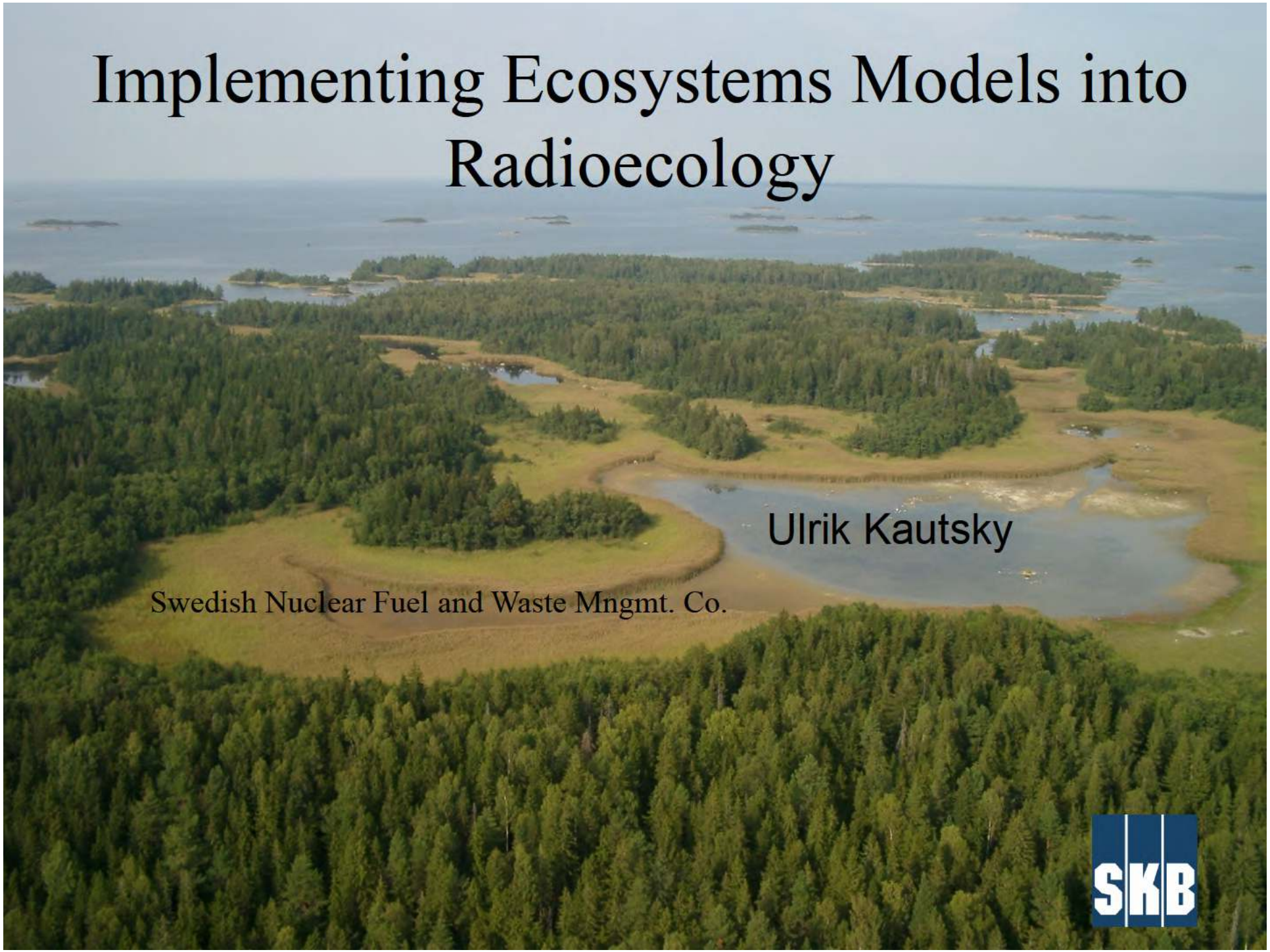
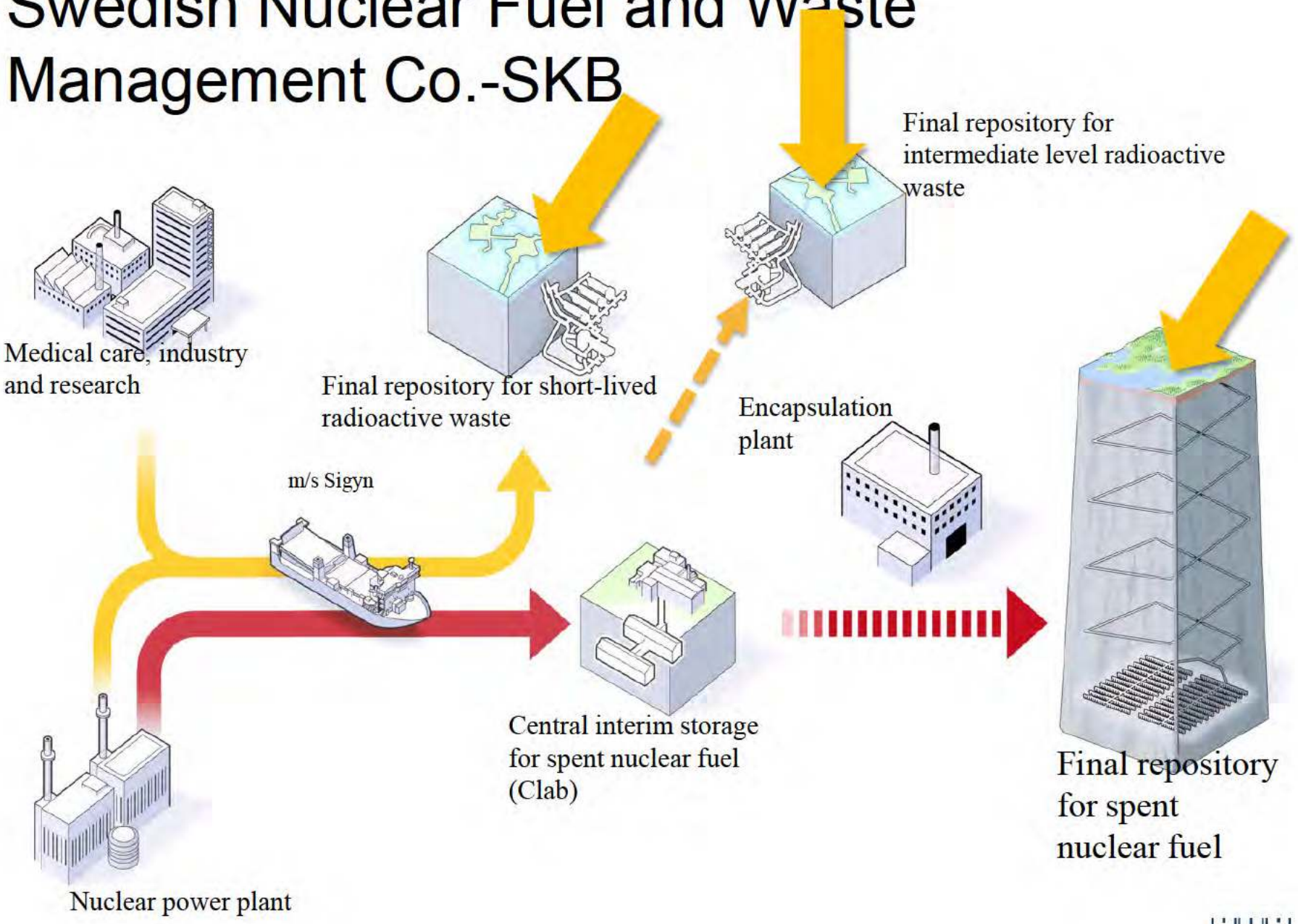
Implementing Ecosystems Models into Radioecology

