Modelling pesticide fate at the landscape scale

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CKB workshop 2017-08-17

SLU

CKB
Center for Chemical Pesticides

Aims

Providing estimations of the **risks** of **pesticide losses** to **surface- and groundwater**, from **arable-land**, in **Sweden** (21 Swedish counties).

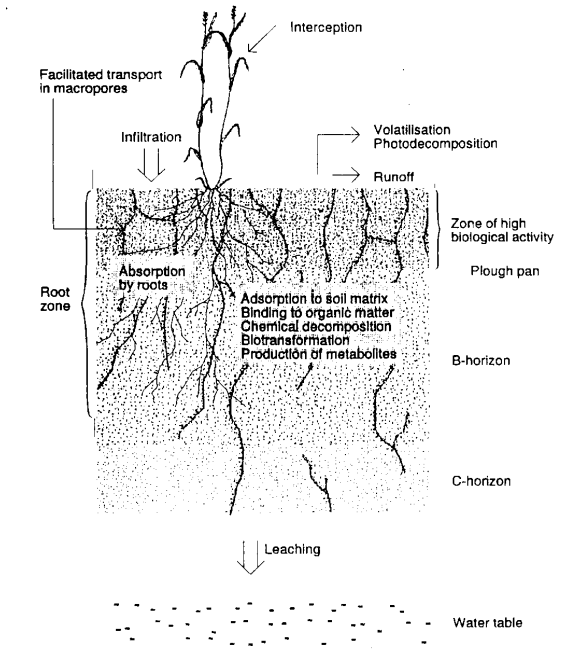
Help **understanding** (*some of*) the **factors affecting pesticide losses** at the regional scale, from **field to catchment**;

for:

1. **Swedish authorities.**
2. Researchers.

The MACRO-model describes ...

- Water flow and mass transport in a soil profile
  - Macropore flow
- Adsorption and degradation of pesticides
- Effects of land use
  - Different crops, drainage systems



Process descriptions

Process	Description
Soil water flow	Richards equation, kinematic wave in macropores
Evapotranspiration	Penman-Monteith equation
Plant water uptake	Modified Feddes sink term with compensation
Drainage	Houghoudt equation and seepage potential theory
Solute transport	Advection-dispersion equation (mass flow only in macropores) First-order mass exchange between pore systems
Sorption	Freundlich isotherm (optional 2-site kinetic sorption)
Degradation	First-order kinetics

Processes missing today: **surface runoff** and **erosion losses, frozen ground** and **temporal variation in soil properties**

The MACRO models

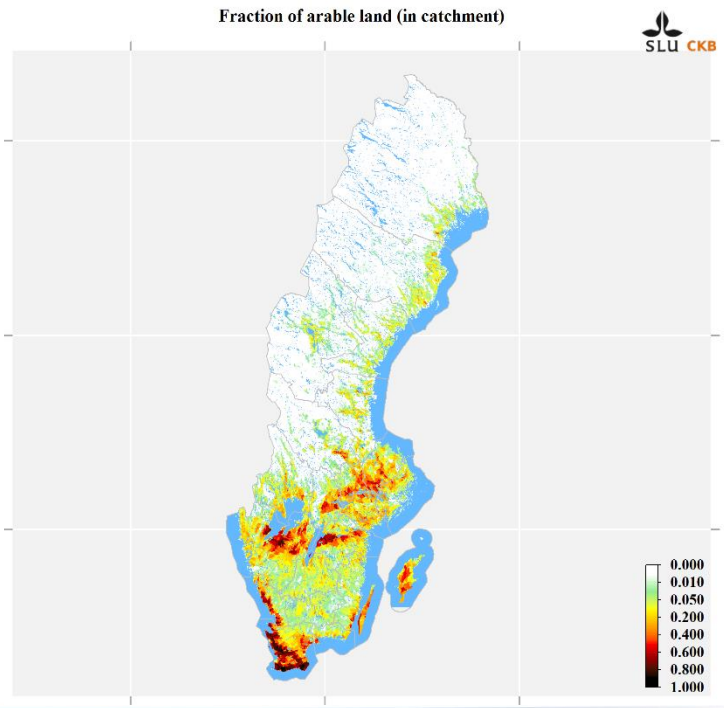
MODEL	PURPOSE	USER/ STAKE-HOLDER
MACRO in FOCUS	Product registration (nationally, EU)	National authorities (e.g. Chemicals Agency), EFSA, industry
MACRO-DB	Decision support for permits in water protection areas, advising	Municipalities, land-owners, consultants and advisors
MACRO-SE	Risk assessment, product registration, research	National authorities (River Basin District Authorities, Agency for Marine and Water Management, Geological Survey, Chemicals Agency)

