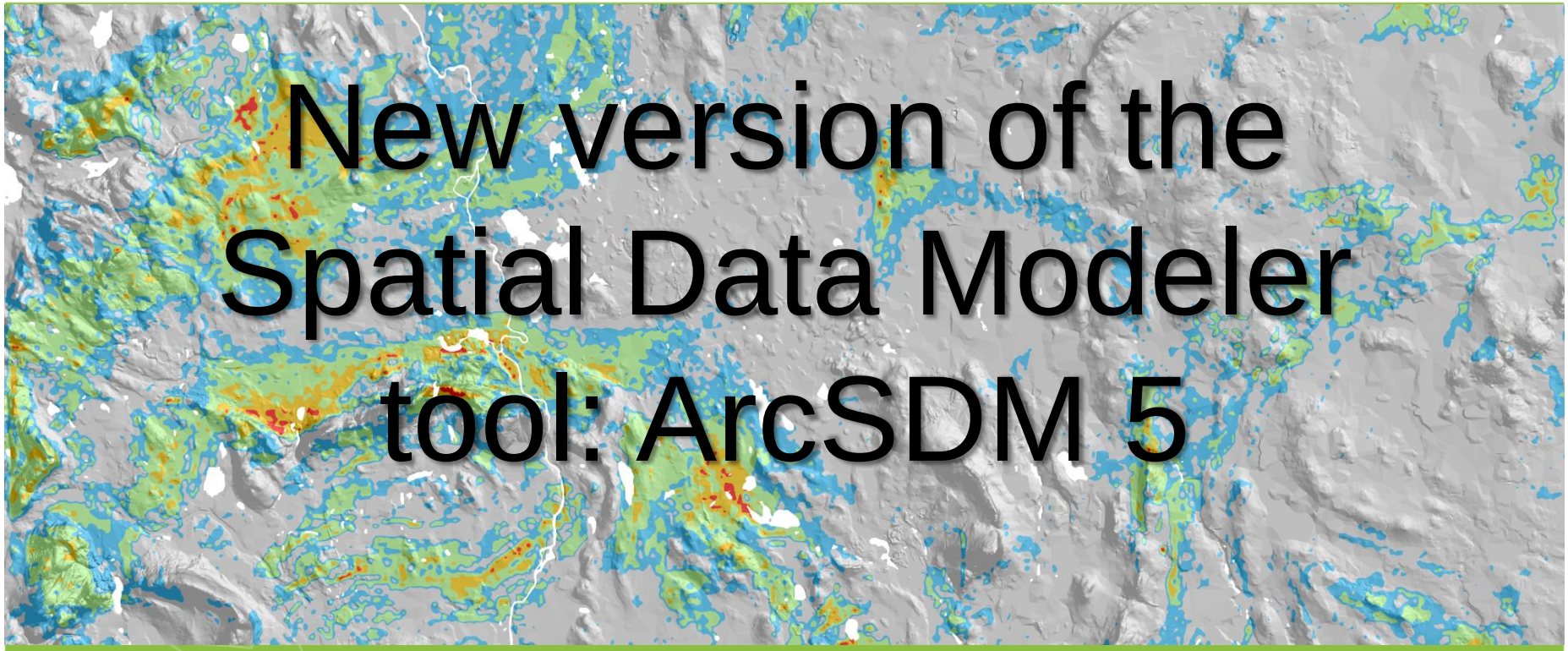


New version of the Spatial Data Modeler tool: ArcSDM 5

ArcSDM 5
Final Seminar
May 4th 2018, Rovaniemi

GTK

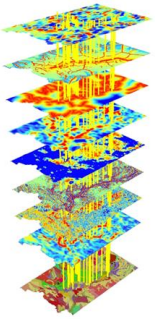
Programme for Sustainable Growth and Jobs

Leverage from the EU 2014–2020

European Union
European Regional Development Fund

Funding

BUSINESS FINLAND Tekes



國家海洋局第二海洋研究所
Second Institute of Oceanography,SOA

AngloAmerican

Sakumpu Exploration Oy

S2R S2 Resources

De Beers
Group of Companies

AGNICO EAGLE
FINLAND

NEW BOLIDEN

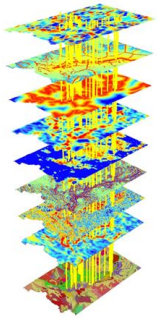
Programme for Sustainable Growth and Jobs

Leverage from the EU 2014–2020

European Union
European Regional Development Fund

GTK

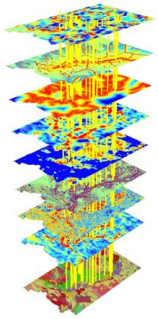
Acknowledgements



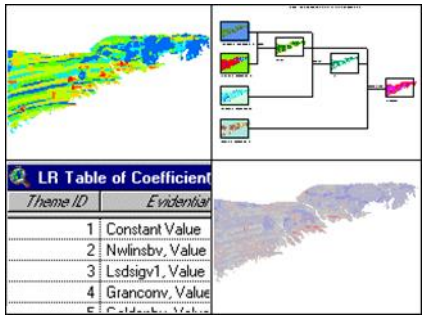
- This presentation may include slides borrowed from the following persons with or without proper citation:
  - Gary Raines
  - Graeme Bonham-Carter
  - Carlos Roberto de Souza Filho
  - Stephen Gardoll

THANK YOU VERY MUCH GUYS!

