Harmonized inventory of soil biodiversity data sources for conservation of European agricultural ecosystem

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Soils are home to over a quarter of all living species on earth and soil organisms perform wide range of soil functions organic matter decomposition, nutrient cycling, disease suppression and crop production. Many conservation managers, farmers, policy makers, businesses and local communities cannot access the biodiversity data they need for informed decision-making on soil resource management. A handful of databases are used to monitor indicators against global soil biodiversity goals but there is no openly available consolidated list of global data sets to help stakeholders, especially in highly vulnerable agricultural ecosystems. The project MINOTAUR will aim to build an inventory of global soil biodiversity databases of potential use in monitoring soil biodiversity status, barriers and conservation responses to sustainable soil management at multiple levels. In the second step, collected data sources will be harmonized to integration of biodiversity data across spatial, temporal and taxonomic scales. Finally, the harmonized data pool will be synthesized to identify knowledge gaps in existing databases and facilitate biodiversity assessments at various scales, from local to sub-regional, culminating in a mechanism for regional scale characterization. Overall, this work will deliver an integrated harmonized soil biodiversity data for validating, monitoring, modelling, and evidence-based policy decisions.

Keywords: Soil biodiversity, data sources, harmonization, policy makers, stakeholders

Pedoclimatic contextualization of soil organic carbon content in Europe for soil health assessment

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Quantifying Soil Organic Carbon (SOC) is necessary for assessing soil health and its contribution to soil ecosystem services such as biomass production, flood and erosion mitigation, climate regulation, etc. Much effort is invested in monitoring SOC at the regional, national and global scale. The variability of measured SOC contents in topsoils strongly relates to different land use and management practices. However, because SOC content also depends on the pedoclimatic context, diagnosing beneficial versus harmful soil management practices is only possible if comparing SOC measures performed in similar pedoclimatic conditions. This requires a dedicated contextualisation framework that takes into account the pedoclimatic factors that influence the SOC content and allows identifying SOC thresholds that represent reference values for healthy versus unhealthy soils. Then, the health status of soils regarding the SOC criterion would be assessed more properly by comparing their SOC content with SOC reference values corresponding to their specific pedoclimatic context.

Based on the statistical analysis of the publicly-available LUCAS Topsoil dataset[1], we propose an unsupervised machine learning approach for the identification of pedoclimatic contexts of SOC in Europe. To allow for explicability of the output, we perform independent clustering of LUCAS sites based on climatic parameters on one side and on pedological parameters weakly related to soil management on the other side. Then the pedoclimatic context of a site is defined as the combination of the pedological- and climatic clusters it belongs to. The analysis of the distributions of topsoil SOC contents within each pedoclimatic context and for different land cover classes is used to assess typical versus extreme values that can be employed as references for a SOC-related diagnosis of soil health.

The proposed method results in the identification of 44 clusters of European soils associated to specific pedoclimatic contexts. We show that the SOC content distributions differ across clusters, for given land cover classes. Then we explore and discuss possible approaches for the definition of SOC threshold values and normalisation functions to allow for a better inter-comparability of SOC diagnosis of topsoils belonging to different pedoclimatic contexts. Our results demonstrate the importance of a pedoclimatic contextualisation for SOC diagnosis at large spatial scales. We suggest that the identified pedoclimatic contexts could be meaningfully used to contextualise other criteria of soil health assessment in Europe.

Keywords: Soil organic carbon; Soil health; Soil quality; Clustering

[1]Orgiazzi, A., Ballabio, C., Panagos, P., Jones, A., Fernández-Ugalde, O. 2018. **LUCAS Soil, the largest expandable soil dataset for Europe: A review.** *European Journal of Soil Science*, 69(1): 140-153. https://doi.org/10.1111/ejss.12499

Structural connectivity of sediment loads via surface runoff in different scales in agricultural lands of Finland

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Processes leading to soil erosion and consequent sediment transport are affected by multiple interlinked landscape characteristics which typically have high spatial variability. These factors inflict challenges on the management of sediment loads. Structural connectivity of sediment loads via surface runoff has not been previously studied in the lowland agricultural areas of Finland. Recent studies have, however, shown that the magnitude and spatial variability of erosion and sediment connectivity can be reasonably estimated with simplistic models and with low data availability. The revised universal soil loss equation (RUSLE) and sediment connectivity index (CI) are among the most widely applied models. Here, we produce the first spatially extensive erosion data (2x2 m resolution) in Finland with RUSLE and analyze structural sediment connectivity (1) within agricultural fields, (2) between agricultural fields (field-scale) and (3) between two catchments with intensive agriculture and different topographical characteristics.

