Artificial neural network for Acid Sulfate Soil mapping: application to Sirppujoki River catchment

Beucher A.*, Martinkauppi A., Österholm P., Fröjdö S. and Edén P.

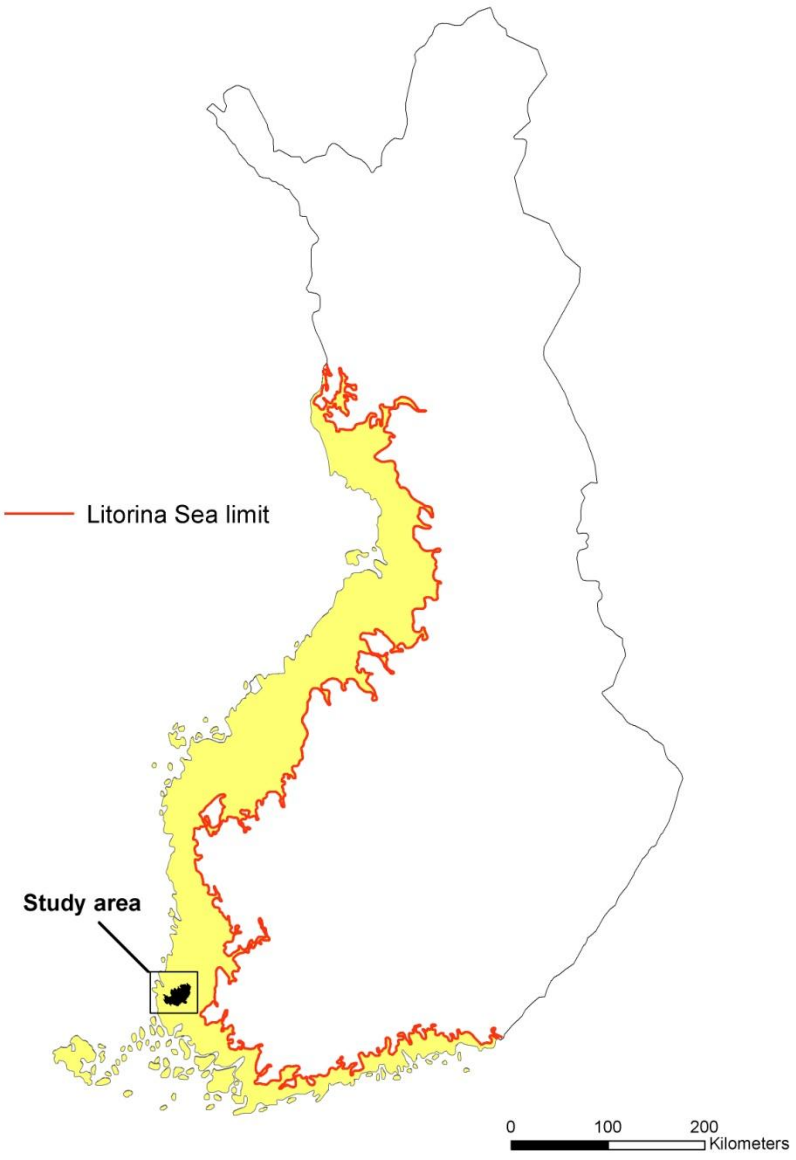
*Department of Geology and Mineralogy,

Åbo Akademi University, Finland

AS Soils in Finland:

- Largest occurrences in Europe (c.1000 km^2)
- Mostly located below the highest shoreline of the former Litorina Sea
- Small hot spot areas affect large coastal waters

➔ Mapping essential to target strategic places for mitigation



Acid Sulfate Soil mapping

- Cooperation network conducted by the Geological Survey of Finland (GTK)
- Within the CATERMASS project (EU- Life+)