MACRO-SE methodology

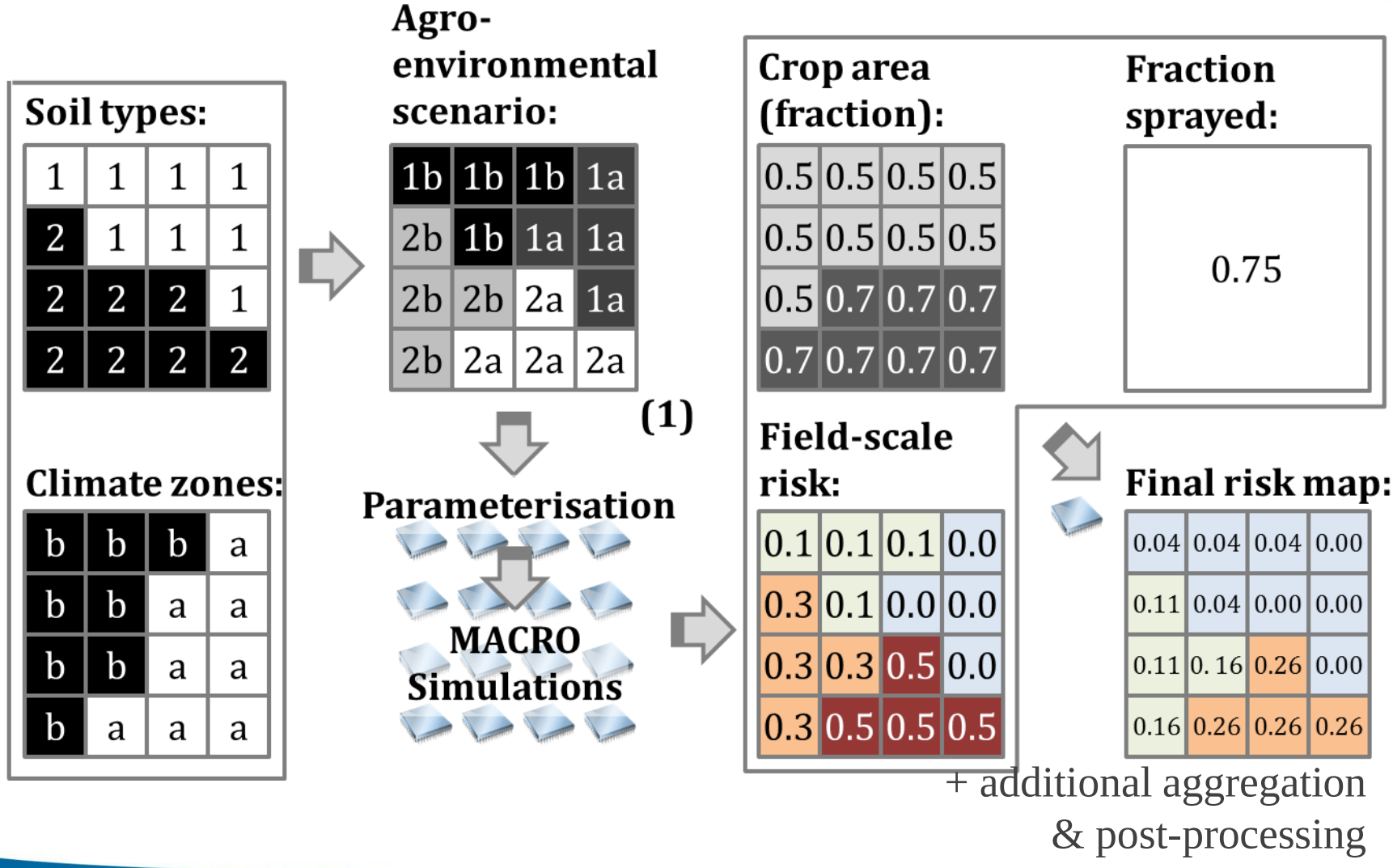
MACRO-SE geo-data:

