„SATURATED AND INTEGRATED BUFFER ZONES AS NOVEL DRAINAGE MITIGATION MEASURES IN DENMARK”

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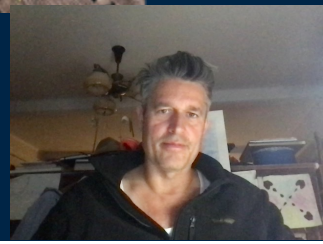
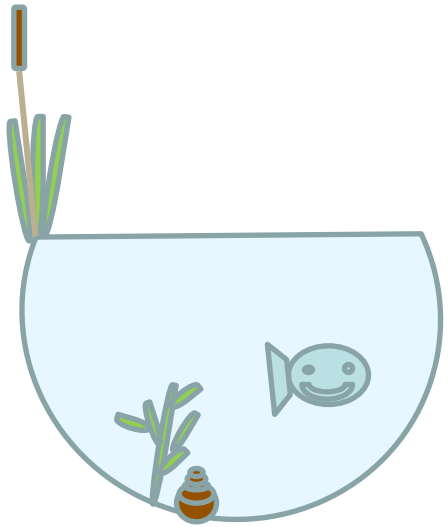
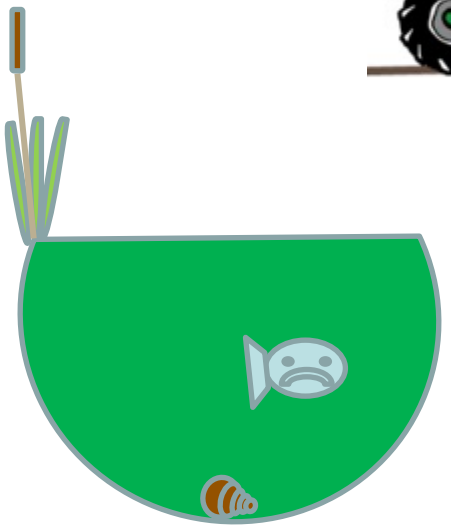
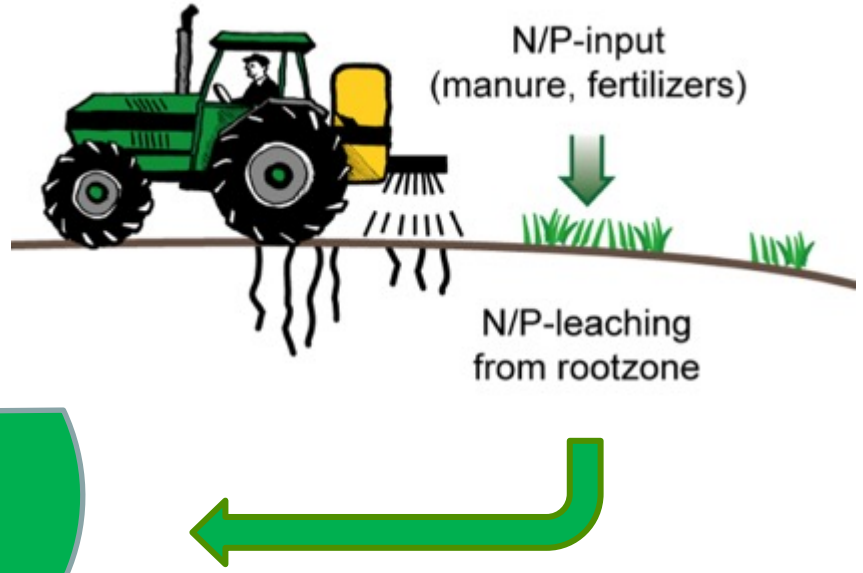
STØTTET AF
Promilleafgiftsfonden for landbrug



WHY DO WE NEED THEM?



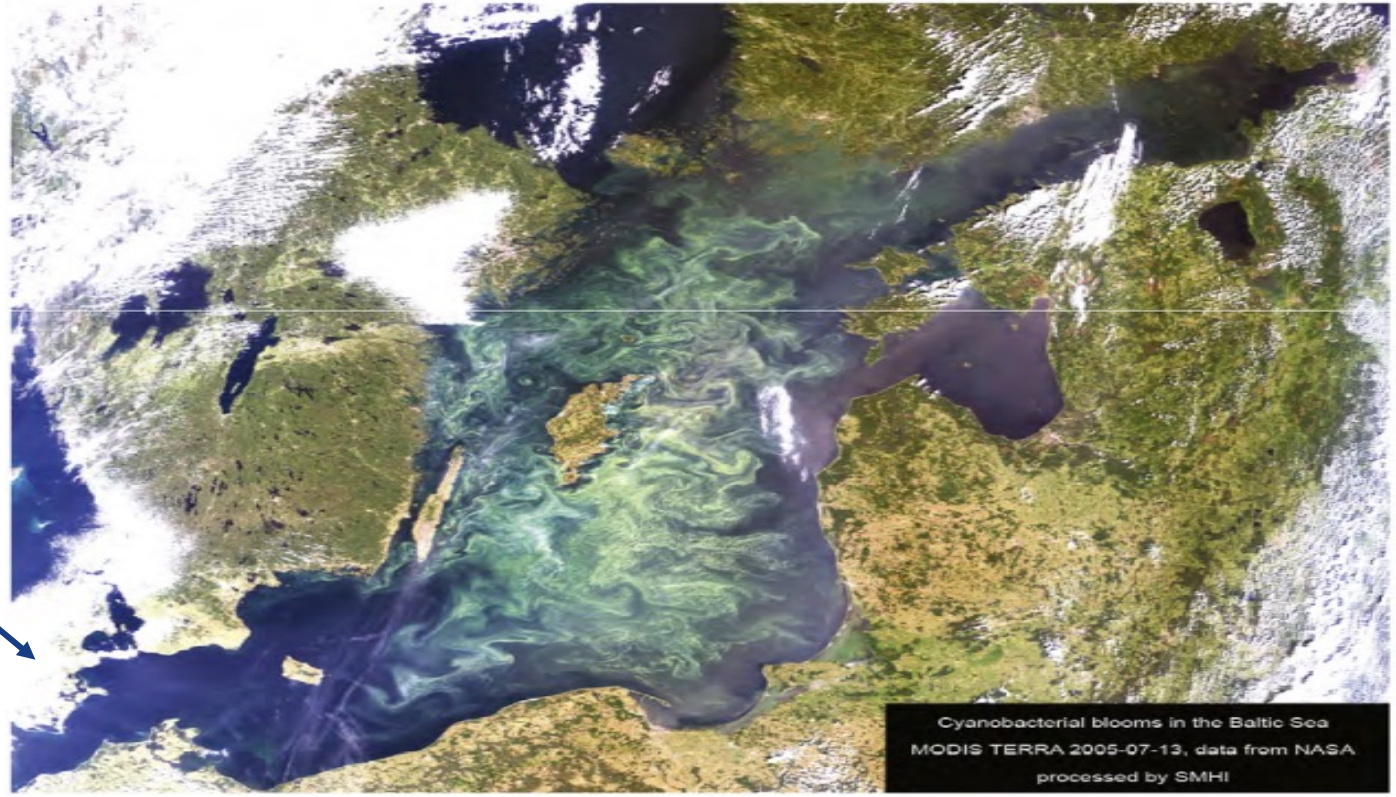




Eutrophication as unsolved problem for streams and lakes!

