Segmentation and sequential classification of a synthetized image composed of spatial environmental data for the compilation of a soil type map


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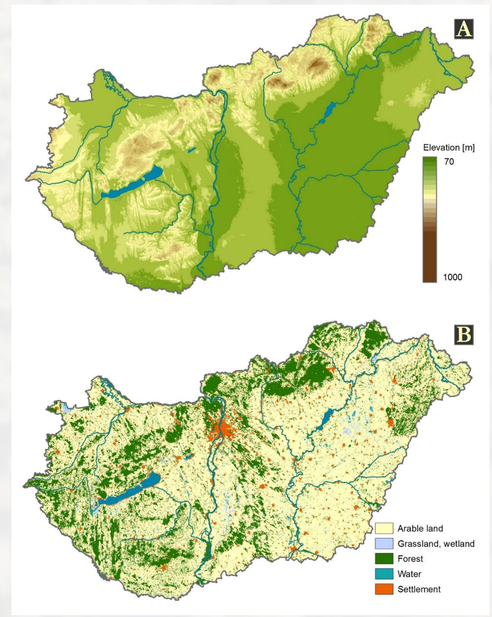
A unified, national soil type map with spatially consistent predictive capabilities was compiled applying traditional and newly tested Digital Soil Mapping classification methods: segmentation of a synthesized image consisting of predictor variables and multi-phase, sequential classification by Classification and Regression Trees, Random Forests and Artificial Neural Networks. Object based classification using spatial-thematic segments was applied to define mapping objects. Classifications were carried out on two levels to achieve better results. Performance of classifiers was continuously assessed and applied for the identification of best performing predictions, which were combined for the production of the final map.

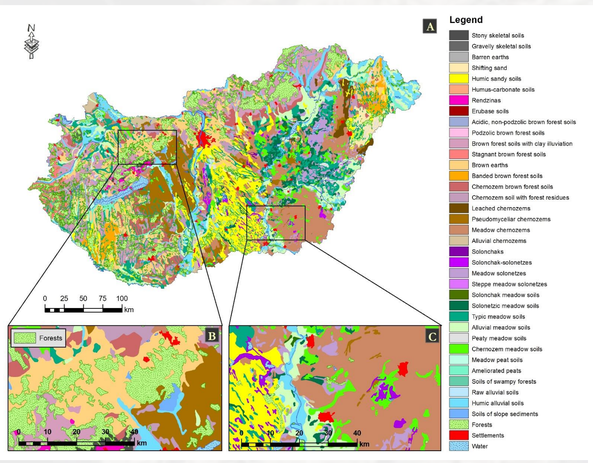
Evaluation of the results showed that the object based, multi-level mapping approach performs significantly better than the simple classification techniques.

The importance of the newly prepared map could actually be evaluated from the practical point of view. This is the first countrywide soil type map that unifies expert inputs and databases from both the agricultural farmlands and forested areas. As a consequence, this map can be equally used for agricultural or forestry oriented purposes providing interoperability between the sectors. Because of the robustness and huge data background, the map is suitable to be involved in nationwide spatial and land use management planning.

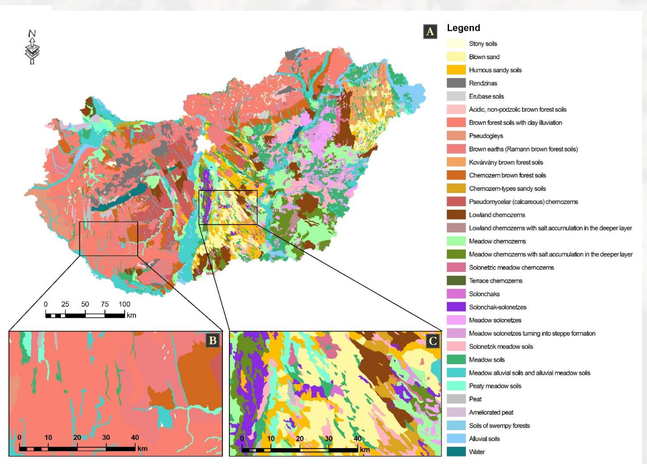


Hungary's general geographical (A) and the related land use (B) conditions. Plains are dominated by arable lands; mountainous regions are mainly characterised by forests

Nationwide legacy soil type maps characterized forest dominated, hilly/mountainous regions either simply as forest, or with significantly lower thematic and spatial resolution.



1:200.000 scale genetic soil map (A). Forest is a unique legend element (B); the map was synthetized from larger scale soil maps, which did not represent the country homogeneously, this fact is strongly reflected in its pattern (C).



Genetic soil type layer of AGROTOPO (A). The representation of areas with different physiography/land use is rather inhomogeneous: hilly regions dominated by forests (B); plains characterised by croplands (C)

Traditionally, soil cover under agricultural and forestry management is typically characterized independently. Countrywide soil type maps were compiled with full national coverage based on soil data originating purely from out-of-forest areas.

