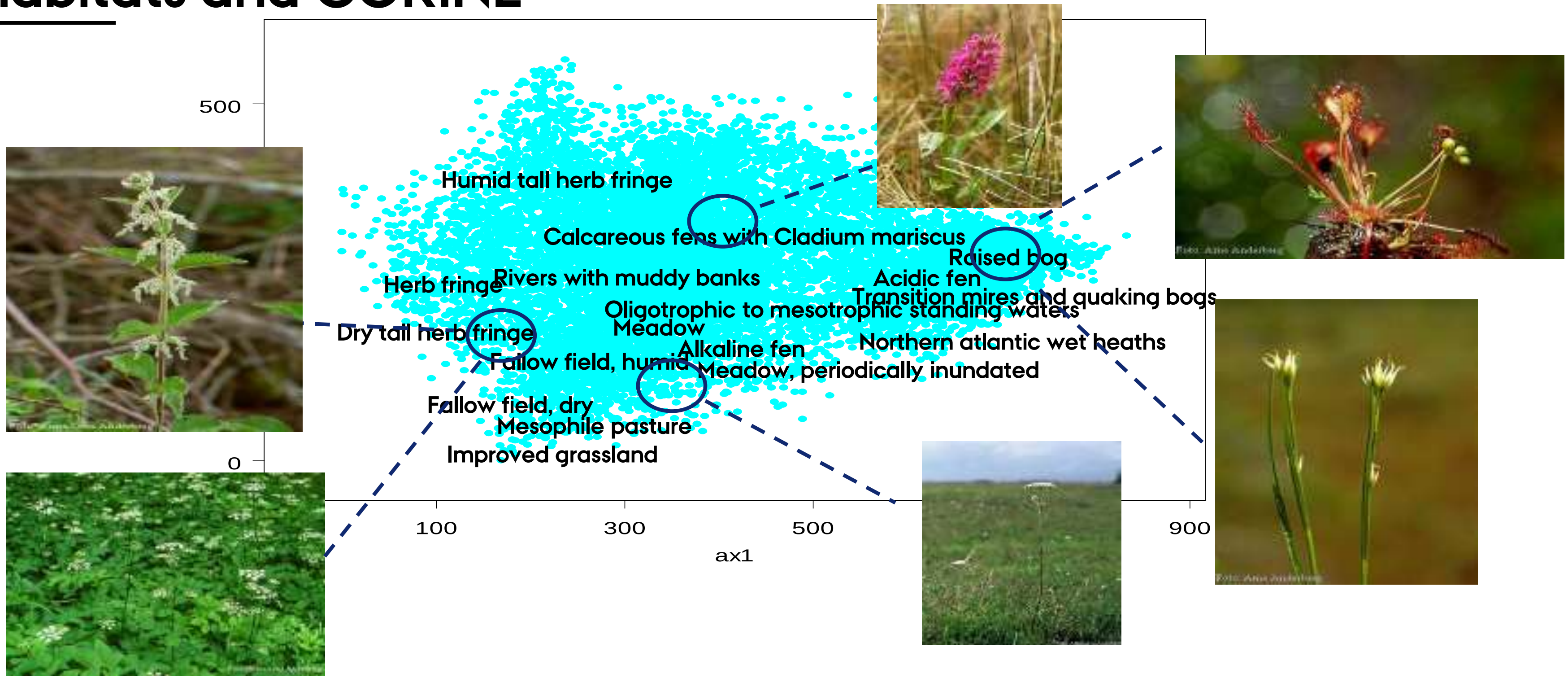
HOW TO achieve a standardized interpretation of the vegetation that is IN ACCORDANCE with the legislation?



