Modelling nutrient loading of Danish marine waters

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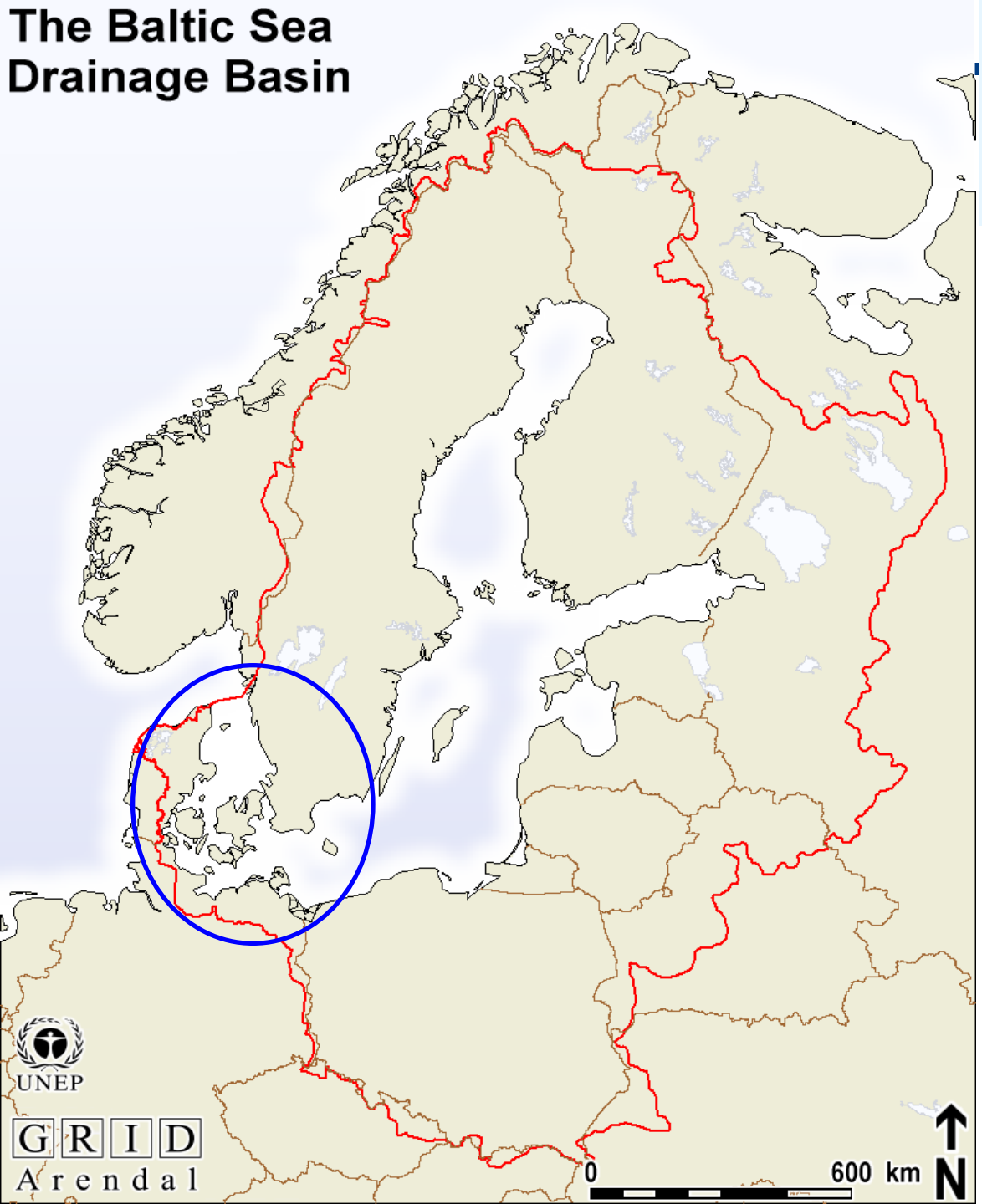
Outline