  ➔ creation of a nationwide AS soil map

- For this large-scale project
  - Conventional mapping only

    ➔ too laborious and time-consuming

  - A spatial modeling method: Artificial neural networks

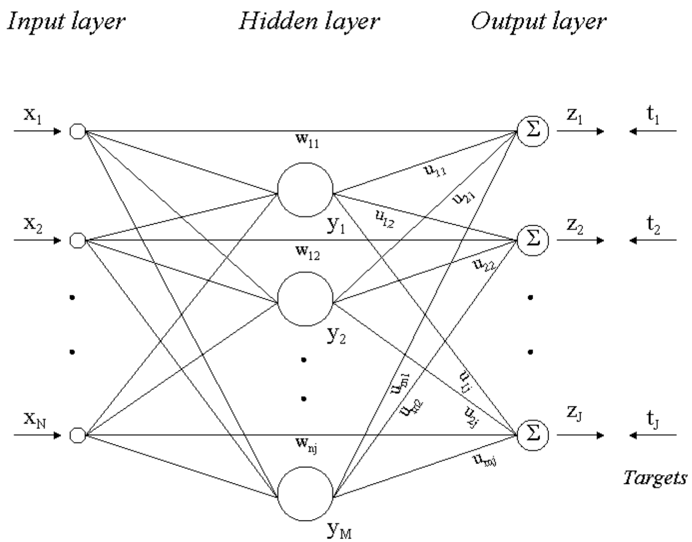
    ➔ objective, cost-effective and covering large areas

    ➔ test on a small study area: Sirppujoki catchment

Artificial neural networks

- Application of an artificial neural network method called:
  ➔ Radial Basis Functional Links Net (RBFLN)
- A modeling technique implemented within ArcGIS (ArcSDM) and requiring:
  - training points:
    - AS soil occurences
    - non-AS soil sites
  - evidential data layers: e.g. soil and geophysical data
- Aim of study:

  Evaluate the ability of the RBFLN method for AS soil mapping ➔ create probability maps for AS soil occurrence in the study area



- Artificial neural networks mimicking biological nervous system
  - Learning new information and compiling it with old one
  - Good pattern recognition and classification tools

➔ Using input data (training points and data layers)
➔Returning an output (probability map)

- Commonly used for mineral prospectivity mapping

Training points

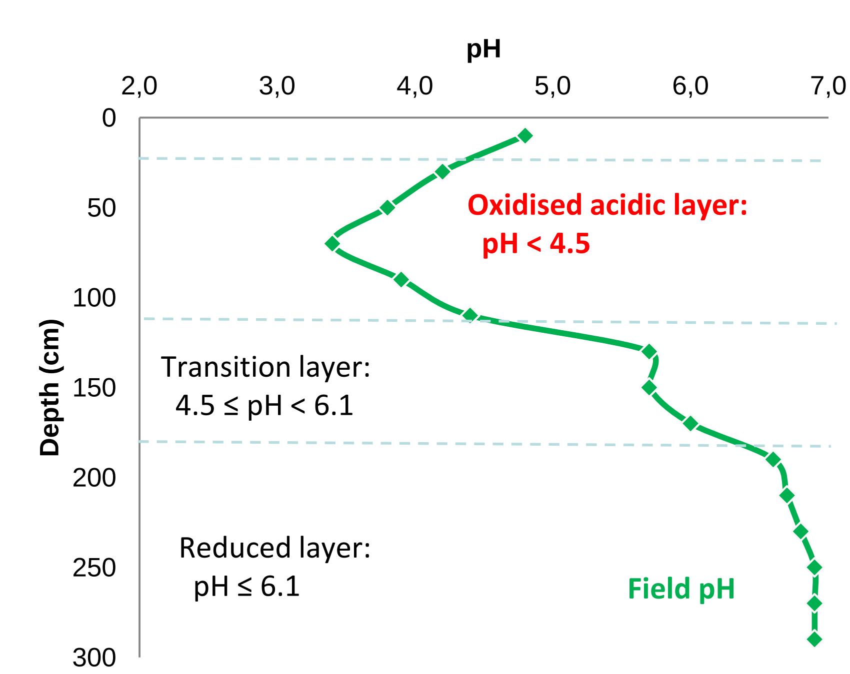
Soil profiles sampled during summer 2010:

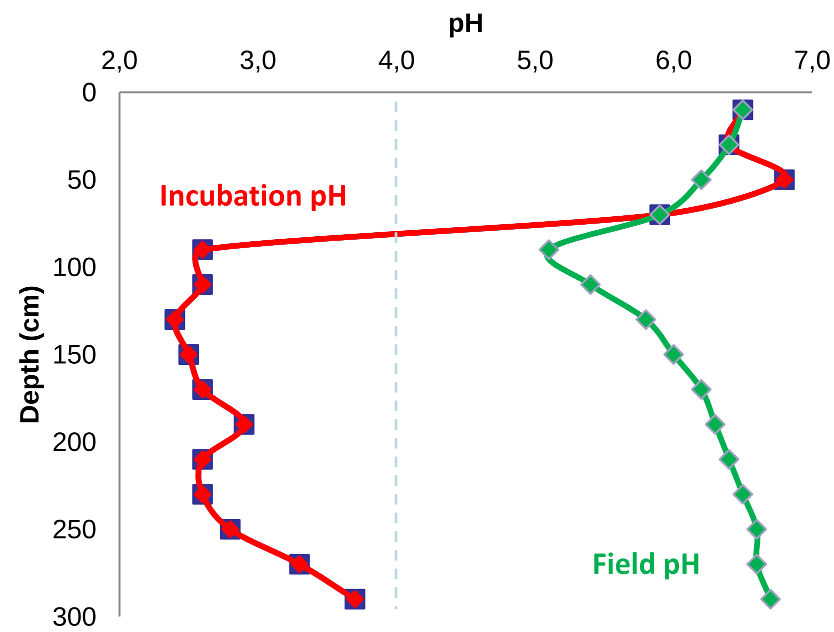
- Samples every 20 cm down to 3 m depth
- pH measured in the field and after 8 weeks of incubation
- Sulfur and metal analyses with ICP-OES (Aqua Regia leaching)

→ Profiles classified in two categories:

AS soil occurrences or non-AS soil sites

▪ **AS soil occurrences used as positive training points within the modeling:**



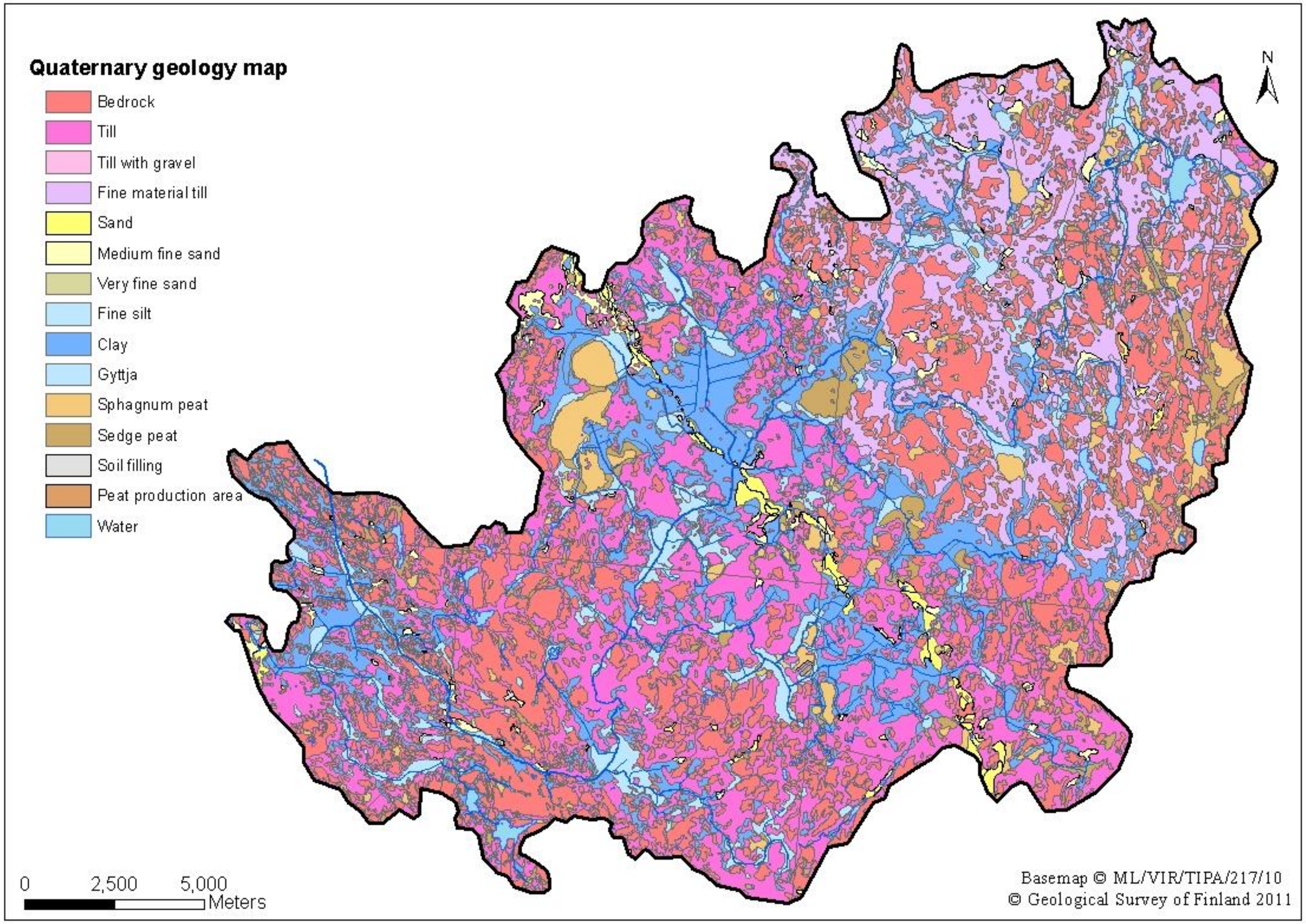


- Profiles with an oxidised acidic layer (Field pH < 4.5)
  ➔ **Actual AS soils**

- After 8 weeks of incubation, profiles containing sulfides (Inc pH ≤ 4.0)
  ➔ **Potential AS soils**