A GRADIENT ANALYSIS was conducted on all available data from Danish wetlands

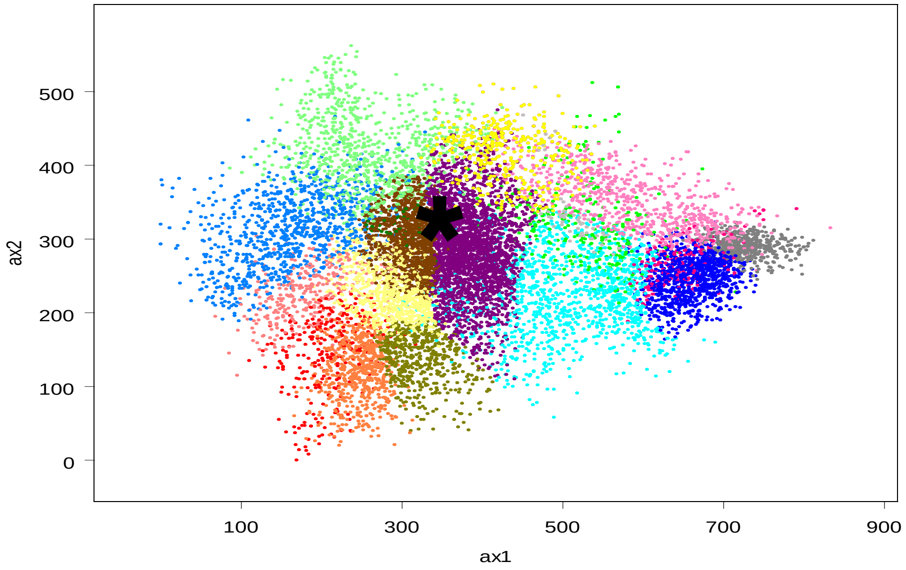


THE VEGETATION was then CLASSIFIED into 18 distinct types applying the INTERPRETATION MANUAL of european union habitats and CORINE



A SUPERVISED CLASSIFICATION was developed that can predict HABITAT TYPES from SPECIES lists in a standardized way and in accordance with the HABITATS DIRECTIVE

Cirsium palustre (marsh thistle)
Holcus lanatus (common velvetgrass)
Carex nigra (black sedge grass)
Festuca rubra (red fescue)
Juncus effusus (common rush)
Galium palustre (marsh-bedstraw)
Juncus articulatus (jointleaf rush)
Rumex acetosa (common sorrel)
Lotus pedunculatus (big trefoil)
Agrostis stolonifera (creeping bentgrass)
Poa pratensis (kentucky bluegrass)
Mentha aquatica (water mint)
Ranunculus bidens
Filipendula ulmaria (meadow sweet)
Lychnis flos-cuculi (ragged robin)
Ranunculus repens (creeping buttercup)



Model prediction

64 % - rich fen (7230)
29 % - meadow
4 % - fallow field, humid
2 % - meadow, periodically inundated (6410)
2 % - rivers with muddy banks (3270)

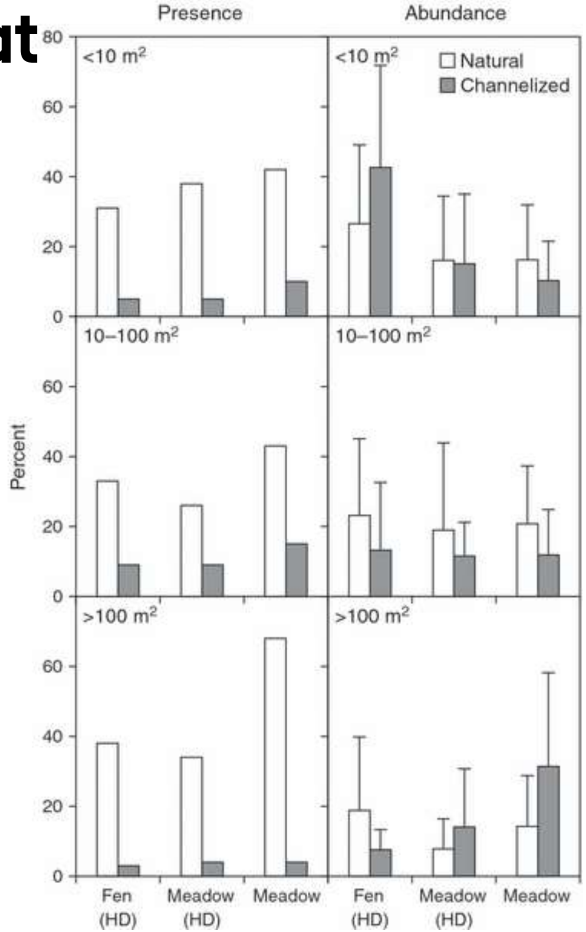
GROUNDWATER dependent vegetation in riparian areas in Denmark

