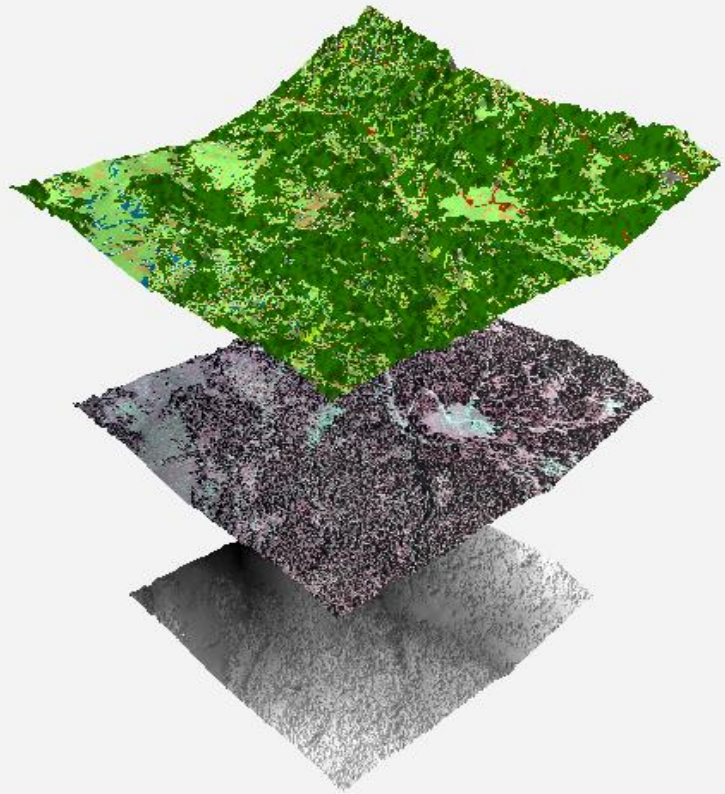
Extraction of forest parameters in a mire environment using airborne spectral data and digital surface models



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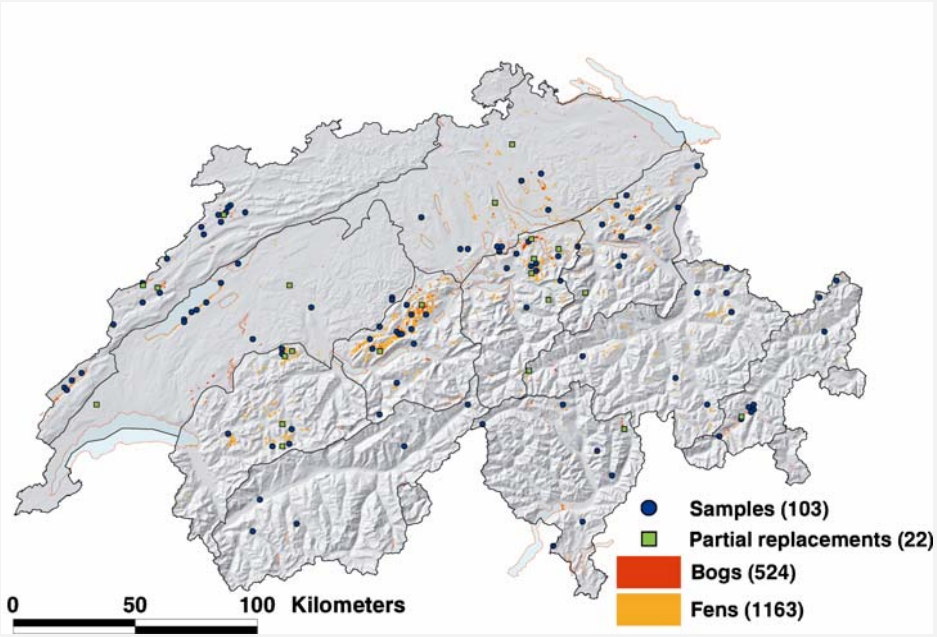
Swiss Mire Monitoring Program