Setting the scene ~ the Baltic Sea area

~ the background for our project

Some challenges

Our modelling strategy

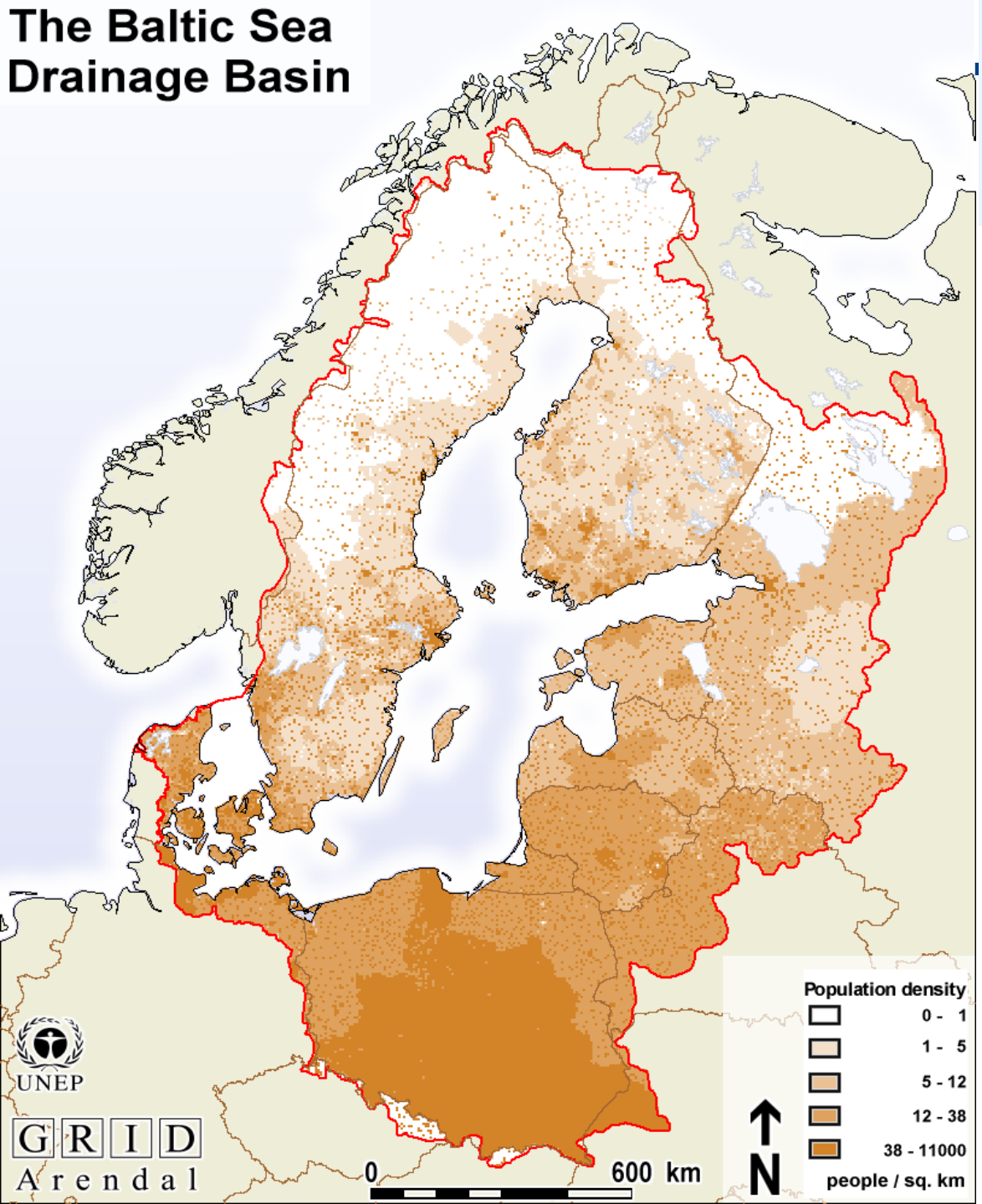


Baltic Sea System:

- 0.4 million sq. km of sea surface

+ 1.7 million sq. km of drainage

- 14 countries



Baltic Sea System:

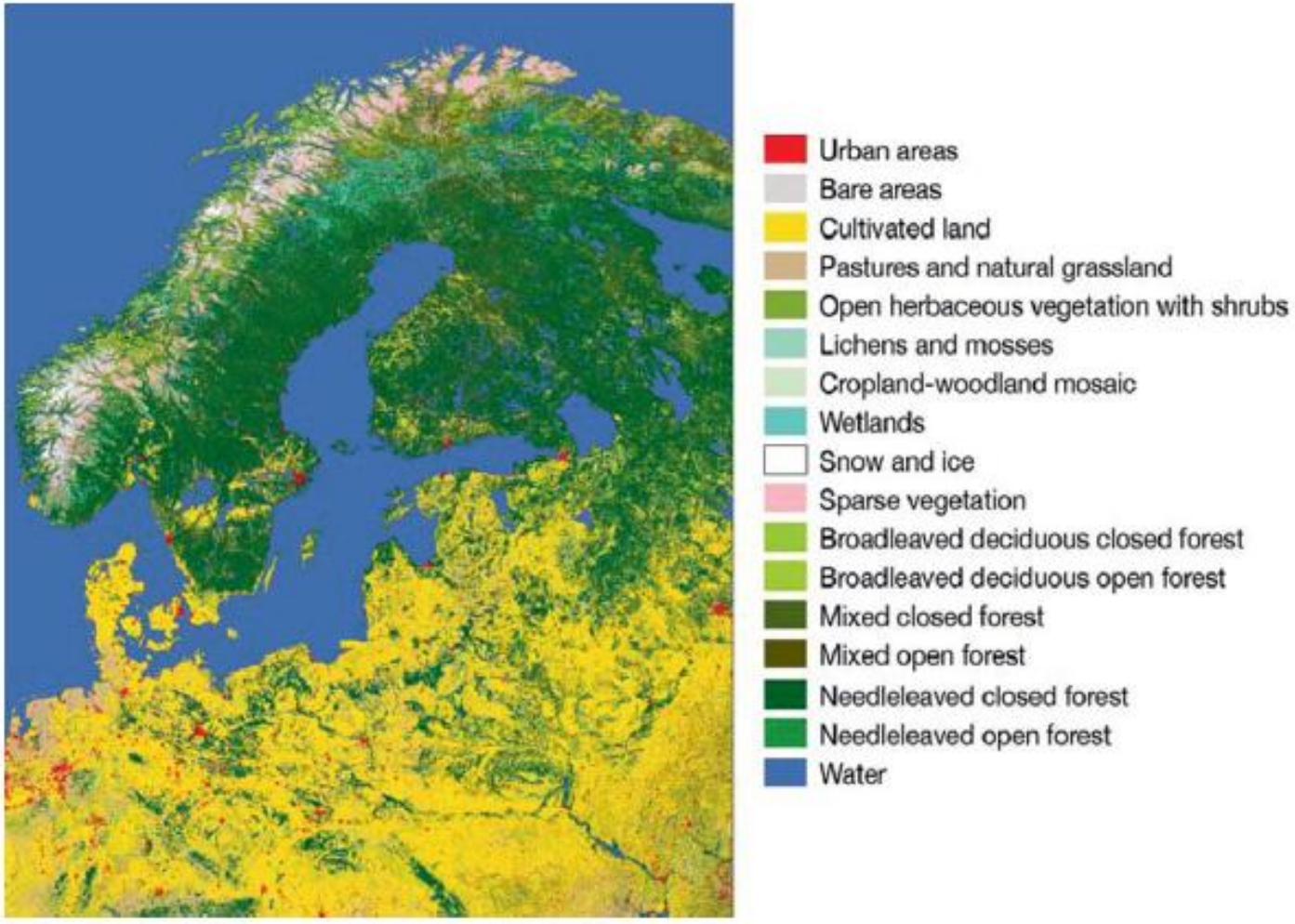
- 0.4 million sq. km of sea surface

+ 1.7 million sq. km of drainage

- 14 countries
- 95 million inhabitants
- the worlds largest brackish sea
- long water residence
- excessive nutrient inputs
- overfishing
- since 1900 change from oligotrophic clear-water sea to eutrophic marine environment

World's Largest Dead Zone Suffocating Sea

Algae blooms (seen in a July 2005 satellite image) have created the world's largest dead zone in the Baltic Sea (National Geographic, March 2010).