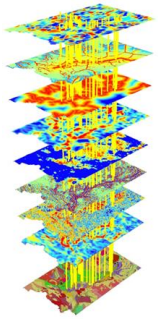
ArcSDM 5
Background



- ArcSDM was originally developed by Gary Raines (USGS) and Graeme Bonham-Carter (GSC) and was coded by Don Sawatzky (USGS)
- ArcSDM has been maintained by Prof. Carlos Roberto de Souza Filho, University of Campinas, Sao Paolo, Brazil, http://www.ige.unicamp.br/sdm/
- MPM project has recoded the tools into ArcGIS 10.4 and ArcGIS Pro platforms and also implemented some new tools

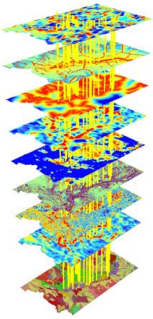


ArcSDM5
New toolbox

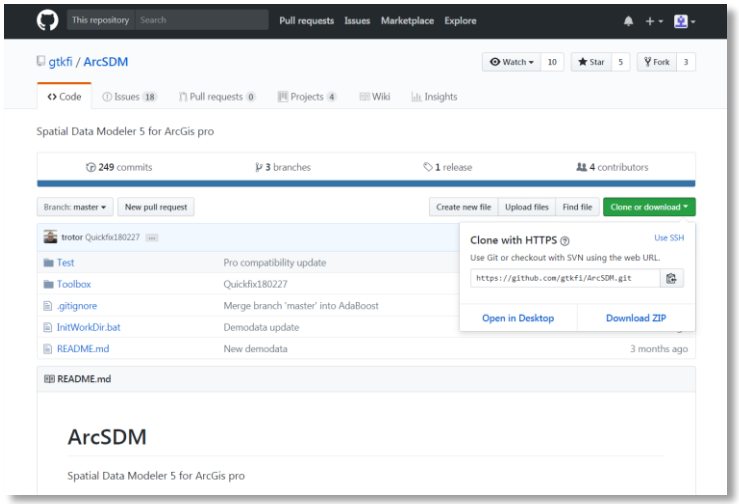


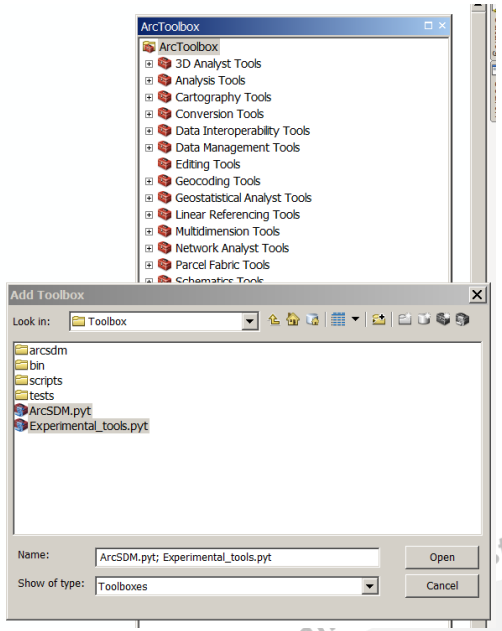
- Runs on ArcGIS 10.4 and beyond + ArcGIS Pro
- Maintained by GTK + open source community
- Available from https://github.com/gtkfi/ArcSDM

GITHUB, ArcSDM 5 Installation

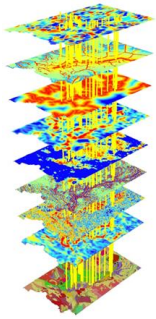


- https://github.com/gtkfi/ArcSDM
- Download ZIP file to your computer
- Add toolbox(es) into your ArcGIS map document





ArcToolbox

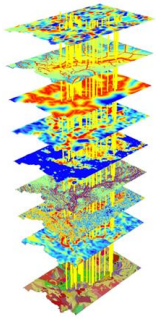


"Traditional" SDM Tools

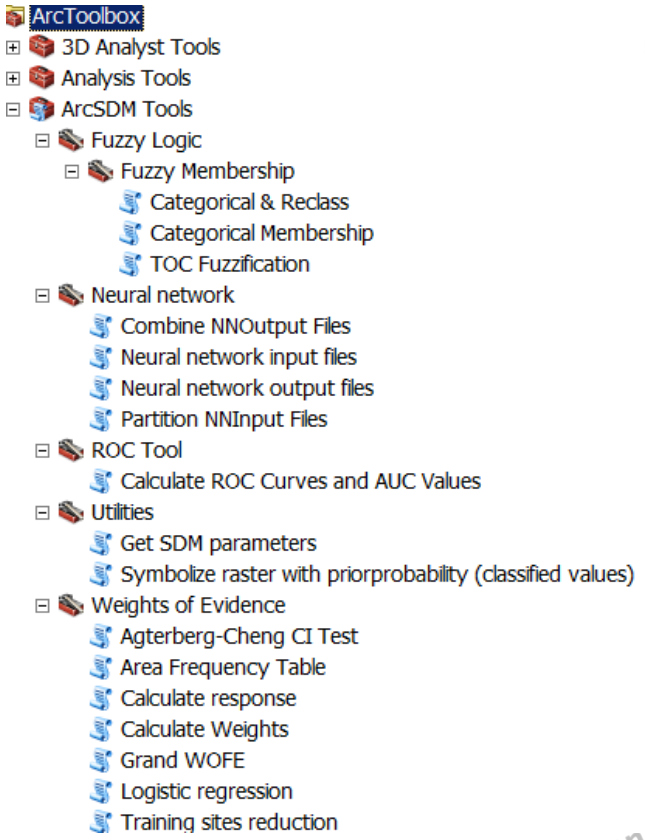
Experimental SDM Tools

- ArcToolbox
  - 3D Analyst Tools
  - Analysis Tools
  - ArcSDM Tools
    - Fuzzy Logic
    - Neural network
    - ROC Tool
    - Utilities
    - Weights of Evidence
      - Agterberg-Cheng CI Test
      - Area Frequency Table
      - Calculate response
      - Calculate Weights
      - Grand WOFE
      - Logistic regression
      - Training sites reduction
  - Cartography Tools
  - Conversion Tools
  - Data Interoperability Tools
  - Data Management Tools
  - Editing Tools
  - Experimental SDM toolbox
    - Modelling
    - Preprocessing
    - SOM
    - Utilities
    - Model Validation