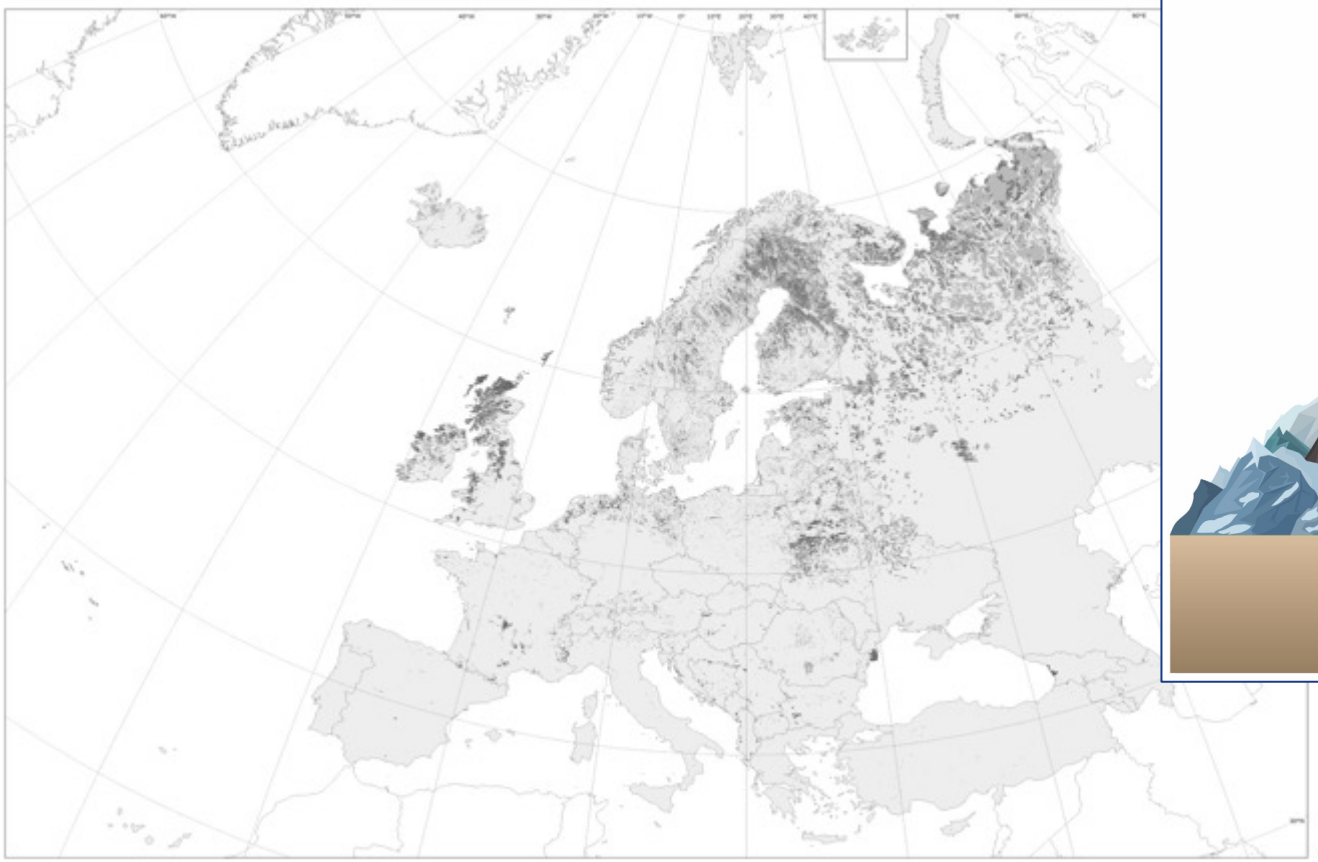
ALSO ON BIGGER SCALES

Denmark

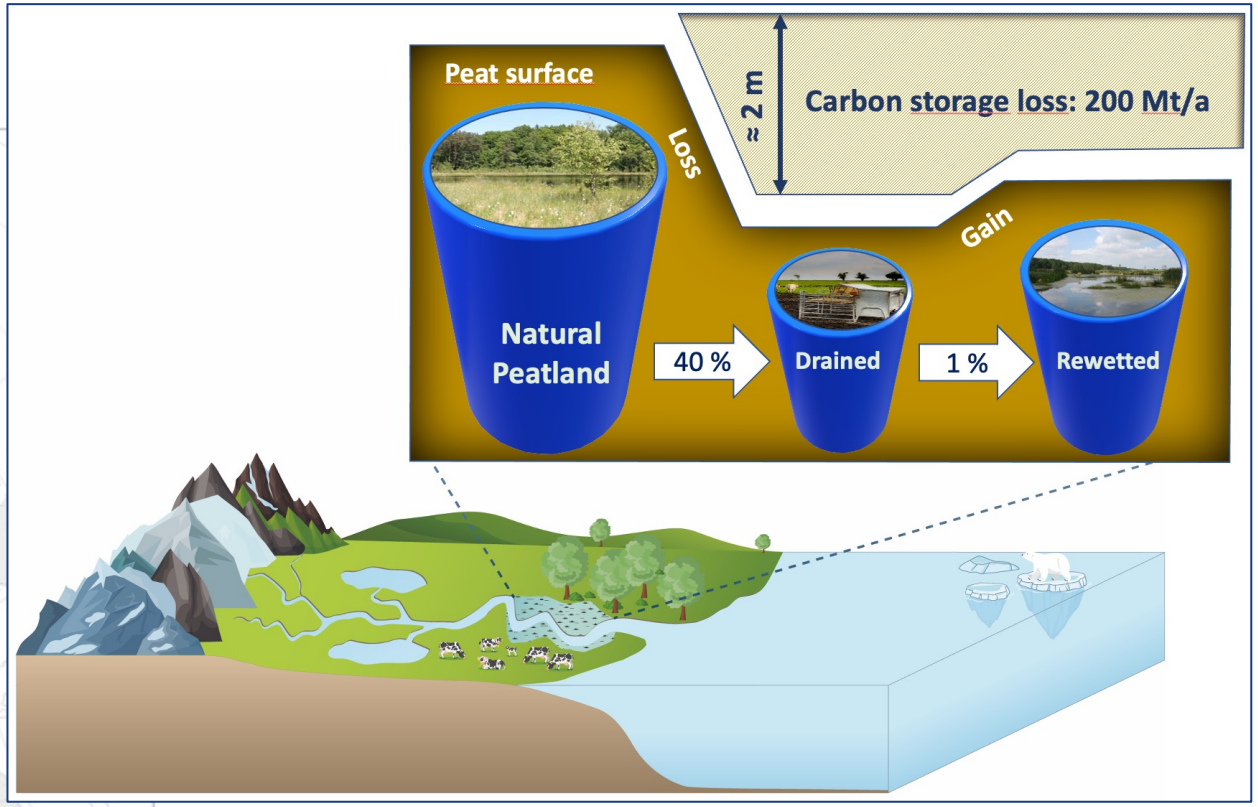


Huge algae carpet in the Baltic Sea in 2005!

“NATURAL FILTERS” IN EUROPE DECLINED



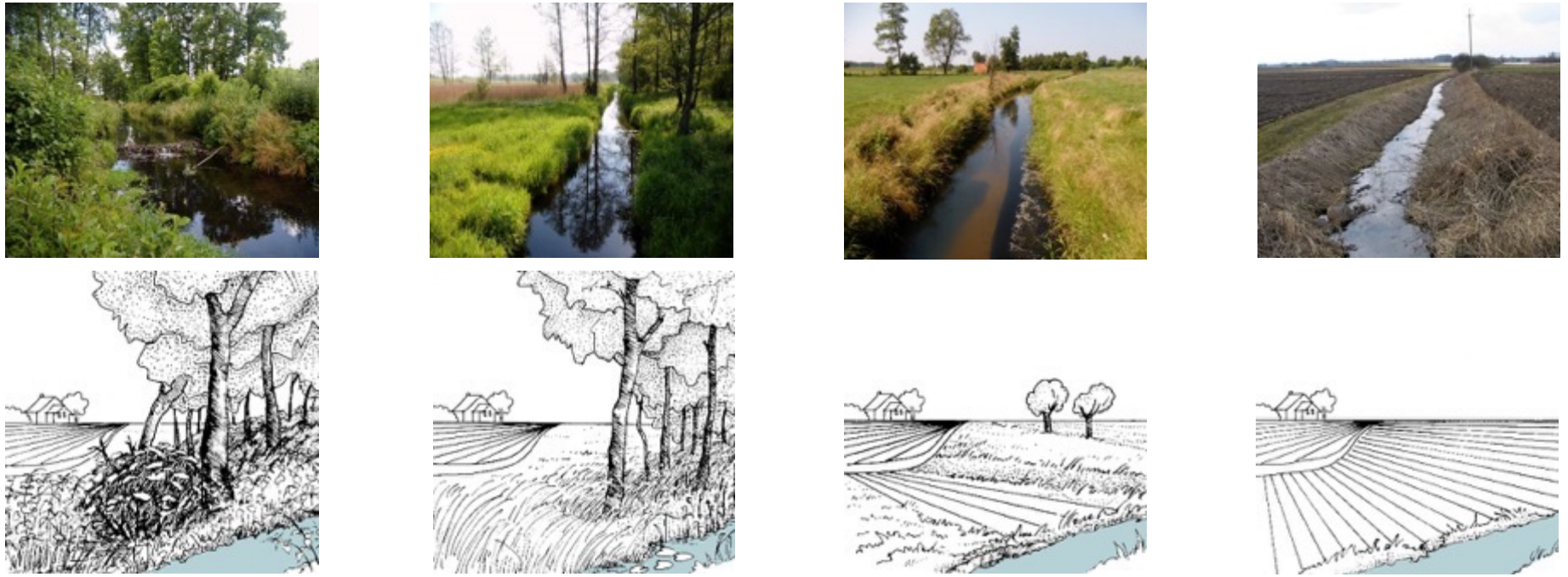
Peatland map of Europe (Tanneberger et al. 2017)



Loss of the “kidneys“ (Zak et al., in prep.)