Urban areas
Bare areas
Cultivated land
Pastures and natural grassland
Open herbaceous vegetation with shrubs
Lichens and mosses
Cropland-woodland mosaic
Wetlands
Snow and ice
Sparse vegetation
Broadleaved deciduous closed forest
Broadleaved deciduous open forest
Mixed closed forest
Mixed open forest
Needleleaved closed forest
Needleleaved open forest
Water

HELCOM

- intergovernmental co-operation between the riparian countries
- works to protect the marine environment of the Baltic Sea

Baltic Sea Action Plan adopted by HELCOM 2007:

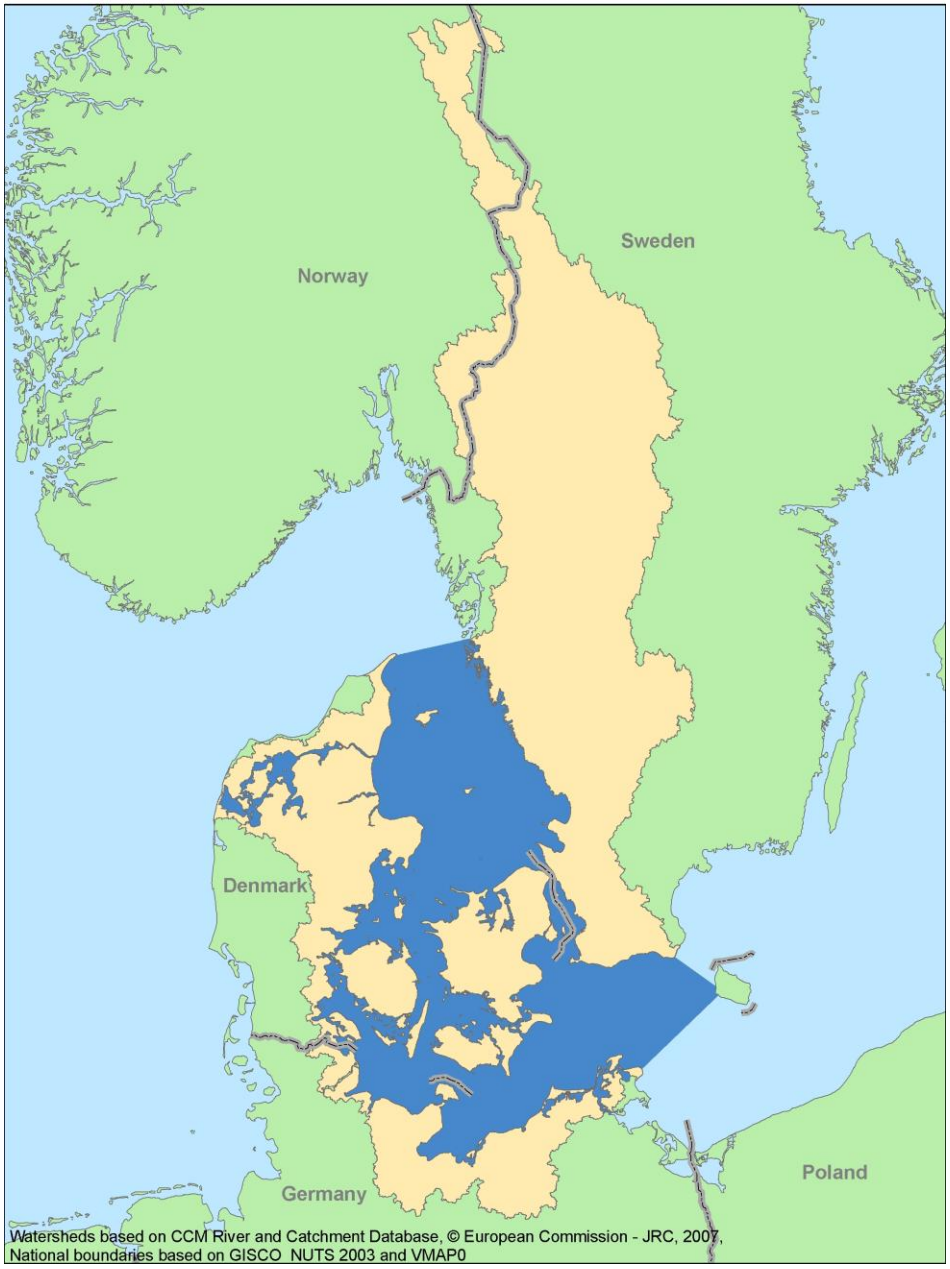
”..restore the good ecological status of the Baltic marine environment by 2021”

- concentrations of nutrients close to natural levels
- an end to excessive algal blooms
- natural oxygen levels

The Baltic Sea Action Plan calculated by catchment nutrient loading models and ecosystem models by the Baltic Nest Institute (BNI) (Savchuk and Wulff (2007), Wulff et al. (2007)).

