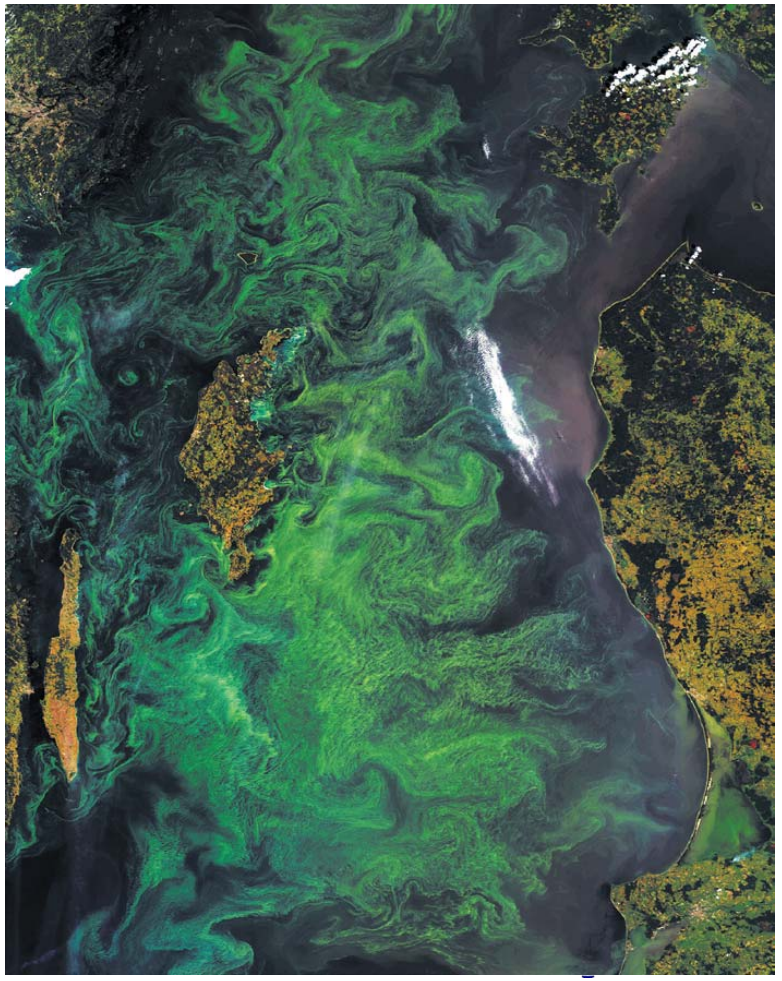
Linking terrestrial and marine ecosystems:

Holocene land-cover changes and their effect on terrestrial carbon pools and coastal ecosystems along the Swedish Baltic coast

ANNELI POSKA, ANNE BIRGITTE NIELSEN, SVANTE BJÖRK, ANNA BROSTRÖM, HELENA L. FILIPSSON, ANUPAM GHOSH, WENXIN NING,CRISTINA ÅKESSON AND DANIEL CONLEY

Background

- On average 60 000 km^2 of the Baltic Sea is affected by hypoxia each year
  - Kills sea-floor organisms
  - Fish like Cod declining
  - Changes elements cycles
- Climate warming is likely to exacerbate matters



Conley, 2012

Background

Area of the Baltic Sea: 415 300 km^2

Area of the catchment: 2 130 000 km^2

Nutrient input from catchment:

Carbon (ton/year): 3 260 000

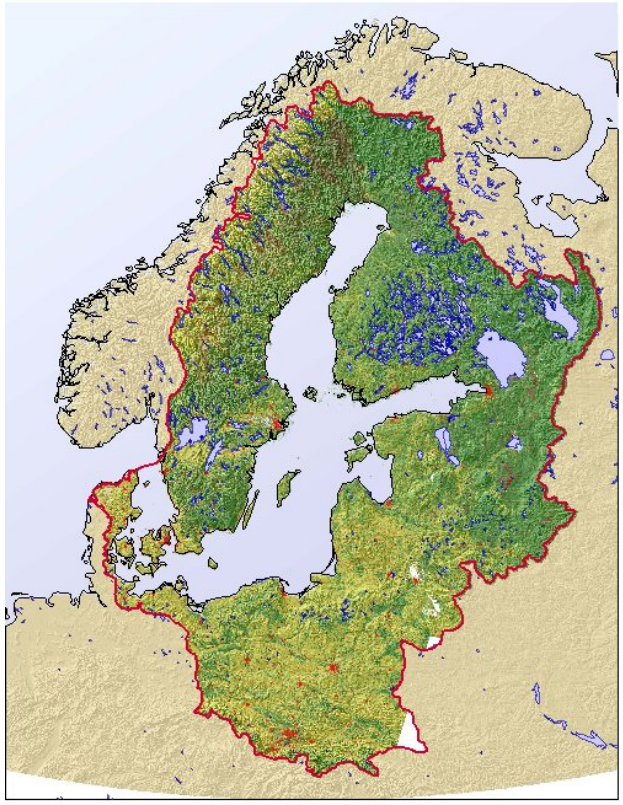
(calculated based on average DOC export of 2.5 g/m^2)

Nitrogen (ton/year): 163 000

(calculation based on C:N ratio 20 for DOC)

Phosporus (ton/year): 16 300

(calculation based on C:P ratio 200 for DOC)



H. Ahlenius,
UNEP/GRID-Arendal

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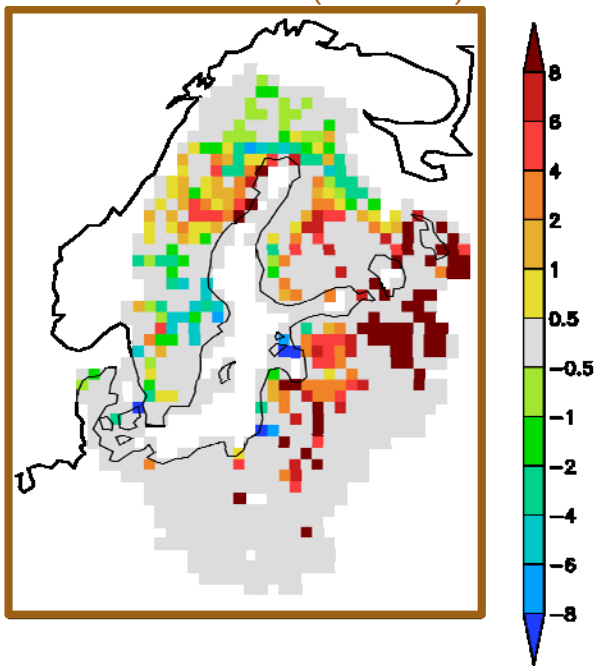
Dissolved Organic Carbon (DOC)

Change in DOC(1980/2000)