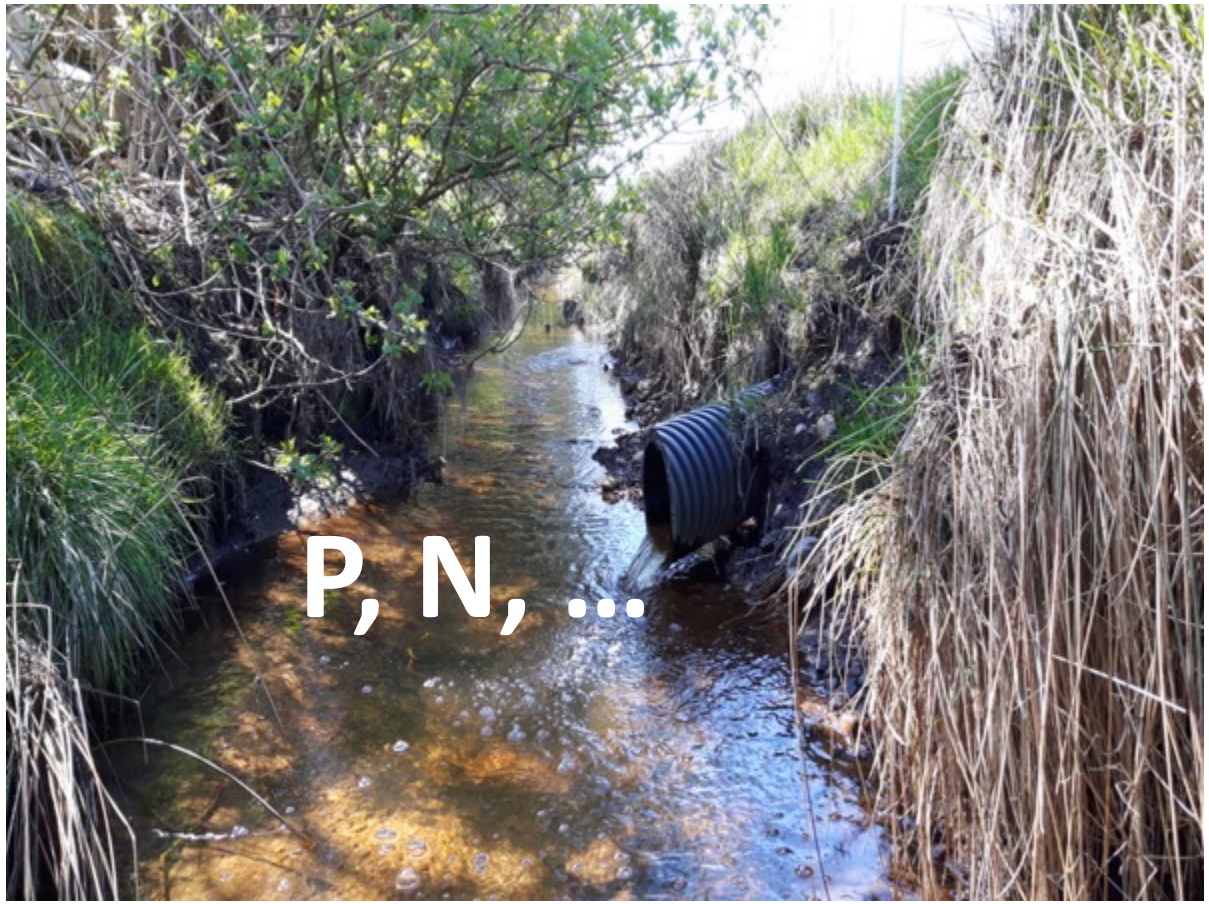
A CLOSER LOOK INTO THE LANDSCAPE

What happend to stream buffers?



Images by Halina Galera (Clearance 2017-2020)

AND NUTRIENTS USE ”HIGHWAYS” NOW!



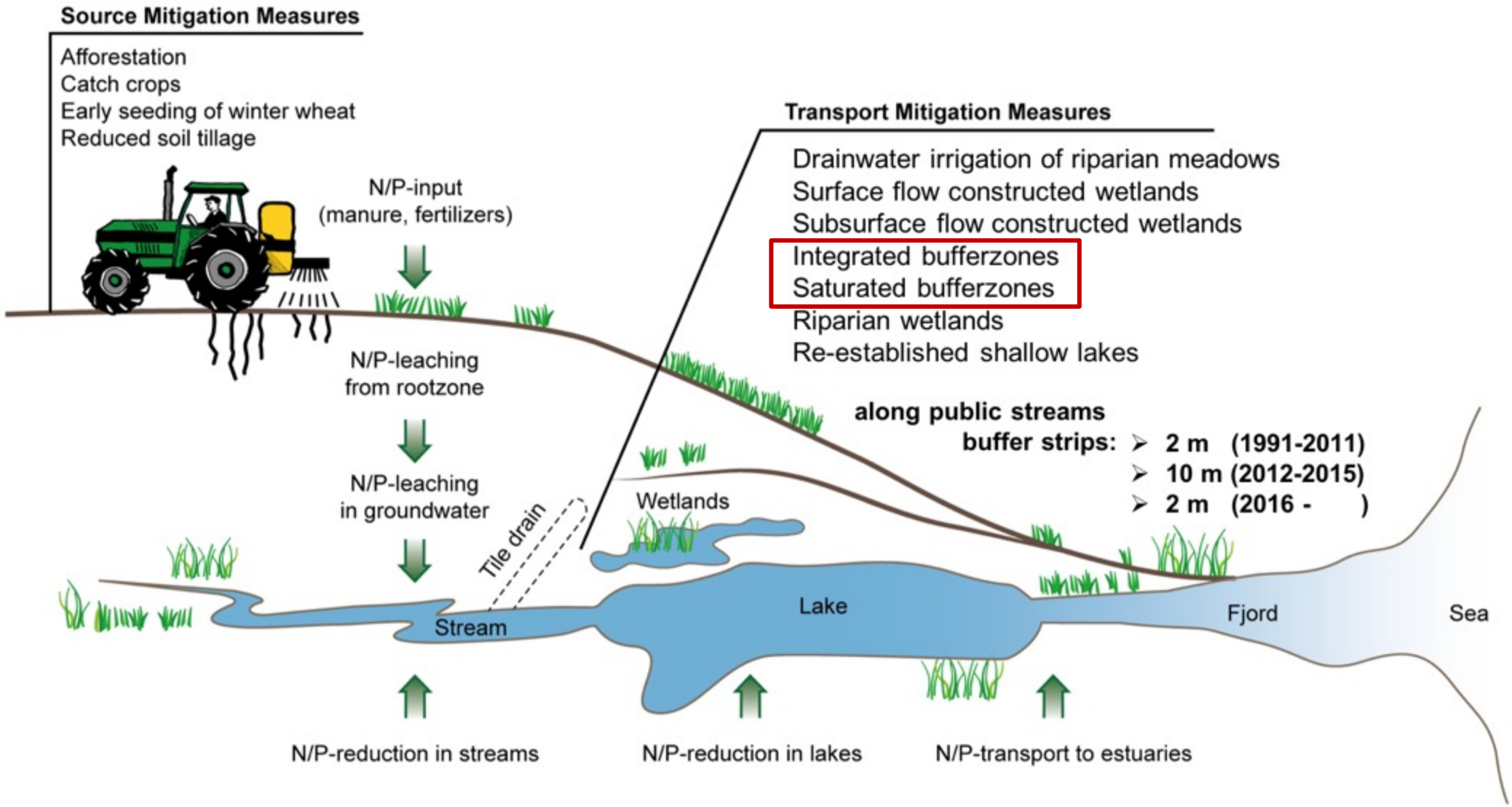
What can or should we do?!