▪ **Non-AS soil sites used as negative training points**

Quaternary geology map

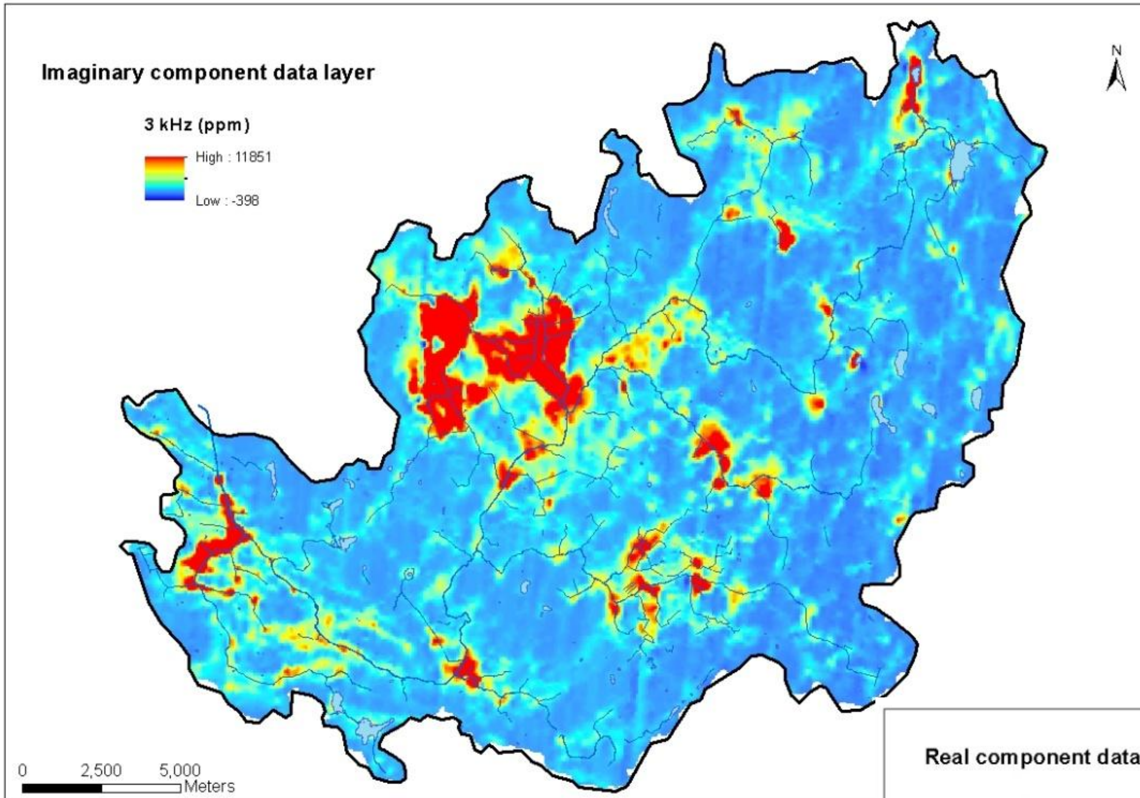


➔ Precisely locate **fine-grained sediments** in which AS soils occur

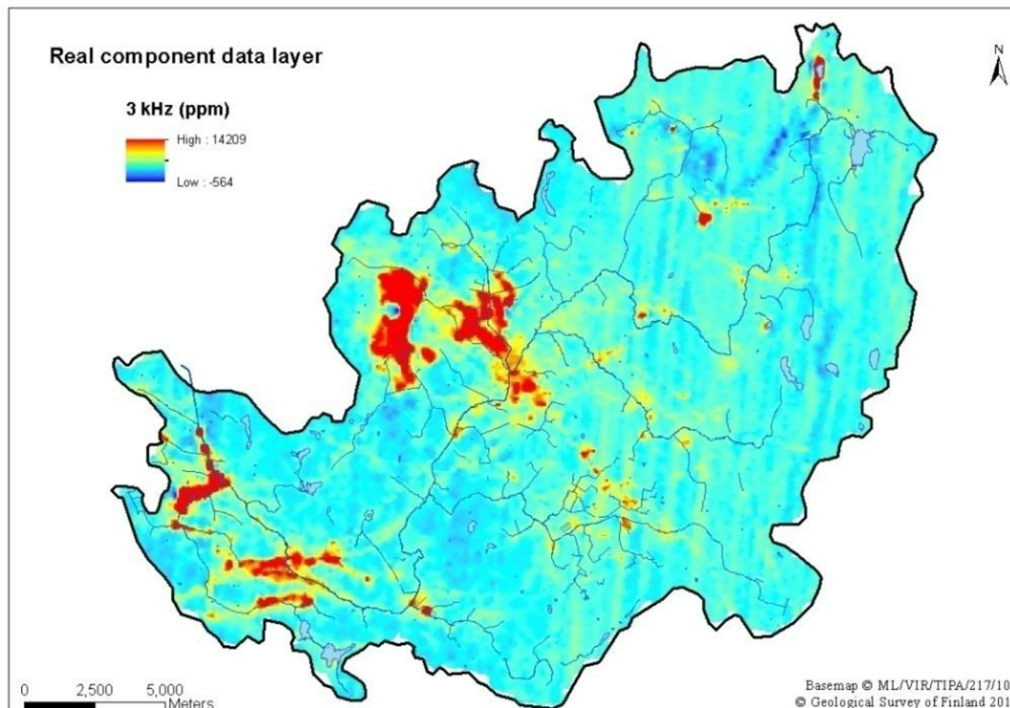
Geophysical data layers

AS soils appearing as **high Electric Conductivity anomalies**

➔ **Shallow anomalies**



➔ **Deep anomalies**



RBFLN ”combining” training points with evidential data layers:

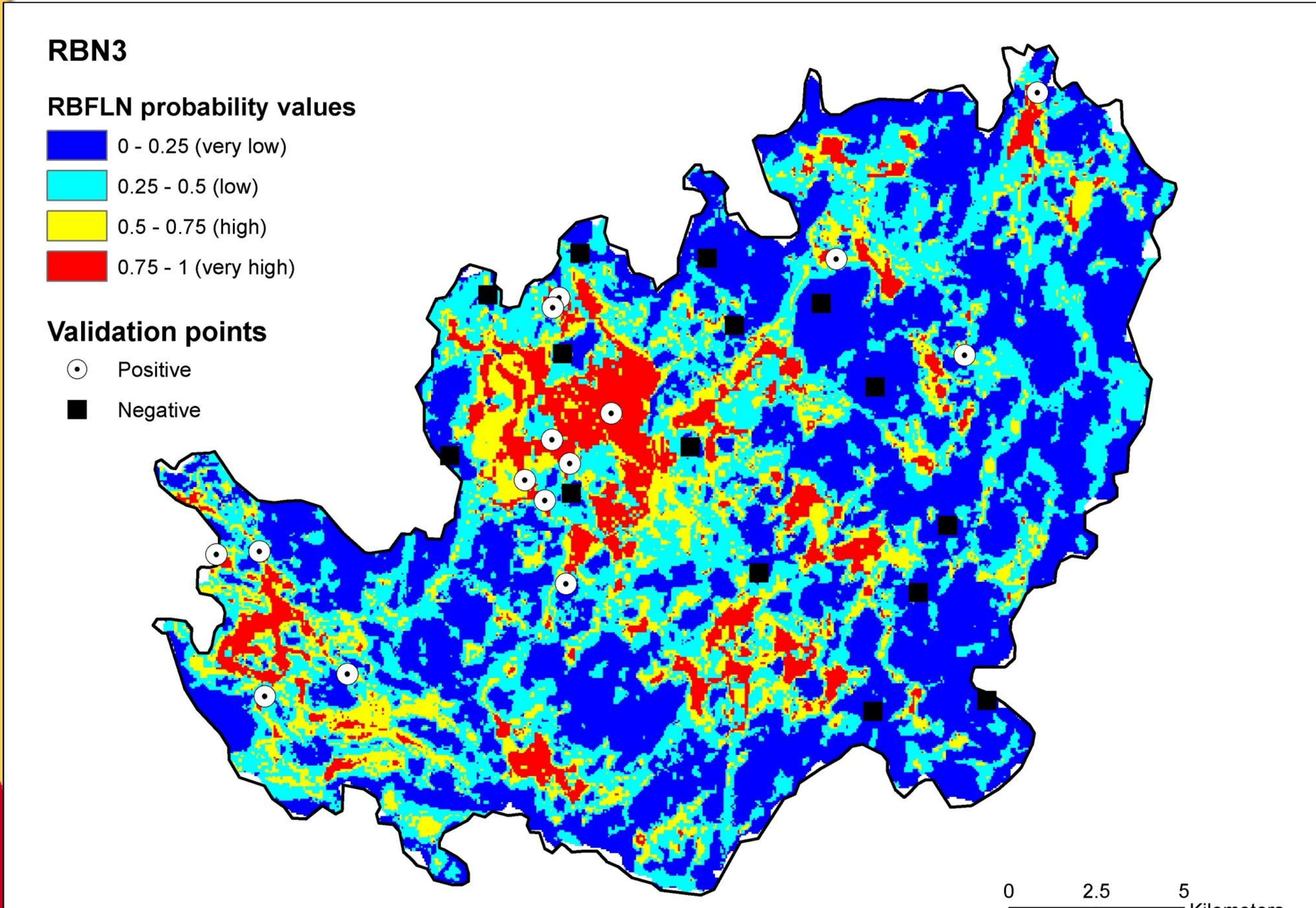
- 1) **RBFLN training:**

  Neural network learning to identify AS soils with

  - the training points (positive and negative)
  - and their corresponding data layers values
- 2) **RBFLN classification:**