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nto the Baltic Sea

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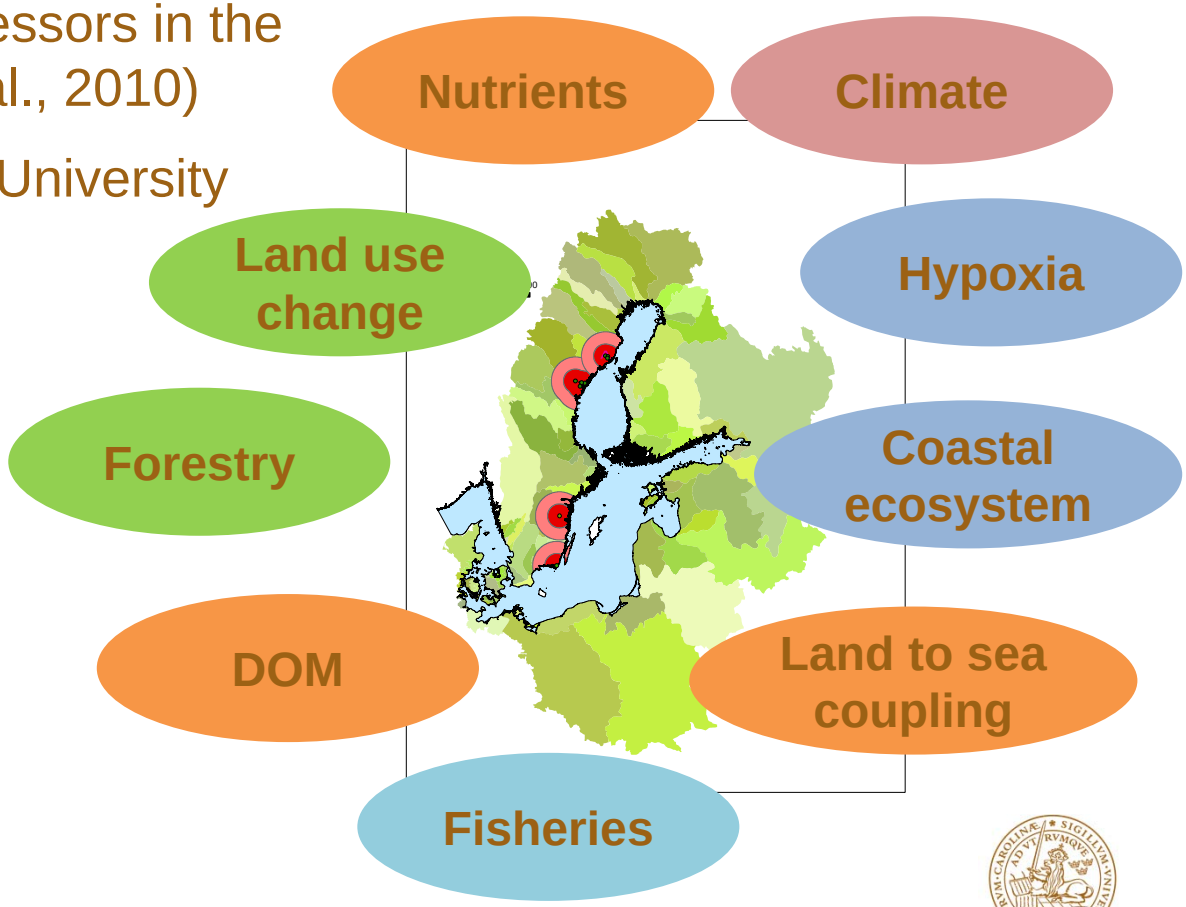
The Multistressors project

- Managing Multiple Stressors in the Baltic Sea (Conley et al., 2010)
- 5 year project at Lund University
- Ca. 20 participants
- Millennial time scale
- 4 target areas



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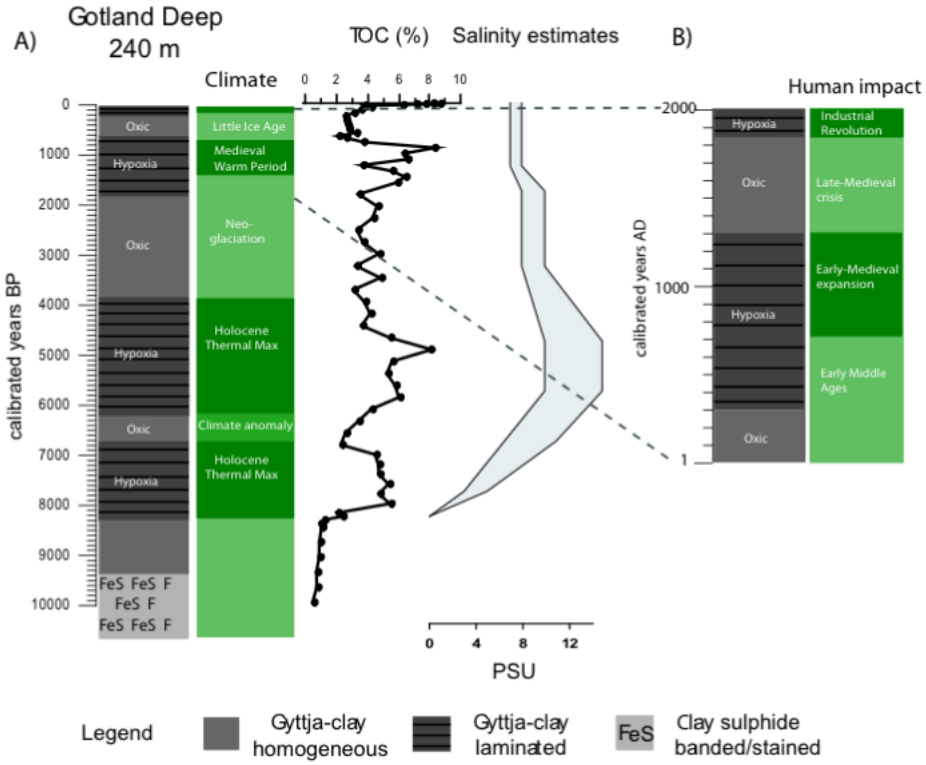
The Multistressors project

Hypothesis: Periods of hypoxia in the Baltic Sea are related to warm climate.