Why Federal Decree on Protection of Mires of National Importance (Federal Constitution Art.78 §5)

Who WSL in partnership with the Swiss Agency for the Environment, Forest and Landscape

How stratified sampling method (103 mire biotopes), 5 years between 1st and 2nd survey, vegetation to assess condition of mire ecosystem

- geographic region
- altitude
- mire type: bog / fen
- mire size




Problem: degradation of vegetation => shrub encroachment

Goals of present study

1. Extraction of small shrubs / trees in open mire areas

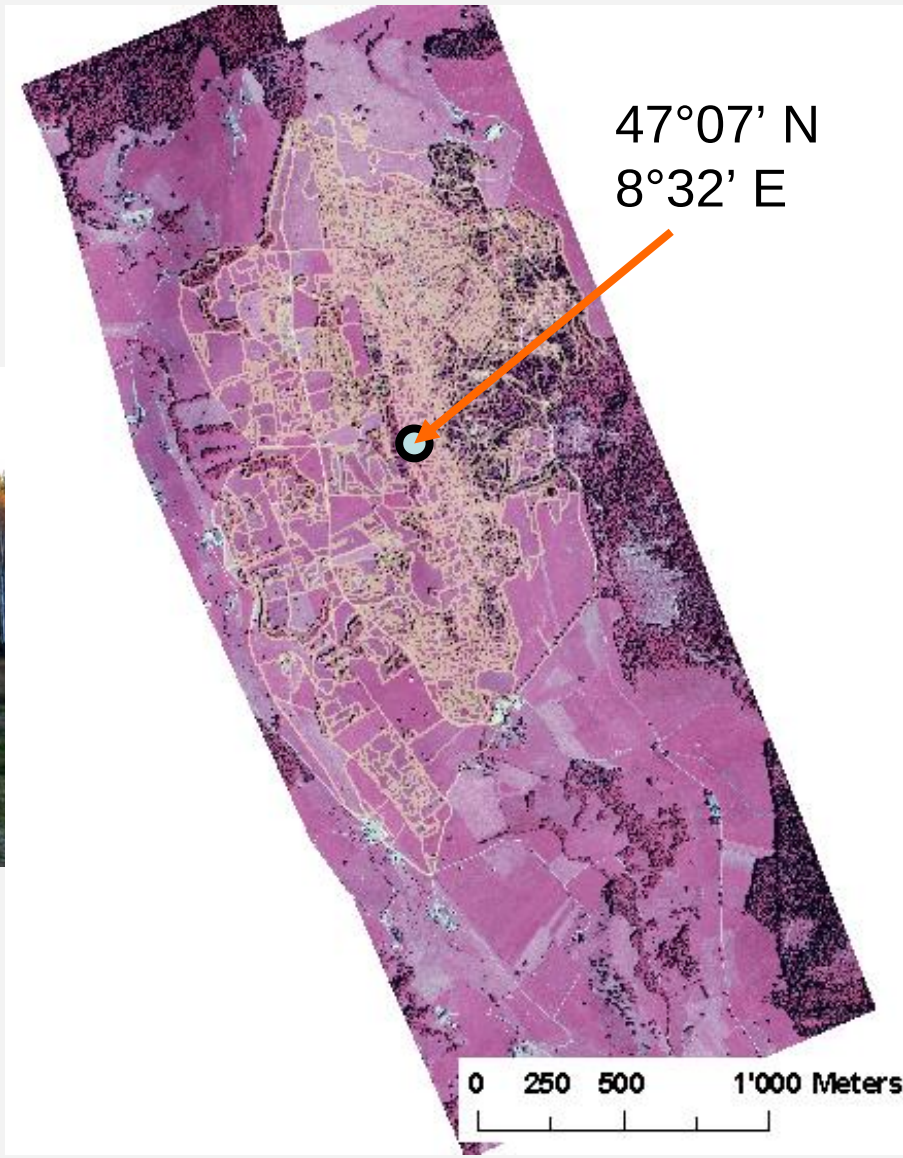
2. Prediction of tree genera

=> Using Generalized Linear Models & airborne remote sensing data

Study Area


LANDSAT TM-Mosaic of Switzerland 1990-1994,
Source: http://www.swisstopo.ch/en/image/npoc