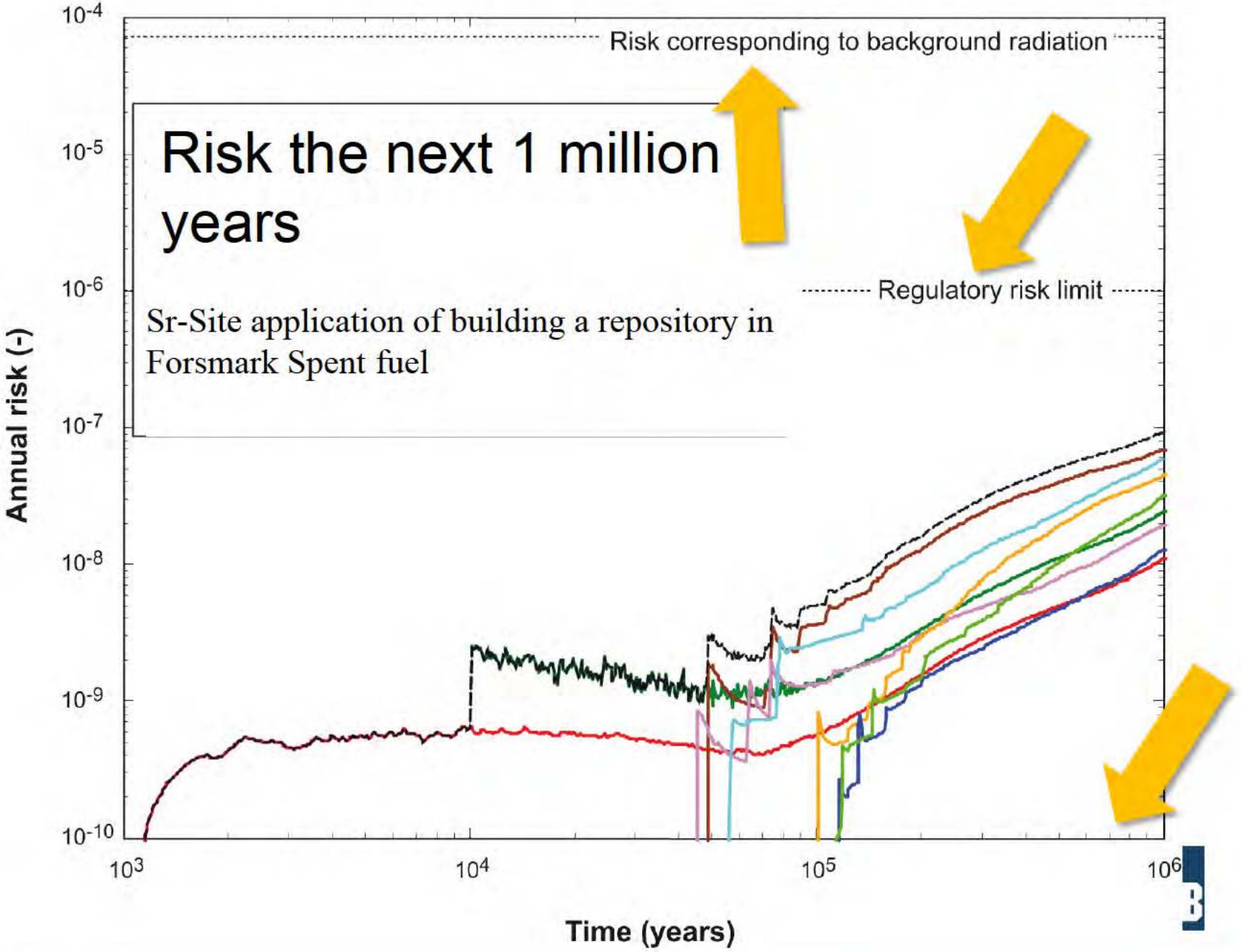


Ulrik Kautsky

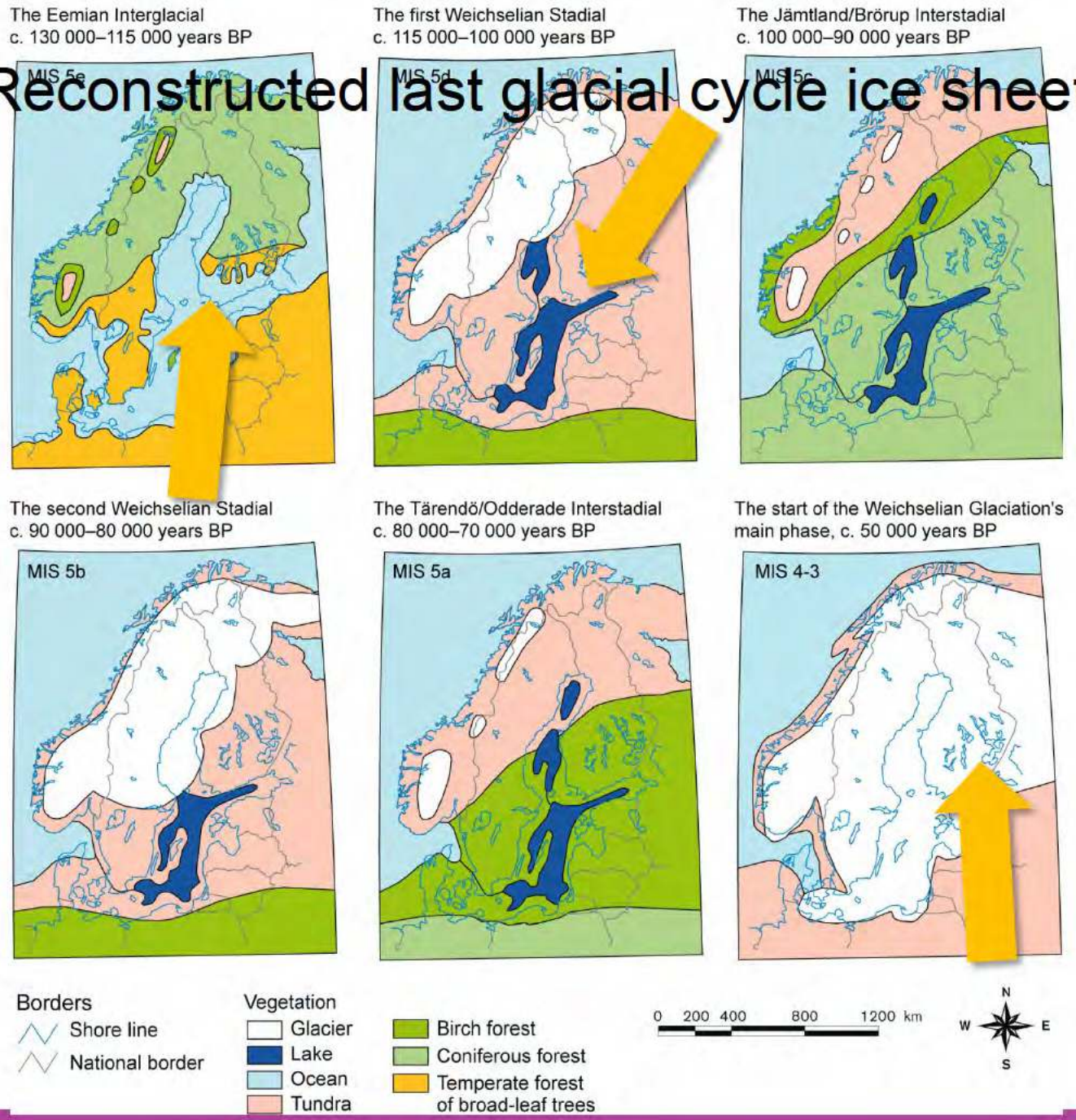
Swedish Nuclear Fuel and Waste Mngmt. Co.

Swedish Nuclear Fuel and Waste Management Co.-SKB

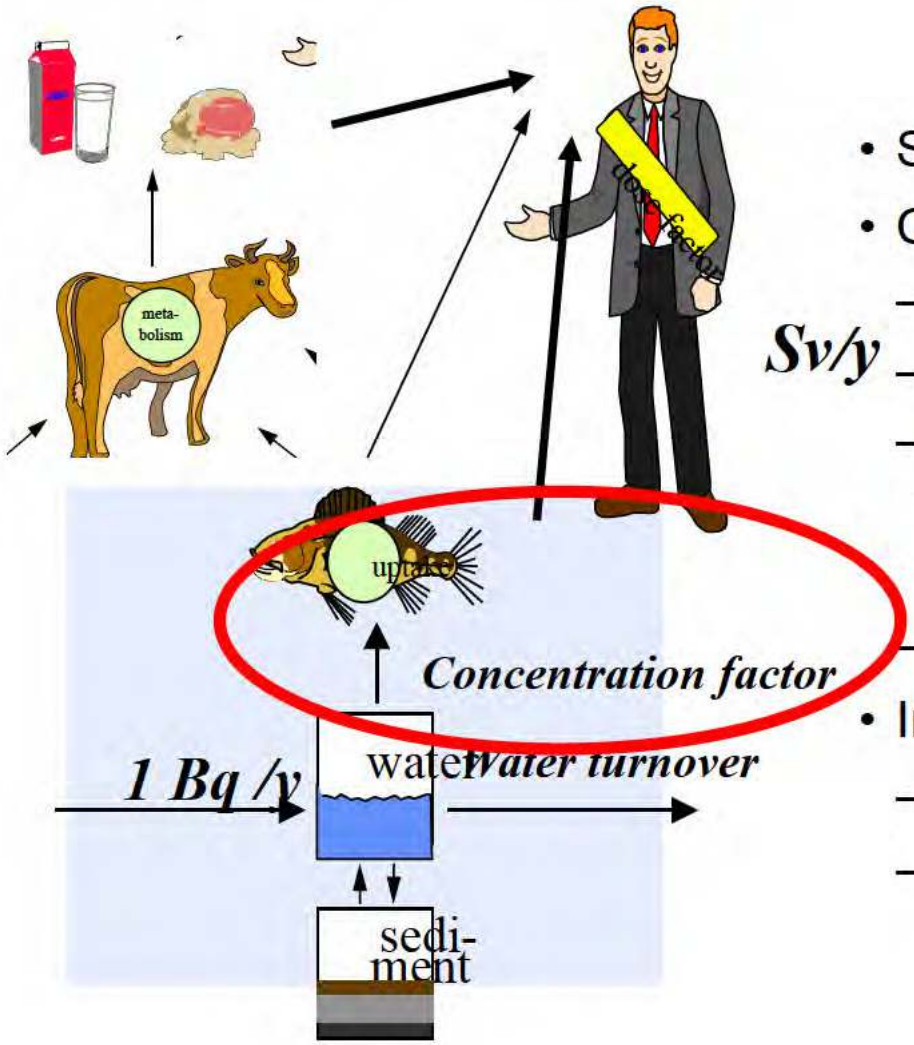



Risk the next 1 million years
Sr-Site application of building a repository in Forsmark Spent fuel
Risk corresponding to background radiation
Regulatory risk limit
Annual risk (-)
Time (years)
10-4
10-5
10-6
10-7
10-8
10-9
10-10
10^3
10^4
10^5
10^6

Reconstructed last glacial cycle ice sheet



Modelling concentration



- Simple model
- Concentration factor
  - Several orders of variation
  - Not scaleable
  - No inference from one element to another, radionuclide and non radionuclide specific variation mixed
  - Conceptual misleading
- Improve database
  - Future conditions?
  - New radionuclides?

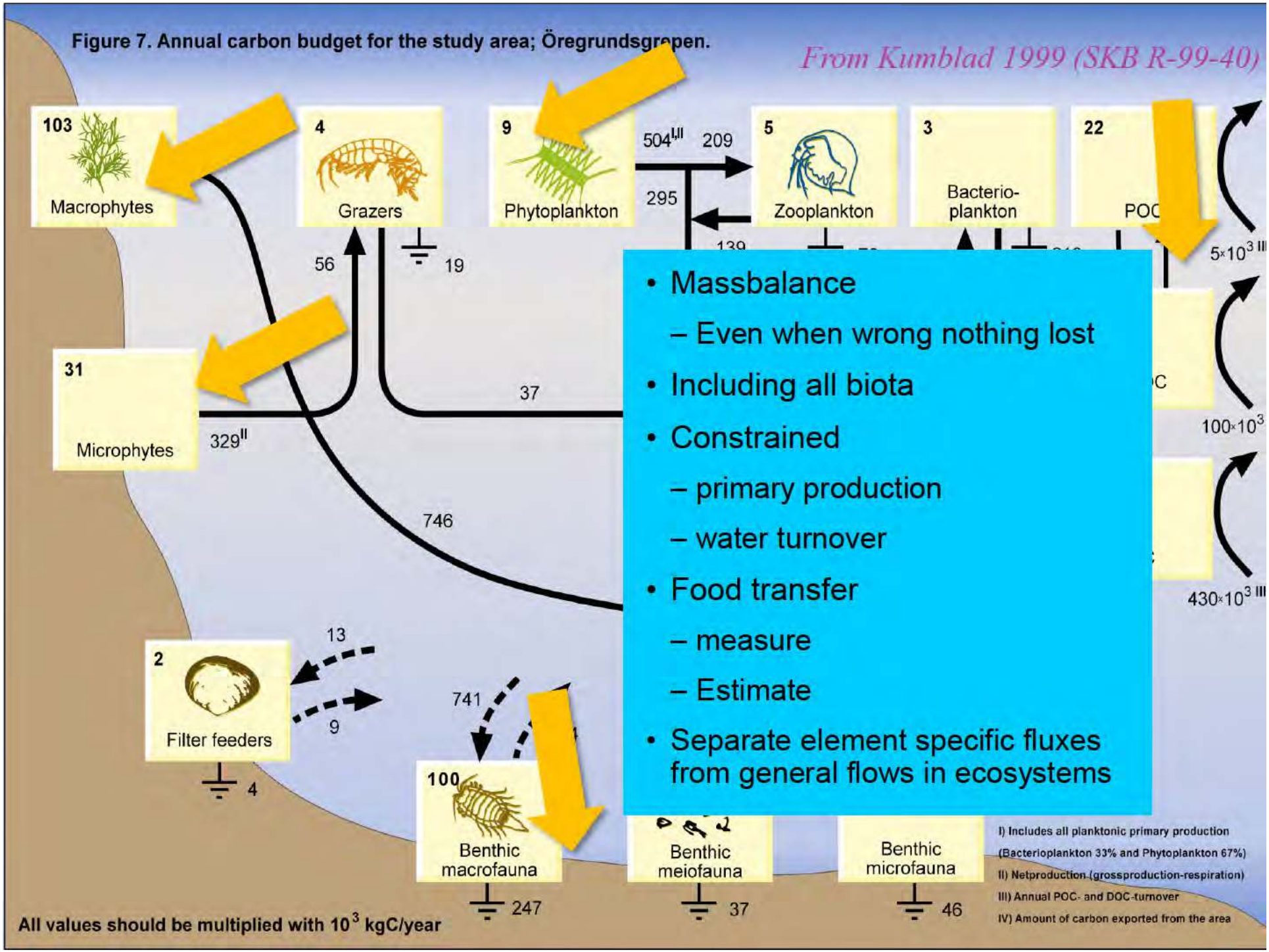
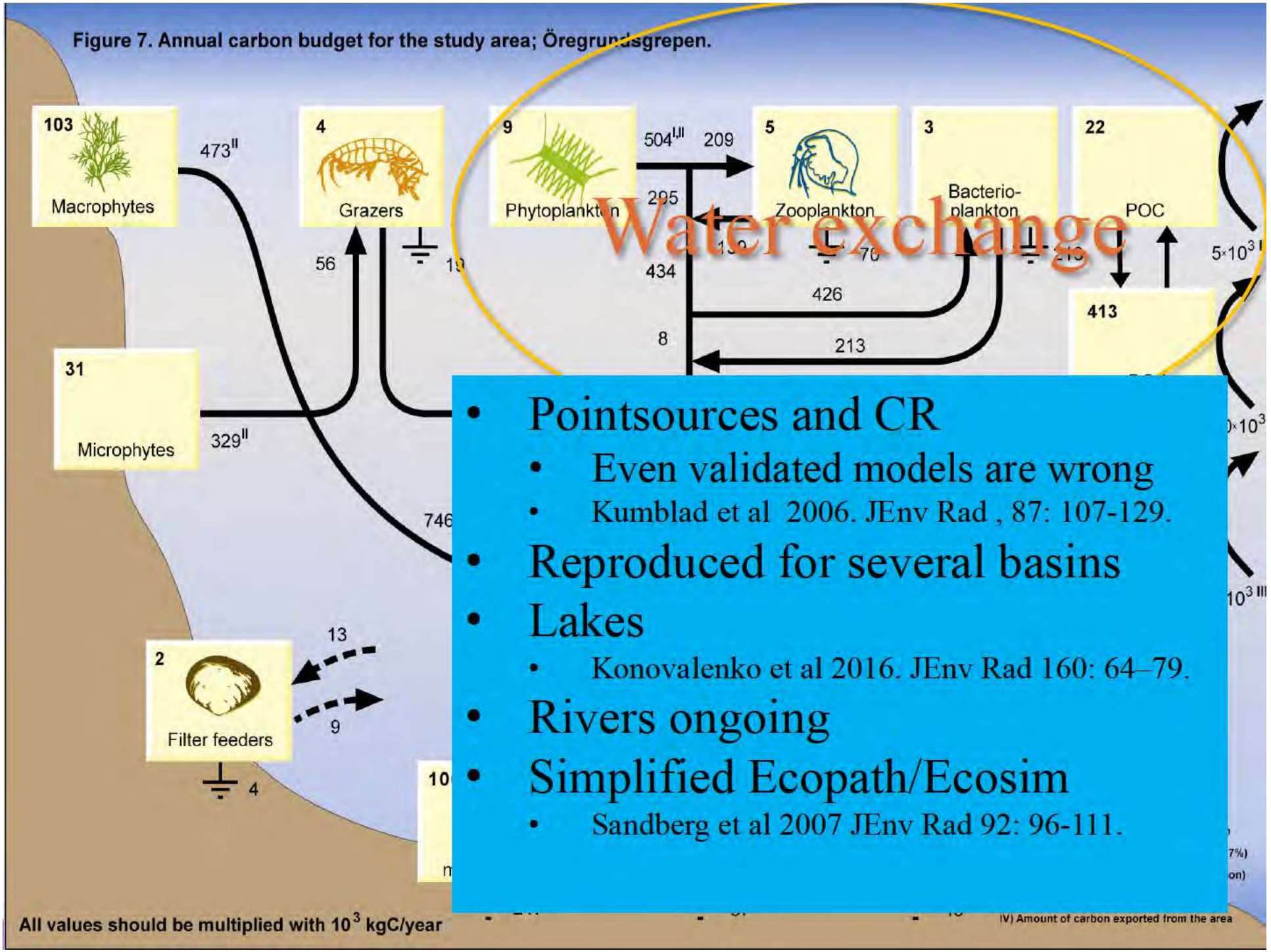
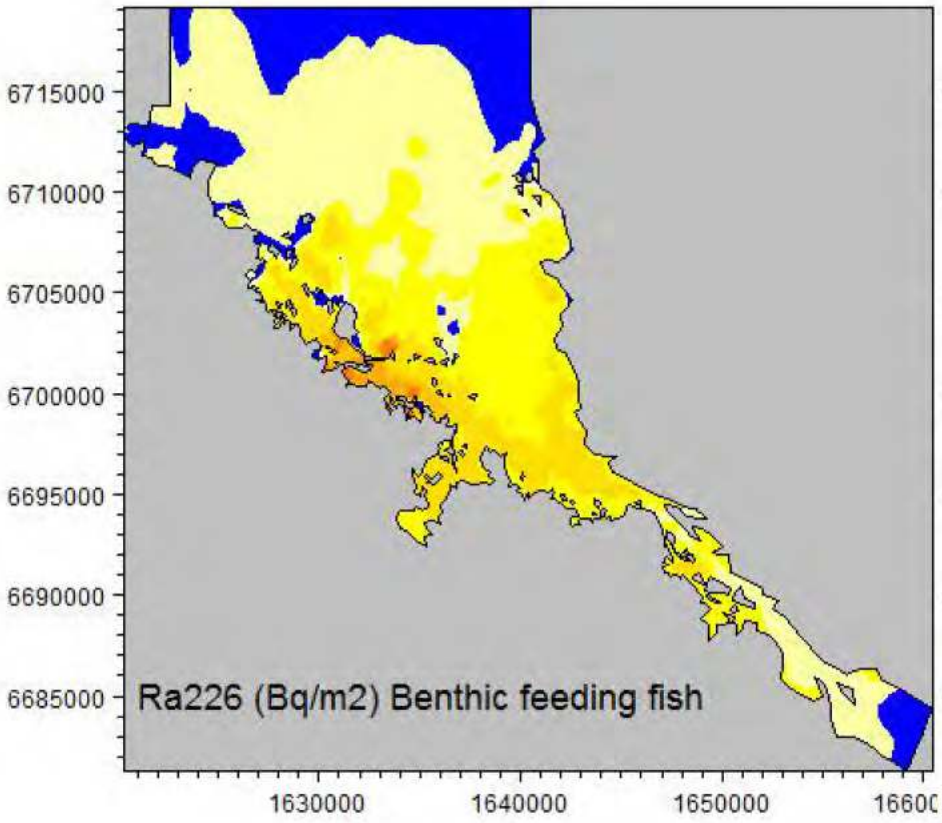