BUT: Over the last 2000 years they may be caused by human impact

To disentangle forcing mechanisms, we are:

- Studying long term dynamics of the marine and terrestrial ecosystems in coastal areas
- Quantifying anthropogenic land-cover change
- Estimating the effect of climate and land-use dynamics on terrestrial carbon pools and fluxes



Zillén & Conley, 2010, Biogeosciences

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The Multistressors project:

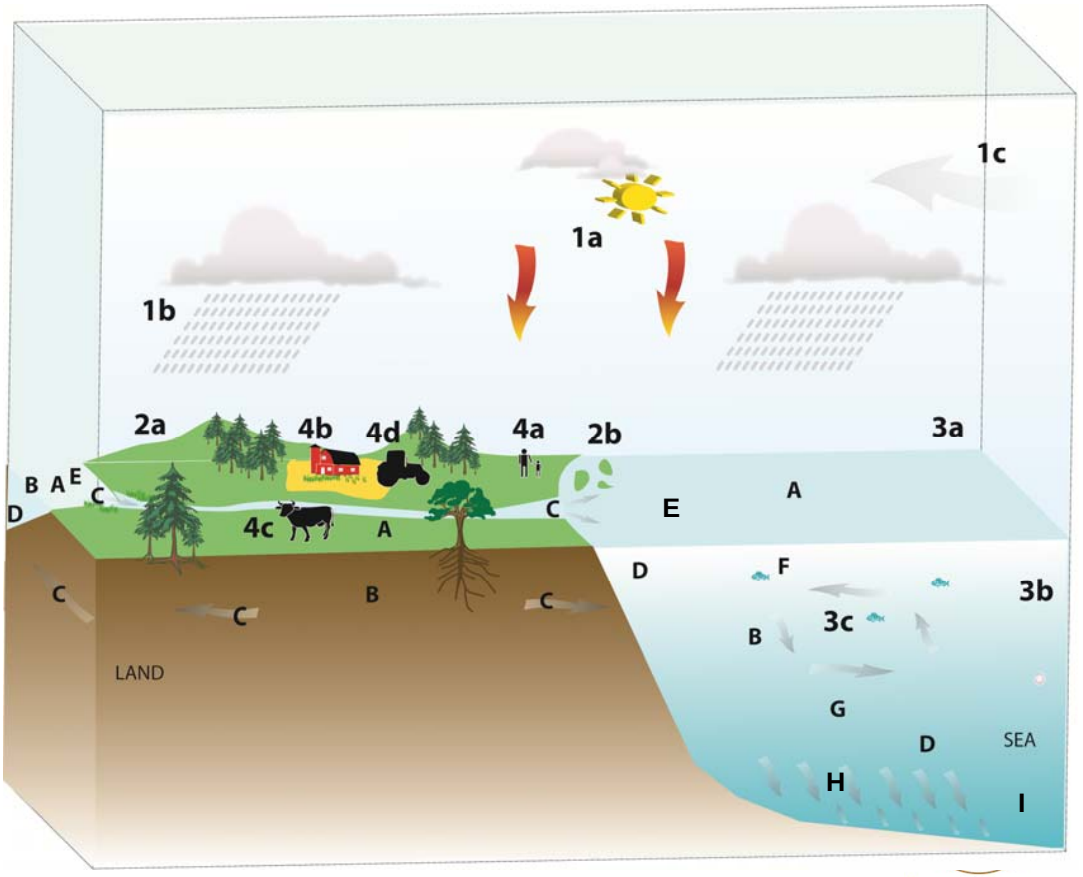
Main drivers, processes and resulting states

Natural drivers: Climatic (1a- temperature, 1b- precipitation, 1c- wind); **Terrestrial** (2a- land-cover, 2b- neotectonic land uplift); **Marine** (3a- sea-level, 3b- salinity, 3c- circulation).

Anthropogenic drivers: (4a- population, 4b- land-use, 4c- fertilization, 4d- technology).

Processes: A- primary production, B- decomposition, C- DOC production and transport, D- sedimentation, E- eutrophication, F- evaporation/transpiration.

States: G- eutrophia, H- hypoxia, I- reduced conditions (phosphate release).



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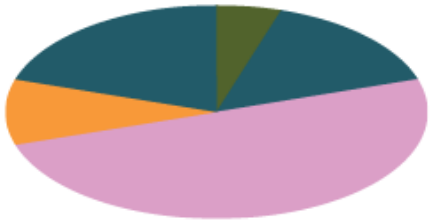
Landcover modelling