The vegetation in riparian areas in Denmark is dominated by common plant communites with relative low conservation interest

Type	Coverage (percent of total area)
Improved grassland	17.36
Dry tall herb fringes	16.40
Meadow	12.16
Fallow fields, humid	10.59
Fallow fields, dry	10.15
Humid tall herb fringes* (HD 6430)	9.12
Mesophile pastures	8.87
Alkaline fens* (HD7230)	8.32
Reed beds	3.05
Meadow, periodically inundated* HD6410)	2.80
Rivers with muddy banks* (HD3270)	0.83
Northern Atlantic wet heaths* (HD 4010)	0.15
Transition mires and quaking bogs* (HD 7140)	0.05
Calcareous fens* (HD 7210)	0.13
Acidic fen	0.03

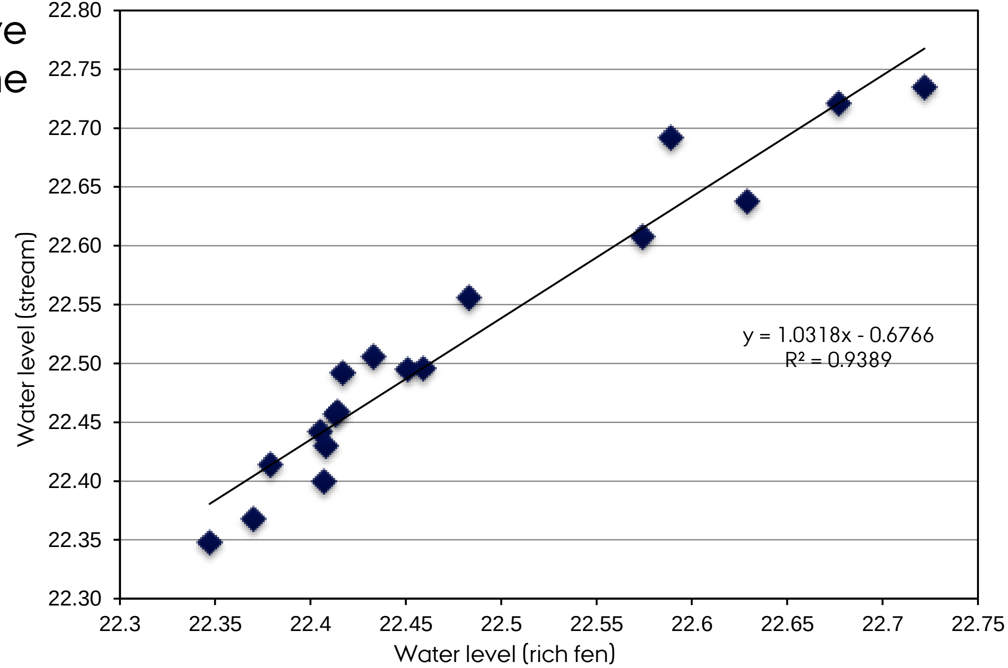
STREAM HYDRO-MORPHOLOGICAL characteristics and how it affects groundwater-dependent vegetation