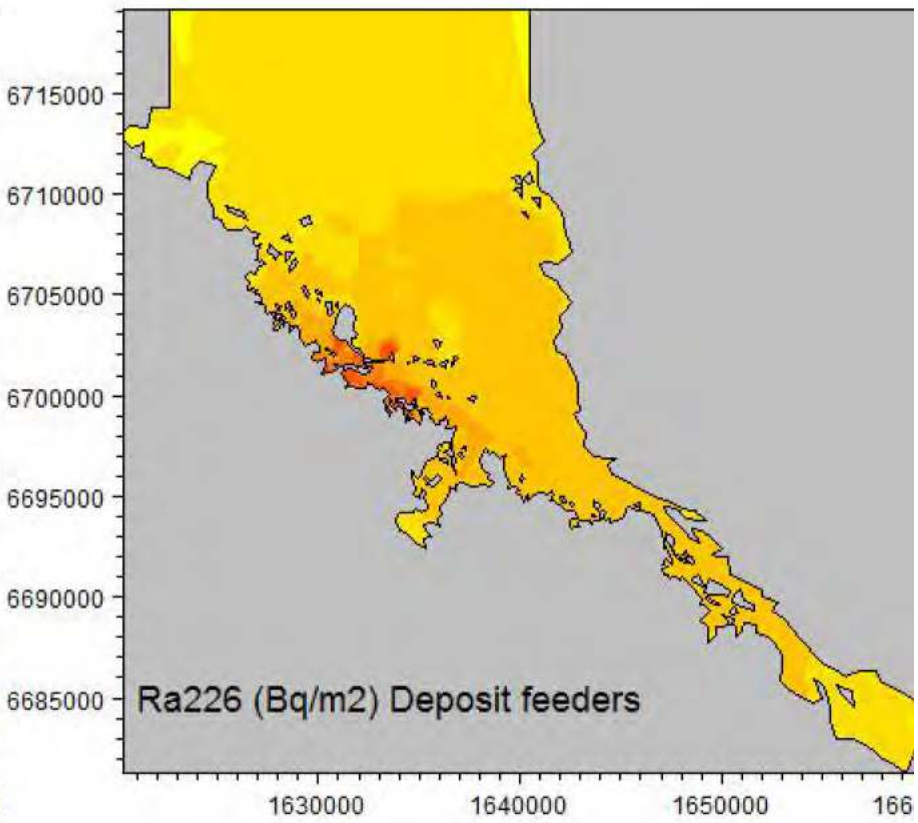
Figure 7. Annual carbon budget for the study area; Öregrundsgrepen.
From Kumblad 1999 (SKB R-99-40)
103
Macrophytes
4
Grazers
9
Phytoplankton
504I,II
209
295
5
Zooplankton
3
Bacterio-
plankton
22
POC
5×10³ III
56
19
139
31
Microphytes
329II
37
746
100×10³
430×10³ III
13
9
2
Filter feeders
4
741
100
Benthic
macrofauna
247
Benthic
meiofauna
37
Benthic
microfauna
46
• Massbalance
– Even when wrong nothing lost
• Including all biota
• Constrained
– primary production
– water turnover
• Food transfer
– measure
– Estimate
• Separate element specific fluxes from general flows in ecosystems
I) Includes all planktonic primary production (Bacterioplankton 33% and Phytoplankton 67%)
II) Netproduction (grossproduction-respiration)
III) Annual POC- and DOC-turnover
IV) Amount of carbon exported from the area
All values should be multiplied with 10³ kgC/year



- Pointsources and CR
  - Even validated models are wrong
  - Kumblad et al 2006. JEnv Rad , 87: 107-129.
- Reproduced for several basins
- Lakes
  - Konovalenko et al 2016. JEnv Rad 160: 64–79.
- Rivers ongoing
- Simplified Ecopath/Ecosim
  - Sandberg et al 2007 JEnv Rad 92: 96-111.

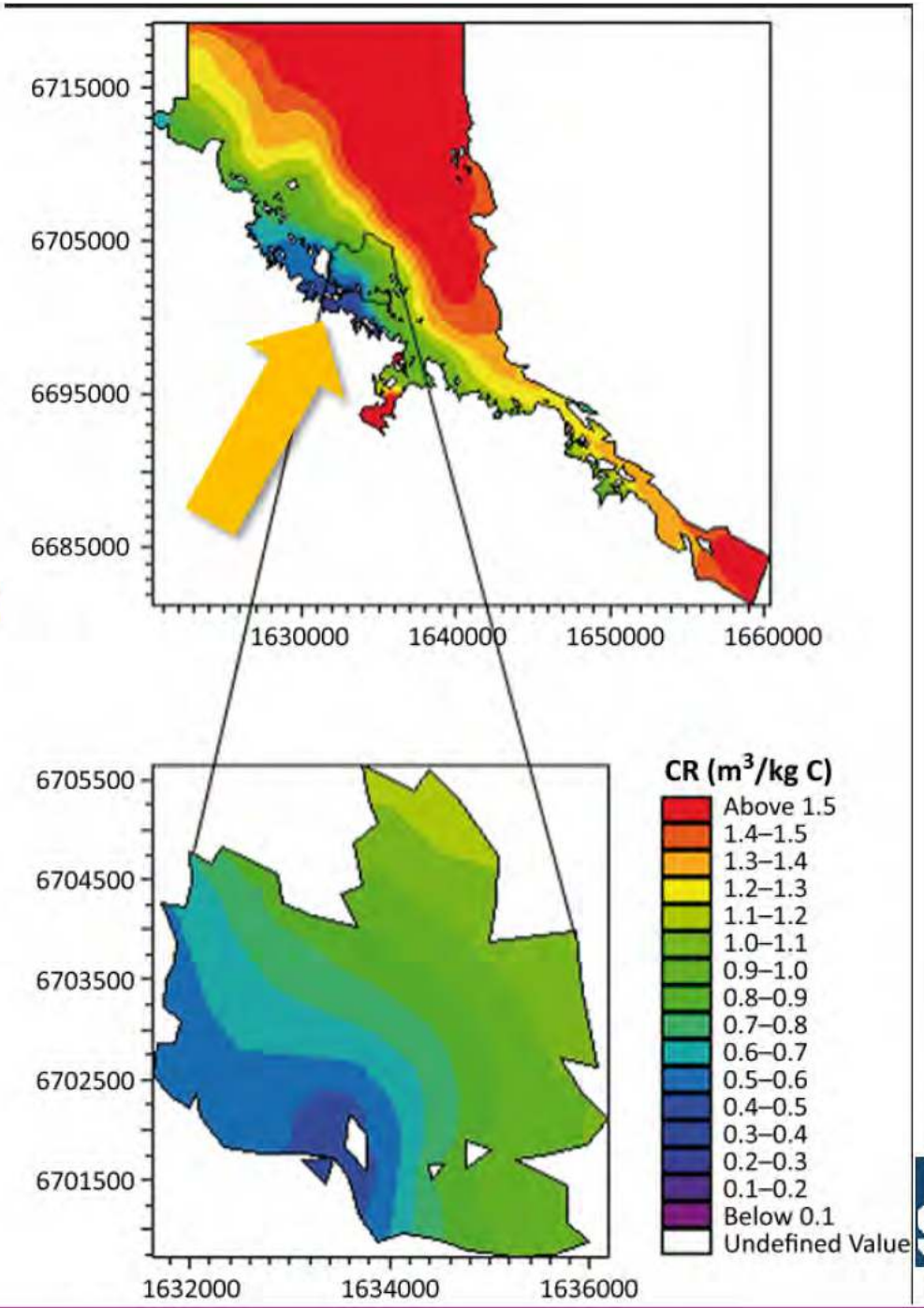
Modelling of radionuclide transport





Concentratio ratio, CR, useful?