THE GREEN TRANSITION IN DENMARK

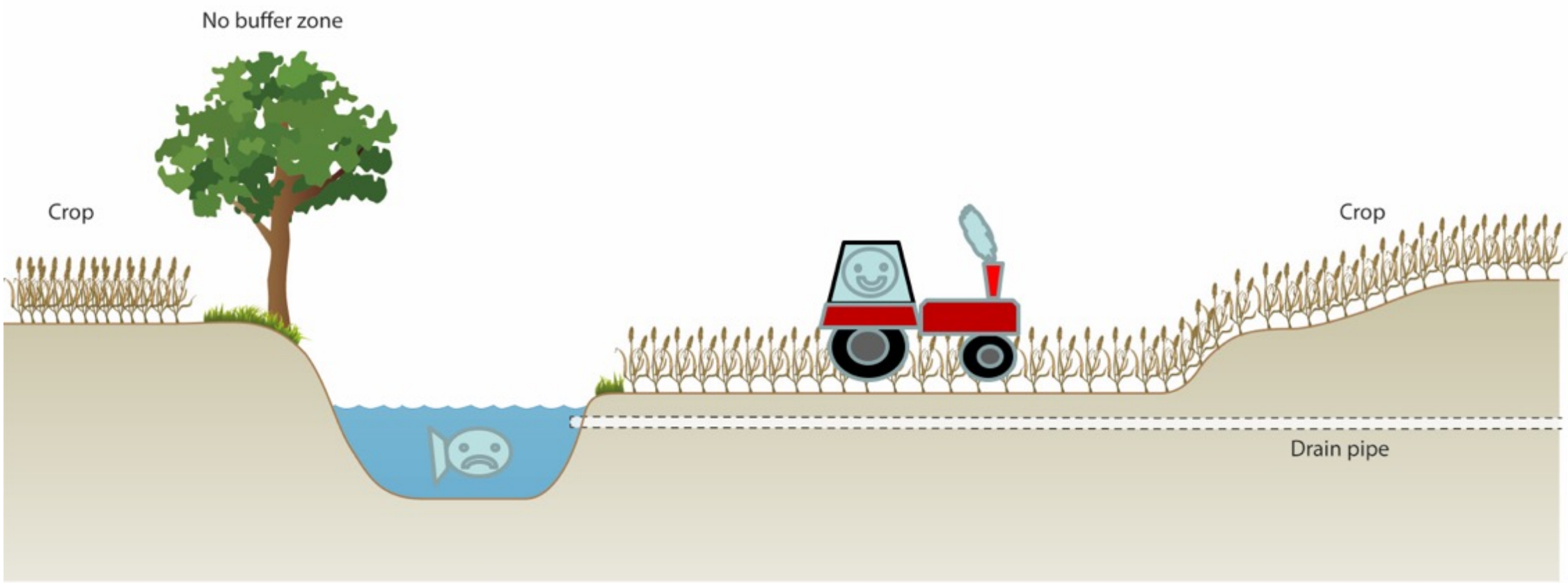
PROLOG

PROCESSES

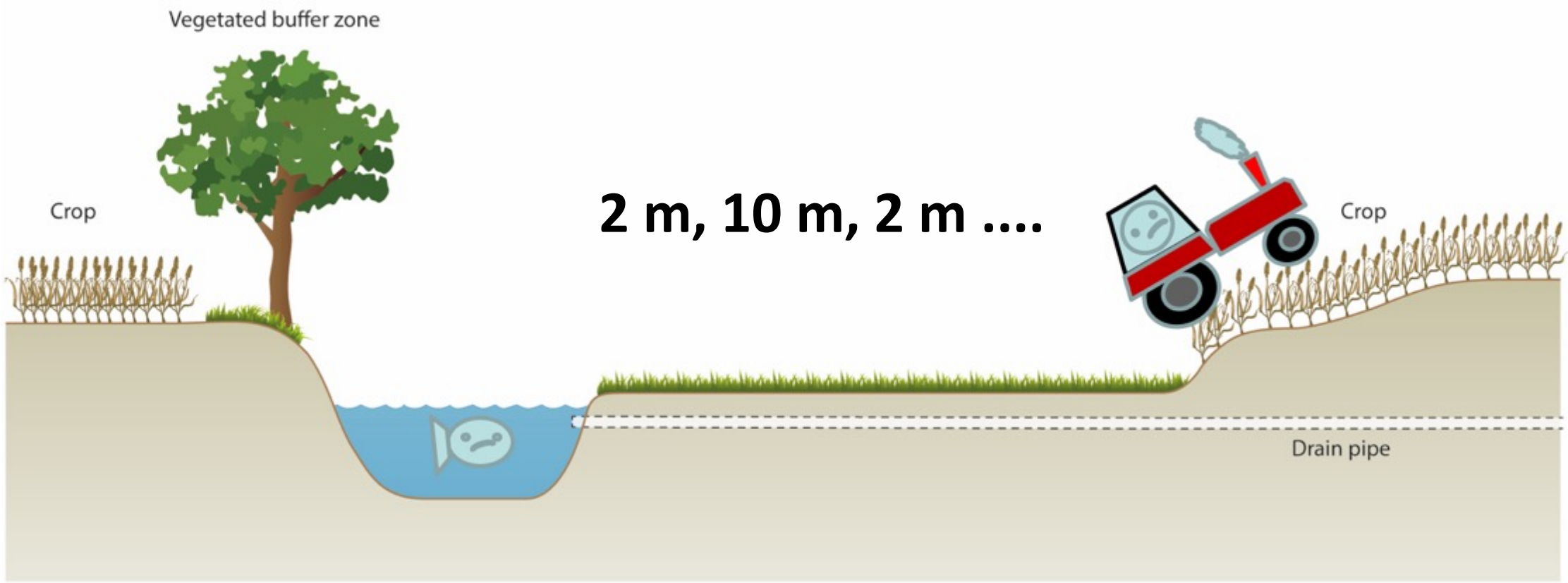
PROGRESS



GENESESIS – NO BUFFERSTRIPS



GENESESIS – VEGETATED BUFFERZONES

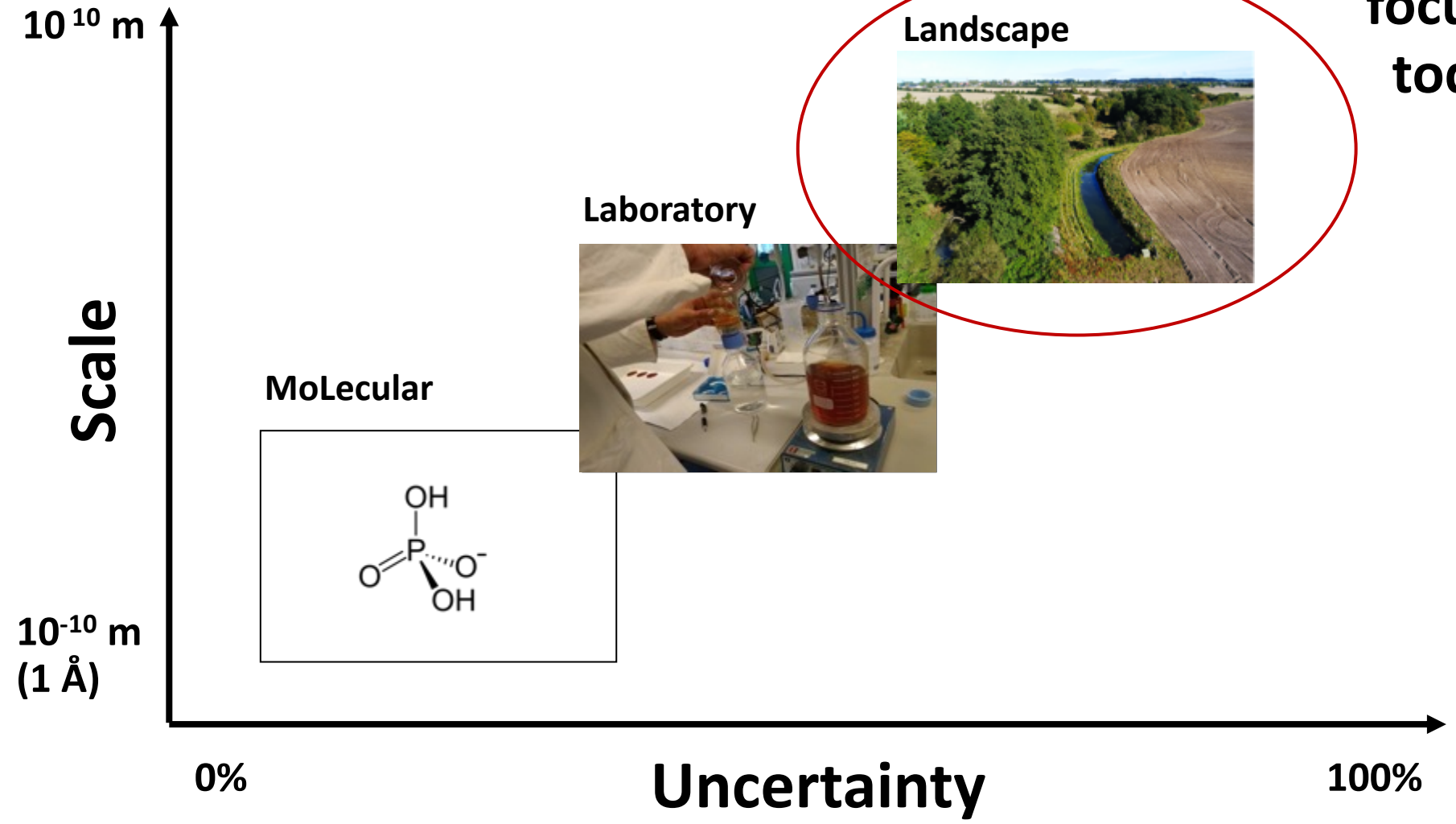


GENESESIS – INTEGRATED BUFFERZONES

GENESESIS – SATURATED BUFFERZONE

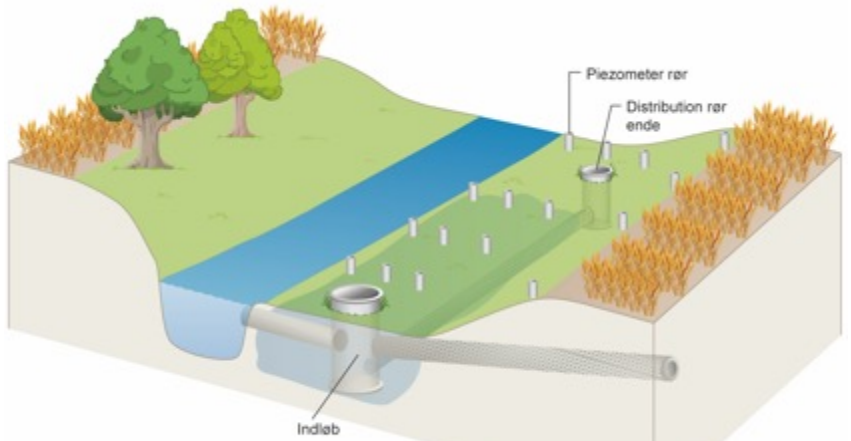
OUR INVESTIGATED SCALES

„Authorities Favorite“ focused today

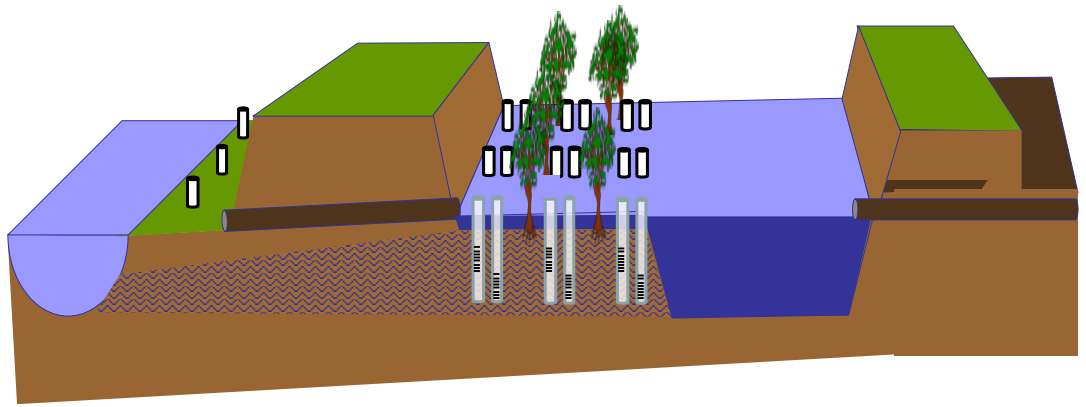


THE IN-SITU MONITORING/INSTRUMENTATION

FOCUS	SATURATED BZ	INTEGRATED BZ
SOIL	QUALITY, e.g. P, C, N, …(START)	SOIL TYPE/FRACTIONS (START)
WATER INFLOW	CONTINUOUSLY (FLOWMETER)	CONTINUOUSLY (FLOWMETER)
WATER OUTFLOW	WATER BALANCE	WATERBALANCE
WATER QUALITY	INFLOW: ALL 3 HOURS PIEZOMETER AND „OUTFLOW“: BIWEEKLY (SRP, TP, NO_3^-, TN, …)	INFLOW: ALL 3 HOURS PIEZOMETER „OUTFLOW“: BIWEEKLY (SRP, TP, NO_3^-, TN, …)
SUSBSURFACE FLOW	FOUR WEEKS (BROMIDE TRACER EXPERIMENT)	FOUR WEEKS (BROMIDE TRACER EXPERIMENT)
WATER TABLES	DAILY TO BIWEEKLY	BIWEEKLY
PLANT UPTAKE	-	END OF VEGETATION PERIOD (P and N)
GHG FLUXES	-	BIWEEKLY (ONE YEAR, METHANE, NITROUS OXIDE)