GROUNDWATER-DEPENDENT habitat types are mainly occuring along NATURAL STREAMS



This likely reflects HIGHER GROUNDWATER tables along NATURAL STRAMS

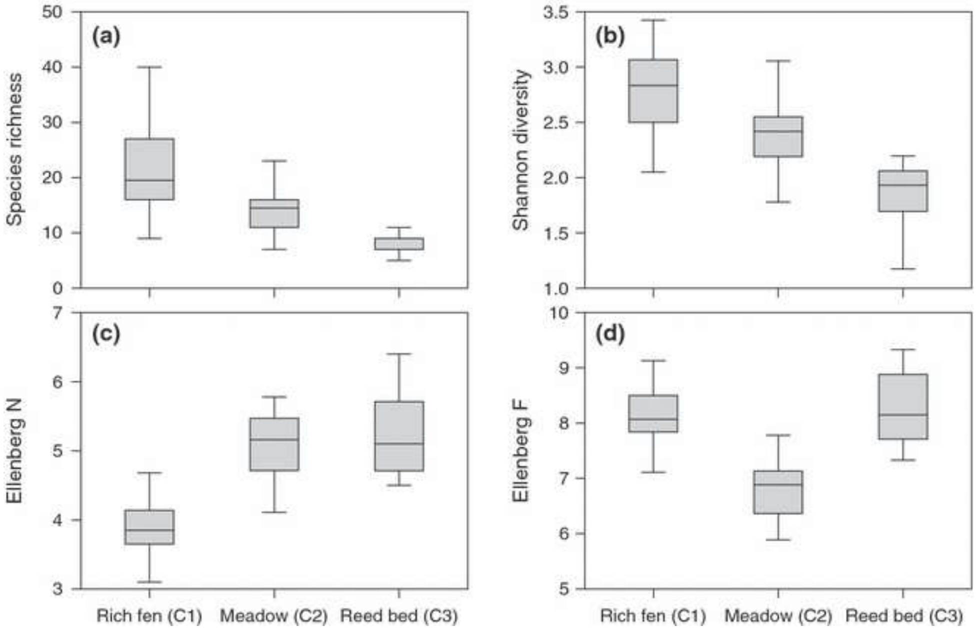
- In areas with a sandy geoglogy, we find close associations between the water level in the stream and the water level in the adjacent areas with groundwater-dependent habitats

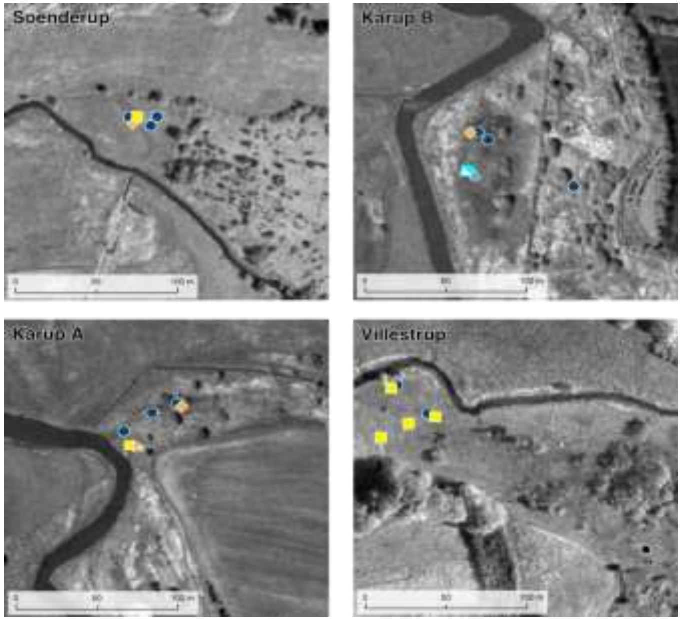


But the HYDRAULIC CONDUCTIVITY plays an IMPORTANT ROLE for the relationship

Afstandsklasse	0-10 m	10-20 m	20-50 m	>50 m
Binderup	0,23 – 0,81	0,04 – 0,71	0,004 – 0,44	-
Gudenå	0,71 – 0,94	0,76 – 0,89	0,67 – 0,89	-
Karup 2	0,16 – 0,84	0,29 – 0,55	0,34 – 0,63	-
Karup 2B	-	-	0,02-0,75	0,23 – 0,66
Karup 3	-	$2{,}2*10^{-6}$ - 0,169	0,0005 – 0,076	-
Karup 4	0,22 – 0,99	0,39 – 0,92	0,17 – 0,80	-
Simested	-	0,006 – 0,25	$9{,}4*10^{-5}$ – 0,43	-
Sønderup	-	-	$3{,}7*10^{-5}$ – 0,23	-
Villestrup 1	0,25 – 0,69	0,04 – 0,44	0,03 – 0,198	-
Villestrup 3	-	0,001 - 0,64	0,03 – 0,78	0,31 – 0,75

But what about FLOODING – can the vegetation TOLERATE FLOODING with stream water ?