- For pointsources CR will vary more than order of magnitude depending the distance to the source
- 3D model (Mike3 + Ecolab)
- Erichsen et al 2013. AMBIO. 42:464-475



Ecological modelling in terestrial systems

Coupmodel Coupled heat and mass transfer model for soil-plant-atmosphere system

Components of Water and Heat Processes

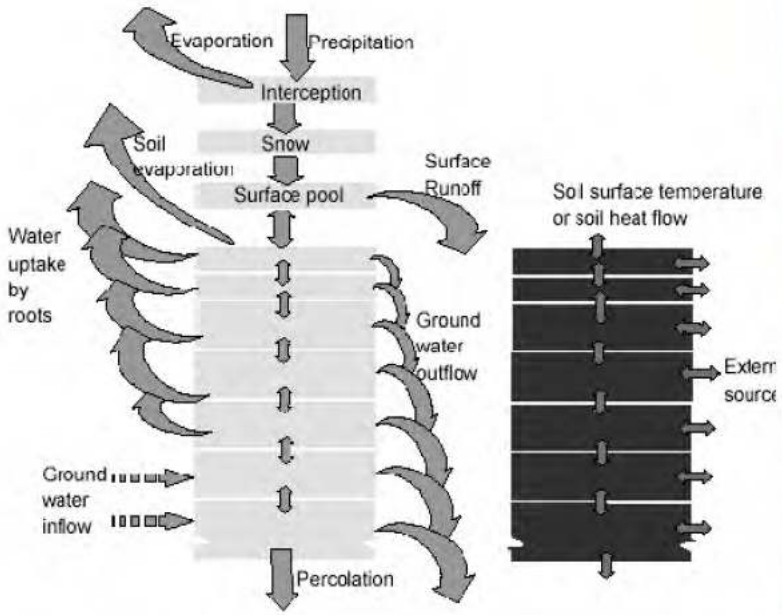
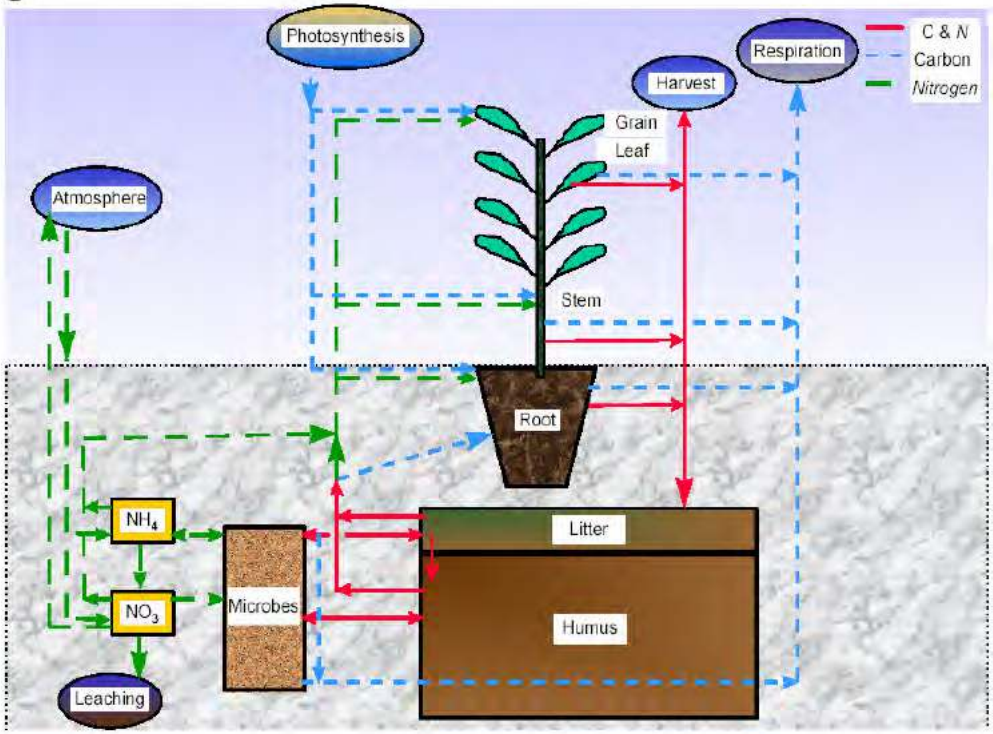


Figure 0.1 Mass balance (left) and heat balance (right) of the SOIL mo



Massbalance (water, carbon, nutrients) coupled with RN transport including uptake
Based on processes and data fielddata
Gärdenäs et al 2009.. SKB TR-09-24.
Gärdenäs, et al , 2006. SKB R-06-47,

Irrigation in Coupmodel

http://dx.doi.org/10.1016/j.scitotenv.2016.08.036

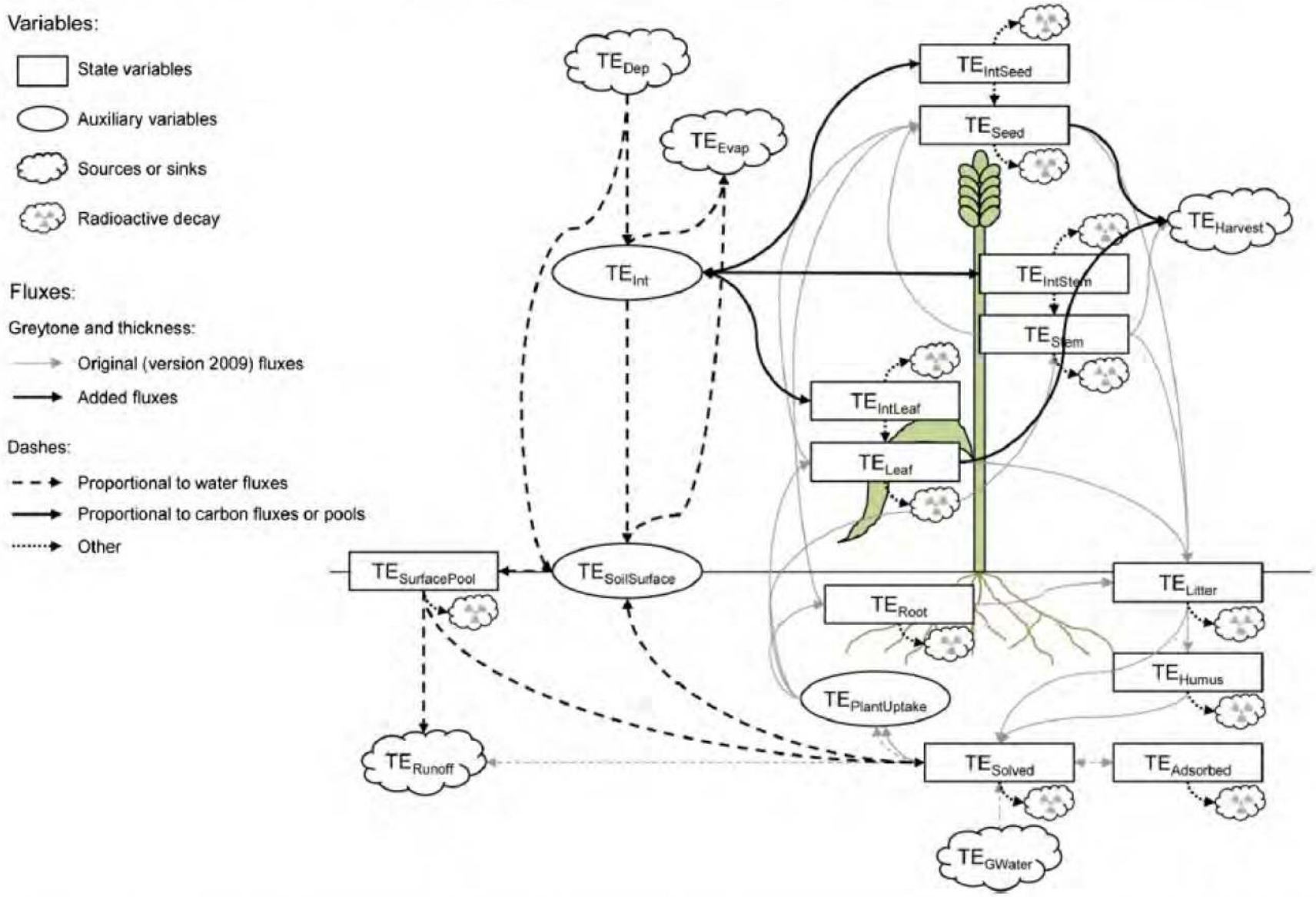
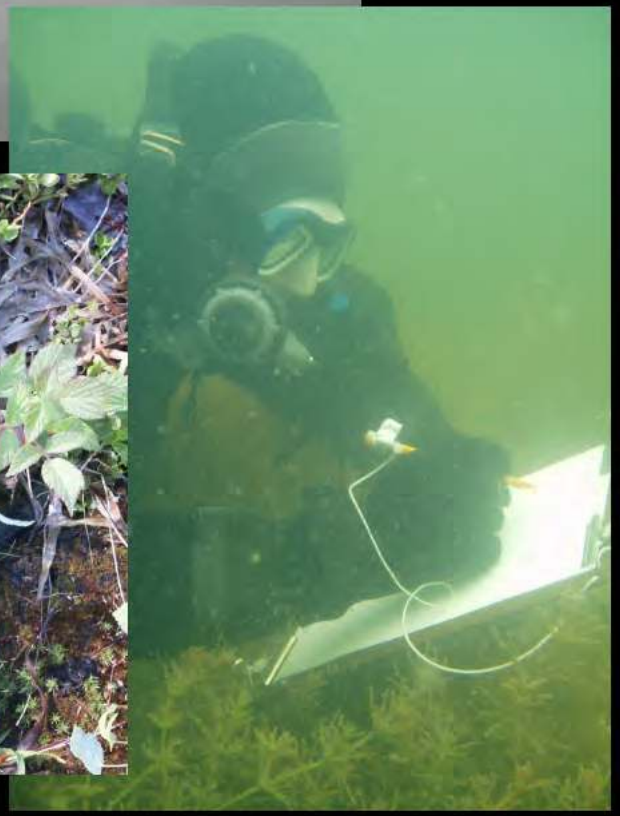


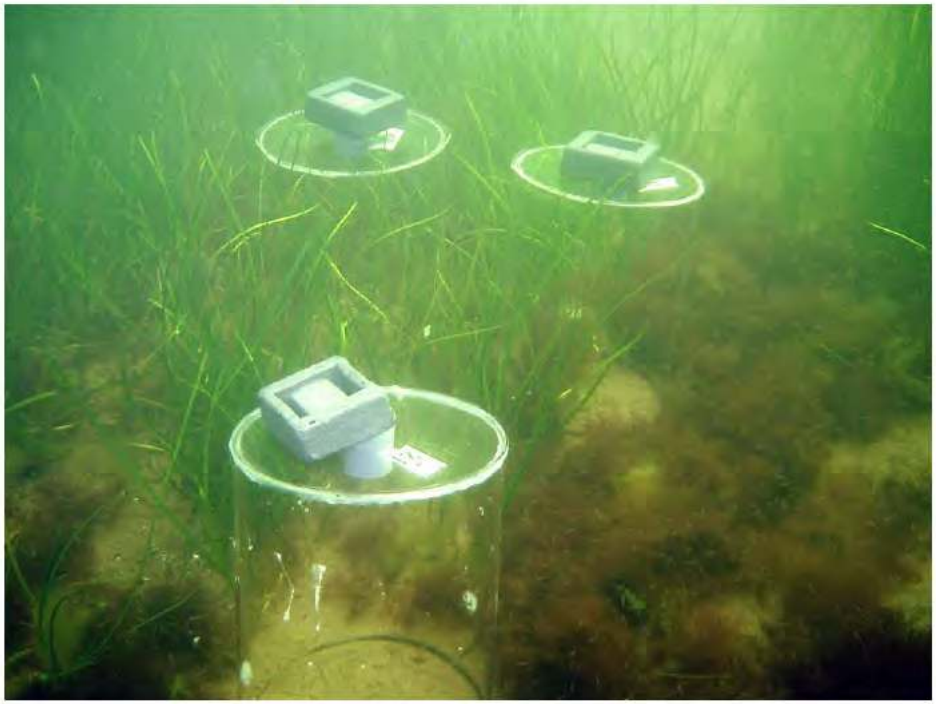
Fig. 1. Pools [Bq m^{-2}] and fluxes [Bq m^{-2} day^{-1}] of a trace element (TE) in the Tracey model. The thin grey arrows represent TE fluxes in the original version by Gärdenäs et a