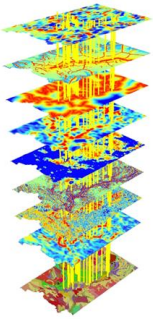
Spatial Data Modeller (SDM) toolbox

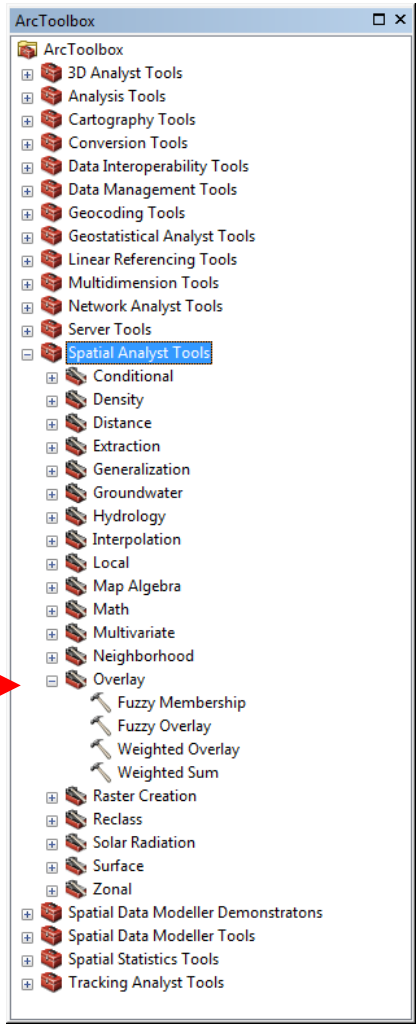


- Geoprocessing tools for integration of spatial data to predict the location to any features (i.e. mineral deposits, animal habitat, disease outbreaks … etc).
- Fuzzy Logic
- Neural Network
- ROC Tool
- Utilities
- Weights of Evidence
- Logistic regression



Spatial Analyst toolbox

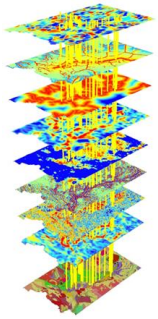




Fuzzy logic tools in Overlay toolset

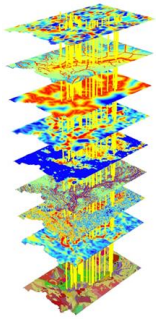
- Fuzzy Membership
- Fuzzy Overlay
- Weighted Overlay
- Weighted Sum

ArcSDM 5
Weights of Evidence

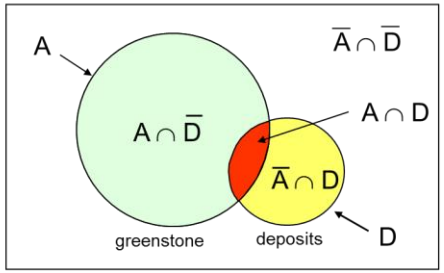


- Originally developed as a medical diagnosis system
  - relationships between symptoms and disease evaluated from a large patient database
  - each symptom either present/absent
  - weight for present/weight for absent (W+/W-)
- Apply weighting scheme to new patient
  - add the weights together to get result
- Can be applied also to predict potential for mineral deposit based on exploration data (geophysical or geochemical anomalies, geology)

ArcSDM 5
Weights of Evidence: Conditional Probability



- Data driven technique
  - Requires training sites
- Statistical calculations are used to derive the weights based upon training sites.
- Evidence (maps) are generally reclassified into binary patterns.



N(D) = 5 (in greenstone)

N(A) = 1,000

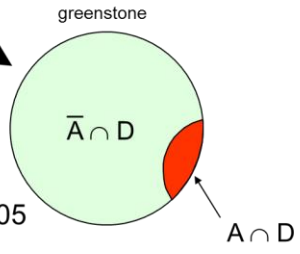
$N(D \cap A) = 5$

N(total) = n = 10,000

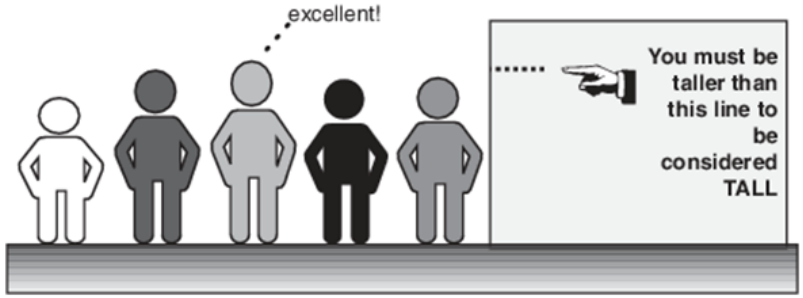
Definition of conditional probability

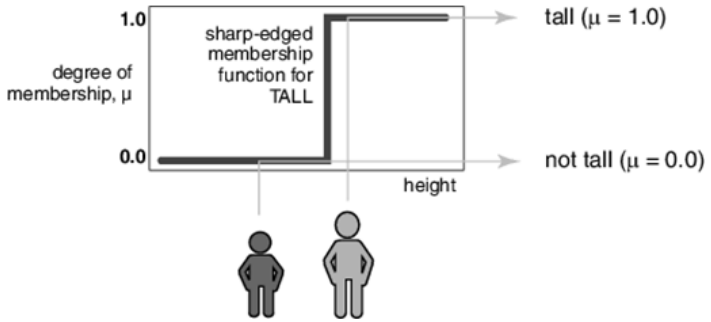
$$P(D \mid A) = \frac{P(D \cap A)}{P(A)}$$

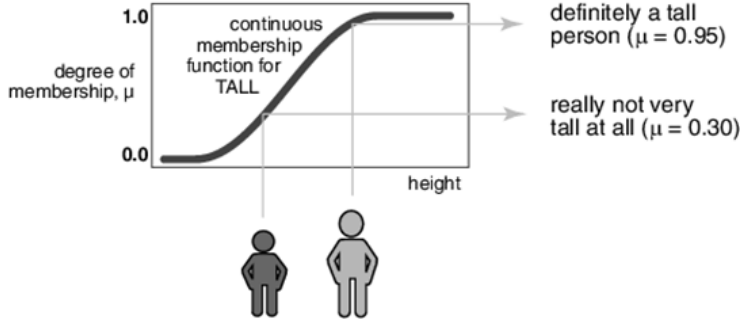
$$= \frac{N(D \cap A) / n}{N(A) / n} = \frac{5}{1000} = 0.005$$