- Functional soil classification
- Climate maps & climate data series
- Statistics on crop area
- Statistics on pesticide usage: What substance? On what crop? What time of the year? What dose?
- Crop physiological stages (emergence, harvest, …)
- Pesticide Properties Database

Note: Multiple data sources: SLU (CKB, Vatten-NAV), SMHI (SVAR, …), Jordbruksverket, University of Herts, SGU, KemI, SCB, Lantmäteriet, …



MACRO-SE methodology

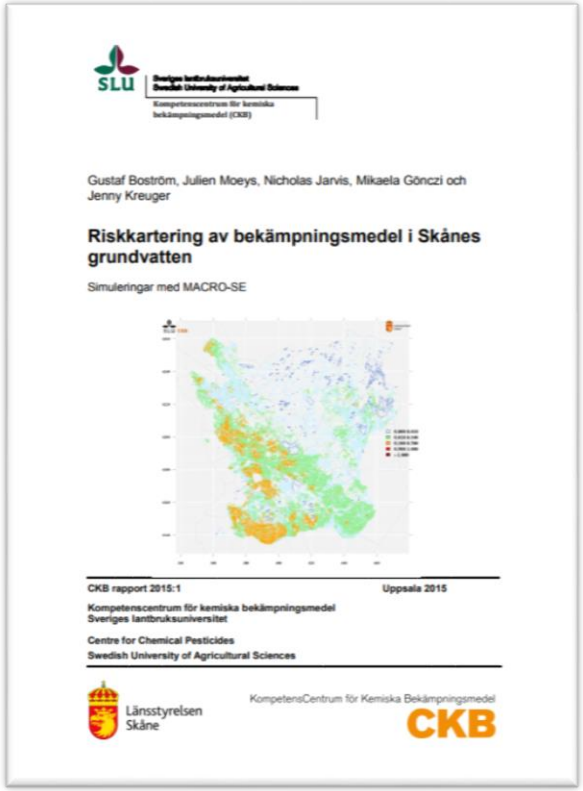


+ additional aggregation & post-processing

Result examples

Two pilot studies in Scania County

Surface water



Groundwater

Result example: surface water

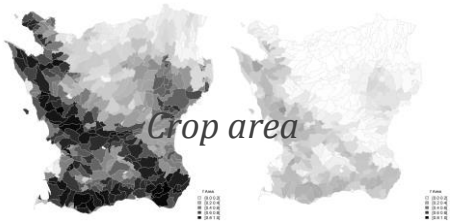
Pesticide applications scenario:

- Scania county
- Winter cereals
- Isoproturon 500 g/ha
- Sprayed mid-October

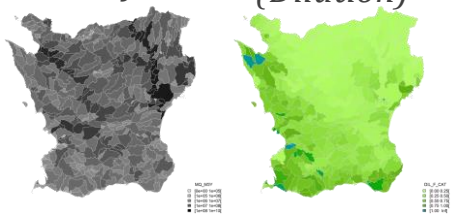
Source: Boström 2013 “Riskkartering av bekämpnings-medel i skånska ytvatten”, Länsstyrelsen i Skåne län.