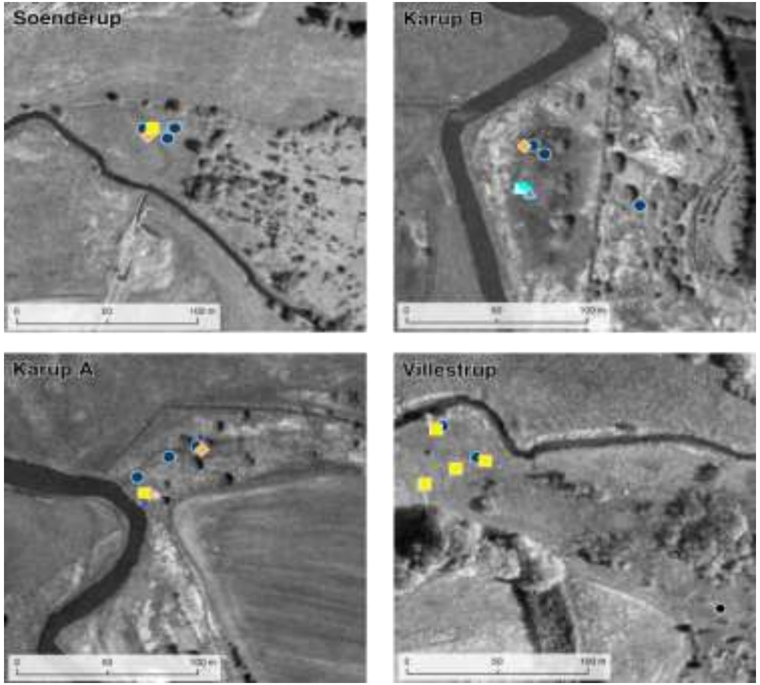


Yellow: Meadow; Blue: Rich fen; Orange: Reed bed; Light blue: Poor fen

Both RICH FENs, MEADOWS and REED BEDS are all flooded regularly

- The various groundwater-dependent habitat types are not distributed systematically in the stream valley
- All groundwater-dependent habitat types are occasionally flooded, both fens, meadows and reed beds

	Rich fen (n=49)	Meadow (n=19)	Reed bed (n=7)
Flooding frequency (year^{-1} 1989-2010)	1.5 (0-5.1)	0.7 (0-4.5)	2.5(0-4.7)
Flooding duration (days year^{-1} 1989-2010)	5.5 (0-27.7)	2.3 (0-23.3)	9.4 (0-23.6)



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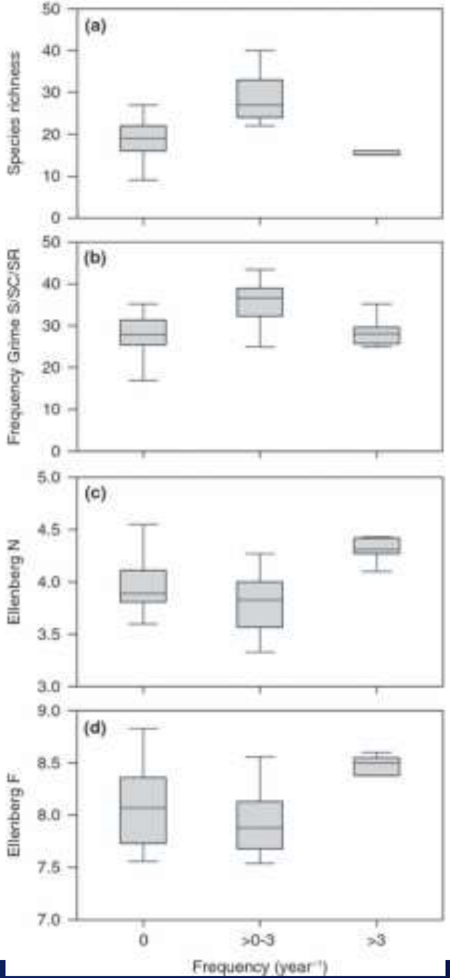
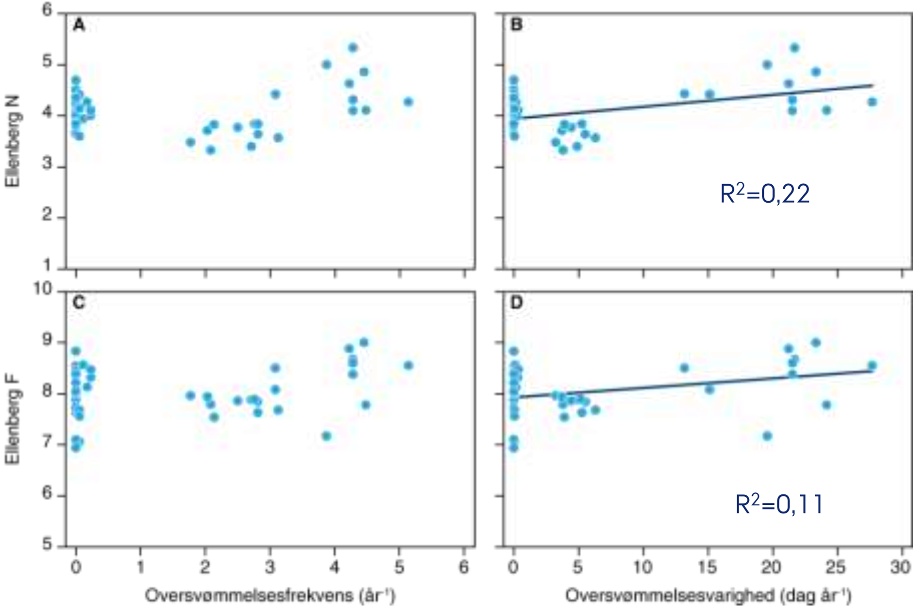
RICH FEN vegetation can benefit from FLOODING