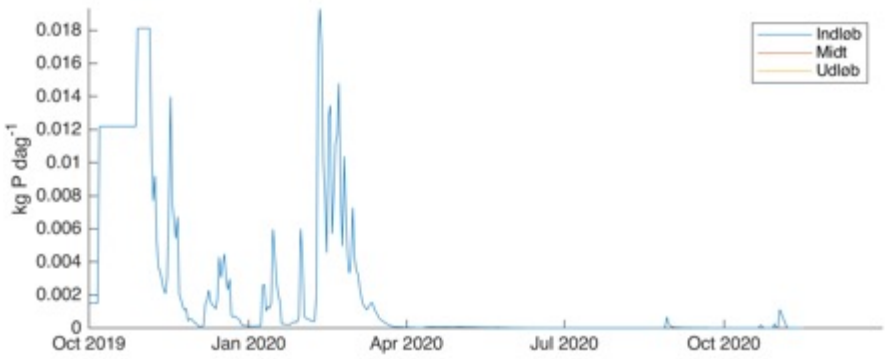
Saturated buffer zone

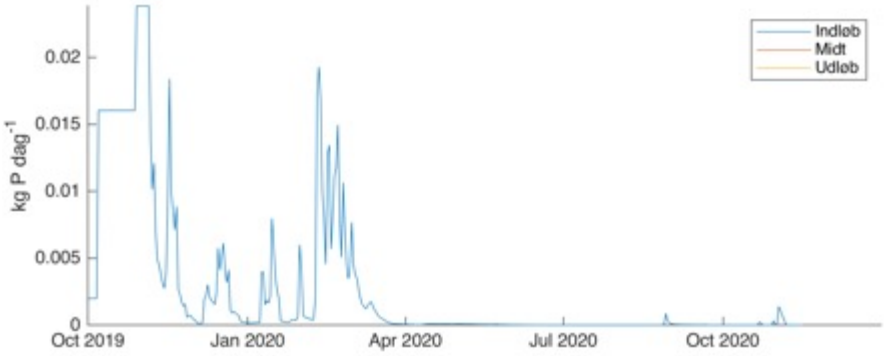


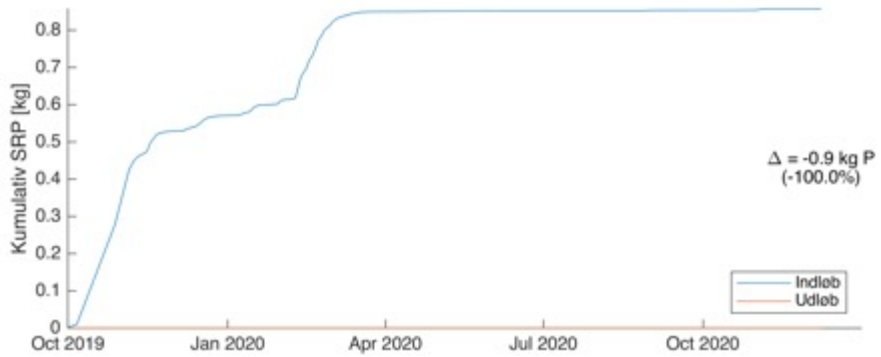
Integrated buffer zone

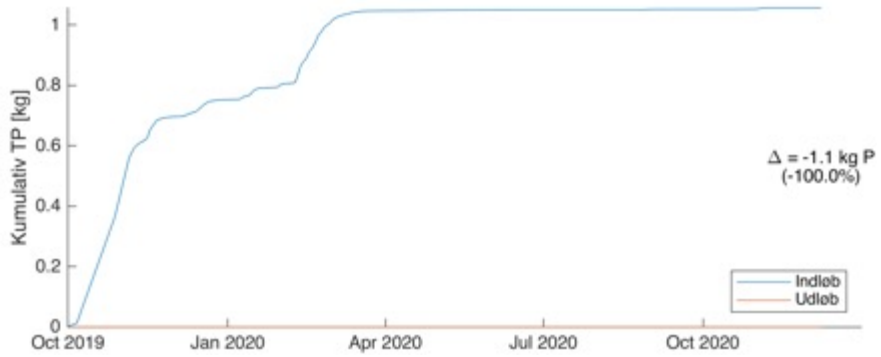
PRELIMINARY RESULTS ON P REMOVAL

at the example of the saturated buffer zone „Ulvskov“



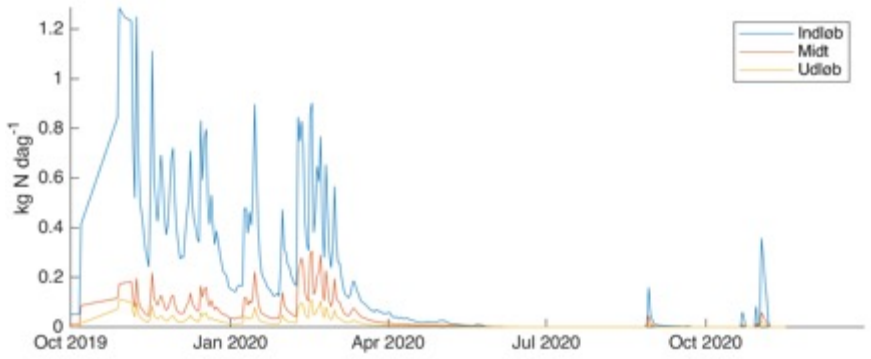


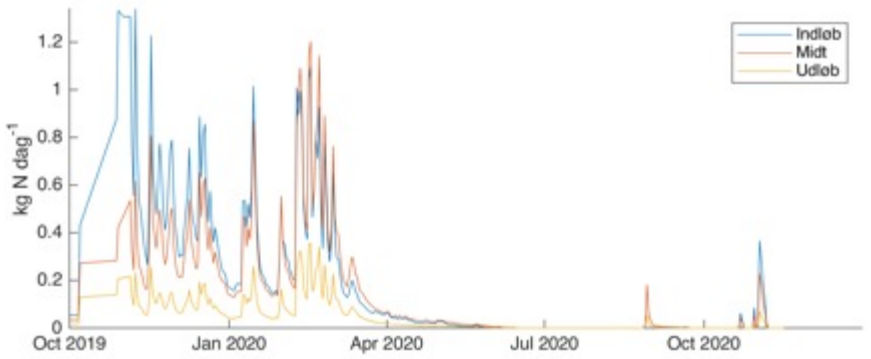


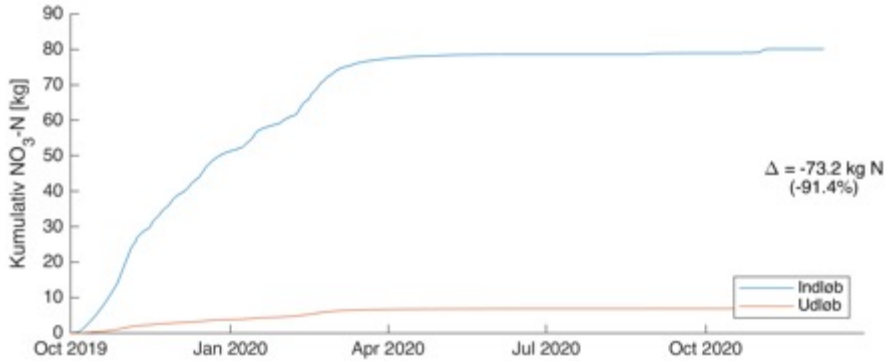


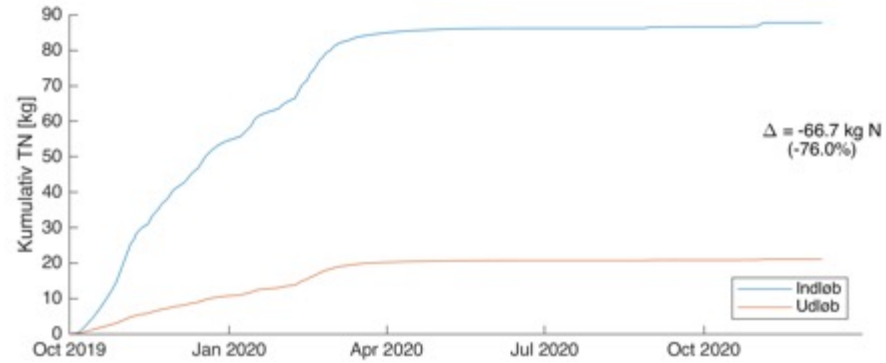
PRELIMINARY RESULTS ON N REMOVAL

at the example of the saturated buffer zone „Ulvskov“



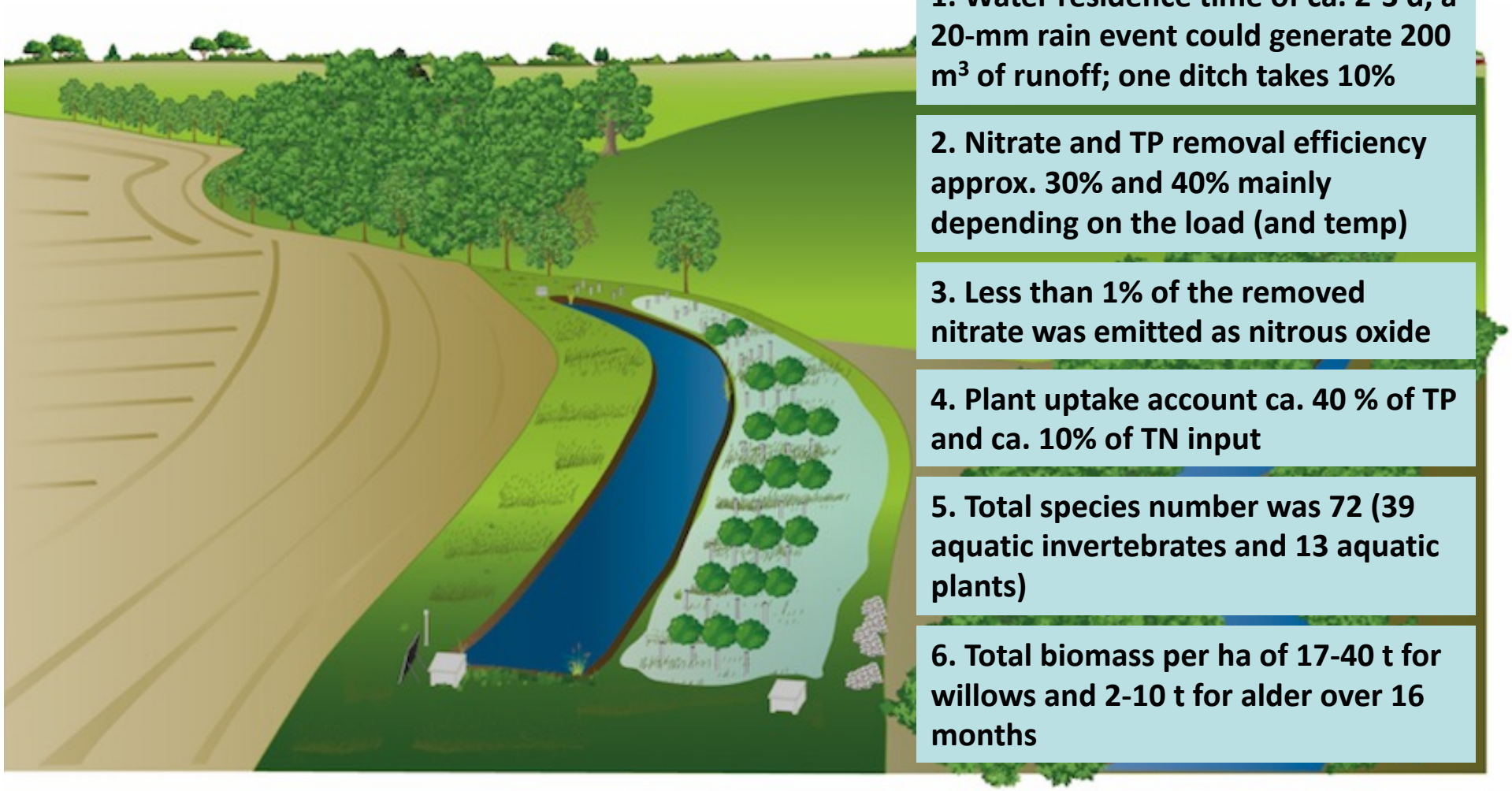






PUBLISHED AGGREGATED RESULTS

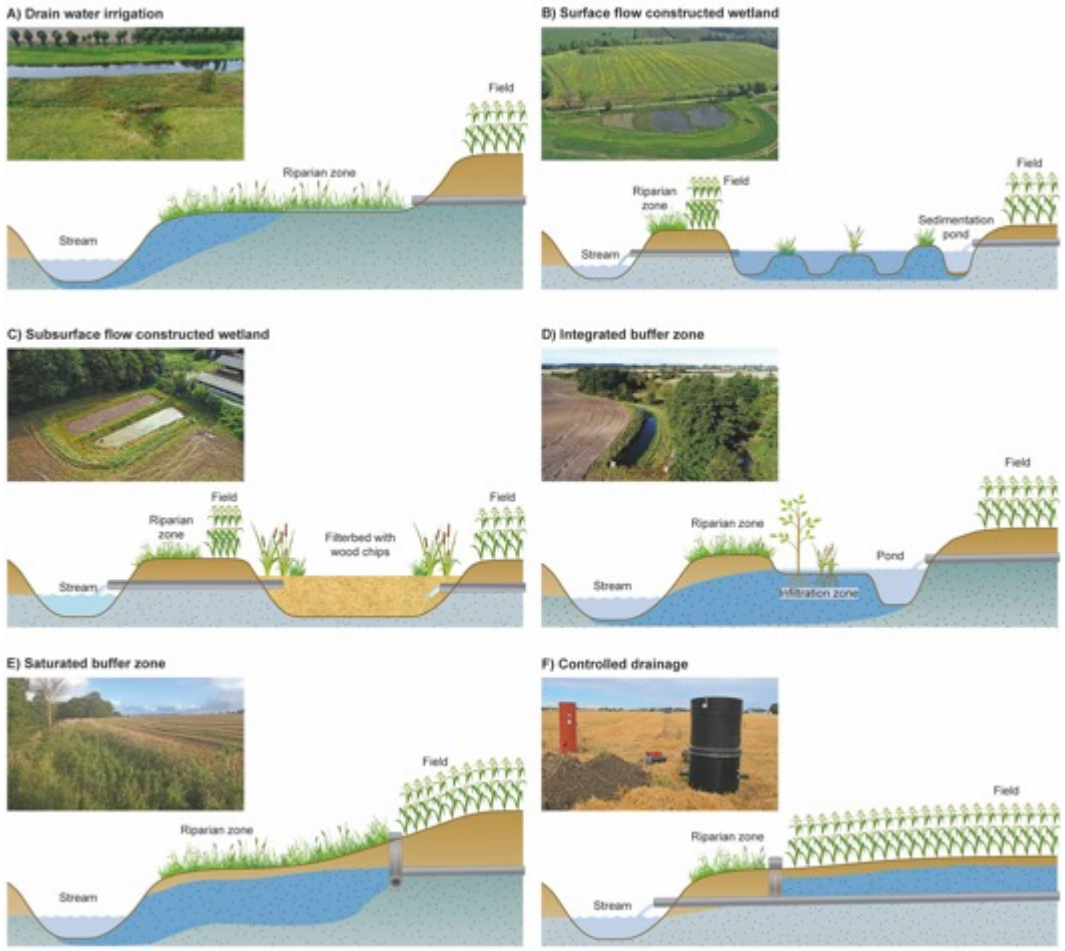
of 11 integrated buffer zones from Denmark, Great Britain, and Sweden



1. Water residence time of ca. 2-3 d, a 20-mm rain event could generate 200 m^3 of runoff; one ditch takes 10%