Major input: Pollen data %

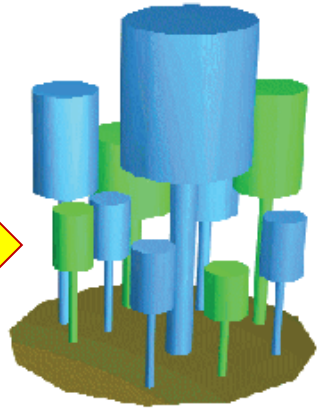
Climate, soil, plant properties



Model: REVEALS

LPJ-GUESS

Land use



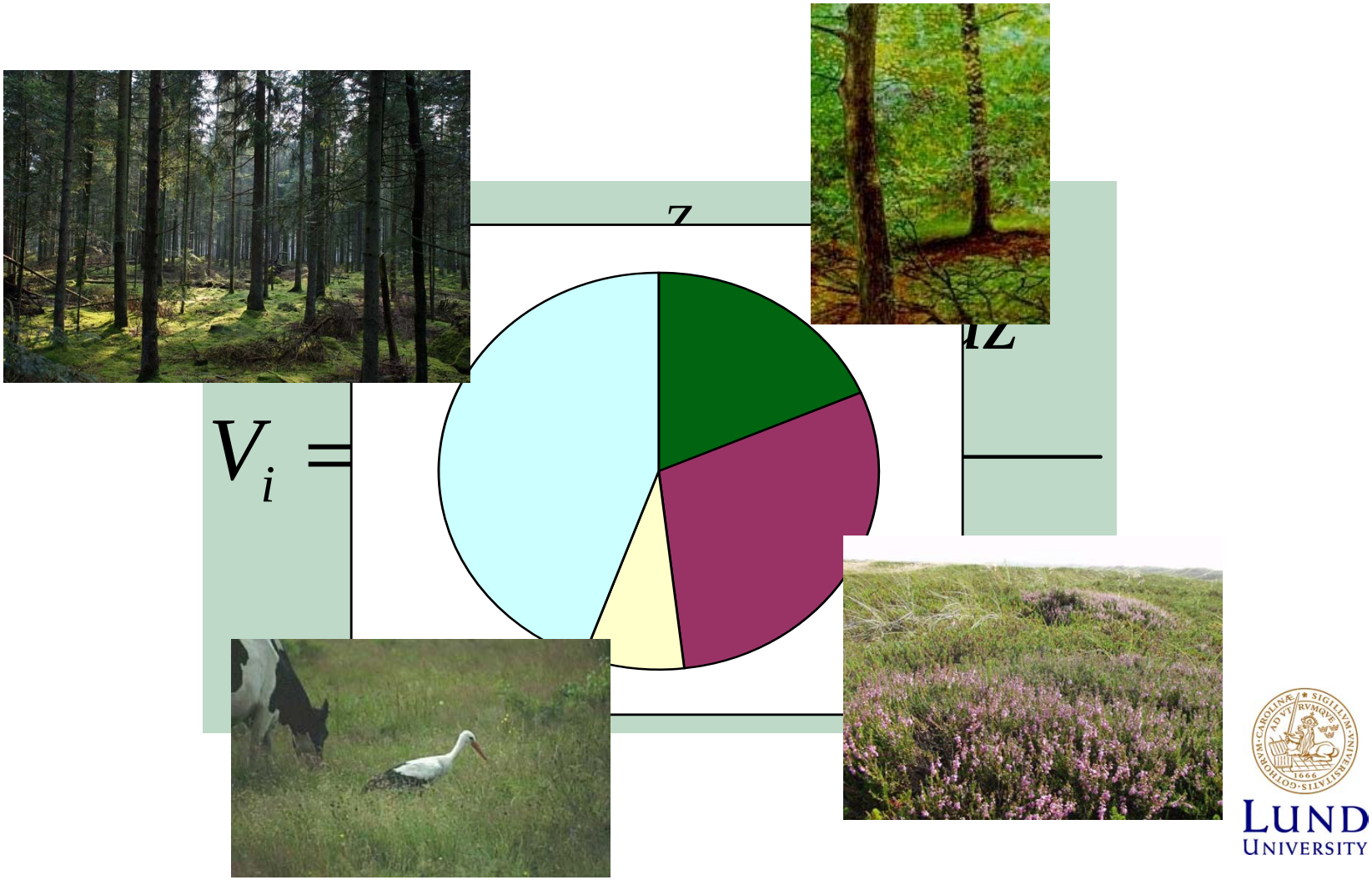
Output: Past vegetation cover %

Potential natural vegetation, Carbon pools and fluxes etc...

Spatial scale: 50-100 km radius

0.5° * 0.5° grid cell

Pollen based land cover reconstructions
REVEALS



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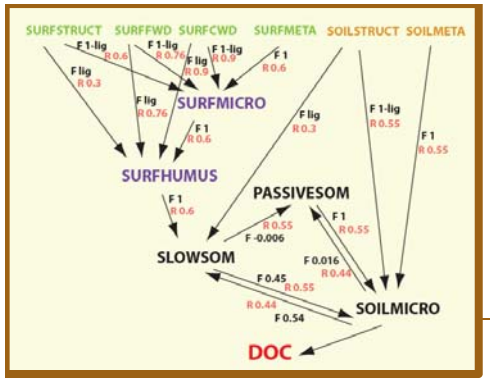


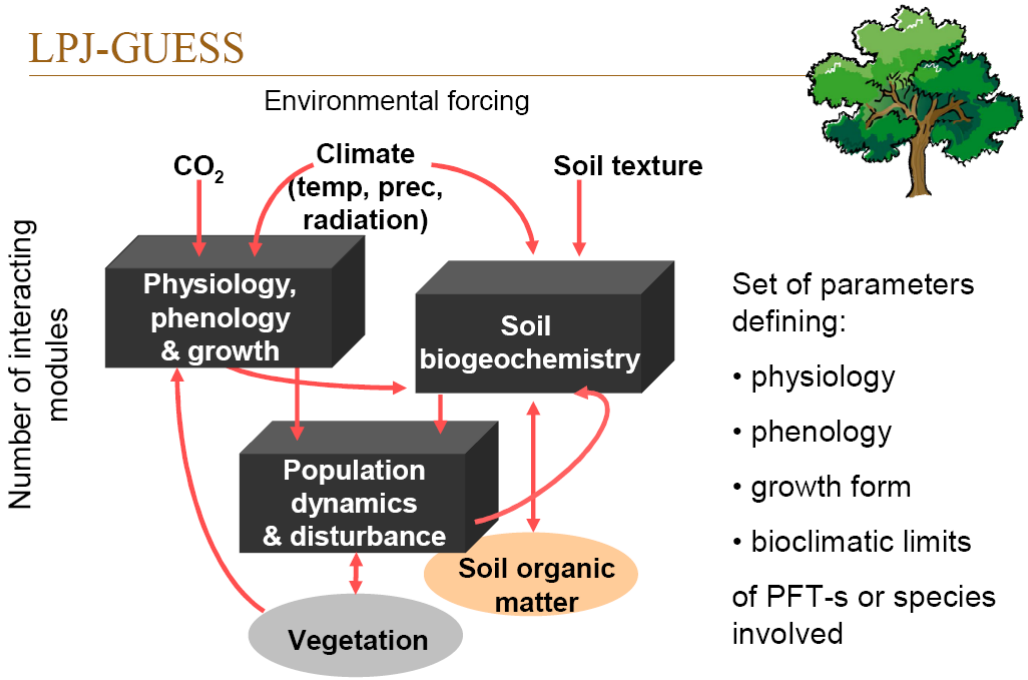
Estimating Carbon pools and fluxes: LPJ-GUESS

LPJ-GUESS is a dynamic ecosystem model

Besides directly vegetation related parameters various pools and fluxes connected with vegetation, litter and soil dynamics are estimated.

Anthropogenic forcing can be included to study effects of land use on:

- Land cover
- Terrestrial carbon pools
- DOC (dissolved organic carbon) export into aquatic systems



Smith et al 2001, Global Ecol. and Biogeogr.

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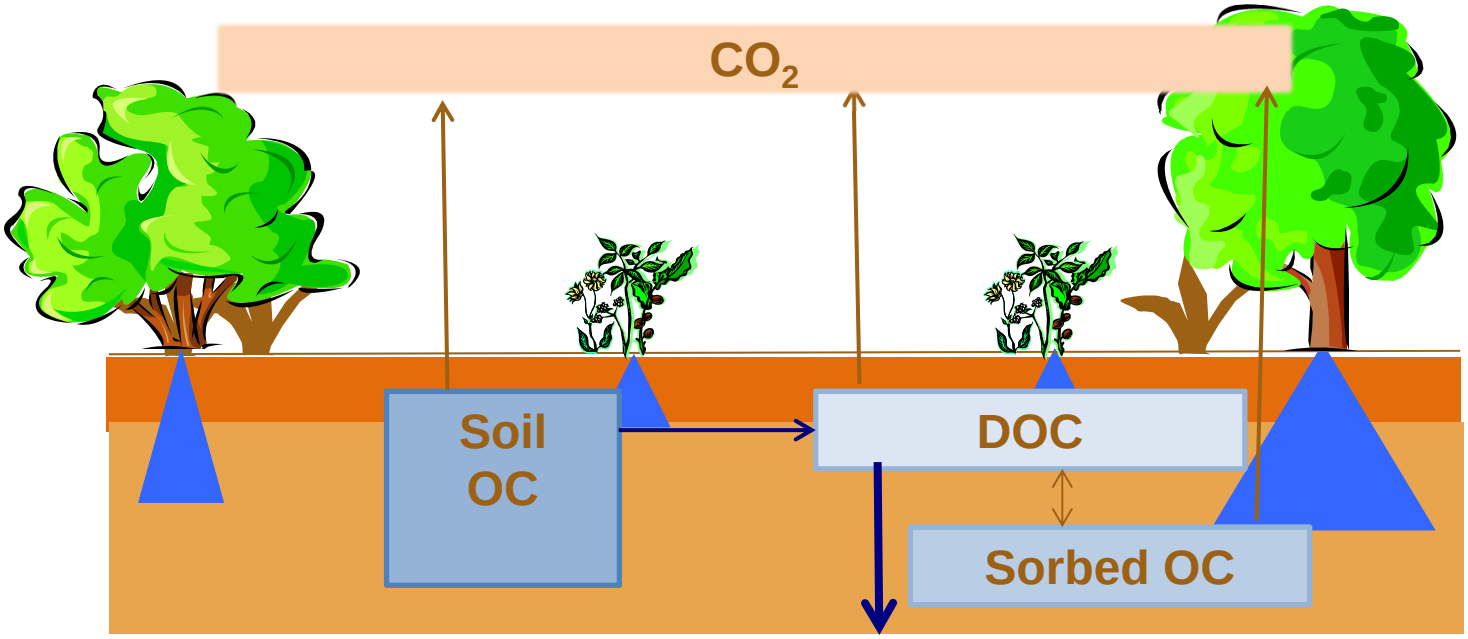
LPJ-GUESS DOC - production