Study Area: Mire Object Nr 99 'Eigenried'

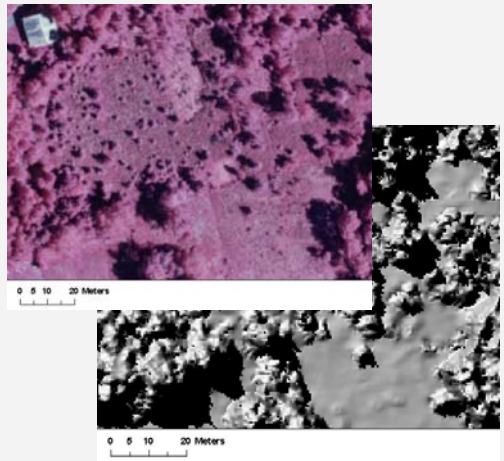


- Pre-alpine zone of Central Switzerland
- extent of core mire area 1.72 km^2
- mean attitude: 1000 m a.s.l

Data

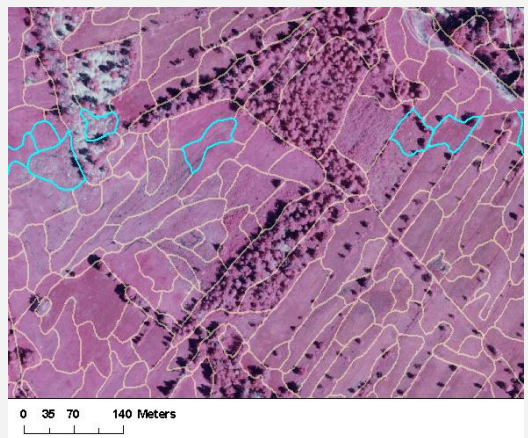
1. Airborne remotly sensed data

- CIR orthoimage (2002, 3 channels, 0.3m)
- Digital Surface Model DSM (0.5m)
- Lidar DTM (2002, 2.5m)



2. Field Data

- Vegetation records of 170 selected areas (2003)
  => estimation of canopy closure,
  dominant tree genera etc.
- 130 tree releves (2005)
  => 8 different tree genera,
  => tree height measurements etc.

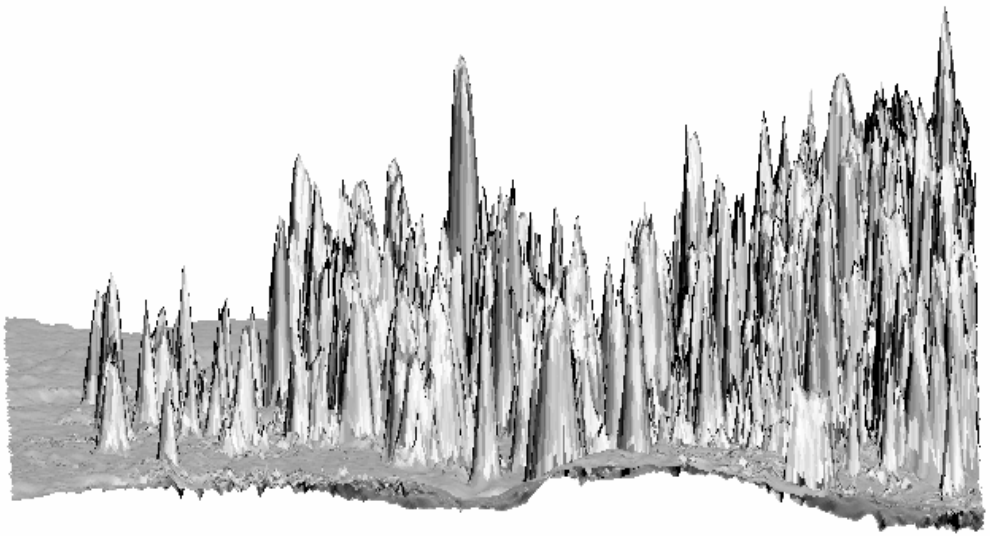


Preliminary Tree Cover: 1st step

1) Automated Detection of Tree Canopy

=> multistage procedure:

- Normalisation of DSM 0.5m
- Slope threshold (discrimination of tree like objects)
- Definition minimum size of tree canopy / gaps



shaded normalized DSM 0.5 m (superelevation 5x)

errors due to:

- systematic bugs in the DSM
- small structured terrain
- other surface objects

Preliminary Tree Cover: 2nd step

2) Separate problematic features by means of spectral information

=> Object oriented image analysis

=> multiresolution segmentation & fuzzy classification

Refinement of Tree Cover

=> Necessary for detection of small shrubs / trees

=> Logistic regression commonly used to predict presence/absence of e.g. vegetation types

- Explanatory variables:

- 16 parameters derived from DSM 0.5m and Lidar DTM (slope, aspect, curvature etc.)

- 7 spectral parameters derived from CIR-Orthoimage (ratio, mean of channels etc.)

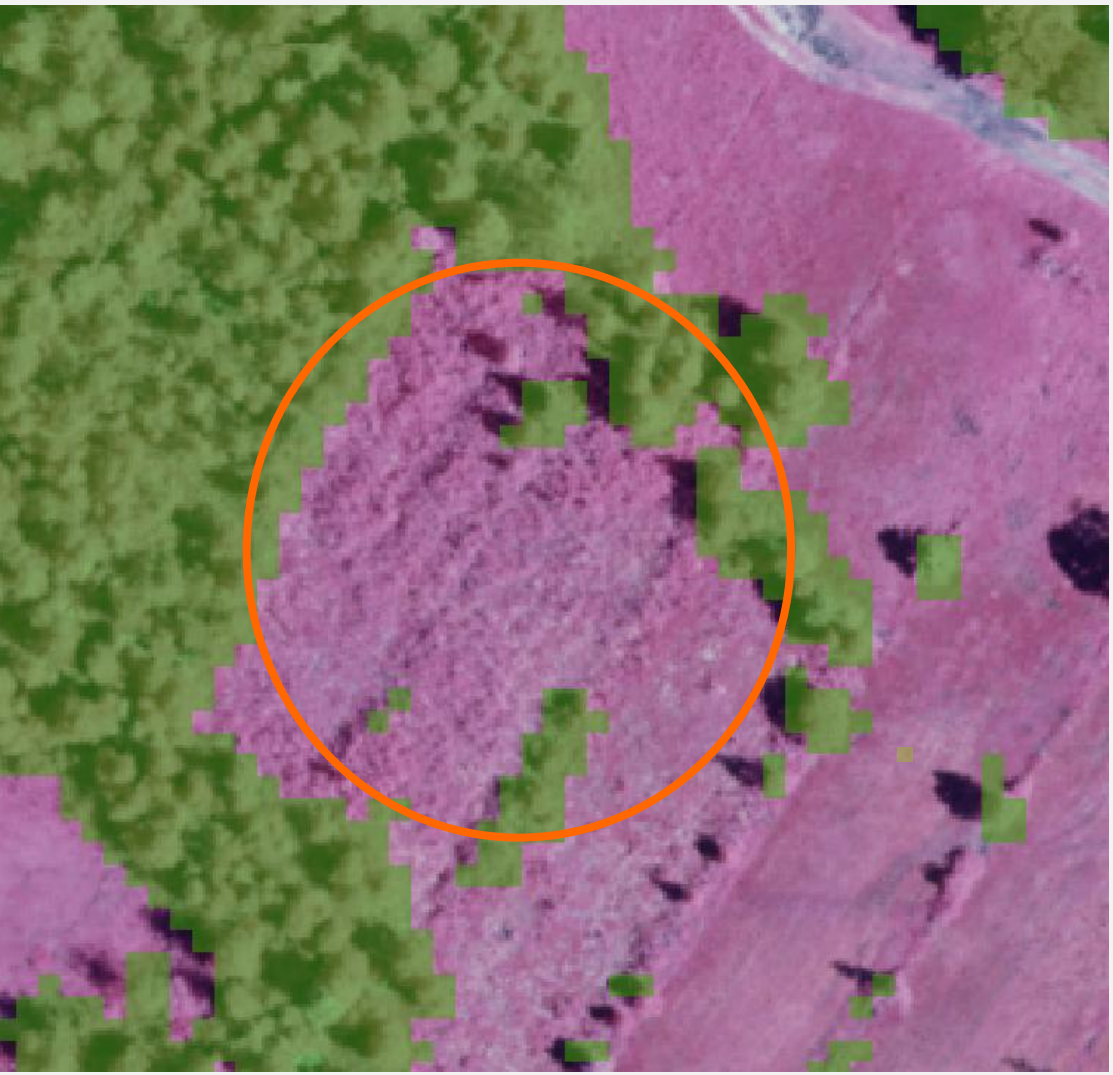
- Response variable: Preliminary tree cover