2. Nitrate and TP removal efficiency approx. 30% and 40% mainly depending on the load (and temp)
3. Less than 1% of the removed nitrate was emitted as nitrous oxide
4. Plant uptake account ca. 40 % of TP and ca. 10% of TN input
5. Total species number was 72 (39 aquatic invertebrates and 13 aquatic plants)
6. Total biomass per ha of 17-40 t for willows and 2-10 t for alder over 16 months

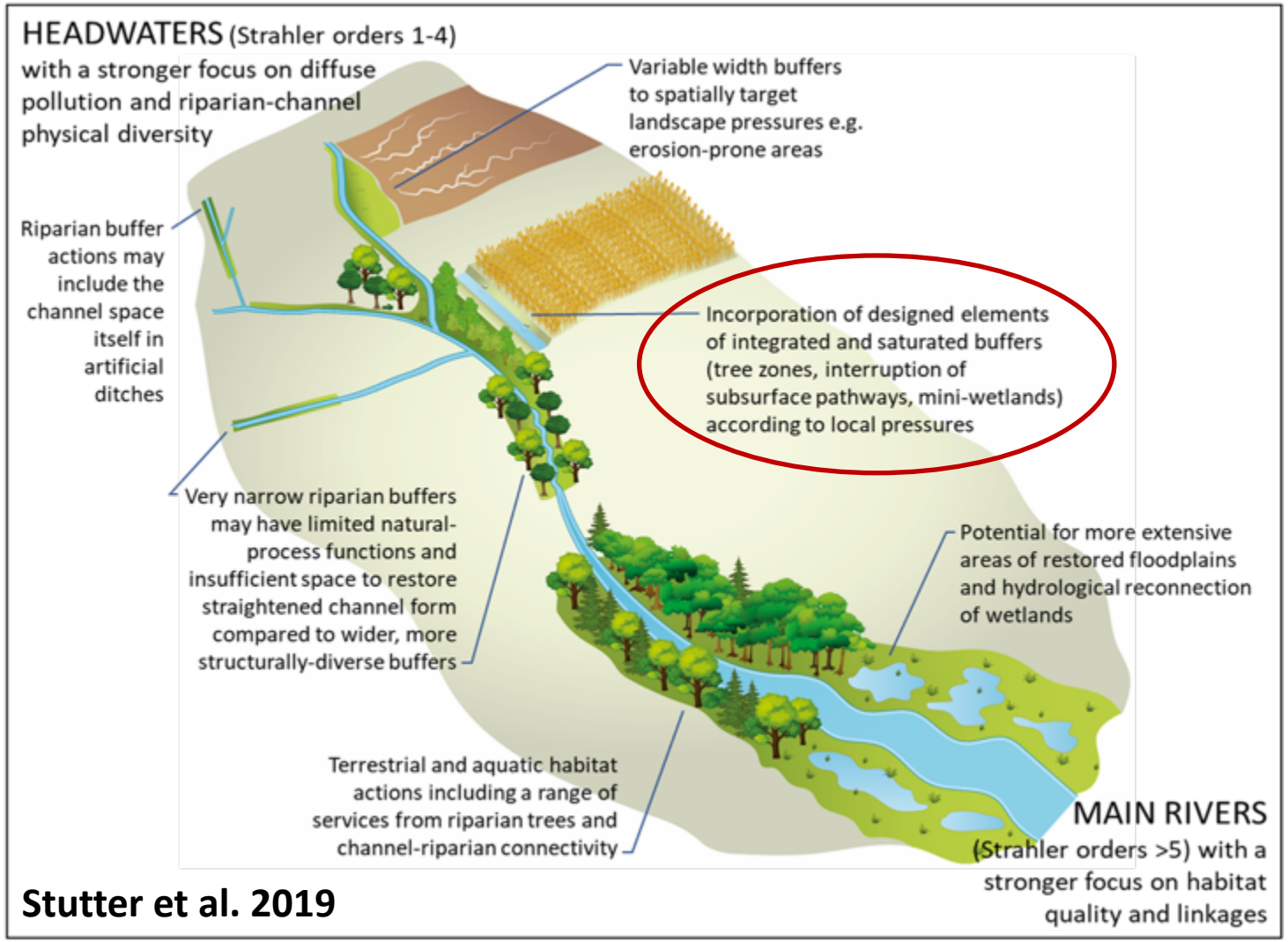
COMPARISON WITH OTHER SYSTEMS

Mitigation Measures	Removal efficiency (%)	
	TN	TP
Restored riparian wetlands	37 ± 31	12 ± 15
Restored shallow lakes	45 ± 21	-2 ± 83
Restored swamps and fens	44 ± 12	11 ± 26
Drain water irrigation	45 ± 22	-51 ± 49
Surface flow constructed wetland	23 ± 10	45 ± 20
Subsurface flow constructed wetland	50 ± 13	12 ± 4
Controlled drainage	33 ± 13	5 ± 29
Integrated buffer zones	45 ± 12	29 ± 60
Saturated buffer zones (preliminary)	*76*	*100*