Traditional ’crisp’ logic vs. fuzzy logic -> fuzzy sets

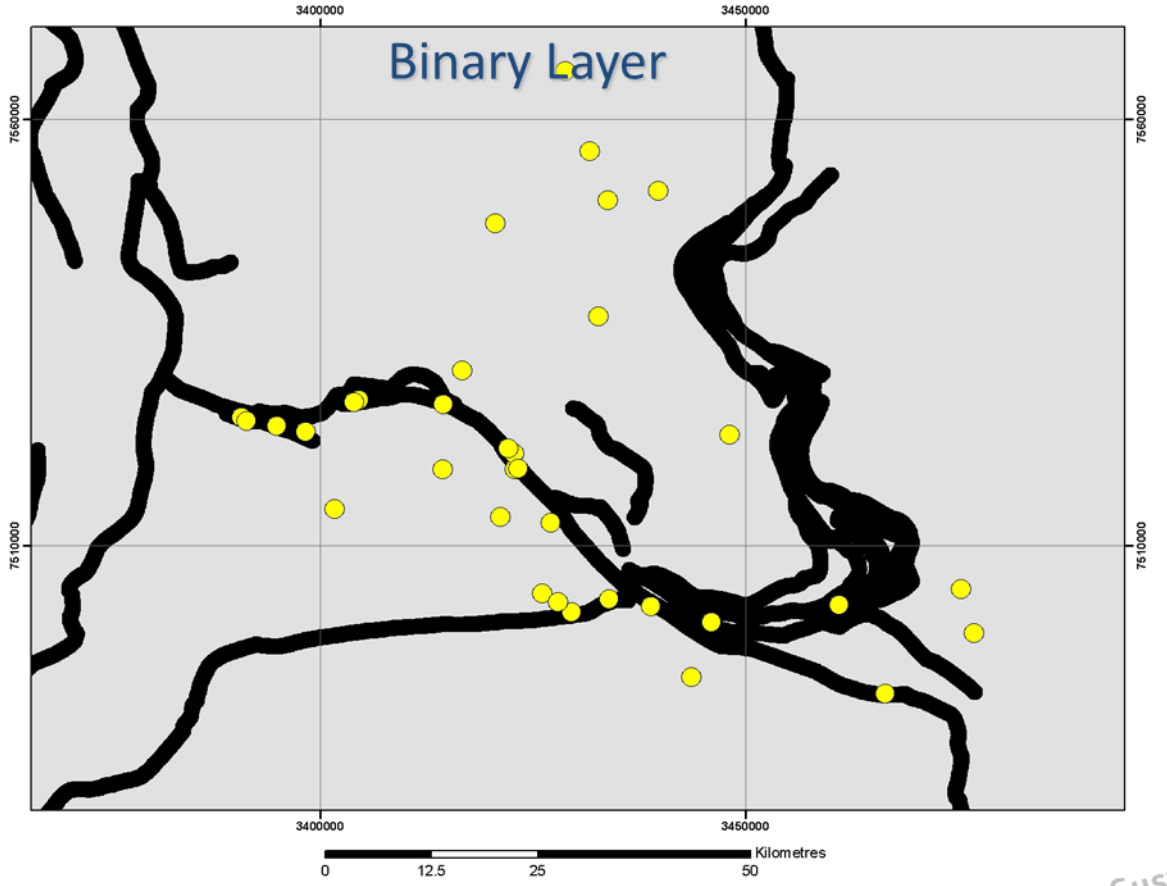




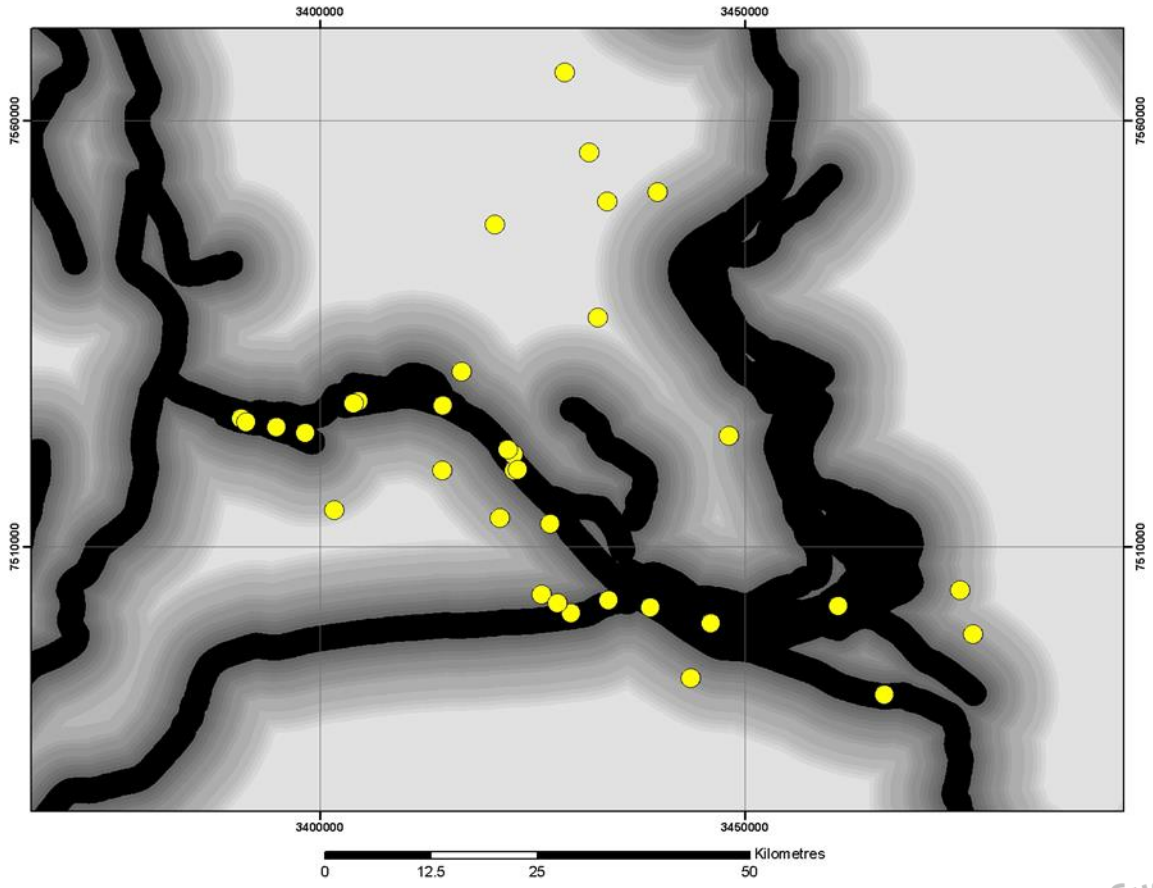


source: MathWorks
http://se.mathworks.com/help/fuzzy/foundations-of-fuzzy-logic.html