	Needed reduction (tonnes)	
Sub-region	**P**	**N**
Bothnian Bay	0	0
Bothnian Sea	0	0
Gulf of Finland	2,000	6,000
Baltic Proper	12,500	94,000
Gulf of Riga	750	0
Danish Straits	0	15,000
Kattegat	0	20,000
Total	**15,250 (42%)**	**135,000 (22%)**

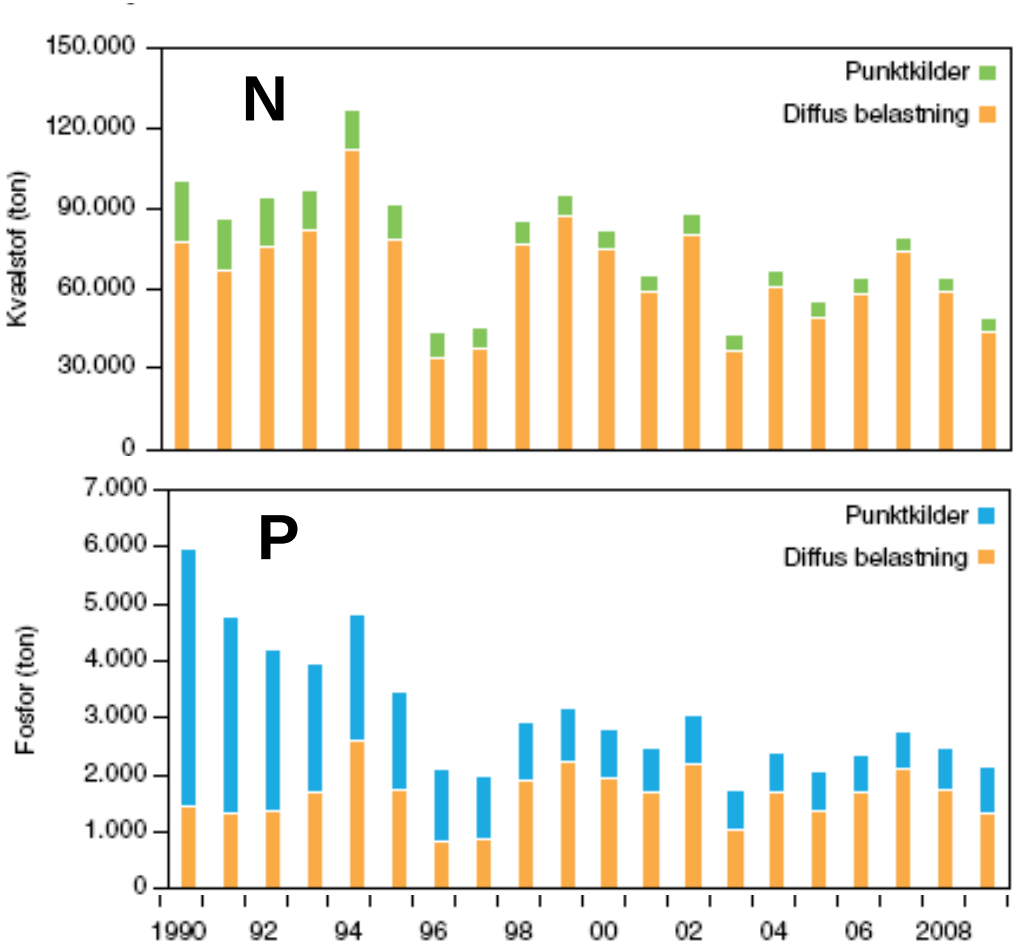
A map of the MAFIA working area covering a total of 211.607 km2, including land cover of drainage basins (120.707 km2, yellow) and marine areas (90.901 km2, dark blue).



The target area of out project:

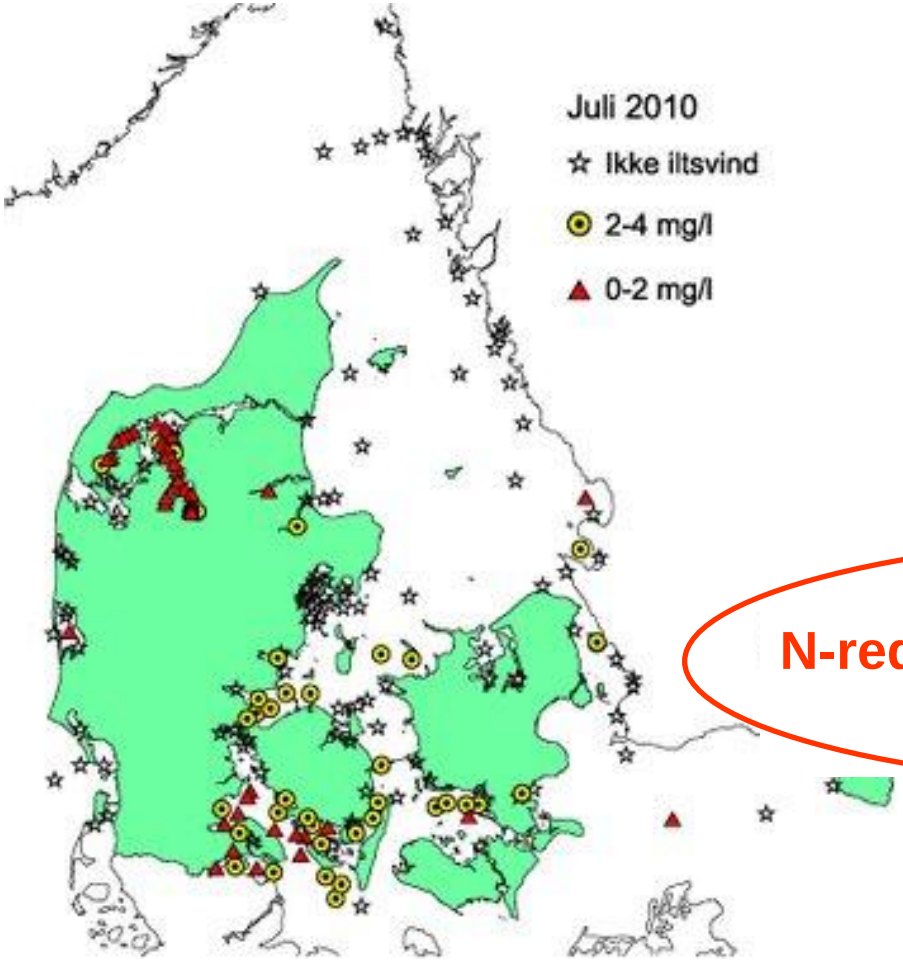
Kattegat, The Danish Straits, the Western Baltic Sea