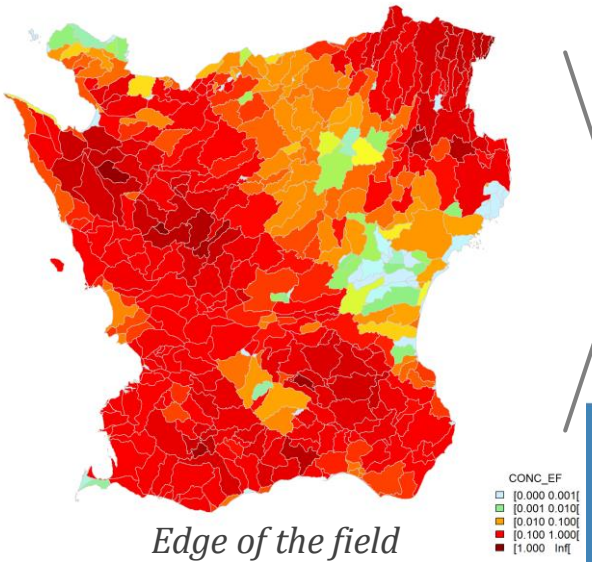
SMHI S-HYPE

Water flow *(Dilution)*

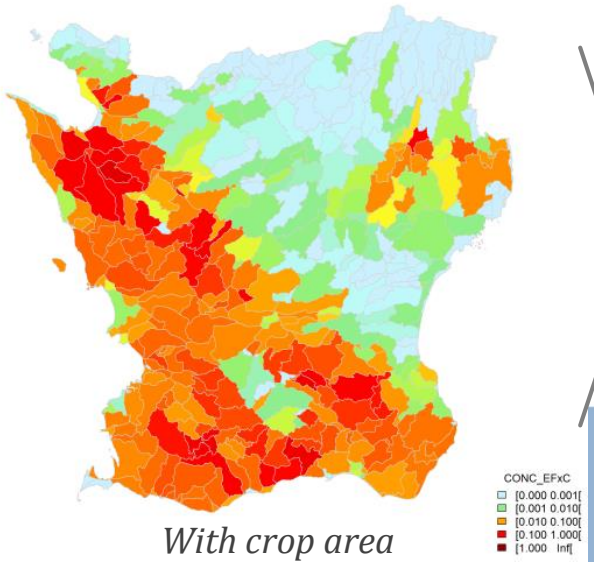


Crop area

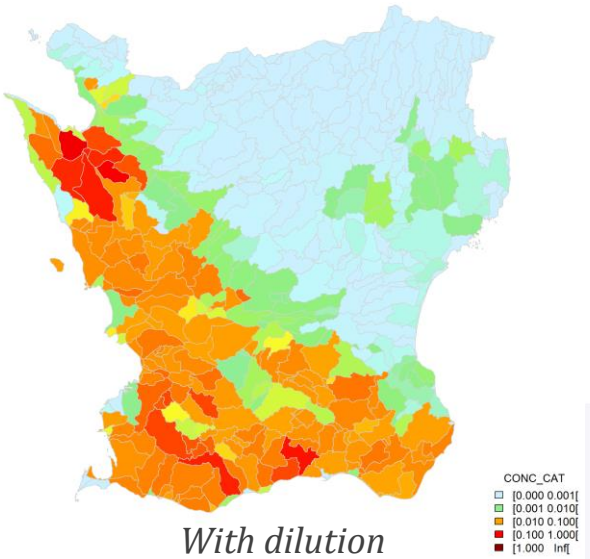




Edge of the field



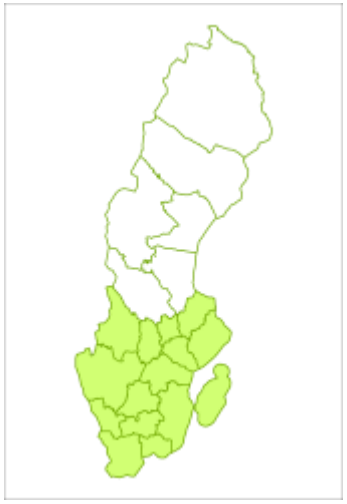
With crop area



With dilution

Ongoing project

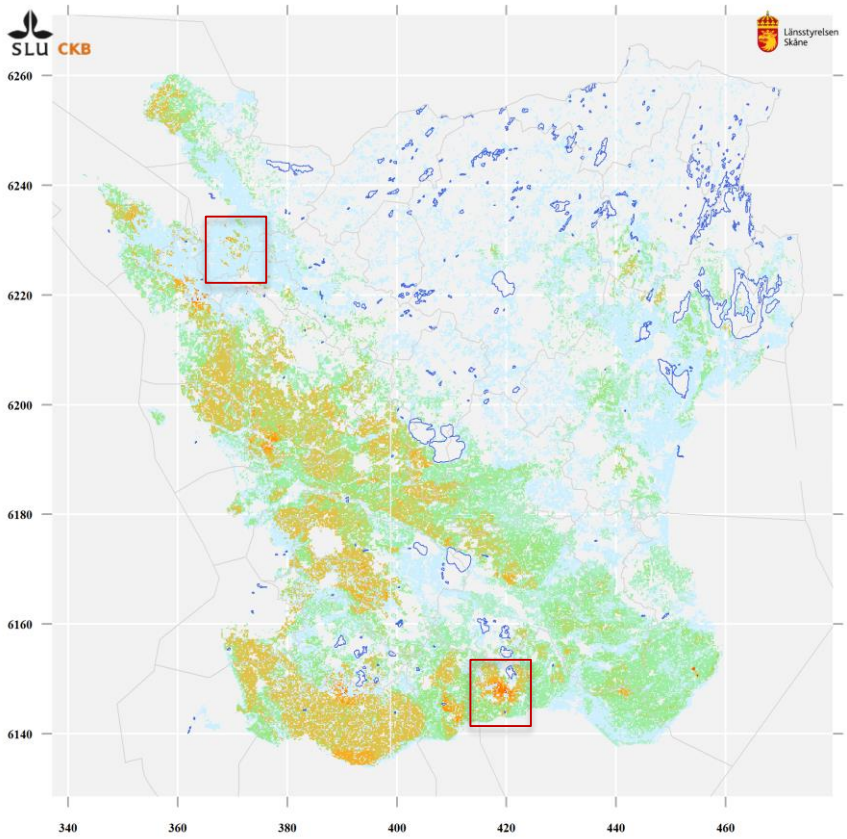
- MACRO-SE will be used as decision support tool in the work with the Water Framework Directive
  - Risk assessment (påverkansanalys)
  - Point to where sampling is most needed, for future status classification
- Project in collaboration with Swedish authorities
- Realistic pesticide application scenarios have been defined
- Simulations starting shortly
  - Counties with high agricultural intensity prioritized



MACRO-SE base maps available for southern Sweden

MACRO-SE interpretation

Uncertainty?