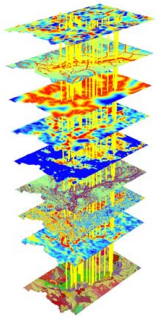
A geological example: Distance to Thrusts



A geological example: Distance to Thrusts



Problems with existing methods



Weights of Evidence

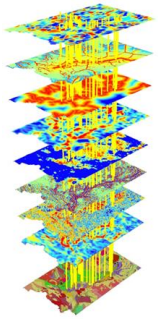
statistically-based => can't use in poorly-explored areas

Fuzzy Logic

subjective judgement => difficult to reproduce

deposit models but a) new deposit types found
b) existing models revised

Why use neural networks?



pattern recognition

Advantages over statistical methods:

uncertain, noisy data

outliers

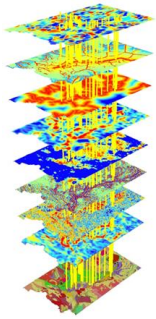
non-linear relationships

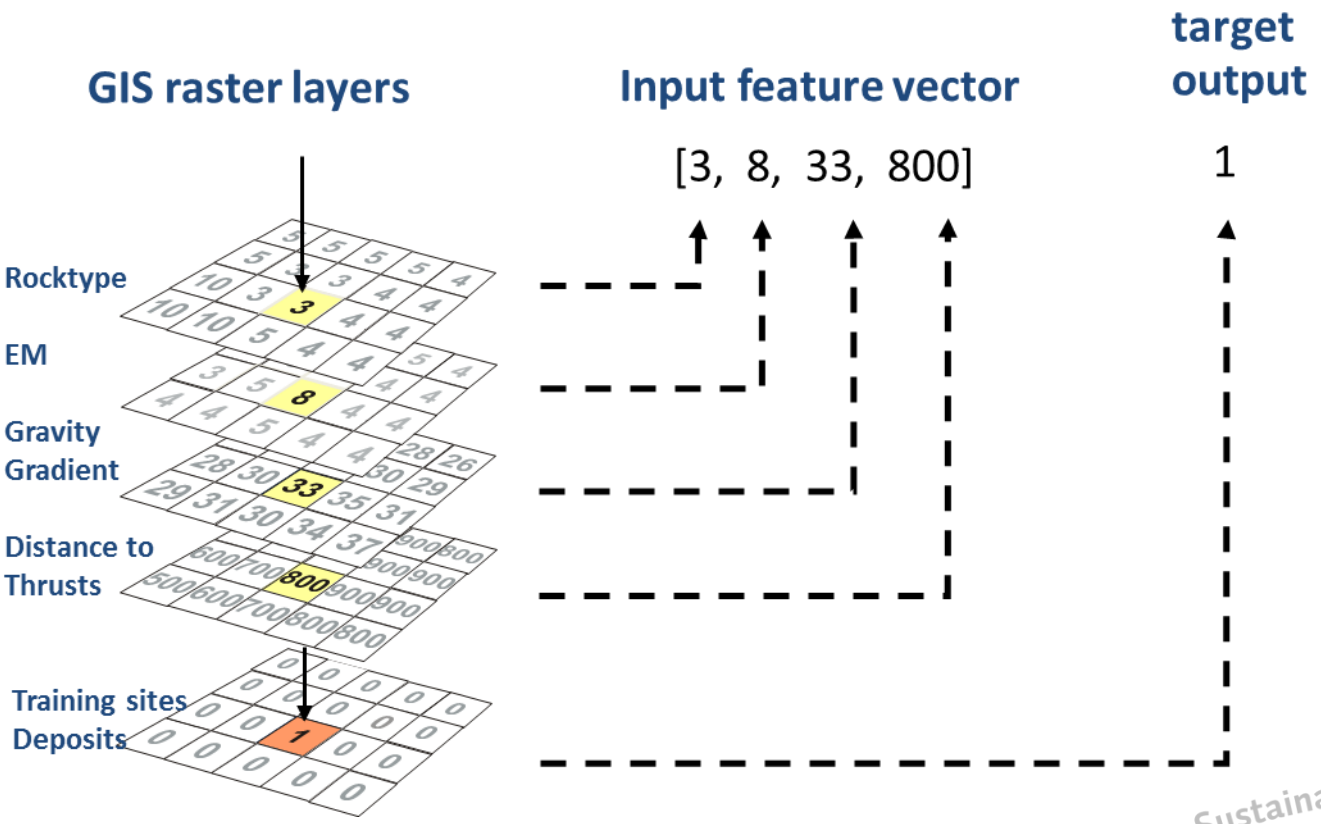
multiple interdependent parameters

multiple populations

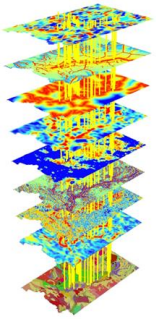
mixed data sets - categorical & ratio

Converting GIS layers to feature vectors



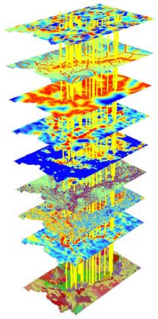


Model validation



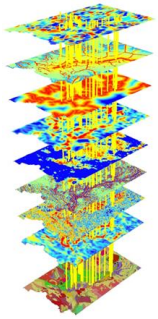
- Efficiency of Classification
  - Training sites
- Efficiency of Prediction (Validation)
  - Sites not used for training
- ROC curves
- Jack-knife/Cross-validation