N and P loadings (tonnes) from the Danish land area to the sea 1990 - 2009



Reduction of 35%

Reduction of 32%



Baltic Sea Action Plan

Reduction targets for Denmark:

17,210 t N

16 t P

N-reduction ~ 35% of 2009-loading !

Source: National Environmental Monitoring Programme, NOVANA.

Integrated Management of Agriculture, Fishery, Environment and Economy (MAFIA)

Develop tools to help managers of river basins and the marine environment to reach targets in a cost-effective way

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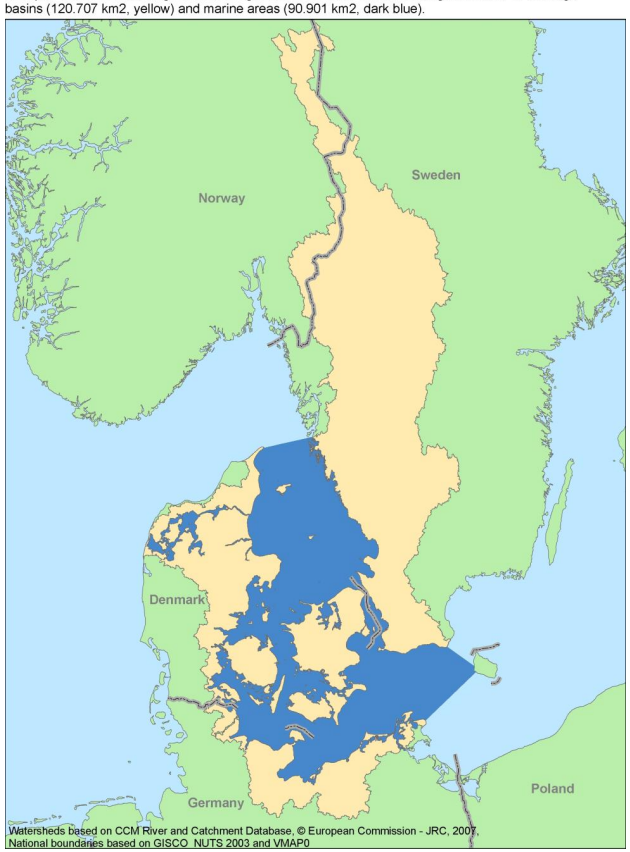
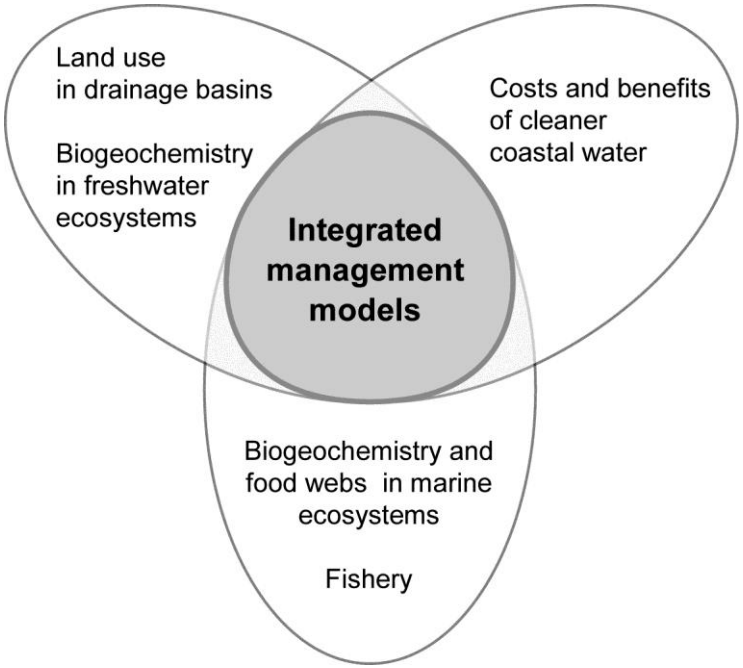




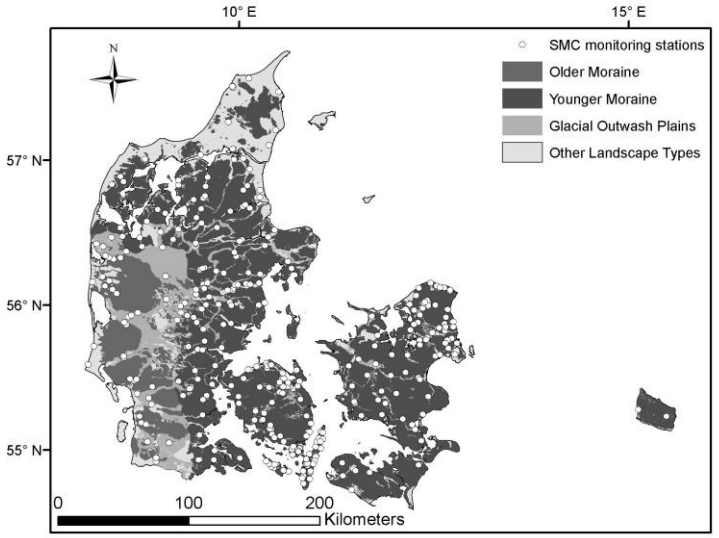
National Environmental Monitoring Programme

