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

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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 occurrences
    - 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 to 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
Precisely locate *fine-grained sediments* in which AS soils occur.
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

RBN3

RBFLN probability values
- 0 - 0.25 (very low)
- 0.25 - 0.5 (low)
- 0.5 - 0.75 (high)
- 0.75 - 1 (very high)

Validation points
- ☺ Positive
- ■ Negative

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**
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