PRC: Efficiency of Prediction
SRC: Efficiency of Classification

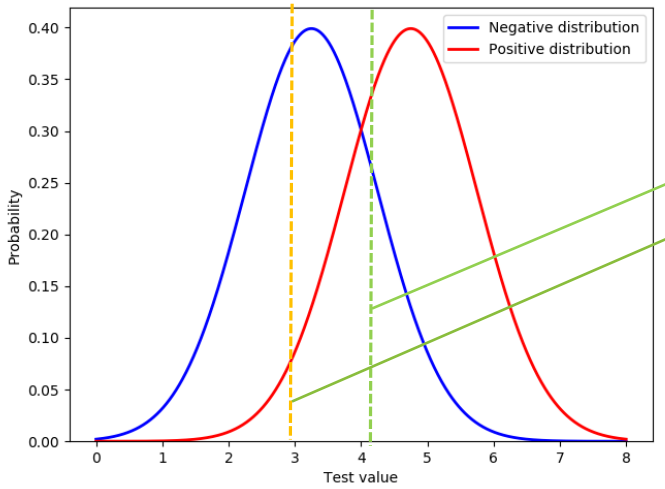


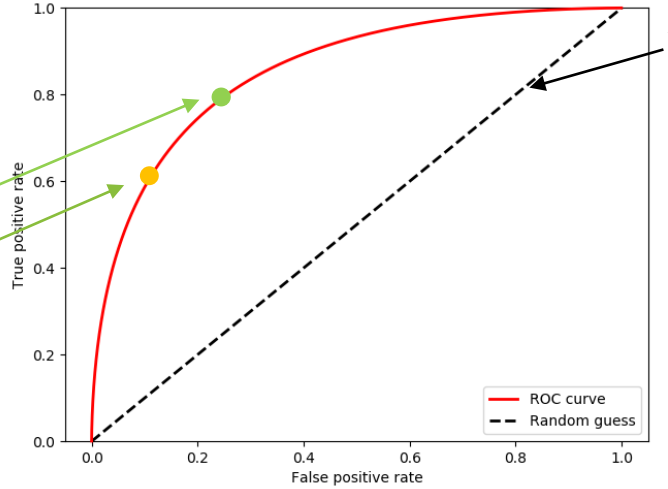
- Intersect points with response grid.
- Plot Cumulative area versus cumulative number of points
- Calculate area under the curve.
  - Area under the curve for sites should be greater than 50% of total area, then have a positive association with points.
  - Area under the curve for “Not” sites should be less than 50% of total area, then have a positive association with points
  - If area under the curve, then have a random association with the evidence. Evidence provides no better information than guessing.
- Point in curve where goes from steep slope to flat slope is an optimal break between predicted sites and not sites.

The ROC curve



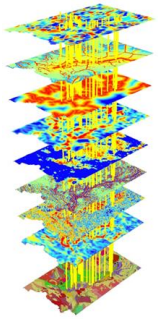
- The ROC curve is a graphical method for evaluating the performance of binary classifiers
- The threshold value takes all possible threshold values
- For each threshold value, the following rates are calculated:
  - False Positive Rate: FPR = number of false positives / total number of negatives
  - True Positive Rate: TPR = number of true positives / total number of positives
- The (FPR,TPR) points are plotted as a line graph

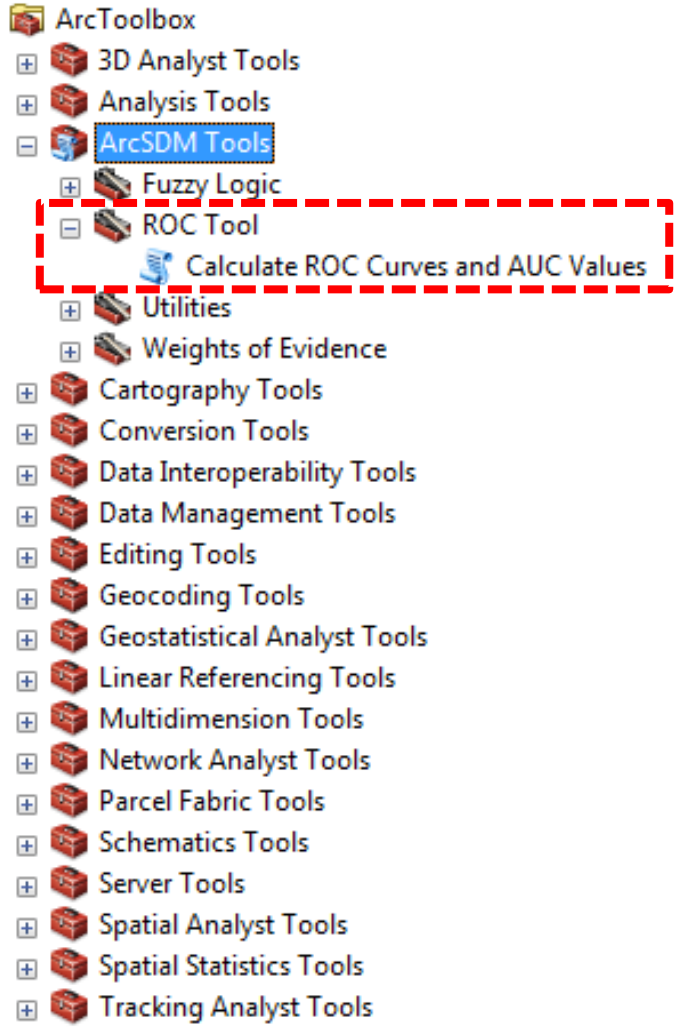




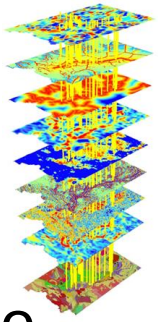
A ROC curve which is equal to tossing a coin to determine the group (positive or negative)