- Species richness increases in fen areas occasionally flooded
- More stress tolerant species can be found indicating that the physical disturbance introduced with the flood water is more important than the nutrients in the water



BUT Long FLOODING DURATIONS can increase productivity within the AREAS



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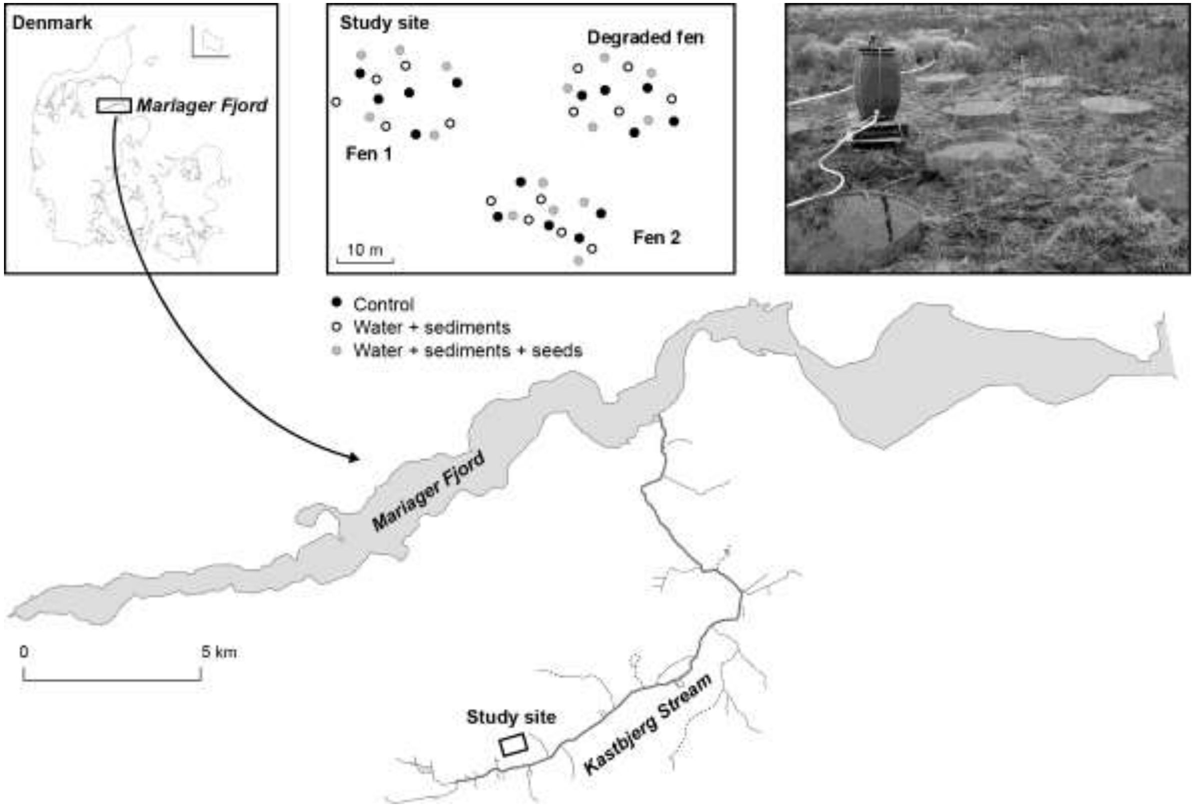
- The flooding frequency does not significantly affect WA of Ellenberg N (produktivity) and Ellenberg F (humidity)
- But both WA of Ellenberg N and Ellenberg F increase slightly with increasing duration