Hungarian Soil Classification System:
- based on the genetic approach of Dokuchaev (1883).
- considers soil forming as a genetic process (pedogenesis)

Soil survey on arable lands

Hungarian Soil Information and Monitoring System (SIMS)
~ 1,200 points
Recently sampled point database
Laboratory measurements (pH, SOM, CaCO3, etc.) & soil types

Hungarian Detailed Soil Hydrophysical Database (MARTHA)
~ 3,900 points
hydrophysical and chemical information collected from various sources

Harmonization of nomenclature

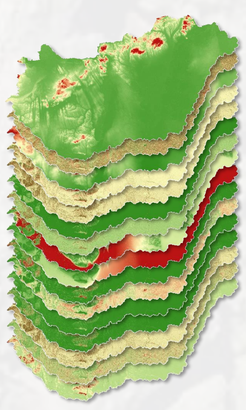
&

Soil survey in forests

Forestry database
~ 55,000 data points of forest compartments
genetic soil type, texture class, rooting depth class

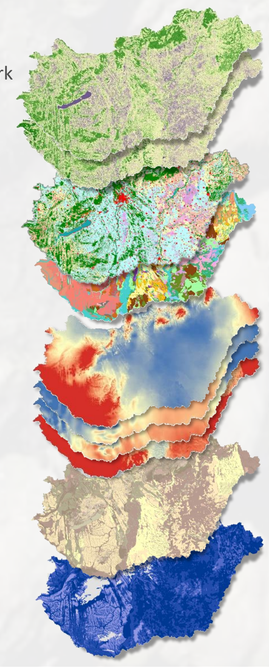
ENVIRONMENTAL CO-VARIABLES

Topography
EU-DEM and derivatives
- Elevation
- Slope
- Aspect
- General-, Plan-, Profile Curvature
- Vertical Distance to Channel Network
- SAGA Wetness Index
- Topographic Wetness Index
- Diurnal Anisotropic Heating
- Real Surface Area
- Channel Network Base Level
- MRVBF - Multiresolution Index of Valley Bottom Flatness
- MRRTF - Multiresolution Index of Ridge Top Flatness
- Mass Balance Index
- Stream Power Index
- LS Factor
- Topographic Position Index
- Distance to Actual Stream Network



Land use and vegetation
CORINE LandCover, CLC50
MODIS images

Soil
Legacy soil data
Digital Kreybig Soil Information System (DKSIS)
AGROTOPO
1:200.000 scale genetic soil map

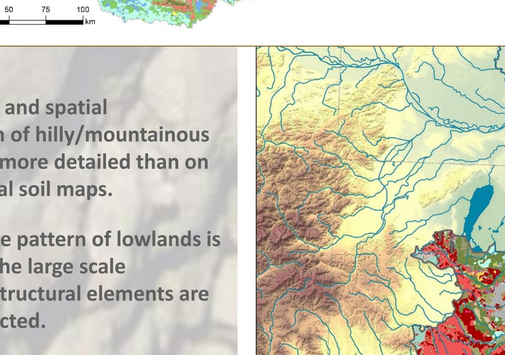


Climate
average annual evapotranspiration
average annual precipitation
average annual temperature
annual evaporation

Lithology
Geological Map of Hungary 1:100.000 – merged FAO categories

Groundwater level
Geological Atlas of Hungary

SEGMENTATION



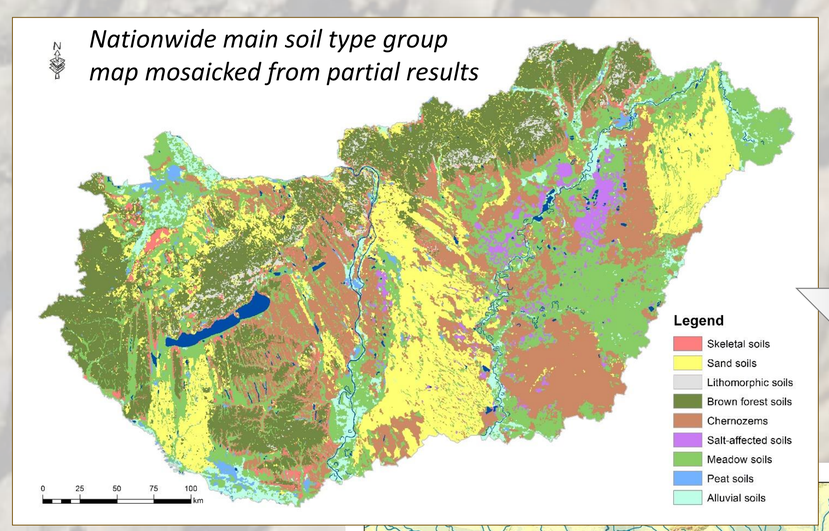
SEQUENTIAL CLASSIFICATION

1st level: main soil type groups (MSTGs)
multiple steps
- overall classification: delineation only for 3 MSTGs
sand, brown forest and lithomorphic soils
- left out MSTGs were classified again to get the spatial distribution of the other six MSTGs
skeletal, salt-affected, meadow, peat, alluvial soils and chernozems

2nd level: Soil types (ST)

Classifiers on both levels:
Classification and Regression Trees
Random Forests
Artificial Neural Network

12 models
Combination of best performing models



The final product:
a unified, national, soil type map
with spatially consistent predictive capabilities

This is the first countrywide soil type map that unifies expert inputs and databases from both agricultural farmlands and forested areas.
It can be equally used for agricultural or forestry oriented purposes providing interoperability between the sectors.

Both thematic and spatial representation of hilly/mountainous areas is much more detailed than on former national soil maps.

The mosaic-like pattern of lowlands is retained and the large scale geographical structural elements are very well reflected.

VALIDATION

Sporadically available (only for agricultural areas) digitized large scale soil type maps were used for external validation. Black lines are soil map delineations with type classification. In the background a part of the newly compiled soil type map.

None of the models overperformed 62% accuracy. However, by a proper combination we could finally produce 70% accuracy.

For forest area validation a collection of independent soil observations was set up from monographies, studies, and reports: accuracy of 65%.

Agreement with the predicted soil type map		Overall accuracy	Overall kappa
AGROTOPO	lowlands	0,31	0,24
	hilly areas	0,27	0,15
	mountainous areas	0,29	0,18
1:200.000 genetic soil map	lowlands	0,36	0,29
	hilly areas	0,25	0,17
	mountainous areas	0,17	0,09

Comparison to the two earlier nationwide soil type maps on a pixel by pixel level