ROC tool in ArcSDM

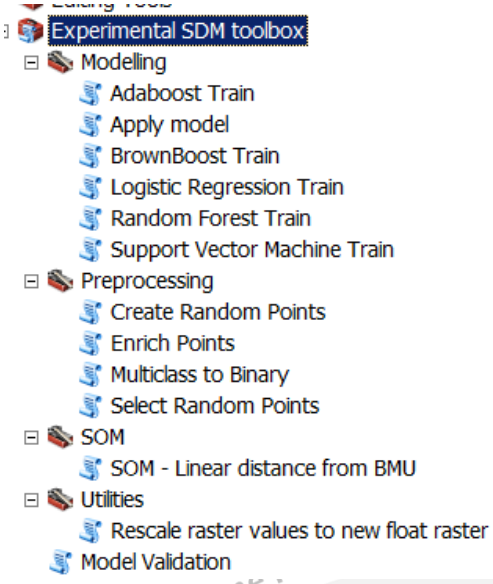




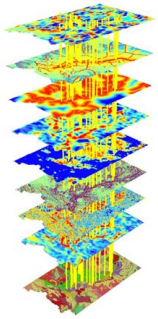
Experimental SDM toolbox



- Created by ESRI Germany: Irvine Gabrera and Melanie Brandmeier.
- Based on ArcPy, Scikit-learn and Matplotlib Python modules
- Algorithms implemented
  - Adaboost
  - BrownBoost
  - Logistic regression
  - Random Forest
  - Support Vector Machine

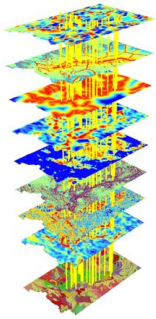


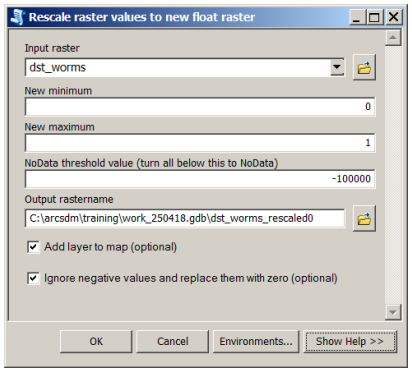
Experimental SDM toolbox
BrownBoost model

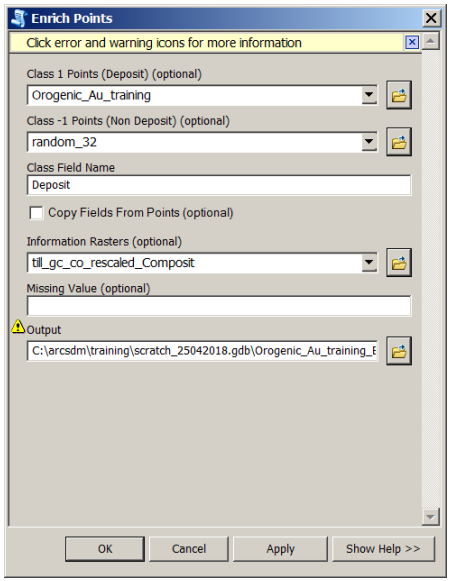


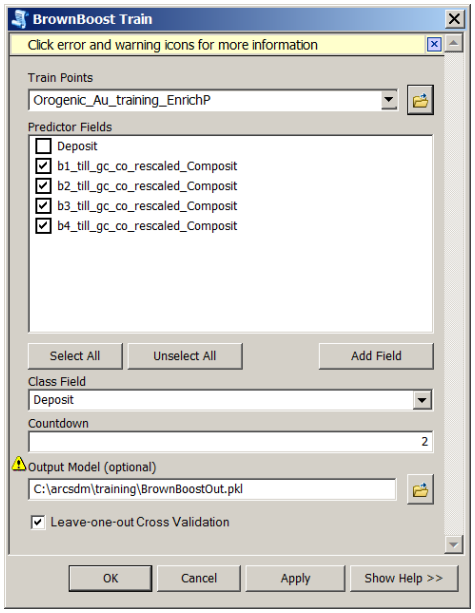
- Steps in Experimental tools:
  1. First need to re-scale data values to 0 – 1
  2. Combine re-scaled grids using **Composite Bands**
  3. Create random points (not deposit sites, N = deposit sites)
  4. Enrich points -> extract grid values to points
  5. Train BrownBoost model
  6. Apply Brown Boost model
  7. Validate model

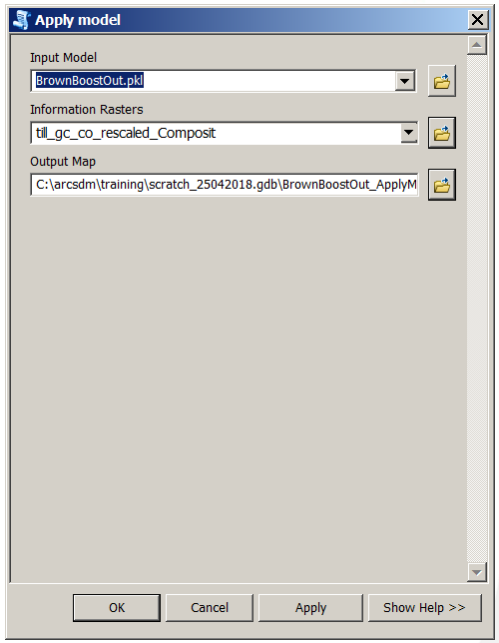
Experimental SDM toolbox
BrownBoos model