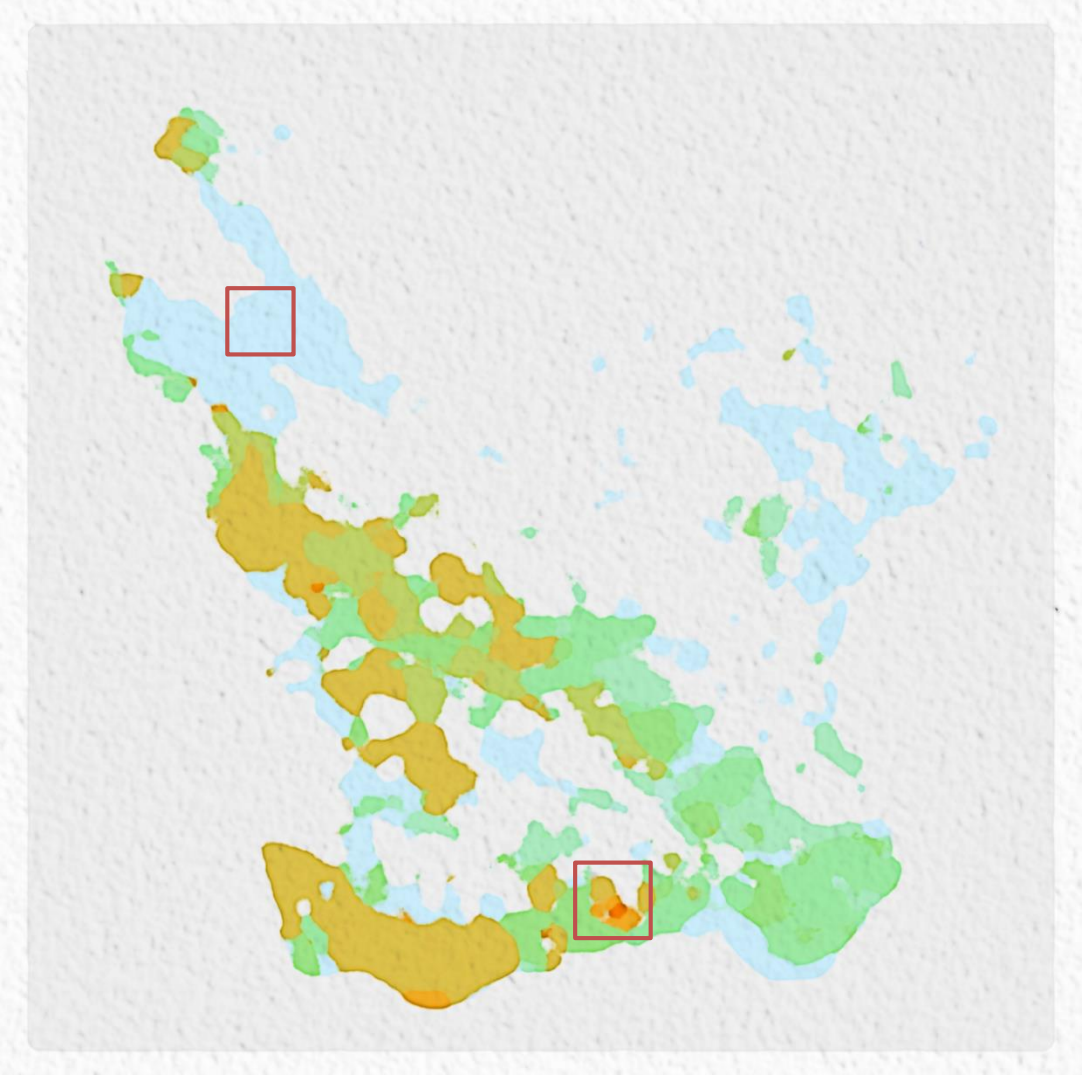


Interpretation?

Need to **discuss best model usage** and a **methodology** to **interpret and use** these results (and not *over-interpret*)