DOC = microbial_Cdec*(1 – (k_1- runoff / k_1)) * (k_2 + k_3 * clay_fr.));

DOC export is a function of the decay rate for active SOM and the clay content of the soil (less loss for clay soils) and occurs if there is runoff (leaching loss increases with increasing water flow up to a critical level determined by fixed parameters k_{1-3} .

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Model and simulation setup

LPJ-GUESS Nitrogen-cycle model accounting for three land cover types (CROPLAND, PASTURE and NATURAL)

- Centennial climate forcing from Echam 5 with dynamical downscaling based on CRU 1901-1930
- Dynamic Holocene CO_2
- Modern soil texture data from CRU
- Runs with and without prescribed land use data (ALCC model KK10 and REVEALS)

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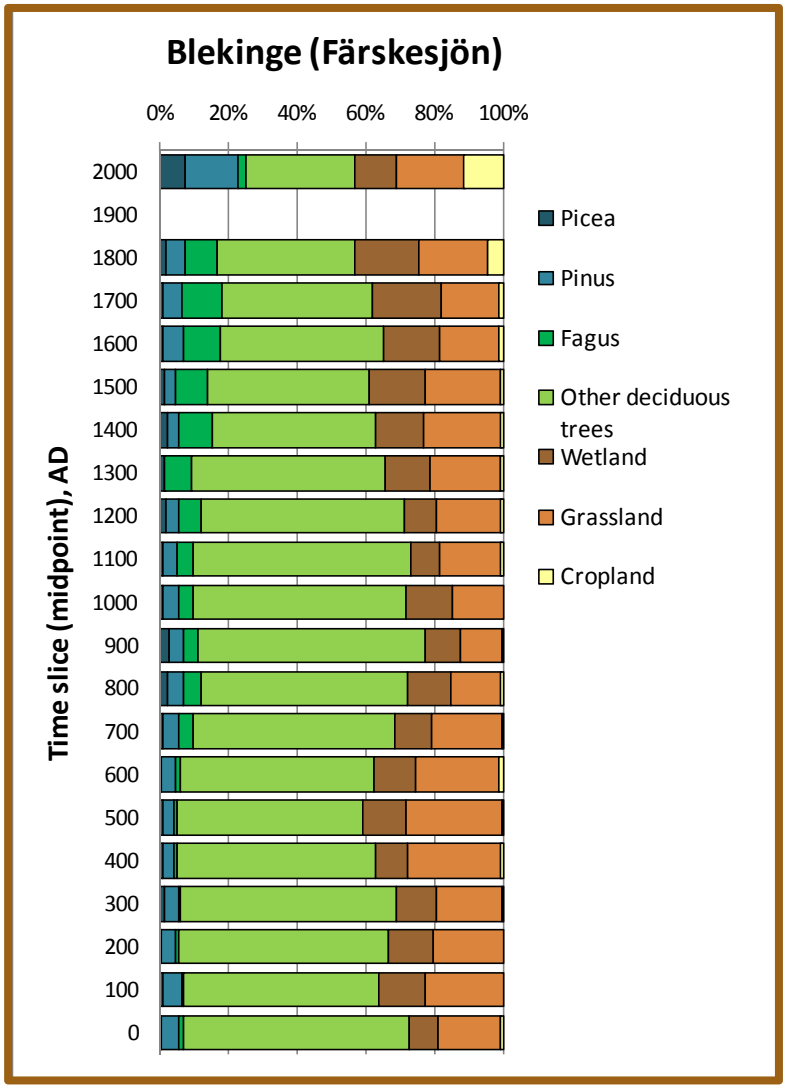
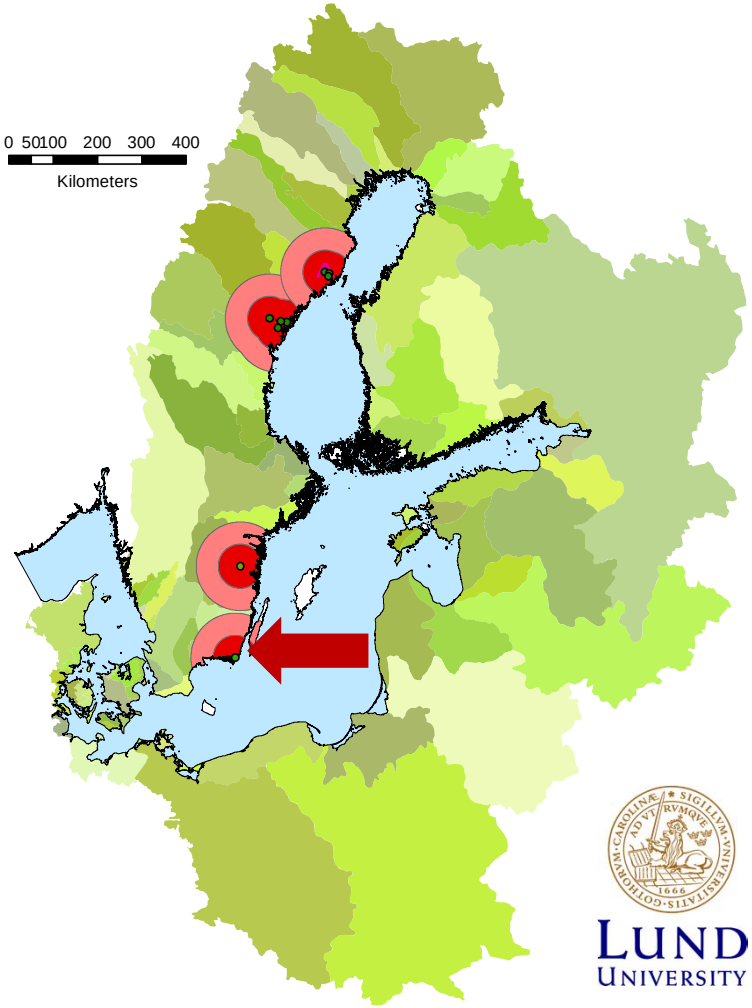
Reconstructed land-cover/land-use change