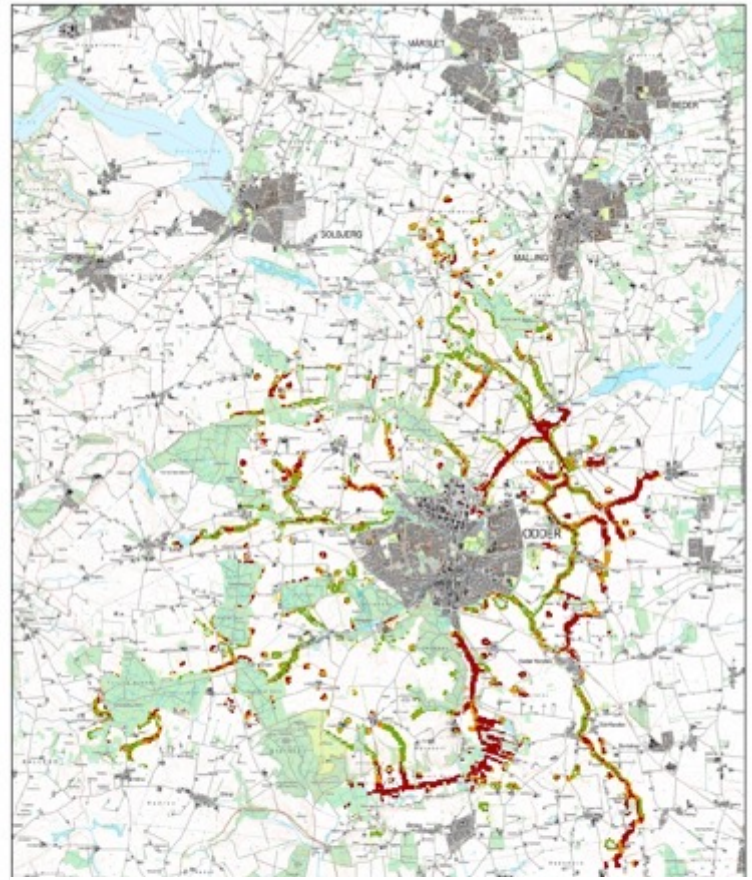


Hoffmann et al. 2020

WHERE TO PLACE THE BUFFER ZONES



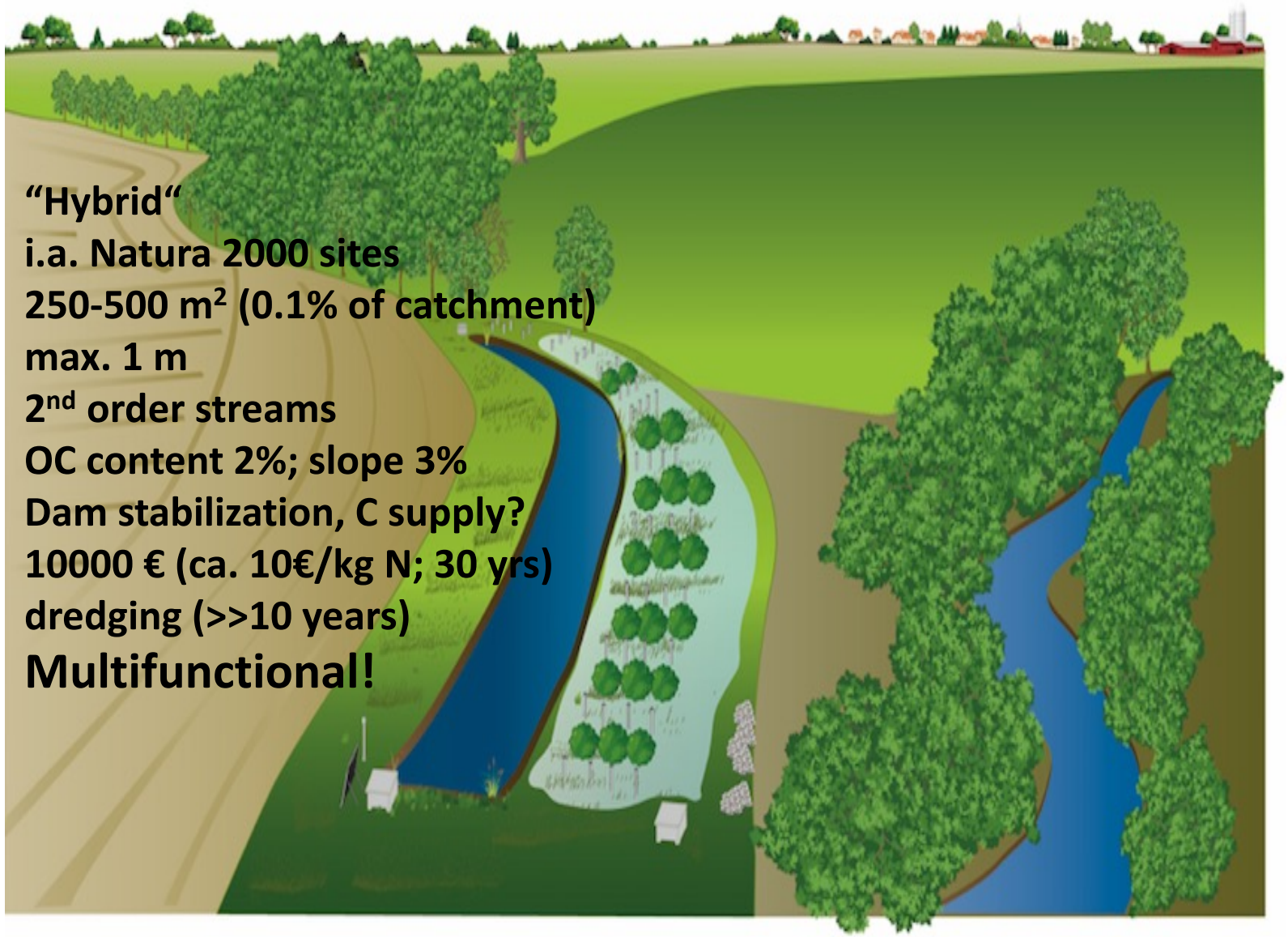
Stutter et al. 2019



A first potential IBZ map was developed: green (suitable areas) and red (unsuitable areas).

MANUAL FOR INTEGRATED BUFFER ZONES

1) Design:	“Hybrid“
2) Barriers:	i.a. Natura 2000 sites
3) Area need:	250-500 m^2 (0.1% of catchment)
4) Water depth:	max. 1 m
5) Where:	2nd order streams
6) Demands:	OC content 2%; slope 3%
7) Extra‘s:	Dam stabilization, C supply?
8) Costs:	10000 € (ca. 10€/kg N; 30 yrs)
9) Maintance:	dredging (>>10 years)
10) Benefits:	**Multifunctional!**



OUTLOOK

1. More test sites
2. Long-term performance
3. Wider benefits and side effects
4. Optimization
5. National Mapping

Many thanks for your attention!

AARHUS
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Further reading:


Science of the Total Environment

Nitrogen removal and greenhouse gas fluxes from integrated buffer zones treating agricultural drainage water

Mette Vodder Carstensen *, Dominik Zak, Sofie Gyritia Madsen van't Veen, Kamila Wisniewska, Niels Bering Ovesen, Brian Kronvang, Joachim Audet


Environmental Science & Technology

Nitrogen and Phosphorus Removal from Agricultural Runoff in Integrated Buffer Zones

Dominik Zak, Brian Kronvang, Mette V. Carstensen, Carl C. Hoffmann, Ane Kjeldgaard, Søren E. Larsen, Joachim Audet, Sara Egemose, Charlotte A. Jorgensen, Peter Feuerbach, Flemming Gertz, and Henning S. Jensen


ENVIRONMENTAL EFFECTS OF A GREEN BIO-ECONOMY

Efficiency of mitigation measures targeting nutrient losses from agricultural drainage systems: A review

Mette Vodder Carstensen, Fatemeh Hashemi, Carl Christian Hoffmann, Dominik Zak, Joachim Audet, Brian Kronvang


Ecological Engineering

An overview of nutrient transport mitigation measures for improvement of water quality in Denmark


Journal of Environmental Quality

SPECIAL SECTION

RIPARIAN BUFFER MANAGEMENT

An Assessment of the Multifunctionality of Integrated Buffer Zones in Northwestern Europe

Dominik Zak,* Marc Stutter, Henning S. Jensen, Sara Egemose, Mette V. Carstensen, Joachim Audet, John A. Strand, Peter Feuerbach, Carl C. Hoffmann, Benjamin Christen, Sandra Hille, Mads Knudsen, Jenni Stockan, Helen Watson, Goswin Heckrath, and Brian Kronvang