MACRO-SE interpretation

artist's impression



Scale down and use model as a **complex indicator?**

Compare modelling and measurements

Combine with other sources of information

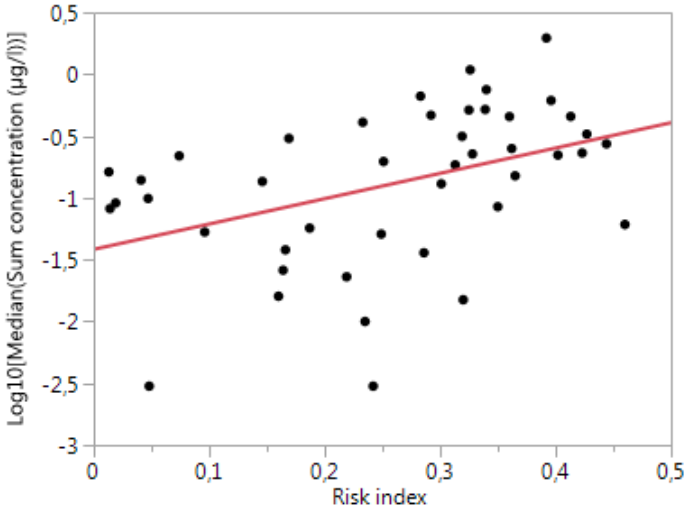
Not a replacement for monitoring

An attempt at a simplified risk indicator

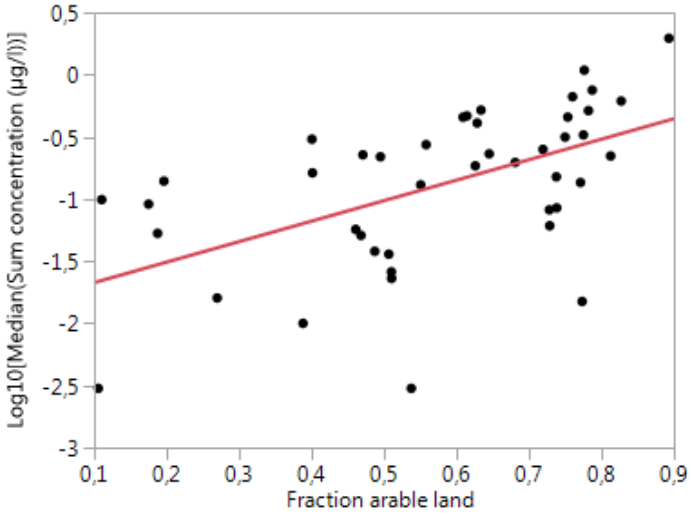
- Research has shown that losses of pesticides are dominated by fast flow paths:
  - Macropore flow to drainage (mainly clay soils)
  - Surface runoff (mainly silt soils)

An attempt at a simplified risk indicator

- Risk index based on
  - Functional soil classification
  - Fraction arable land in catchment
- Compared to measurements of pesticides from 44 catchments in Sweden



$R^2 = 0,16$
$p = 0,0045$



$R^2 = 0,28$
$p = 0,0001$

An attempt at a simplified risk indicator

Ideas for future analyses

- Define smaller catchments for the sampling points
  - E.g. up to the first lake
- Include climate effects
- Multivariate analysis
    - E.g. percentiles of clay, sand, SOM in topsoil and subsoil etc…
    - Climate variables
    - Percent arable land
    - Hydrologic class
    - Stream density
    - Pesticide use intensity (county scale data)
- Other suggestions?

THANK YOU for listening!

QUESTIONS or SUGGESTIONS?

Please contact me at: gustaf.bostrom@slu.se

Risk index - classification

HC = L and TEXT ≠ 3 (topsoil)
or TEXT = 1 (topsoil)
or TEXT = 6 (topsoil)

yes → 1

no ↓

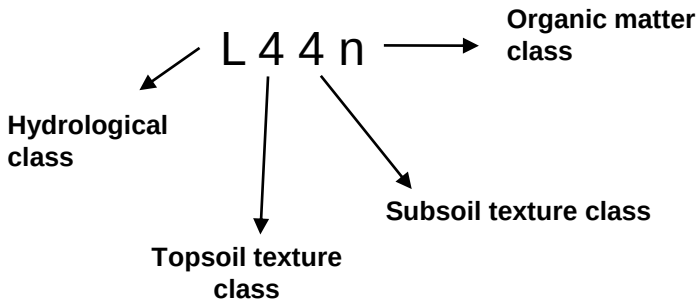
TEXT= 4 (topsoil and subsoil) or
TEXT = 3 (topsoil) and SOM = u

yes → 3

no ↓

2

Soil-hydrological code:



Risk class	Description
1	Recharge areas with permeable subsoil, coarse topsoils with no macropore flow, peat soils
2	Silty soils with moderate or high organic matter content or loamy soils
3	Clay soils with macropore flow or silty topsoils low in organic matter

Hydrological class (HC)	Texture (TEXT)	Topsoil organic matter class (SOM)
L: Recharge to groundwater U: Discharge to surface water W: Intermediate – more to groundwater Y: Intermediate – more to surface water	1 : coarse 2 : medium 3 : medium-fine 4 : fine 5: very fine 6 : organic	u: = SOM ≤3% n: = 3% < SOM ≤ 5% h: = SOM > 5%

Risk index - calculation

$$Risk\ index\ =\ \frac{1}{n}\left\{\sum_{i=1}^{m}\left(\frac{RC_i-1}{2}\right)\right\}$$

m is the number of pixels in the catchment area for arable land
n is the number of pixels in the catchment area
RC_i is the soil-hydrologic risk class in pixel *i*