Biota characterisation and mapping



Fluxes in ecosystems
–primary production, respiration

Primary production of Eel grass

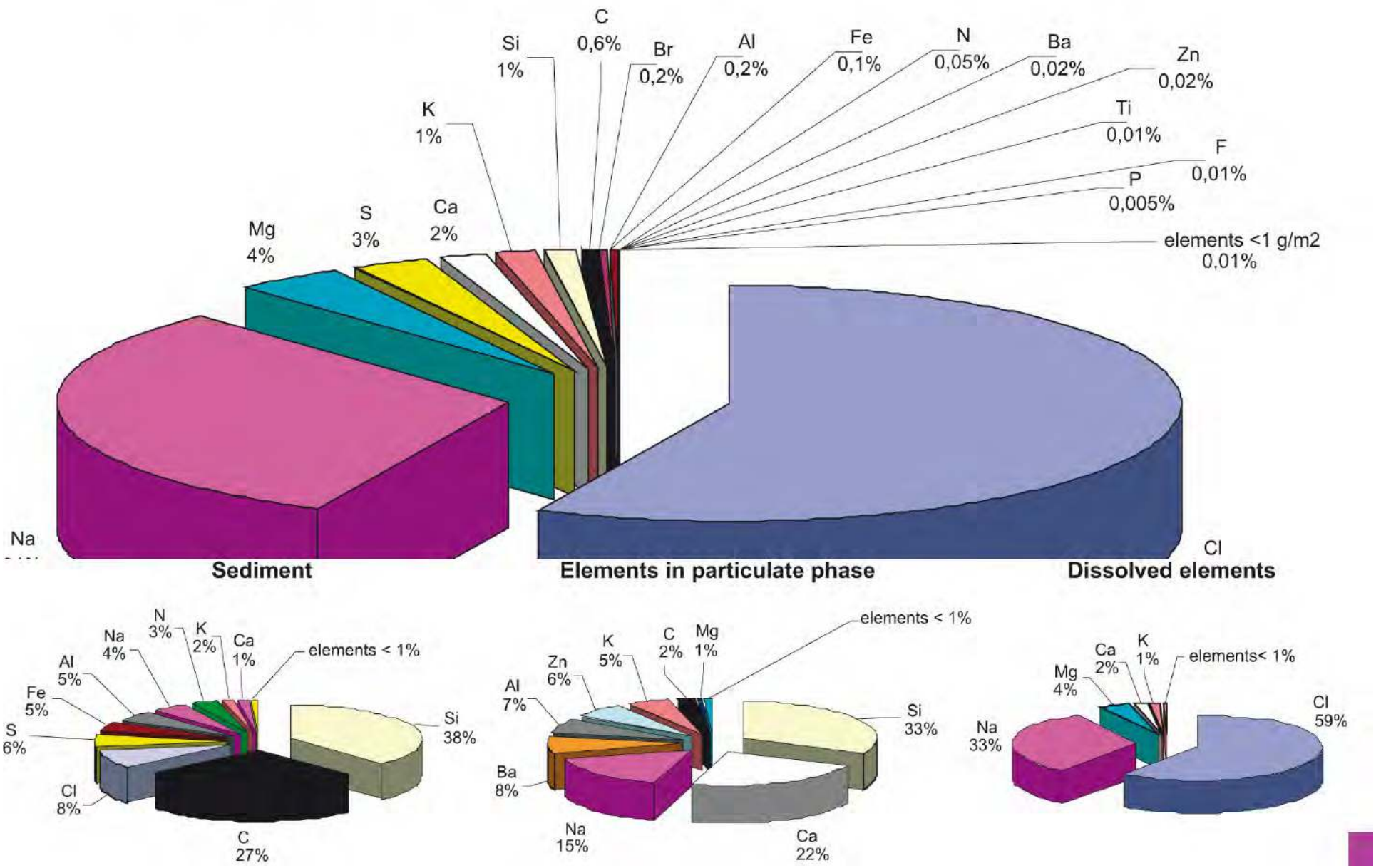


Respiration in forest

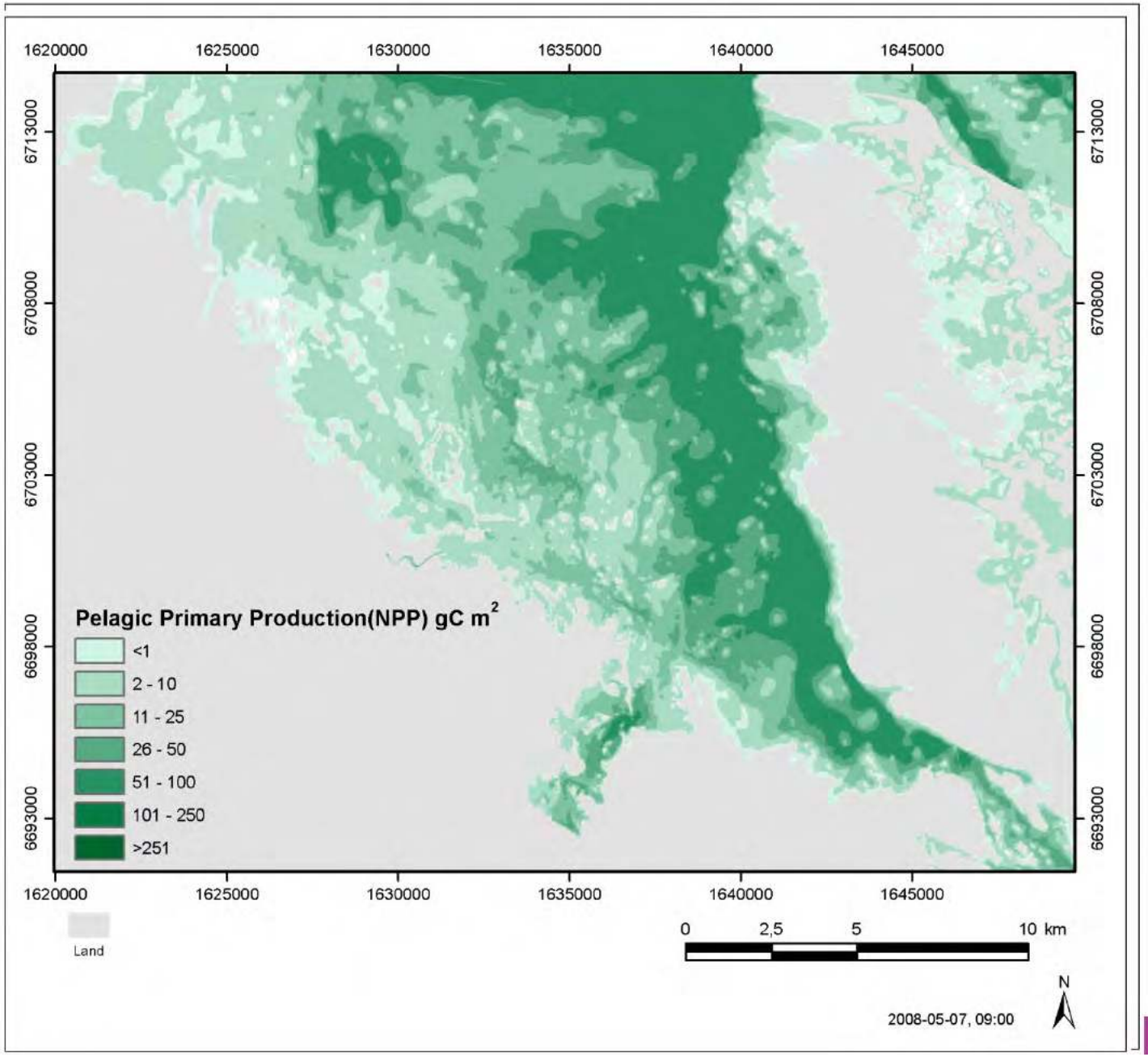
Water chemistry time series

Bradshaw, C., U. Kautsky, L. Kumblad. 2012. Ecological stoichiometry and multi-element transfer in a coastal ecosystem. *Ecosystems* 15: 591–603.

Chemical composition (e.g. ICP-MS, AS)