=> Step-wise selection of variables

=> 5 remaining explanatory variables (all derived from DSM 0.5m)

1st Model: Extraction of small shrubs / trees

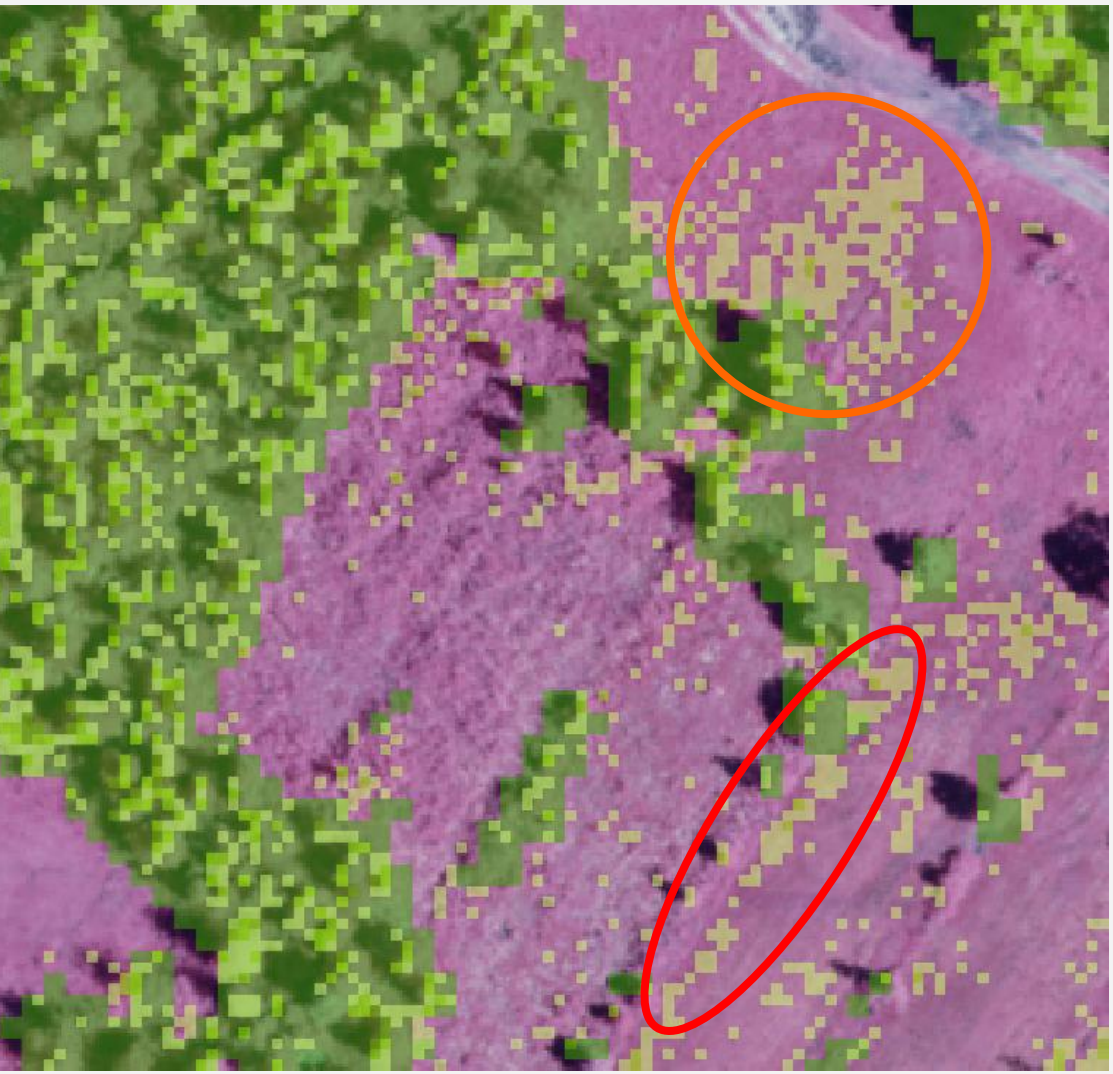
Response variable: Preliminary tree cover