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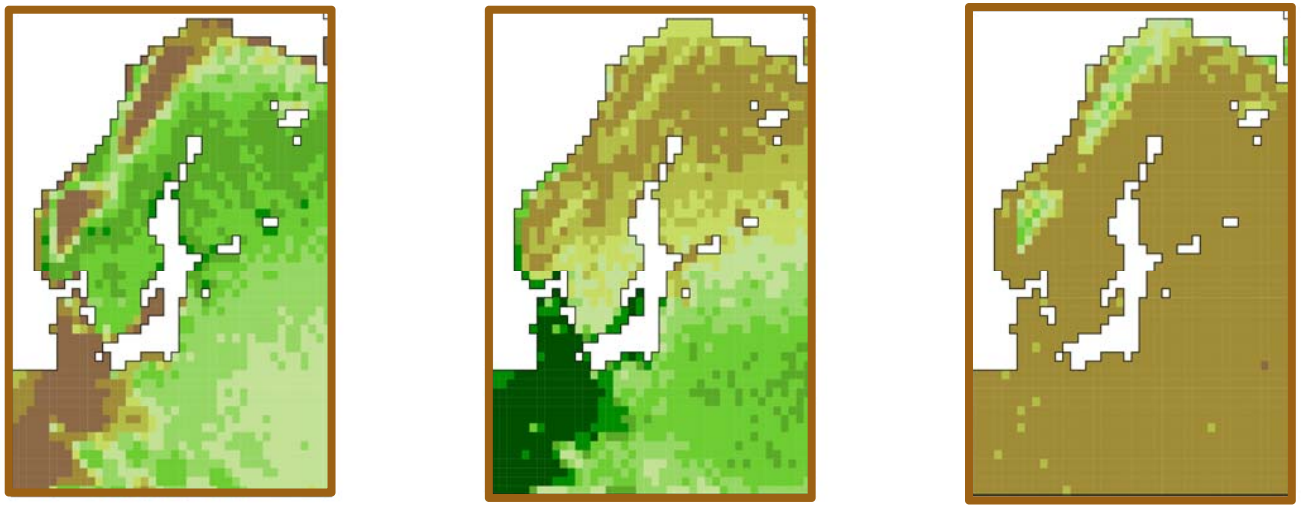
Potential natural vegetation (LAI m^2/m^2)

coniferous trees **broadleaved trees** **grasses**



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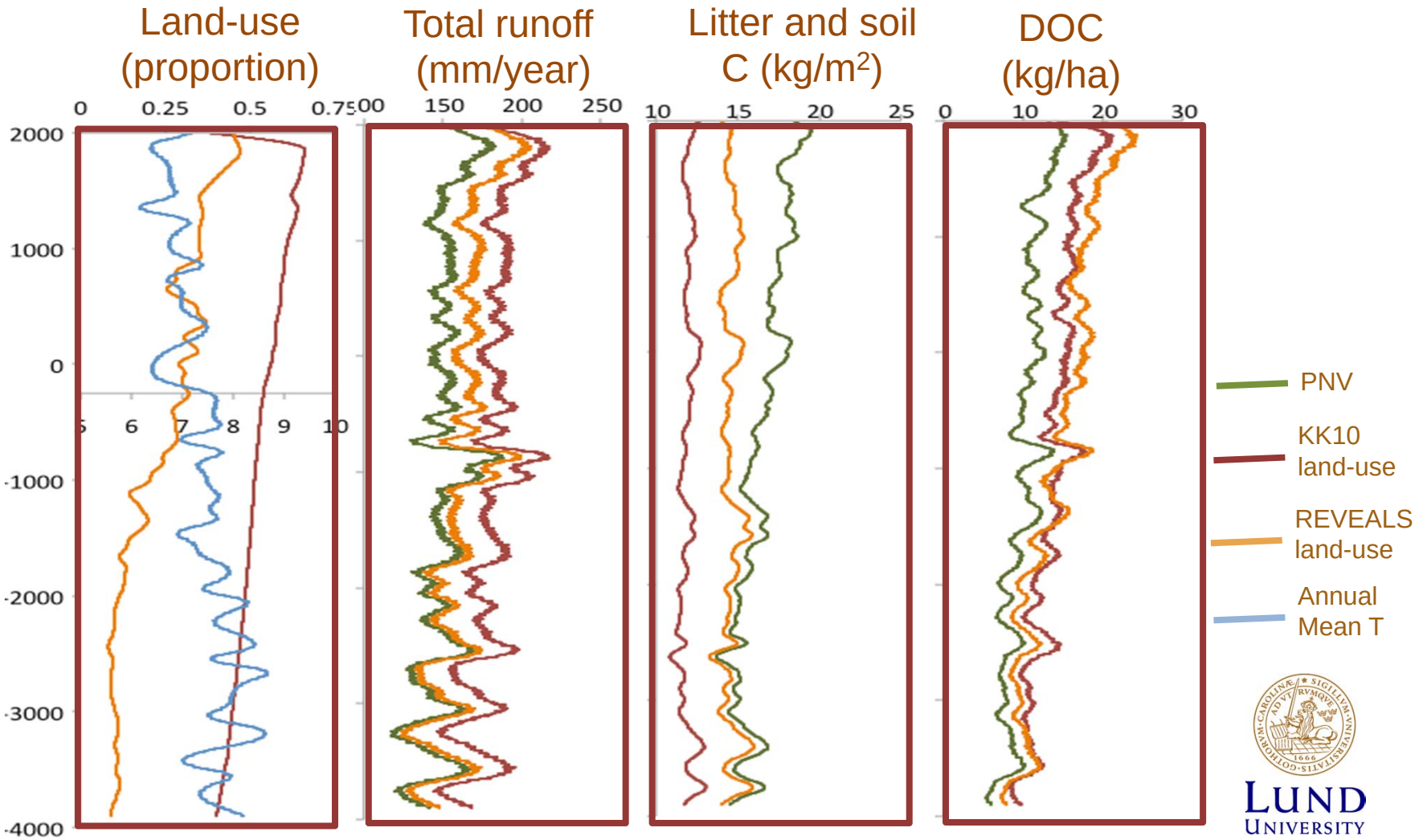
Preliminary results: DOC modelling