SEDIMENTS can be DEPOSITED under flooding particularly in agricultral catchments

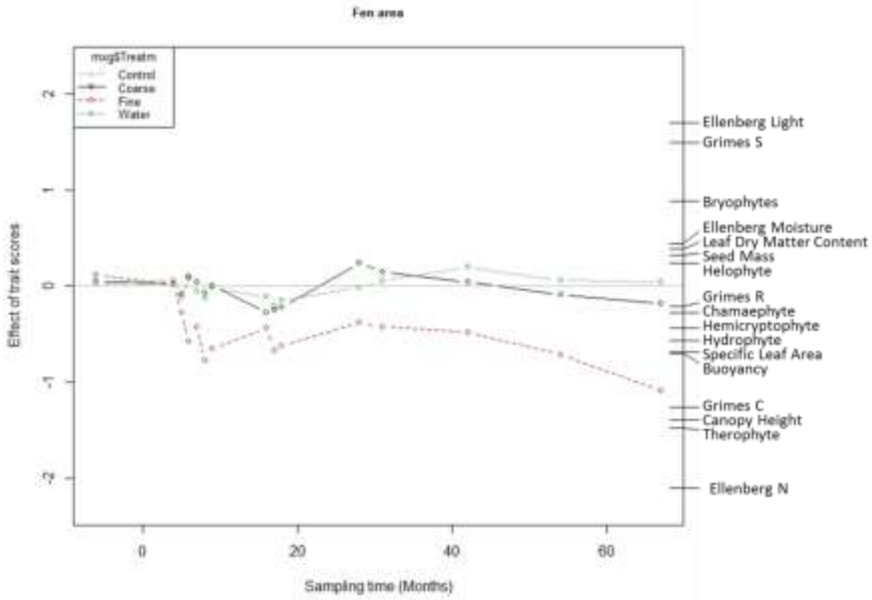
By applying a controlled approach we disentangle effects of flooding from sediment deposition