- small shrubs / trees are not detected

1st Model: Extraction of small shrubs / trees

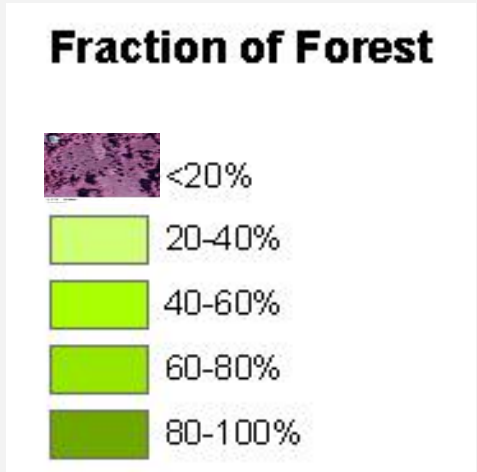
Extraction of small shrubs using spectral and DSM 0.5m variables



- Over-detection of shrubs
- Extraction of tall grass (*Molinia sp.*) due to spectral variables
- Extraction of ditches due to spectral variables

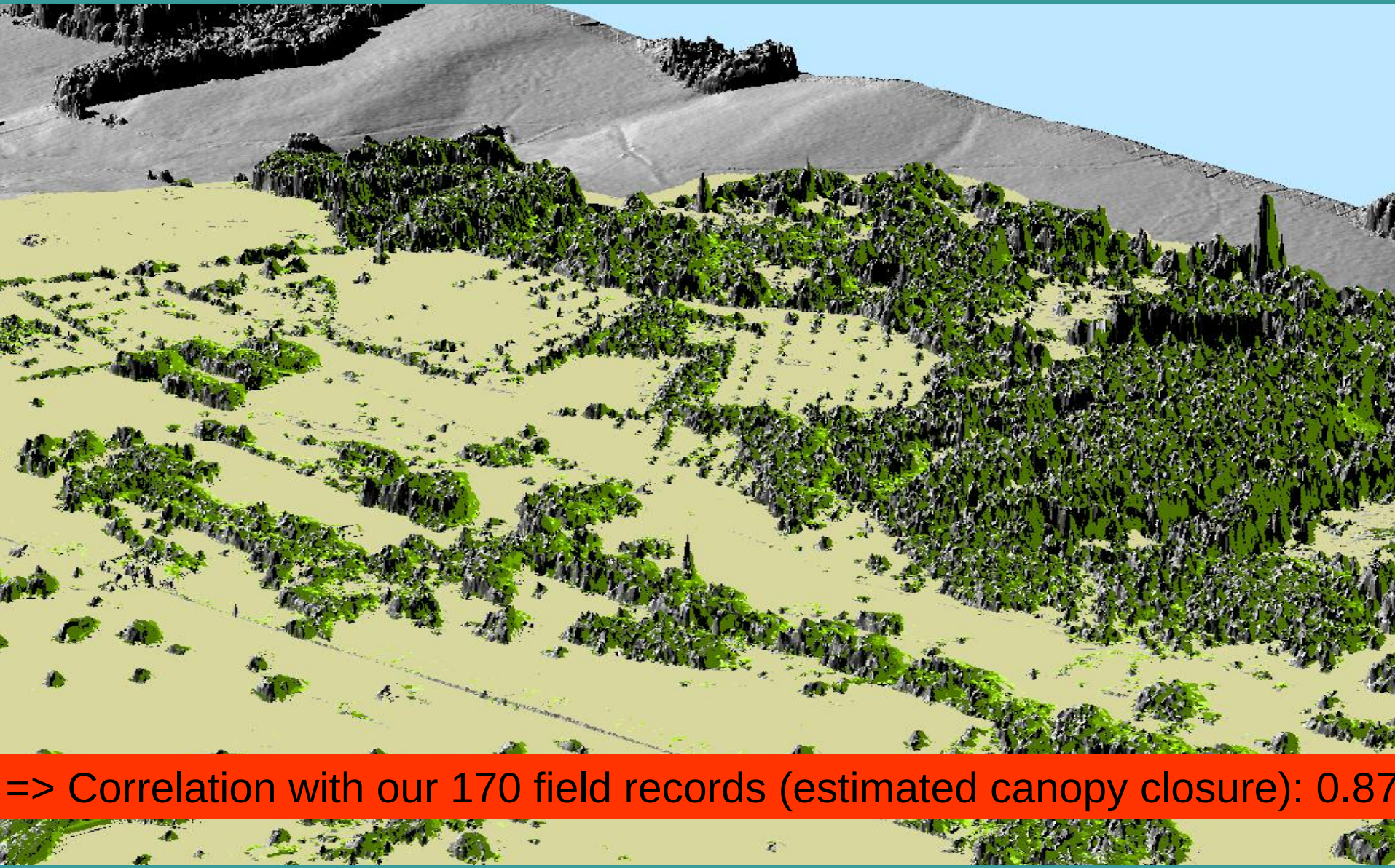
1st Model: Extraction of small shrubs / trees

Extraction of small shrubs only using 5 DSM 0.5m variables



- Previous errors eliminated
- pixelwise prediction of shrubs
- Threshold: pixels < 0.2 ignored

Validation of 1st Model



=> Correlation with our 170 field records (estimated canopy closure): 0.87

2nd Model: Prediction of tree genera

=> Considering pixels with forest probability of > 0.2

=> Multinomial Model (8 categories of tree genus)

=> Main tree genera of the mire:
Acer, Betula, Frangula, Populus, Salix, Sorbus, Picea and *Pinus*

- Explanatory variables:

- 5 DSM parameters (of 1st model) and 6 spectral parameters (mean & ratio of channels)

