A stratified two-stage sampling design for digital soil mapping in a Mediterranean Basin

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Introduction

The quality of environmental modelling often depends on reliable soil information. In order to obtain soil data in an efficient manner, several sampling strategies are at hand depending on the level of prior knowledge and the overall objective of the planned survey (Brus and de Gruijter 1997). This study focuses on the collection of soil samples in an undulating, 16km²-sized river catchment. It considers available continuous secondary information based on the concept of environmental correlation (McKenzie and Ryan 1999). Accordingly, we decided to apply a design-based, stratified, two-stage sampling aiming at the spatial prediction of various soil property values at individual locations.

Preliminary considerations

- no prior knowledge on local soil data (variogram) and no primary target variable (general-purpose) ⟶ design-based
- auxiliary information on soil forming factors available in adequate resolution and quality ⟶ stratification
- overall objective is geostatistical interpolation with 20m target grid resolution including a data-driven trend analysis
  ⟶ creation of two distinct calibration and validation sets (ratio of 4:1) with a desired total sample size of apprx. 200

The implementation of sample point selection is based on ESRI software (ArcGIS) extended by Hawth's Tools and its later replacement, the Geospatial Modelling Environment (GME, http://www.spatialecology.com/gme/).

Stratifying variables

Stratification based on quantiles from density functions of two land-surface parameters

- topographic wetness index
- potential incoming solar radiation

derived from a 10m resolution digital elevation model and four main categories of a 1:25000 geological map.

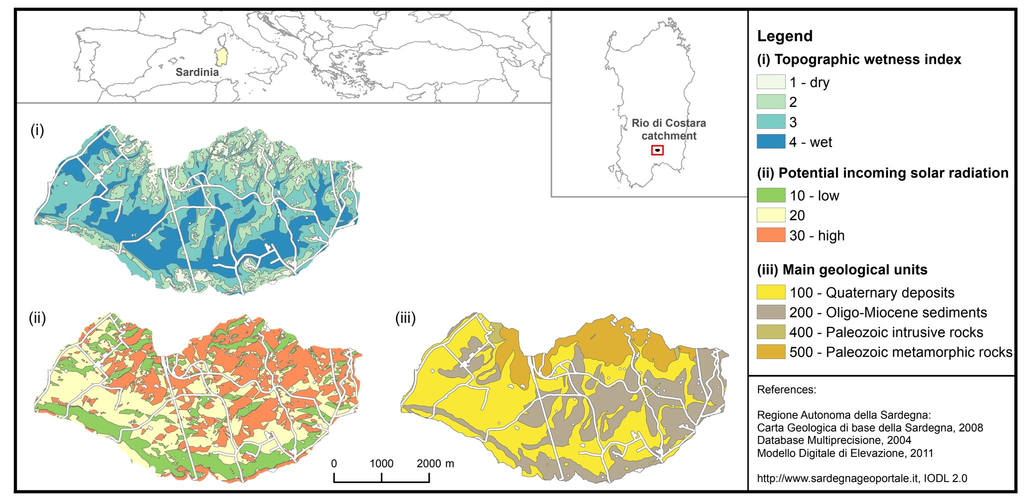

Figure 1: Rio di Costara test site location and maps of stratifying variables

Results

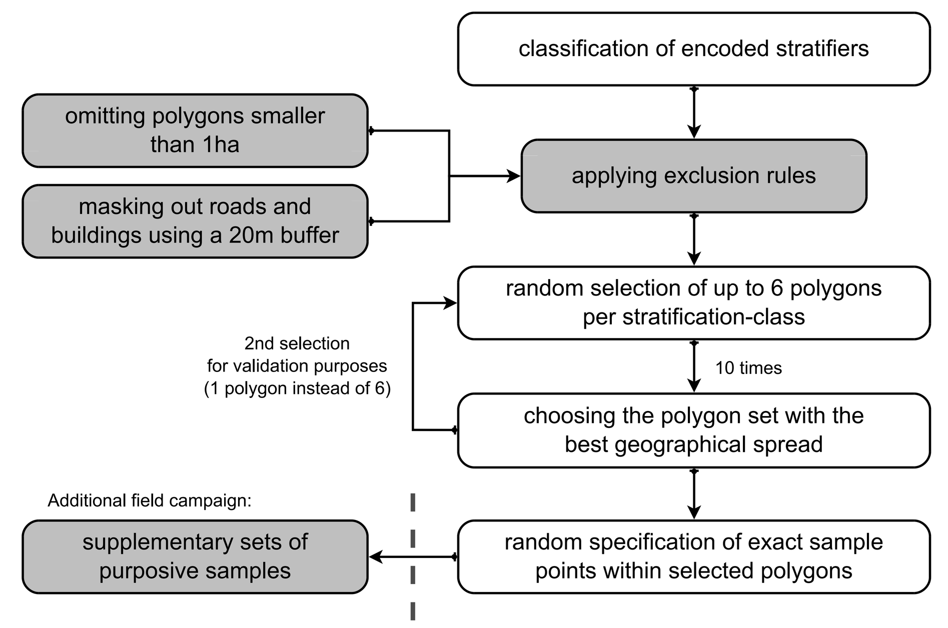

Figure 2: Flow diagram of the soil sampling procedure, Rio di Costara

All selected sample locations were tracked down using the Trimble Juno SB handheld device with a positional accuracy of 2-5m. If a point was out of reach, we tried the same stratification-class polygon elsewhere.