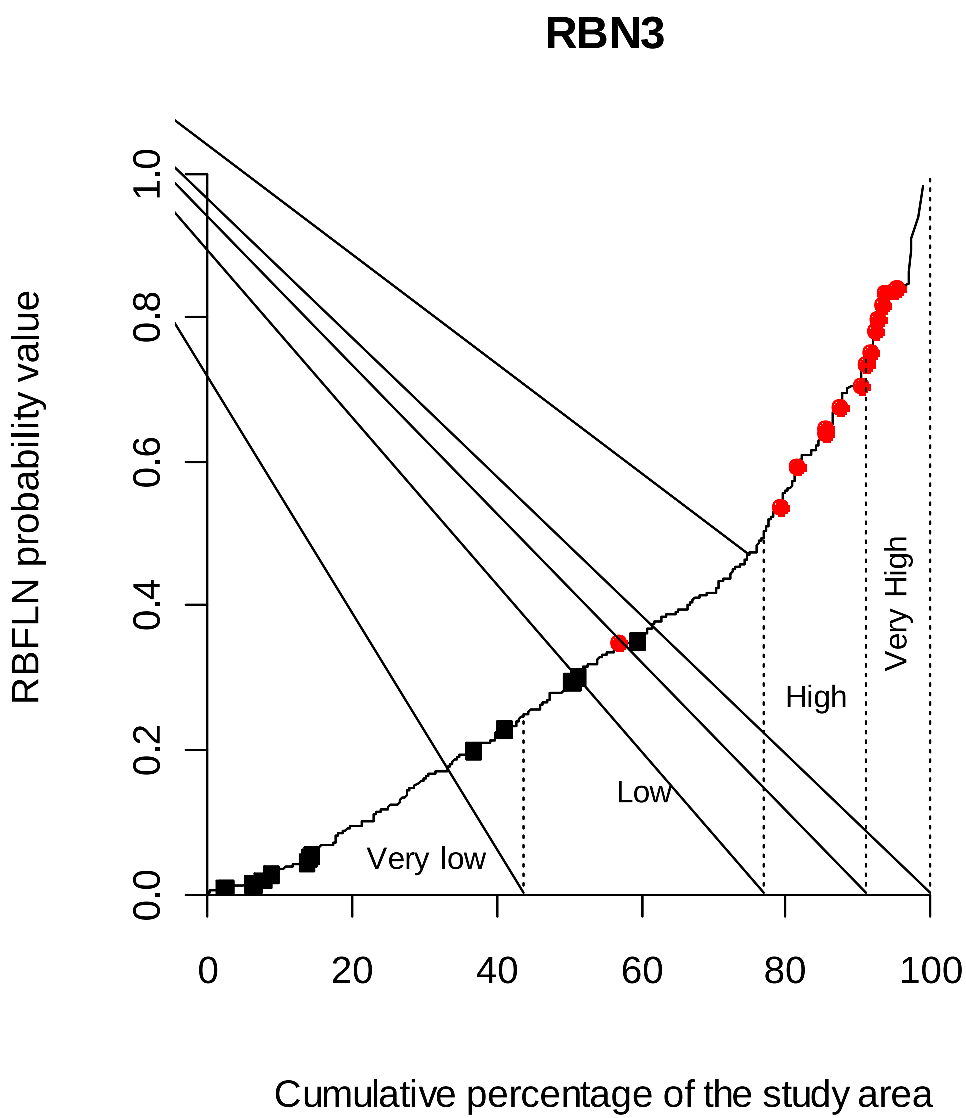
  Classifies all the unknown points according to its training

Probability map for AS soil occurrence



From Beucher et al. (2012) (accepted for publication in Journal of Geochemical Exploration)

Use of validation points



- *Very high probability areas* ➔ **9%** of catchment area
- *High probability areas* ➔ **14%**
- **14/15 positive validation points** located in very high/high probability areas
- **15/15 negative validation points** in low/very low probability areas

Conclusions

- **Actual AS soil extent** estimated for the study area: **12%**

  ➔ in line with the **very high amount of metals and sulfate** in the recipient streams (from previous water studies)

  ➔ **high proportion of AS soils** in the catchment

- **RBFLN**: very good ability for AS soil mapping in the study area
- **Objective method** requiring some conventional mapping data and as many as possible evidential data layers

➔ Importance of getting more evidential data layers:

e.g. geochemical data and pH/EC from water samples

- Use of **expert knowledge** to refine the model

- Use of RBFLN for the **whole Finnish coast mapping**

Acknowledgement:

- Annu Martinkauppi (GTK)
- Peter Österholm (ÅA)
- Sören Fröjdö (ÅA)
- Peter Edén (GTK)

Thank you!

abeucher@abo.fi