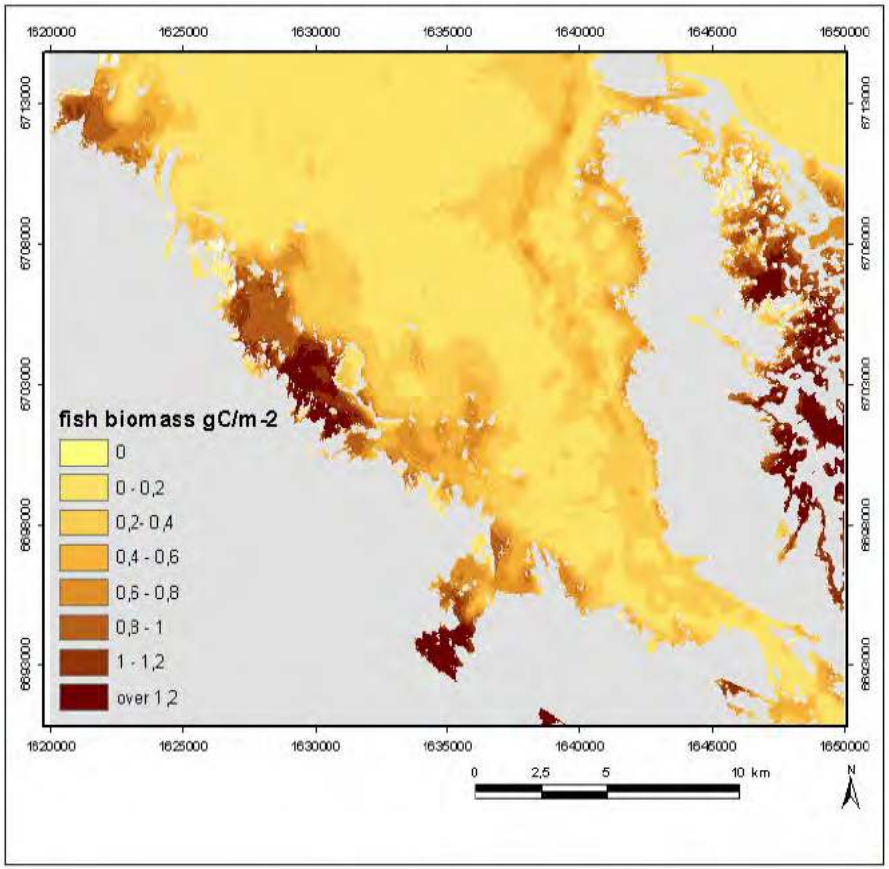
Modelling of primary production



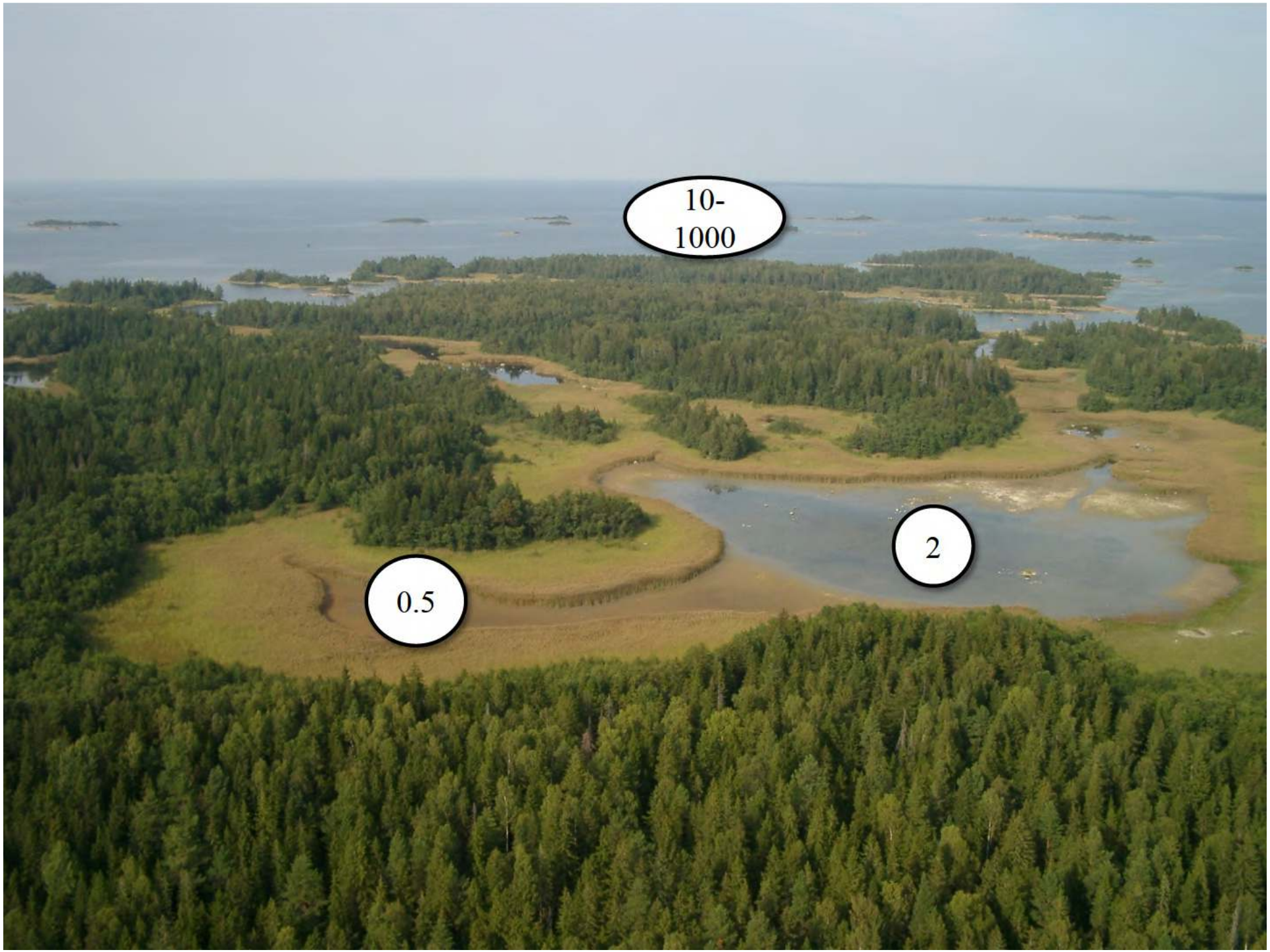
Modelling Amount of fish

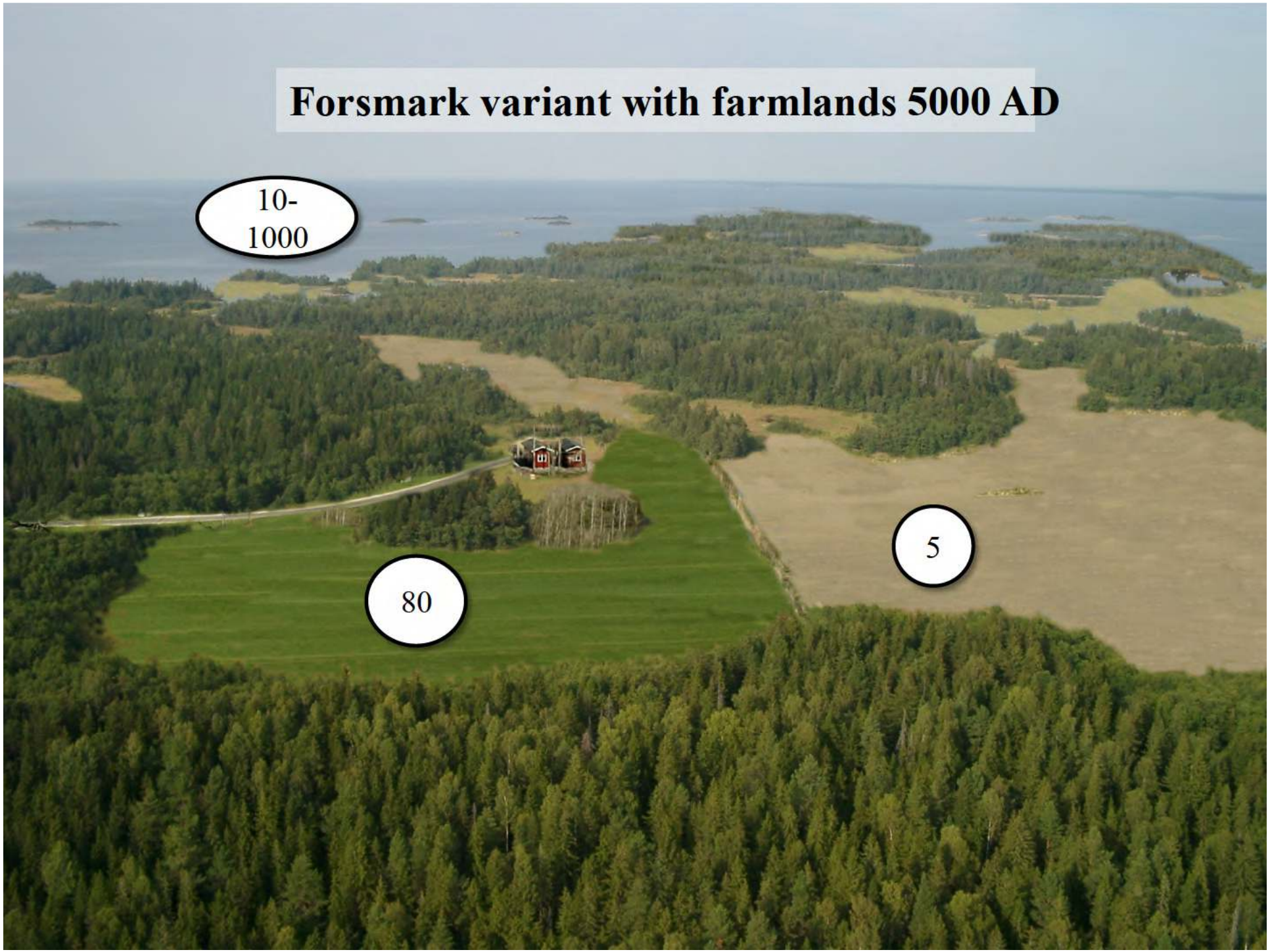
- Coastal fish community, Herring and sprat dominates (60-70 kg/ha)

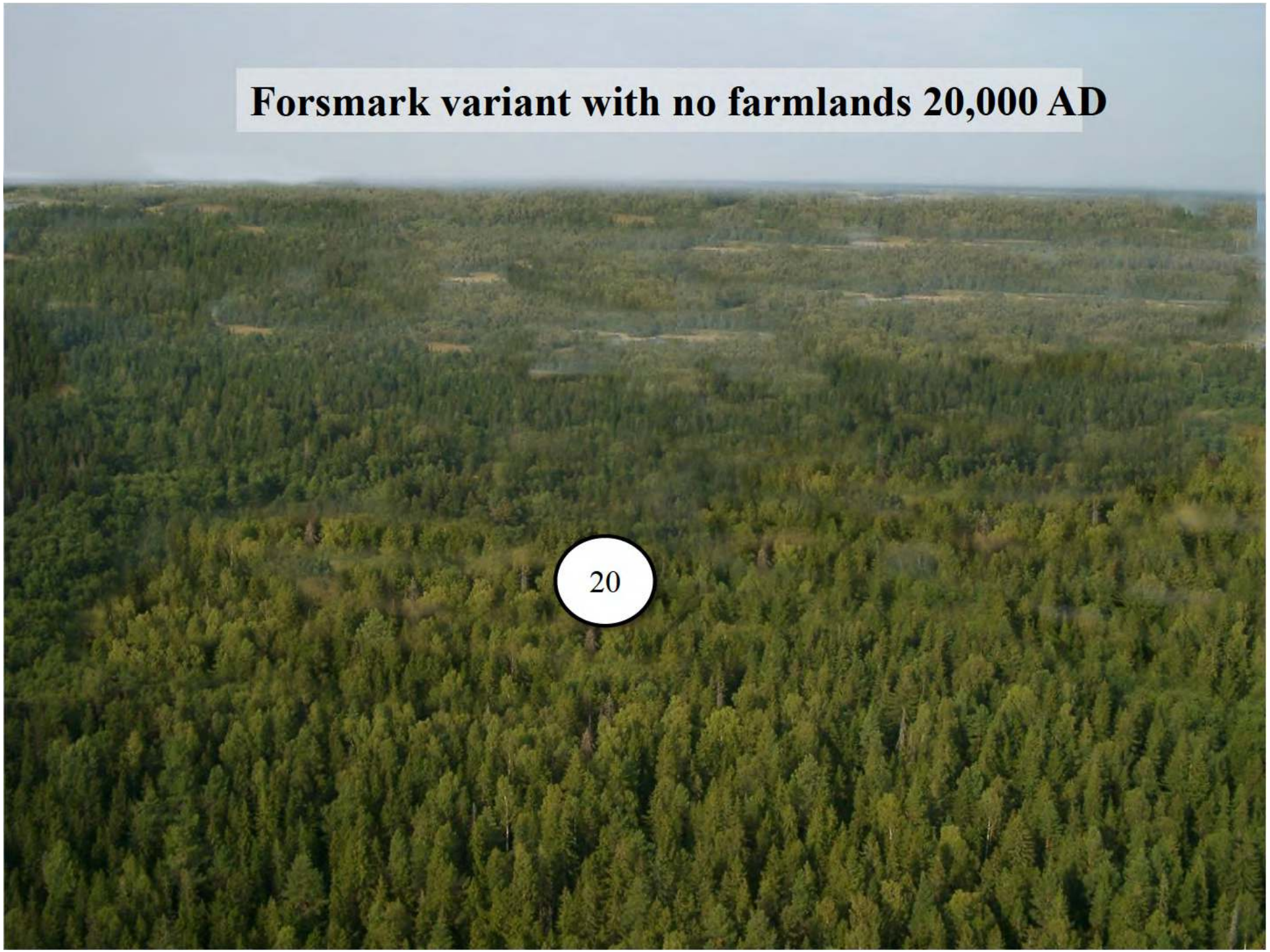
- Inner bays, perch, roach and white bream dominates

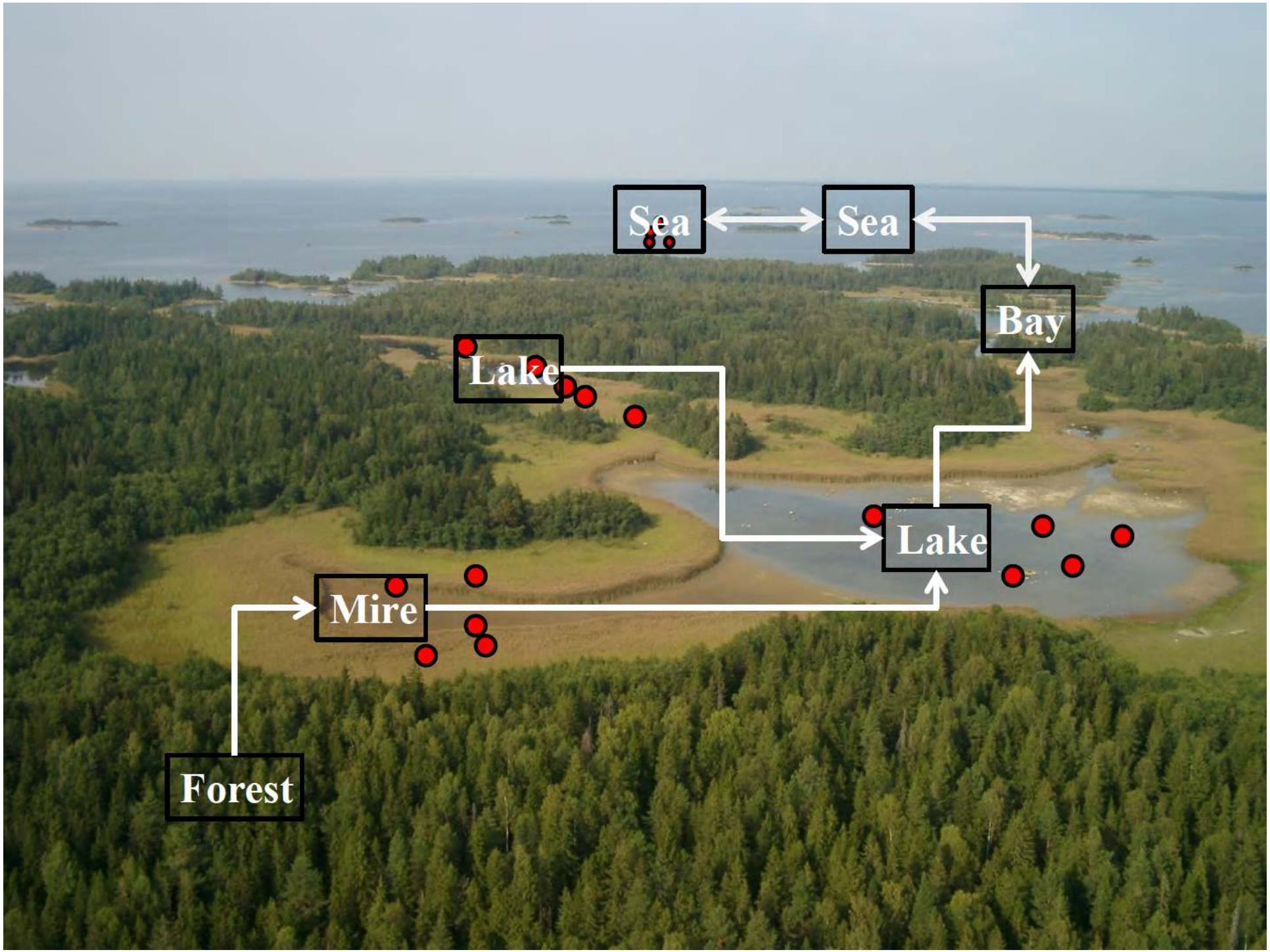


Ecosystem aspects
AMBIO 35:8 (2006)
AMBIO 42:4 (2013)