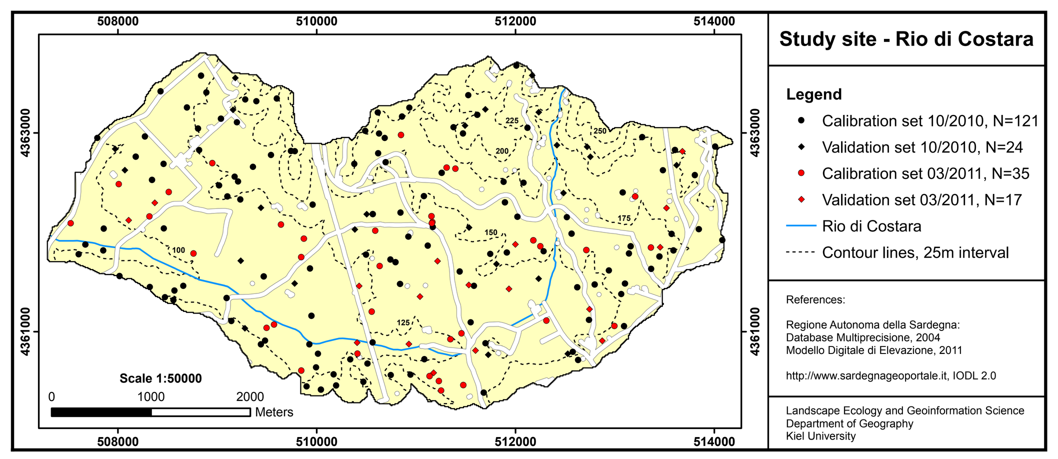

Figure 3: Location of finally sampled points in the Rio di Costara catchment

88% of all desired points could actually be reached in the field and were successfully sampled.

With regards to soil separates, calibration and validation data are found representative for each other in terms of multivariate hypothesis tests.

Table 1: Hypothesis test results

TEST	STATISTIC	P-VALUE	DF[1]
Hotelling T^2 for equal multivariate means	2,29	0,079	3; 193
Bartlett's test for variance homogeneity	6,43	0,377	6

[1]DF = Degrees of Freedom

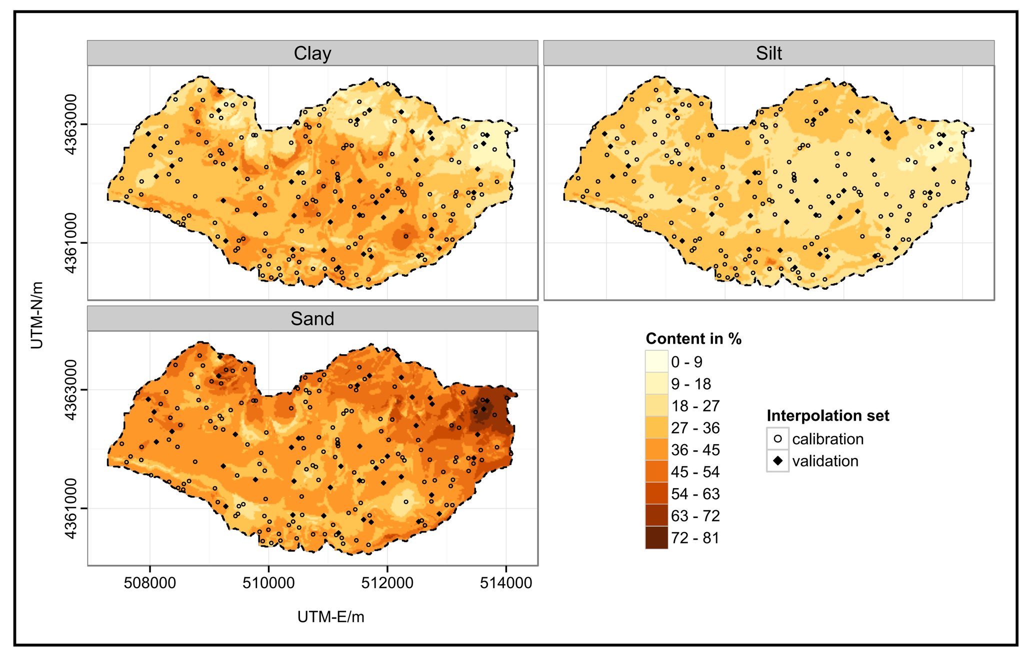

Figure 4: Estimates of soil textural fractions in the Rio di Costara test site

The multivariate prediction of clay, silt and sand content based on the collected interpolation data using a neural network residual cokriging approach lead to explained variance levels of 56%, 48% and 63%, respectively.

Conclusions

Our results indicate that the sampled calibration and validation sets are representative for each other and could be successfully used as interpolation data for spatial prediction purposes. Consequently, the presented case study can be seen as a successful example of considering readily available continuous information on soil forming factors such as geology and land-surface parameters as stratifying variables for designing sampling schemes in digital soil mapping projects. In order to allow further use of the prediction results, final soil property maps and underlying sample locations are disseminated in forms of Web Map and Web Coverage/Web Feature Services.

References/Acknowledgments

Brus, D.J. and J.J. de Gruijter (1997). "Random sampling or geostatistical modelling? Choosing between design-based and model-based sampling strategies for soil (with Discussion)". In: Geoderma 80.1-2, pp.1-44

McKenzie, N.J. and P.J. Ryan (1999). "Spatial prediction of soil properties using environmental correlation". In: Geoderma 89.1, pp.67-94

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