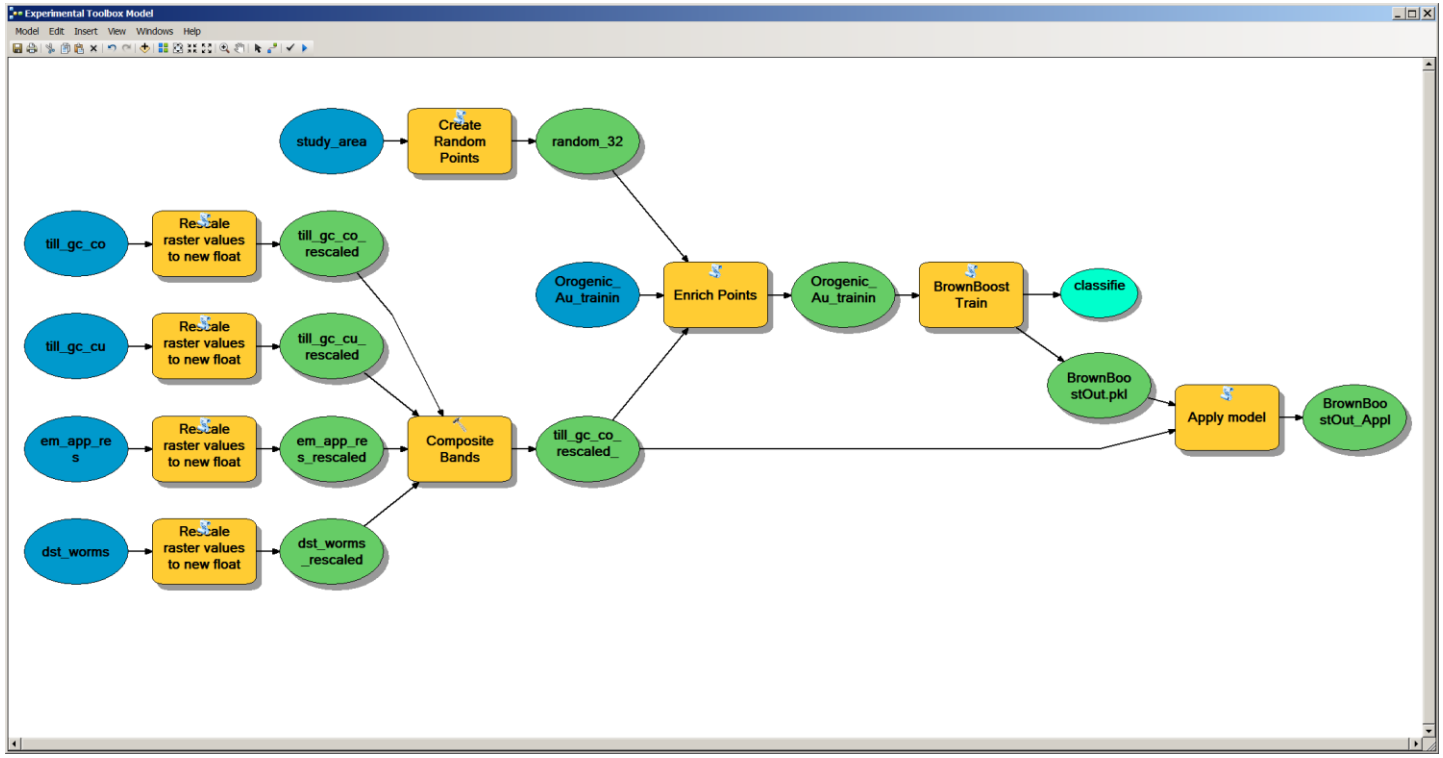




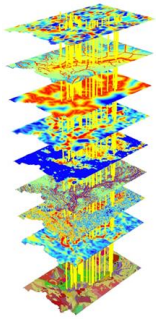


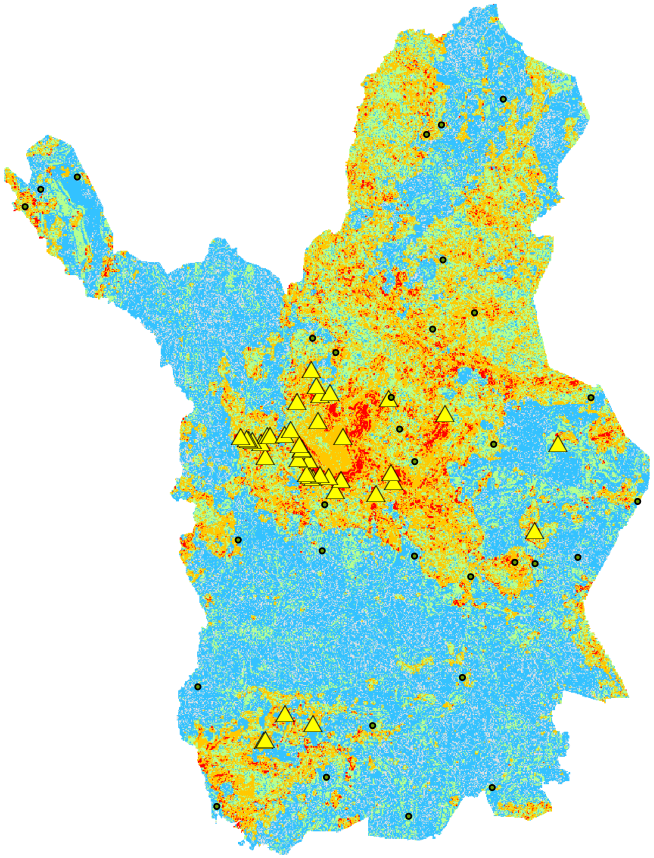
Rescale data | Enrich points | Train model | Apply model

Experimental SDM toolbox
BrownBoost

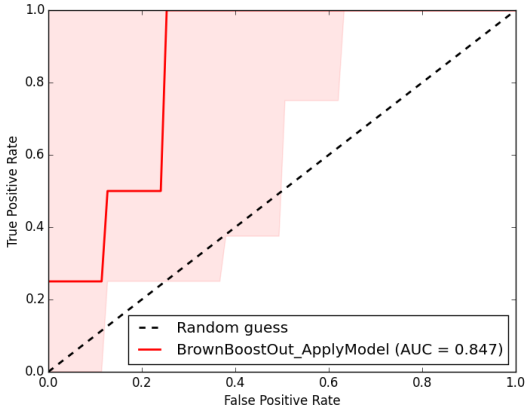


Experimental SDM toolbox BrownBoost

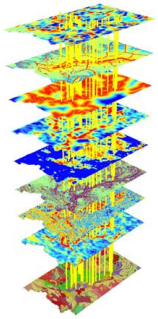




- Validation done using ROC method
- AUC=0.847



ArcSDM5
Summary



- Runs on ArcGIS 10.4 and beyond + ArcGIS Pro
- Maintained by GTK + open source community
- Available from https://github.com/gtkfi/ArcSDM