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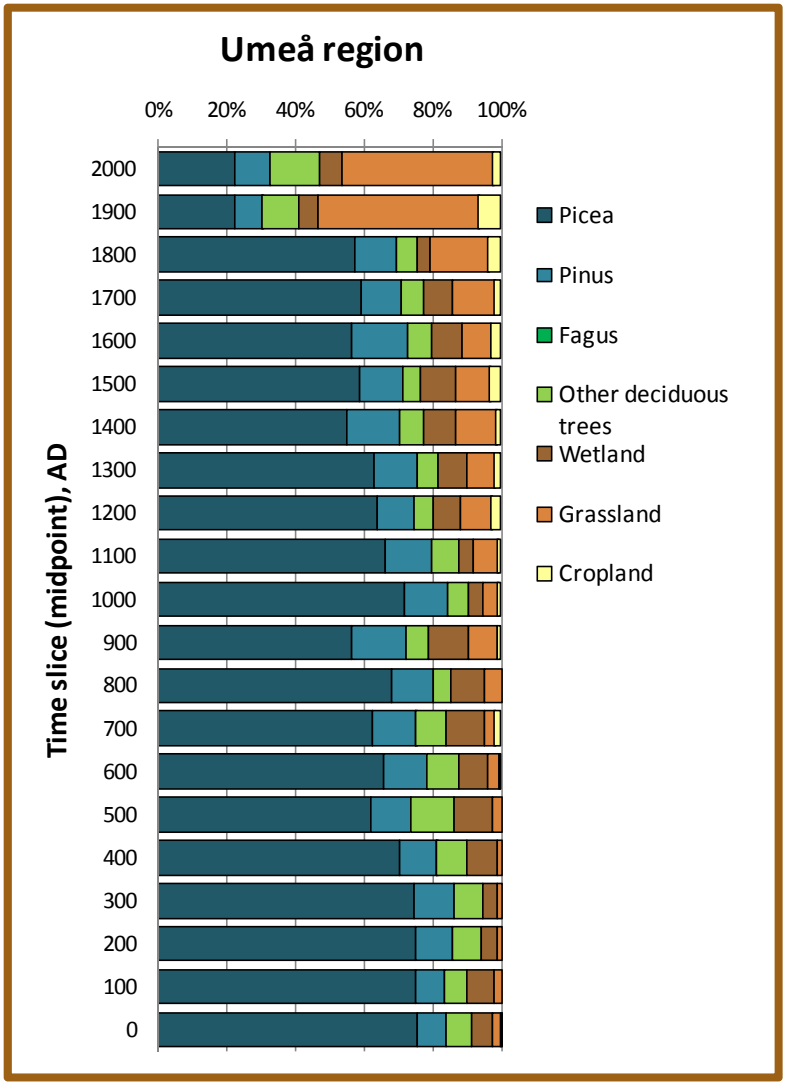