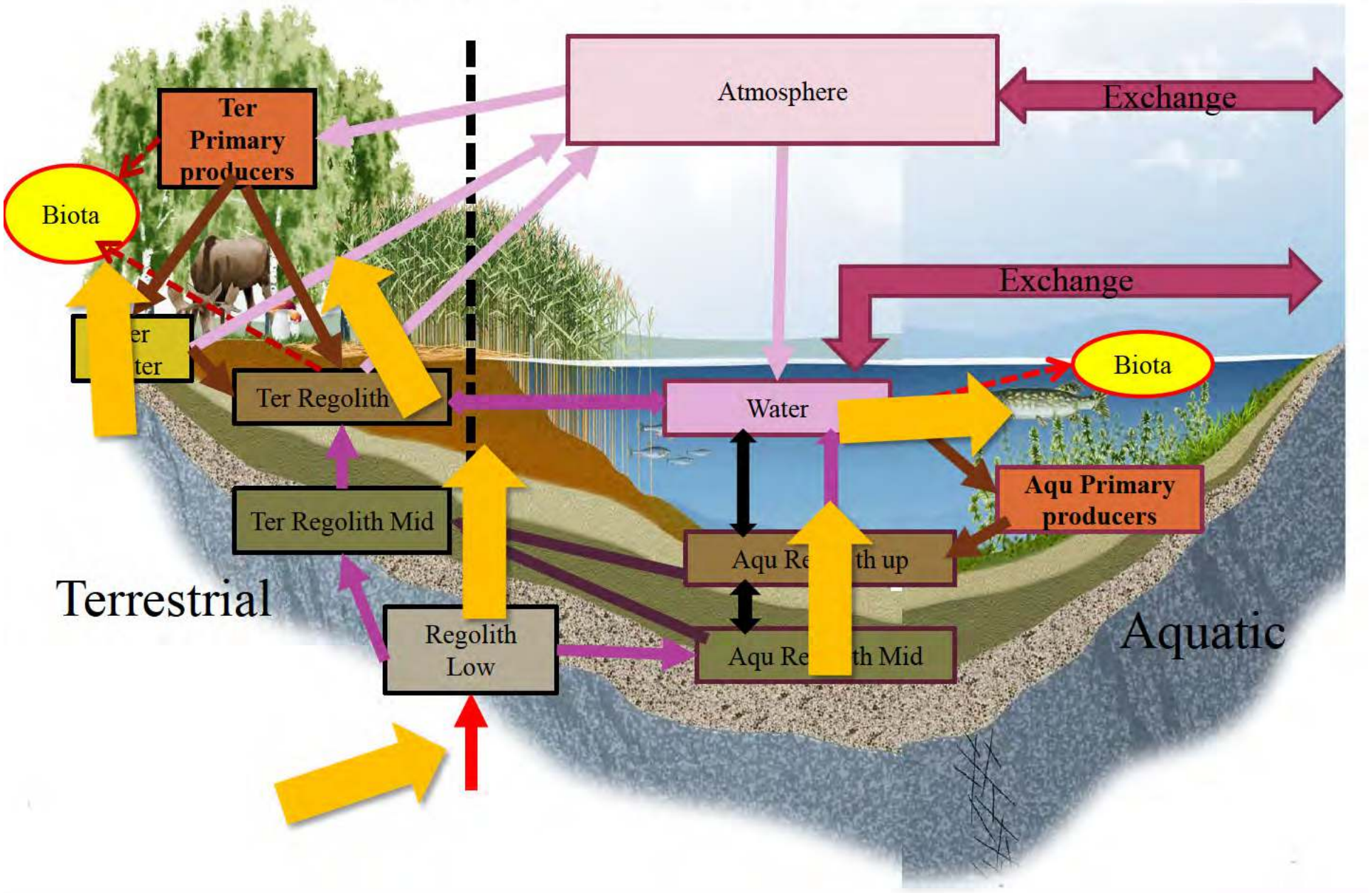

10-
1000
2
0.5


Forsmark variant with farmlands 5000 AD
10-
1000
80
5

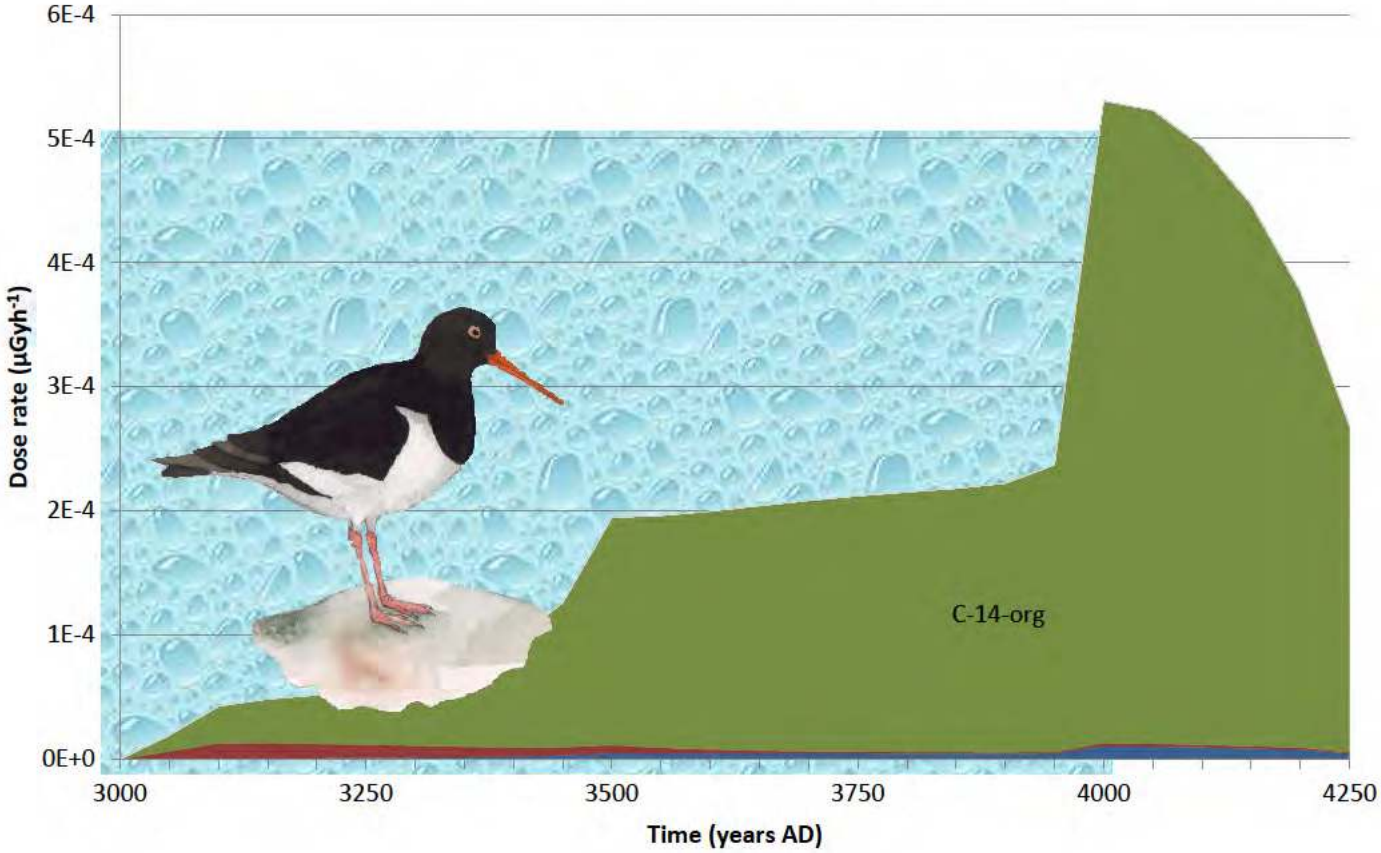

Forsmark variant with no farmlands 20,000 AD
20

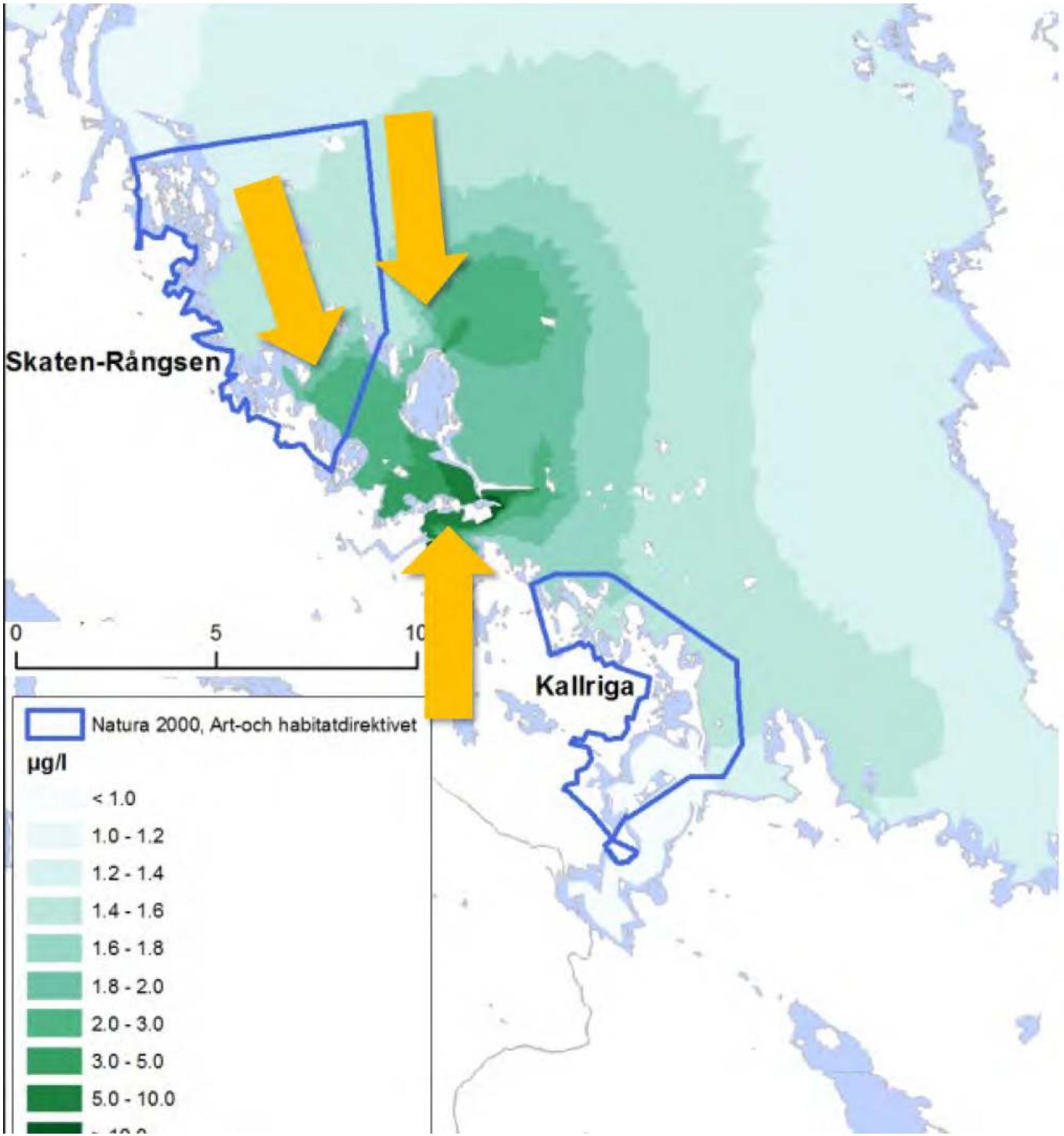

Sea
Sea
Bay
Lake
Lake
Mire
Forest

Ecosystem model for asssessemt



Radionuclide contribution to dose in most exposed marine organism - (Wading) bird