Stream water monitoring

-Established 1989

- 200+ stream water stations

- Discharge (continous), N and P (2 - 4 weeks)



Compilation of national agricultural management data (annually):

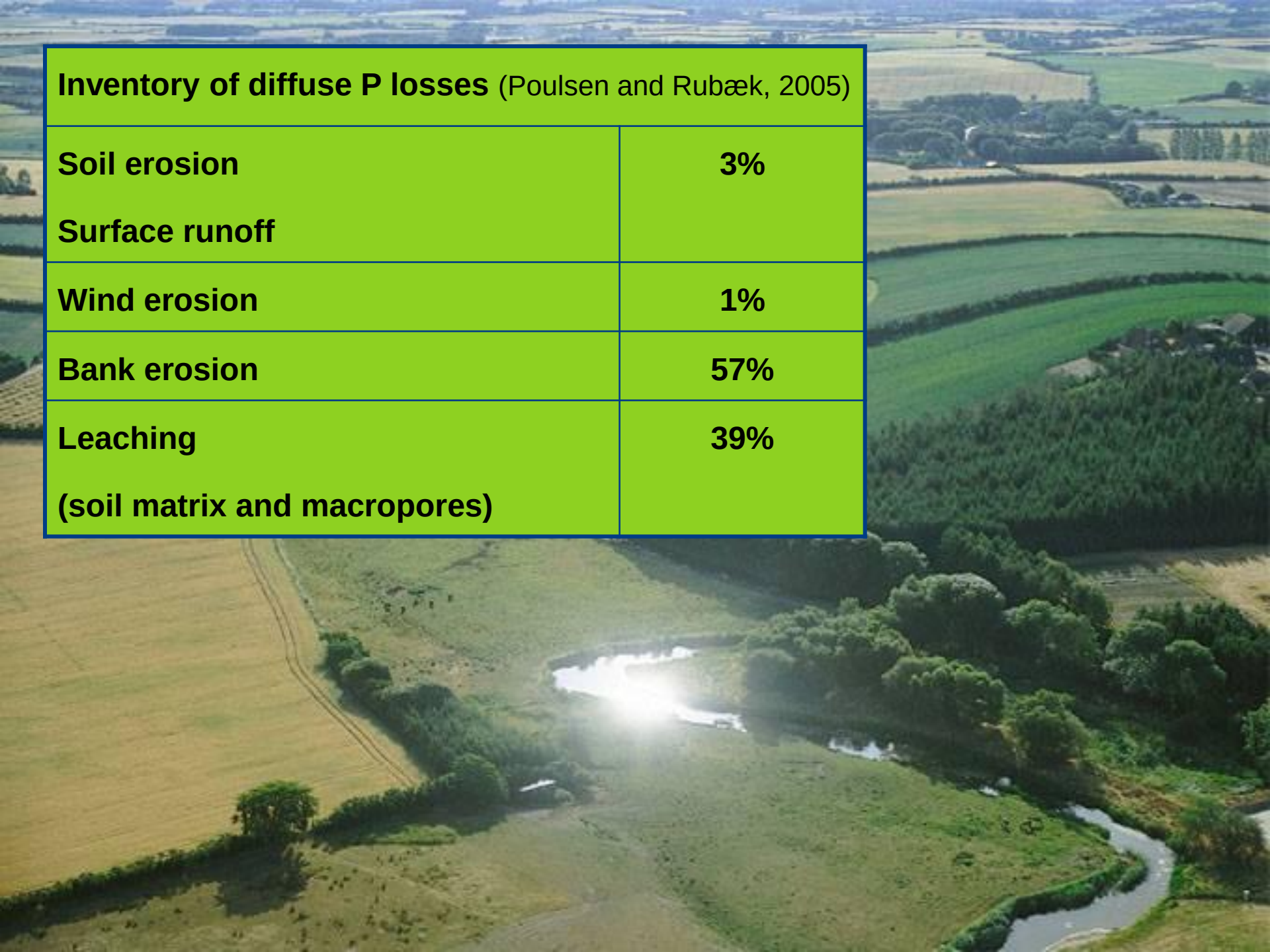
- Crops at field level

- Livestock, use of fertilizer, manure at farm level

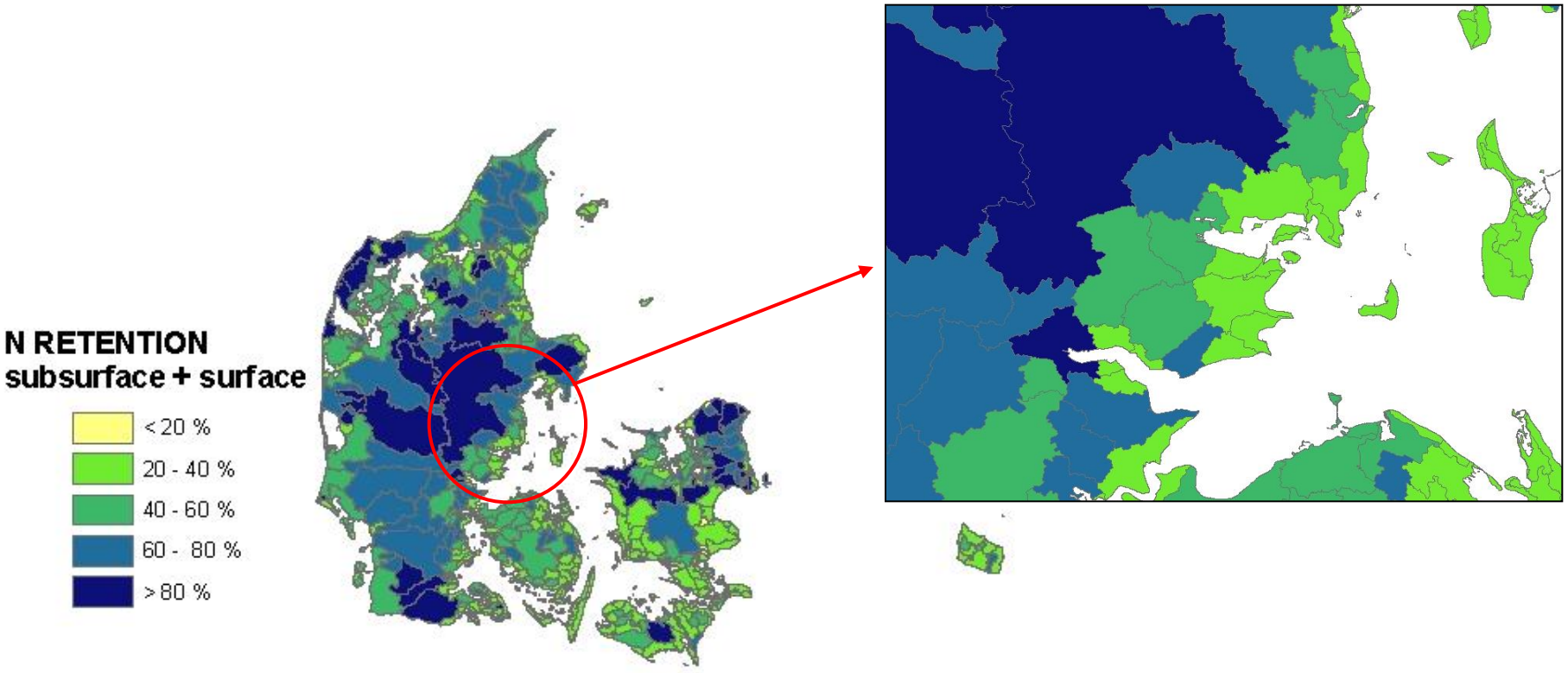
- Crop yields at regional level

Agricultural Watershed Monitoring Programme

- 5 agriculturally dominated catchments (5 – 15 km^2)
- Detailed sampling: root zone, tile drains, groundwater, streams
- Annual questionnaire involving all fields, farms: crops, yields, fertilizer, manure, livestock, timing of operations



Inventory of diffuse P losses (Poulsen and Rubæk, 2005)	
Soil erosion **Surface runoff**	**3%**
Wind erosion	**1%**
Bank erosion	**57%**
Leaching **(soil matrix and macropores)**	**39%**



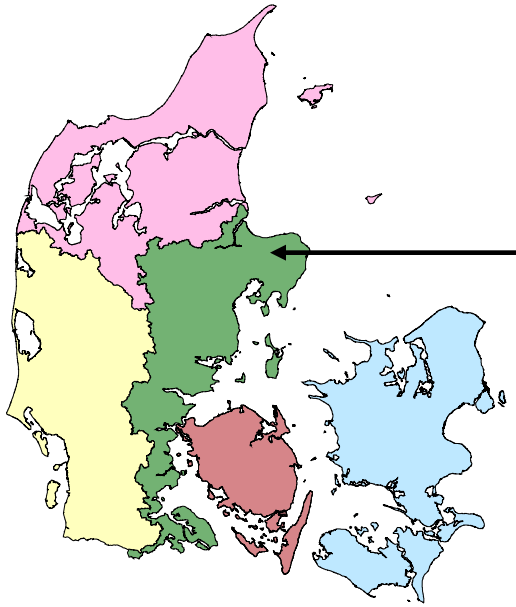
Denitrification – microbiological reduction of nitrate (NO_3^-) to atmospheric nitrogen (N_2)

Heterotrophic: $C_6H_{12}O_6 + NO_3^- \longrightarrow N_2 + CO_2\ H_2O$

Autotrophic: $FeS_2 + NO_3^- + H^+ \longrightarrow N_2 + SO_4 + Fe^{2+}$

$Fe^{2+} + NO_3^- \longrightarrow Fe(OH)_3 + N_2 + H^+$

Modelling strategy



For each region the land use class Agriculture is split into 14 different crop rotations (5 year cycles)

Denmark divided into 6 regions + Sweden + Germany to reflect regional differences

SWAT input	Spatial-temporal resolution
DEM	32 m (1.6 m Lidar)
Soil map	3-layer, 500 m grid
Tile drained areas	500 m grid
Weather: precipitation, temperature, humidity, solar radiation, wind speed	10 km grid (50 km grid), daily
Landuse (Corine + Danish inventory)	1 ha
Management: crops, fertilizer, manure. livestock	Field level / farm level, annual
WWTP, scattered dwellings (Q, N, P)	coordinates