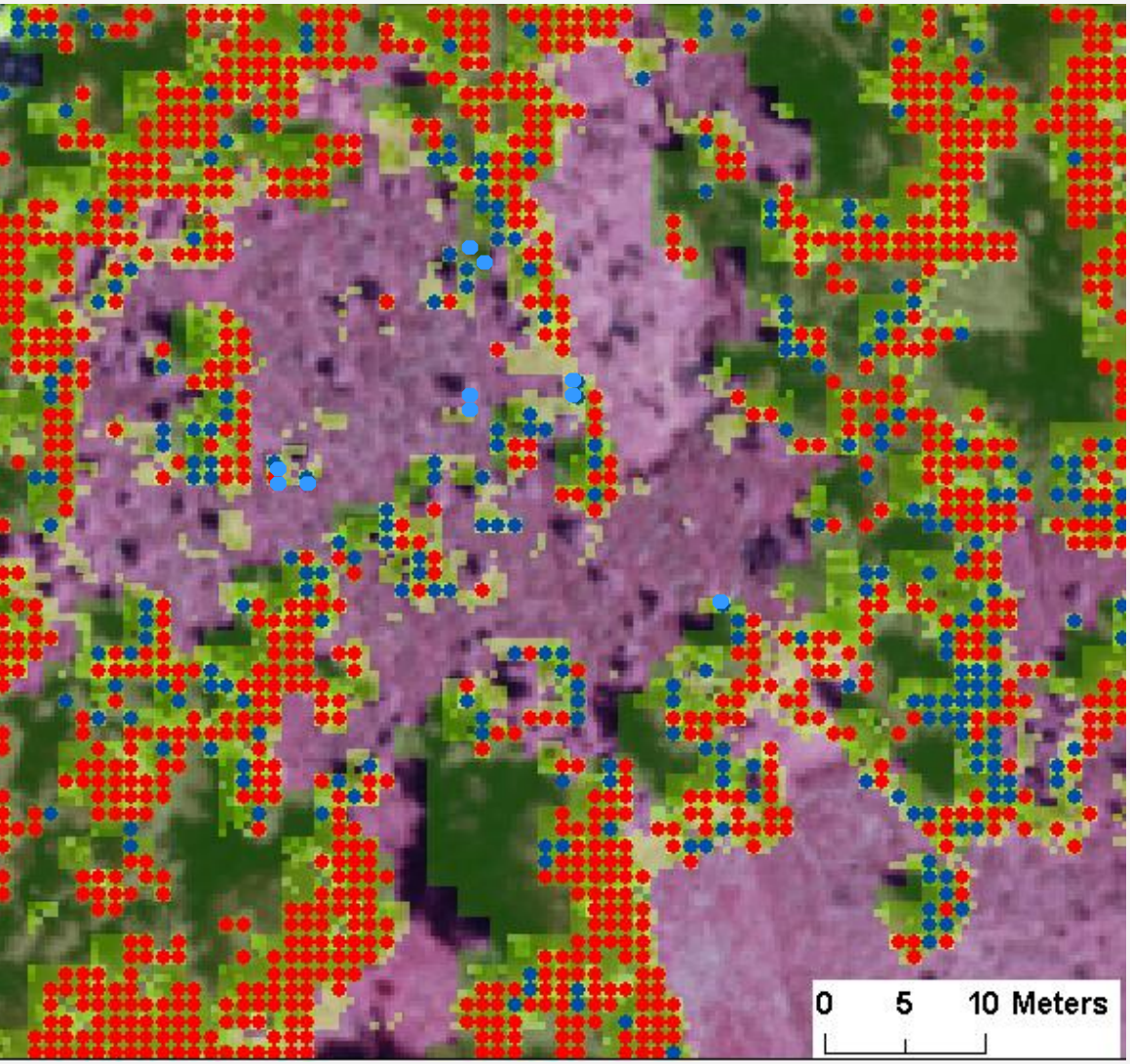
- Response variable:

- Dominant tree genus from each of our 170 field records

=> Spatial resolution: 1m

2nd Model: Prediction of tree genera

Prediction of birch, pine, spruce



- *Betula pubescens*
- *Pinus sylvestris*
- *Picea abies*

=> Calculation of the probability of each pixel belonging to a certain tree genus

Validation of 2nd Model

=> Validation performed with 130 tree releves (8 genera)

=> Reliable results only für *Betula, Pinus* and *Picea*

- Prediction of deciduous / coniferous trees

Overall accuracy	0.98
Kappa	0.96
Gamma	0.98

- Prediction of *Pinus* and *Picea*

	Overall accuracy
Single tree	0.56
Group of trees	0.68
Forest border	N.A.
Within forest	0.85

=> Prediction depends on the forest affiliation

Conclusion / Outlook

+ 3D information is indispensable (study not feasible only with spectral data)

+ Importance of high resolution DSM data for ecological modelling purposes

+ Preliminary tree cover: good basis for Mire Conservation Program

+ 1st goal: satisfactory, detection of location of shrub encroachment

- 2nd goal: partly satisfactory, prediction of more tree genera needed
  => Using additional spectral information (Leica ADS40)

- Testing the models in other mire objects