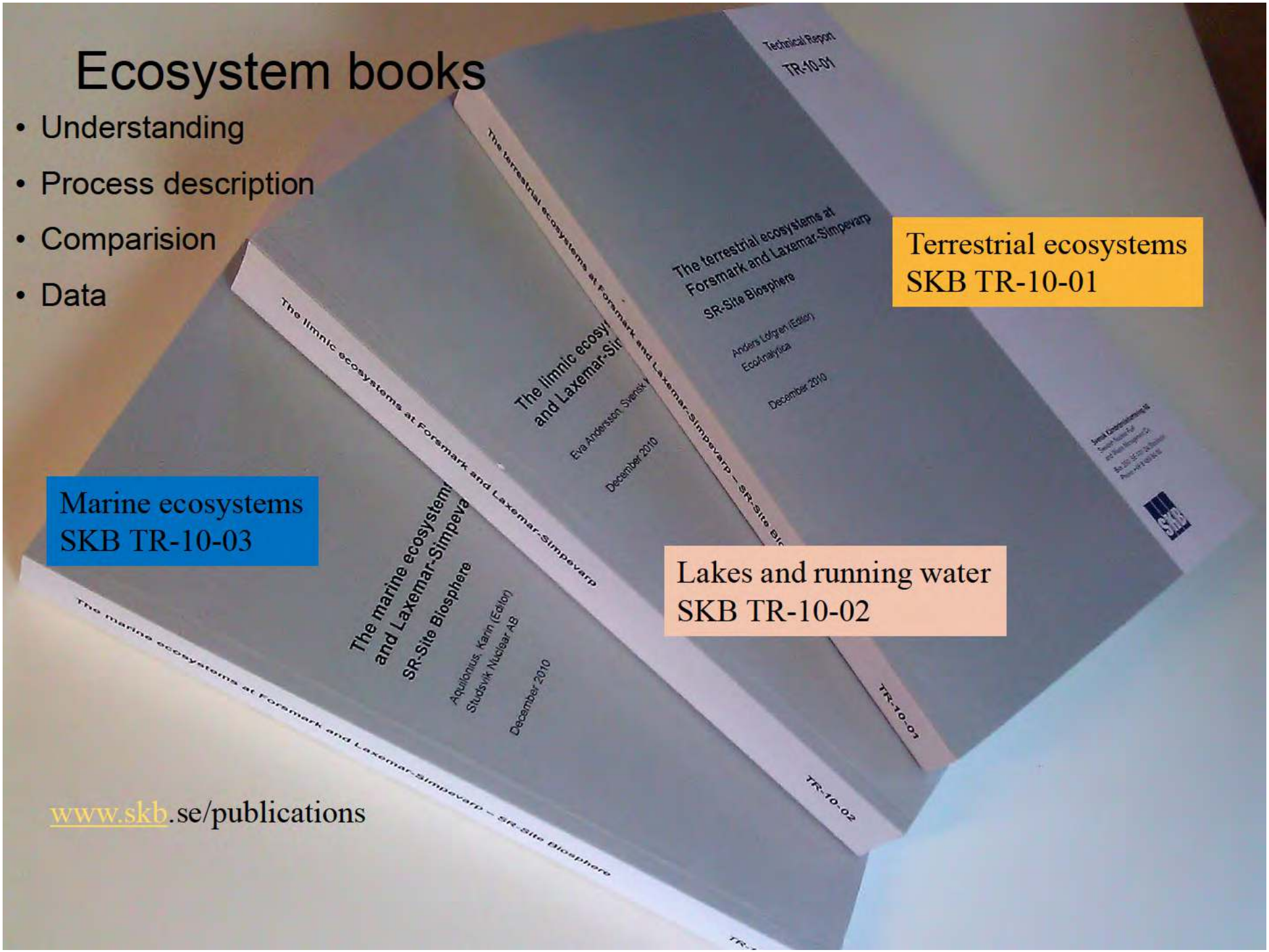
- Data and expertise used in EIA
  - Nitrogen release from blasted rock → eutrophication affects nature reserves ?
  - Authorities happy

Greenland permafrost analogue

Tobias Lindborg , PhD t
SLU Umeå

Ecosystem books

- Understanding
- Process description
- Comparision
- Data

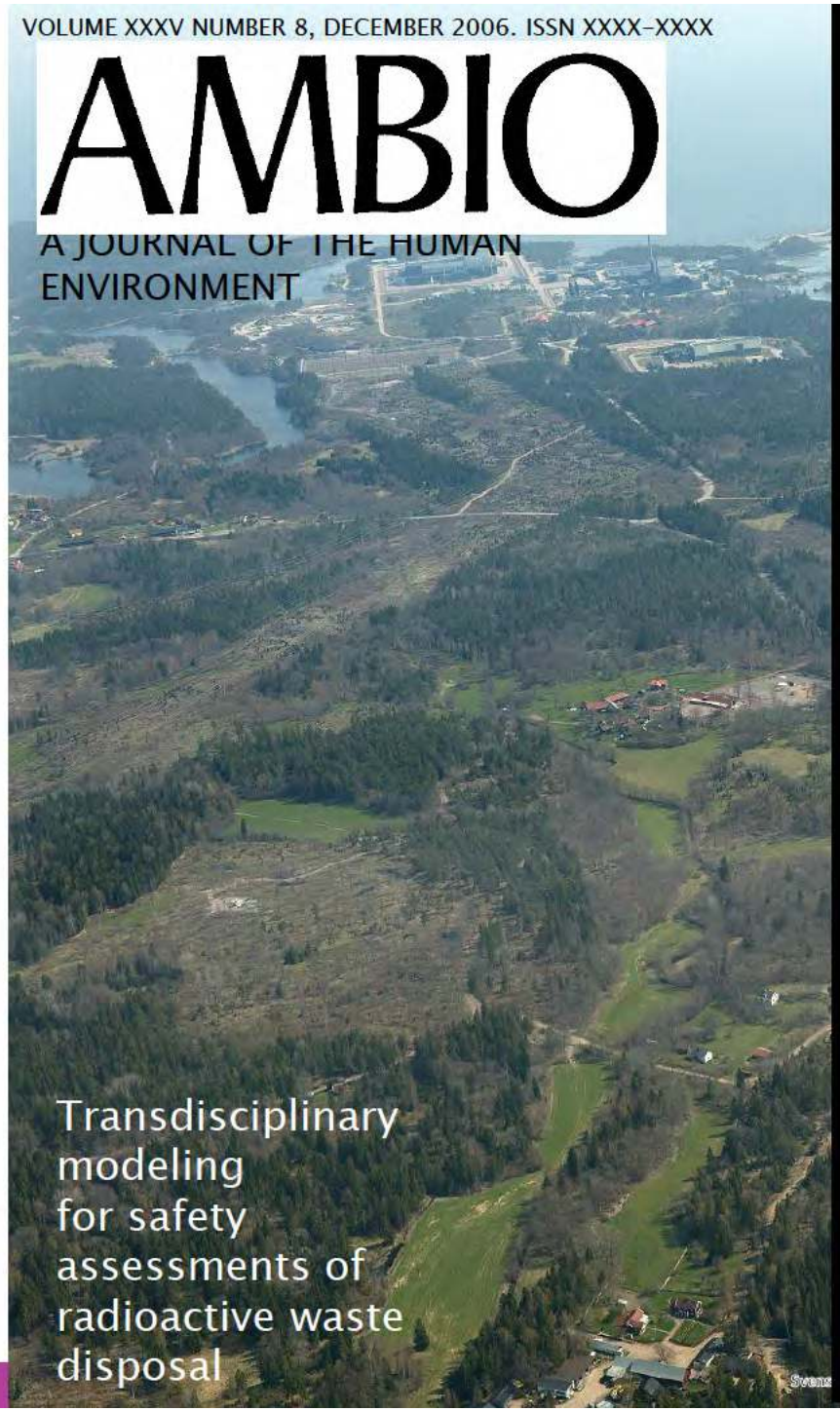


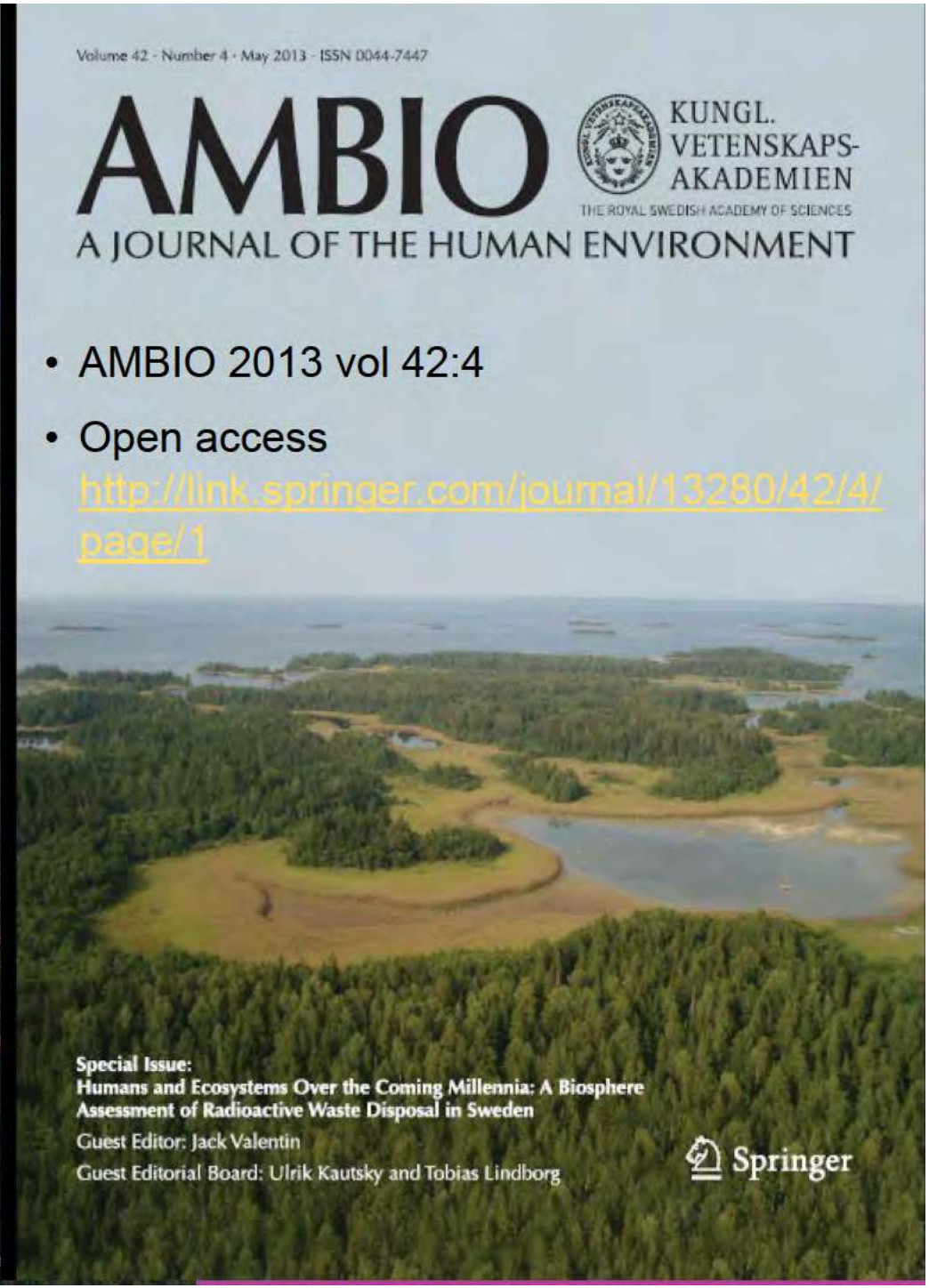
Terrestrial ecosystems
SKB TR-10-01

Marine ecosystems
SKB TR-10-03

Lakes and running water
SKB TR-10-02

www.skb.se/publications





- AMBIO 2013 vol 42:4
- Open access
  http://link.springer.com/journal/13280/42/4/page/1

Conclusions

- Spent fuel doesn't affect the future environment or humans
  - Application to build a repository in march 2011
- Ecosystem modelling
  - Feasable
  - Scaleable
  - Induction to unknown elements , ie can replace CR
  - Same data and models for humans, NHB and EIA (nutrients)
  - Fielddata
    - Swedens most sampled site ?
  - Some reviewers at authorities happy others not
    - Radio ecology based on physics → lack of basic ecology
- There a lot of data, models, ideas to work on
- Everything reported www.skb.se publication >> 100 reports
- Currently 6 ecologist at SKB and network of consultants ranging 20-40, 3 PhD