Modelling strategy

- **Division of the drainage basin into regions with separate models**

- **Parameterization and calibration of SWAT in data rich mini catchments**

- **Particular focus on phosphorus cycling and denitrification**

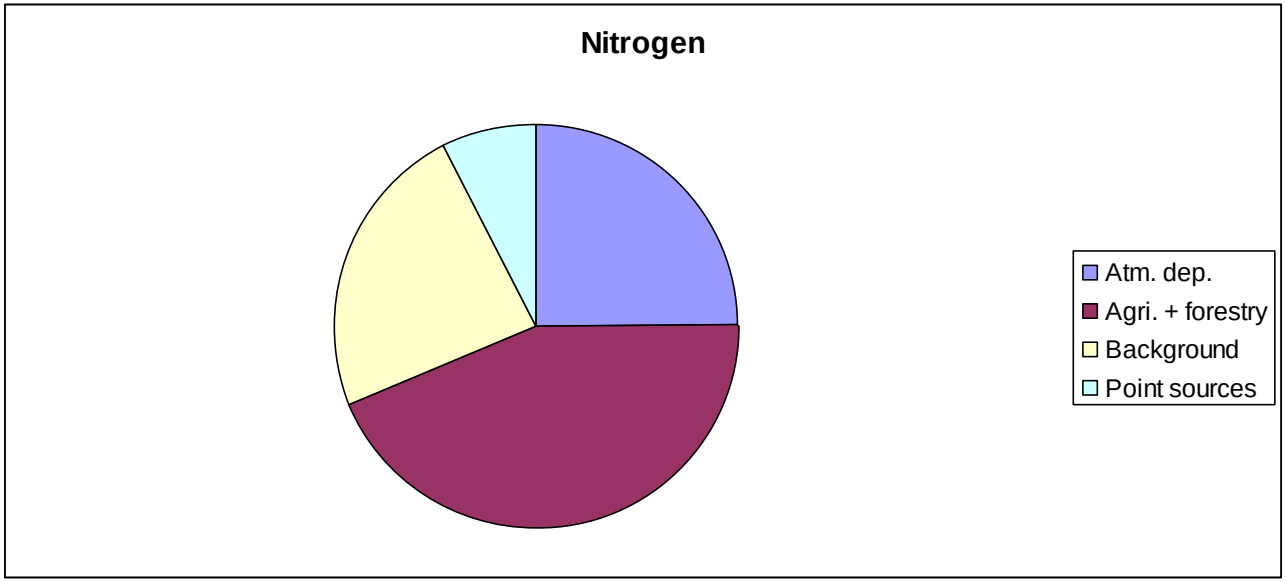
- **Transfer of calibrated parameters to regional models and evaluate model performance for regional monitoring stations.**

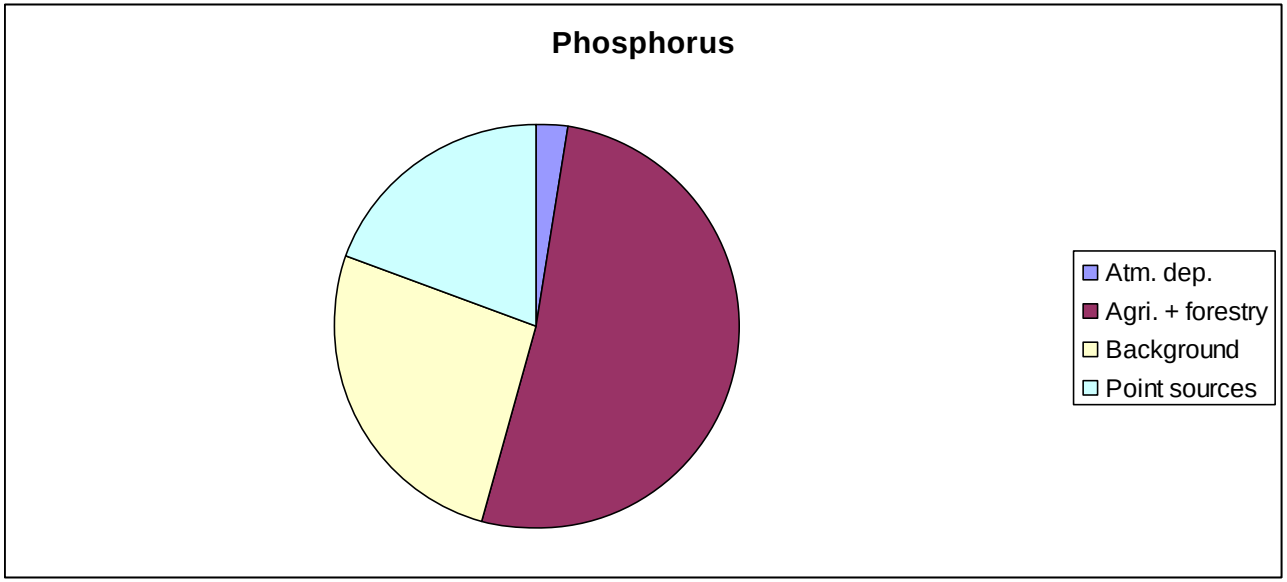
12 p.m. - 1:25 p.m. **SESSION G3 - SENSITIVITY CALIBRATION & UNCERTAINTY**
Building 37 - Room 0.10

Moderator: Brett Watson
University of Saskatchewan, Canada

12:00 - 12:20 p.m.	Jiwon Lee	*Analysis of Effects on Validation of Spatiotemporal Changes in Cropping at Agriculture-dominant Watershed*
12:20 - 12:40 p.m.	Maria Ermitas Rial Rivas	*Calibration and Sensitivity Analysis of SWAT for a Small Forested Catchment, North-Central Portugal*
12:40 - 1:00 p.m.	Felix Witing, Martin Volk	*Comparing Different Model Calibration Strategies for Improved Representation of Landscape Conditions in SWAT at the Example of a Large Heterogeneous Catchment*
1:00 - 1:20 p.m.	Shenglan Lu	*Multi-objective Calibration on Flow and Sediment on a Small Danish Catchment*
1:20 - 1:25 p.m.	*Discussion & Wrap Up*	

Monitoring data	Spatial-temporal resolution
Discharge	Daily, +200 stations
Suspended sediment concentration	+ 5 times/year, +200 stations
TN, NO_3 concentration	2 – 4 weeks, +200 stations
TP (unfilt.), PO_4 (filt.) concentration	2 – 4 weeks, +200 stations
Crop yields	Regional stat., annual


Nitrogen
Atm. dep.
Agri. + forestry
Background
Point sources


Phosphorus
Atm. dep.
Agri. + forestry
Background
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