Our results show that the majority of the field areas are structurally connected to adjacent open ditches or streams. The connectivity pathways were dominated by sporadically occurring flow accumulation networks, controlled by elevation differences in the model. Thus, targeting sediment disconnectivity elements (e.g. buffer strips) in the landscape is challenging without spatial data on the connectivity pathways. Within agricultural fields (2x2 m resolution), there was a statistically significant correlation (Pearson $r=0.44-0.48$, $p<0.001$) between the computed erosion loads and CI, which showed that a large share of erosion can occur in such locations which are also highly connected. Stronger relationship as well as rank correlation was found between mean erosion and mean IC on field-scale (Pearson $r=0.69-0.81$, $p<0.001$ and Spearman rank correlation $r>0.69-0.79$, $p<0.001$). Finally, we computed sediment yields (as a function of the RUSLE and IC results) with different parameterizations and show that even though the different parameterizations can lead to high uncertainties in sediment yields, ranking of the fields in terms of the sediment yields can be similar (Spearman $r>0.9$ and $p<0.001$ between the different parameterizations). Despite differences in the spatial distribution of erosion within the catchments, the above relationships were generally qualitatively similar in the two studied catchments. Overall, the results show that taking into account connectivity in efficient targeting of erosion mitigation measures may require spatial data describing relative differences in erosion and connectivity in different scales. Our study produces spatial data on the phenomena which can be used when targeting water protection measures.

Keywords: erosion; connectivity; lowlands; RUSLE; connectivity index

The LANDSUPPORT "best practices tool": identification of the trade-off between soil health and crop production.

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Keywords: Nitrate leaching, yield, soil organic carbon

The web-based "Best Practices tool" (https://dev.landsupport.eu/template.html) has been developed to be applied by public authorities, such as regional environmental agencies, to find the best solutions according to a goal (e.g., increase in soil organic carbon stock, reduction of nitrate leaching) in a region of interest (ROI). The is ROI is automatically associated with soil properties described for each horizontal layer (data available from the pedological database or LUCAS European database). The user sets up a combination of agronomic practices via web interface. The identification of optimal solution can be done in 5 climate scenarios specific for each ROI (20-year period of current, near and far future under RCP 4.5 and 8.5 IPCC scenarios).

The tool was developed in the framework of the LANDSUPPORT project (H2020-RUR-2017-2/No. 774234) and applies a what-if scenario approach at regional scale (average area of approximately 2500 km^2) in three case studies (Marchfeld – Austria, Campania Region – Italy, Zala County – Hungary). The tool is dynamically linked to the ARMOSA process-based model, which simulates at daily time step many combinations of farming systems (conservation, organic, conventional), crops, nitrogen fertilization rates, tillage solutions, crop residues management. Out of the wide set of daily ARMOSA outputs, the tool returns the mean annual value of (1) the crop yield, (2) the nitrate leaching at the bottom of the soil profile, and (3) the change of the soil organic carbon stock in the upper soil layer (0-0.4 m). The tool also gives the value of the synthetic "best practices index" (I_{BP}) that is computed as a linear combination of the three variables and the weights that the user dynamically assigns to each of the variables according to the specific goal (e.g., increase in soil organic carbon). The user then sorts the I_{BP} values in descending order to identify the most suitable combinations of practices. The mean value of I_{BP} is plotted in charts for each of the simulated combinations.

A high number of combinations (up to 2520 combinations) derived from 5 climate scenarios, 7 crops, 2 systems (conventional, organic), 3 fertilization rates (optimal amount, 15% and 30% reduction), 2 residues management (removal, retention), 3 tillage practices (ploughing, minimum tillage, sod seeding), and 2 uses of cover crops (yes, no) allowing to automatically evaluate many cropping system including those typical of regeneration agriculture. The user-friendly interface hides the high complexity of the soil and crop processes which are simulated on the fly by ARMOSA, which has many crop and soil parameters already calibrated using the dataset available in the project and in previous studies. As the close link with ARMOSA, the tool allows the close representation of actual and optimized cropping systems with the possibility of further applications at a larger scale (e.g., European), in other regional case studies, and in tailored scenarios in which the user enters her/his data of soil properties and climate.