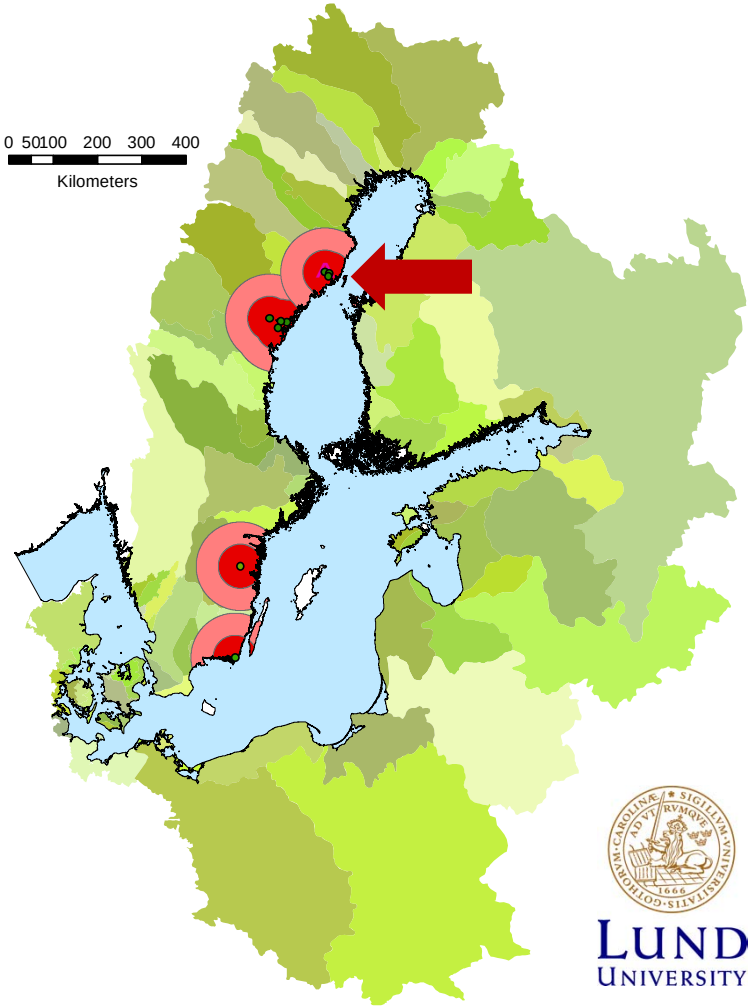

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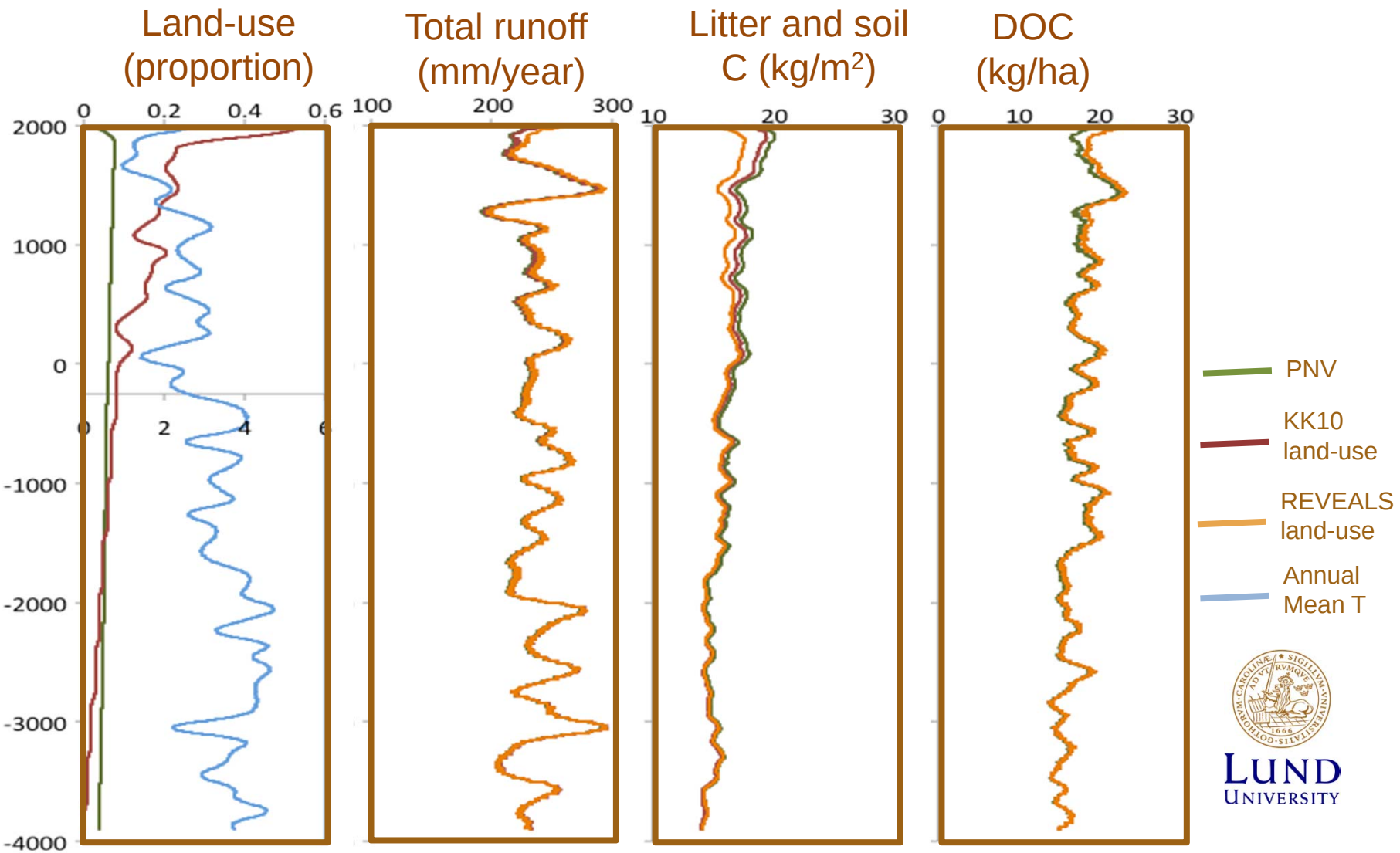

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Conclusions

- The timing and extent of human impact on the landscape differs widely between focus areas, being earlier and stronger in the south.
- Some areas show decreased land use during the late medieval crisis, which may be related to the period of improved oxygen conditions.
  - However, forest recovery does not occur everywhere in Sweden, and is of relatively short duriation
  - Further studies of coastal cores will allow us to determine the effect on regional scale

But: Other factors, like salinity changes, land uplift and climate, may be more important for most of the marine organisms studied at this site

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Conclusions

- Dynamic simulation of DOC fluxes can help to understand the changes terrestrial carbon input to aquatic systems.
- Both climate (temperature and precipitations) and land-cover have a direct influence on DOC production.
- Climate model derived environmental forcing can diverge from past actual climates and lead to discrepancies between modelling results and observed changes.
- Export from peat-lands and processes during river transport were not accounted for, but could play a significant role in DOC production and export.

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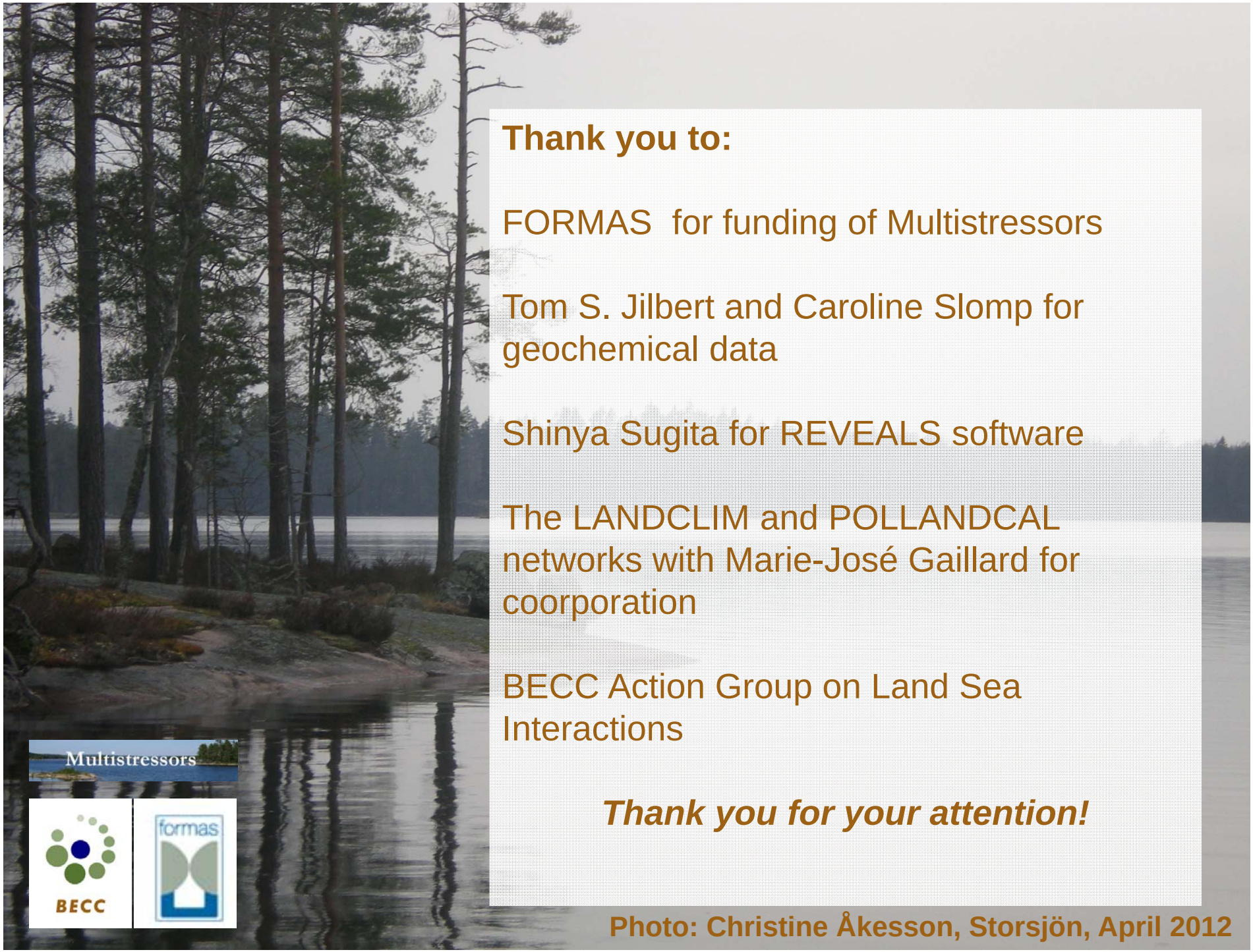

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BECC Action Group on Land Sea Interactions

Thank you for your attention!

Photo: Christine Åkesson, Storsjön, April 2012