EXPERIMENTAL SETUP in kastbjerg

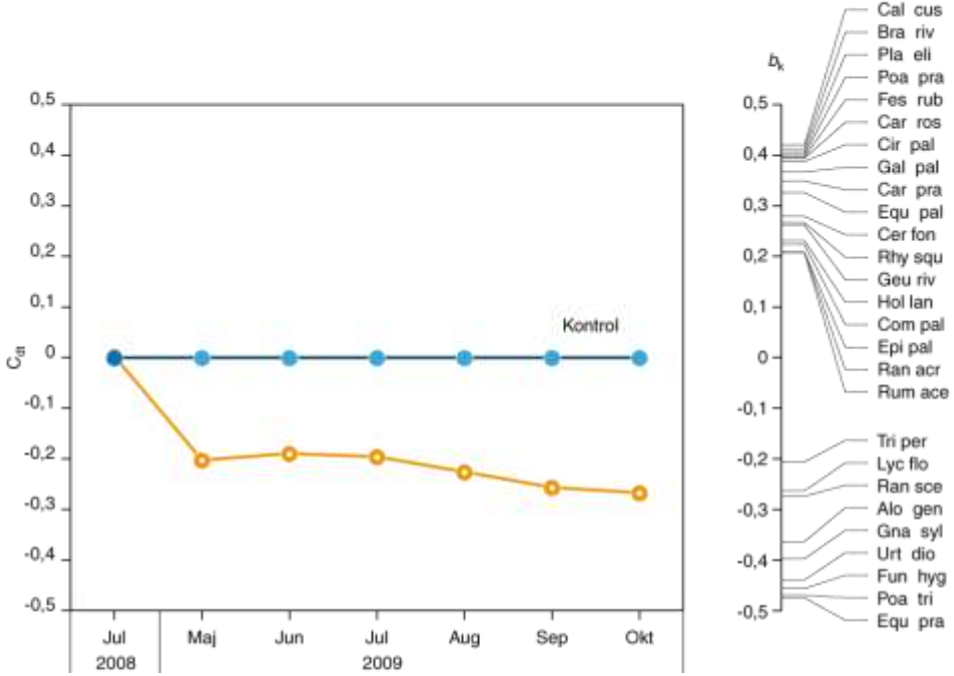


5 YEARS AFTER in the rich fen

- Fine sediment mediates an increase in the productivity of the fen community – a trend that is not seen when adding coarse sediments
- Prolonged flooding does not have long lasting effects on community characteristics.



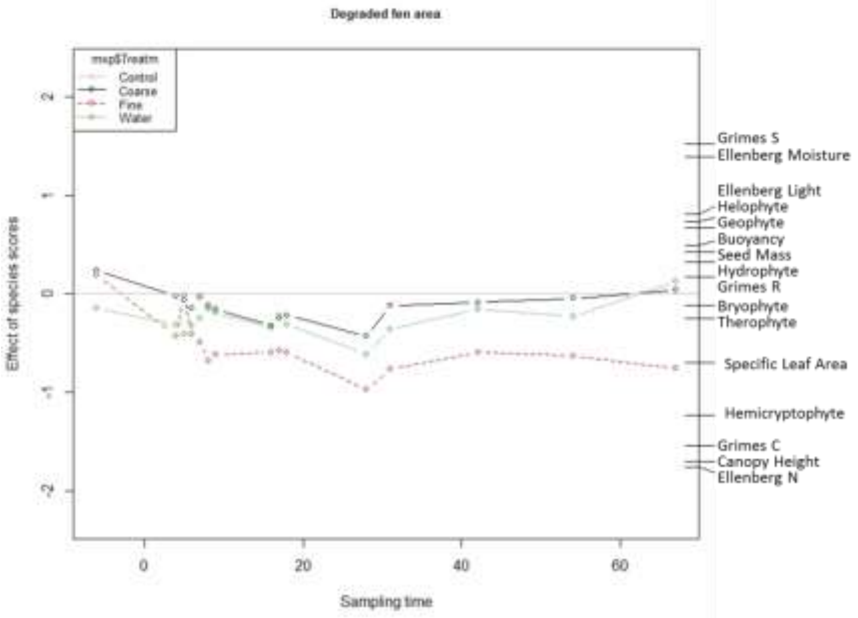
SEEDS in deposited sediment CAN AFFECT the rich fen vegetation NEGATIVELY



- New species are introduced with the sediments – these are common species at the expense of some typical fen species

5 YEARS AFTER in the degraded fen

- Fine sediment mediates an increase in the productivity of the degraded fen community as well – a trend that is not seen when adding coarse sediments
- Prolonged flooding doesn't have long lasting effects on community characteristics



RECOMMENDATIONS for conservation and restoration

- Restoration measures in streams should include considerations regarding effects on groundwater discharge in the adjacent riparian areas. Remeandring and elevation of the stream bottom does not threaten protected groundwater-dependent vegetation
- Flooding does not constitue a risk for protected groundwater-dependent vegetation if these occur naturally during winter and early spring. Summer flooding may be problematic becuse of a risk of enhanced infiltration
- Reestablishment of a natural hydrology by removing ditches and drainage pipes in riparina areas can improve conditions for protected groundwater-dependent vegetation.
- Reduced weed cutting and dredging in stream may improve groundwater discharge and thereby improve conditions for protected groundwater-dependent vegetation.
- Depostion of fine sediments to mitigate pollution of downstream ecosystems can threaten protected groundwater-dependent vegetation (nutrients and species). Similarly, flooding with drainage water should be avoided.

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