

Topographic control on soil function evaluation - a case study from South Tyrol

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Abstract

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1. Introduction

Information on soil, a, at least from a human time perspective, non-renewable resource, is of increasing importance given erosion, soil degradation and soil sealing. It is necessary to know where and where not certain practises are applicable and to adjust land-use planning appropriately. According-
5 ly, soil function evaluation is an invaluable tool for the future.

Haslmayr et al. (2016) and further literature

10 In this study, we present the soil evaluation tool *Soil Evaluation for Planning Procedures (SEPP)* and investigate topographic and parent material control of the different soil functions by applying a cross-validated machine learning approach based on available soil pit information in the Oltradige/Überetsch region of the Autonomous Province Bolzano - South
15 Tyrol.

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2. Data and methods

2.1. Study area and soil data

2.2. SEPP - Soil Evaluation for Planning Procedures

The software SEPP currently computes a soil function evaluation based on soil pit descriptions. It requires that the pit descriptions are performed following the Austrian Soil classification (Nestroy et al., 2000, 2011) and related mapping manuals. The minimum soil profile site characteristics are local slope, thickness of organic horizons, soil depth, groundwater table, soil parent material, soil type, humus form, altitudinal zone, moisture level, land use ... For each horizon, the minimum characteristics necessary for computing the soil function are the master horizon designation, depth, pH value, proportion of the dominant soil structure type and class membership with regard to carbonate content, soil texture, organic content, abundance of rock fragments, bulk density, soil structure. These class attributes can be substituted by exact values if available. The soil functions, for which 15 different potentials are computed, are *habitat for living organisms* (specifically the potential as habitat for drought-tolerant species, moisture tolerant species, soil organisms and crops), *infiltration and drainage regulation* (minimum, average and heavy precipitation retention capacity as well as groundwater reformation rate), *natural soil fertility* as well as *filter and buffer for pollutants* (heavy metal, organic, acidifying and water-soluble). The result is a grade between 1 and 5 for each soil function potential, with 1 signifying a high potential and 5 a low one.

Potential as a habitat for drought-tolerant species. Both this potential and the following potential as a habitat for moisture-tolerant species are performed based on modifications of the approaches described by BayGLA and BayLfU (2003) and Lehmann et al. (2008). The evaluation of a soil's potential as a habitat for drought-tolerant species is based on the parameters land use, soil type and available field capacity. While the first two parameters are applied to distinguish especially suited (ruderal locations and corresponding soil types) or unsuited (mire deposits and soil types commonly found on these) sites, the latter is used to grade those soil profile sites showing the remaining landuse and soil type combinations.

Potential as a habitat for moisture-tolerant species. This potential is evaluated similarly to the the one for drought-tolerant species, in that specific soil

types, e.g. Gleysols, are attributed specific grades. In addition, the depth of the groundwater table is used to distinguish sites with high potential, and the available field capacity is used to differentiate even further.

Habitat for soil organisms. This potential is evaluated according to Beylich
55 et al. (2005) with some minor adaptations. In this framework, a number of species groups are used as indicators for the composition of soil life, with emphasis on earth worms (Lumbricidae) as they are influential on soil structure and bioturbation. This method is based on the relationship between soil organism communities and a number of abiotic soil parameters. Specifically,
60 one of 14 possible soil organism communities, which are the basis for the grade awarded to a site, is attributed to a site according to a classification tree applying the parameters pH, moisture level, land use and soil texture.

Potential for agricultural production. The assessment of the potential for agricultural production is performed according to the method proposed in
65 the framework TUSEC-IP (Lehmann et al., 2008) by an accumulative rating of five criteria. The criteria *general conditions of the profile site* is rated based on soil depth and topsoil aggregate structure and bulk density as well as Unterboden bulk density.

Average and minimum precipitation retention capacity.

70 *Retention capacity for heavy precipitation events.*

groundwater reformation rate.

Potential for providing nutrients for plants.

Potential as a CO₂ sink.

Potential for retention of heavy metals.

75 *Potential for transforming organic contaminants.*

Potential as filter and buffer for organic contaminants.

Potential for retention of water-soluble contaminants.

Potential as buffer for acidic contaminants.

3. Results

80 The soil function grades for each of the 15 potentials was calculated for each of the 108 soil profile pits in the study area with the SEPP app. Figure 1 shows the distribution of these grades. A first evaluation of the feature

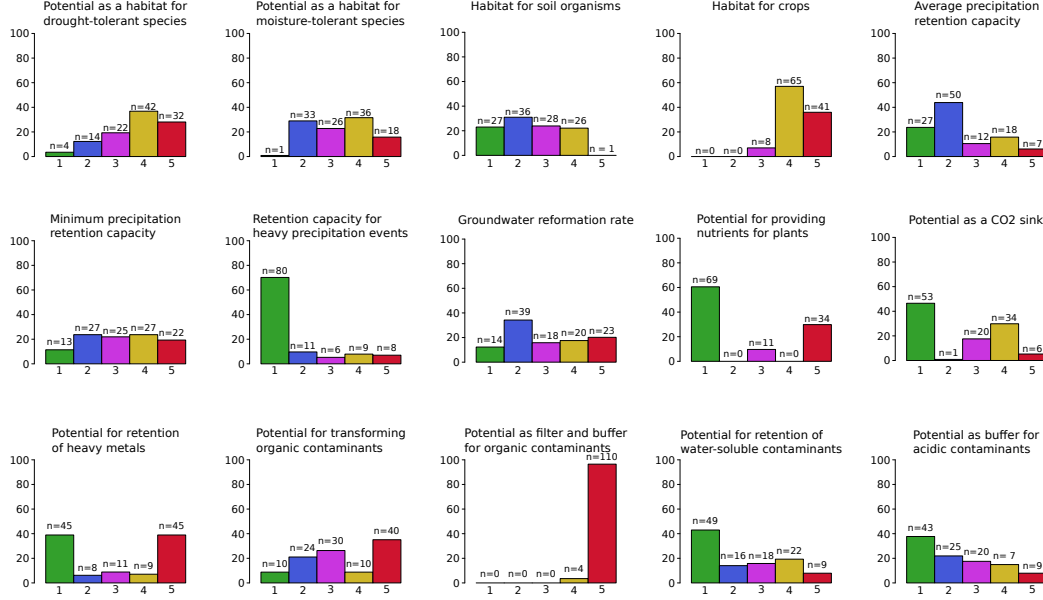


Figure 1: Barplots representing the distribution of the soil function grades for the various analysed potentials.

selection procedure shows that mostly 2 parameters are sufficient, that is that there is no increase in cross-validated prediction accuracy by adding
 85 more predictors, and most of the time these a combination of a landform classification and a roughness or also local terrain parameter.

3.1. Potential as a habitat for drought-tolerant species

Figure 1 shows that of the 108 soil profile sites in the study area, 38 fall into class 4 (35%) and 32 into class 5 regarding the potential as a habitat for
 90 drought-tolerant species. The intermediate class 3 contains 21 soil profiles whereas the high potential classes 1 and 2 are attribute to only 4 and 13 sites, respectively. As the predictor set does not contain landuse nor soil type, the SVM classification essentially attempts to model the different classes of available field capacity. In the majority of the feature selection runs a landform

95 map based on a flatness threshold between 3 and 5°, a spatial resolution of
 10 m and a search radius of 100 m was chosen as the first predictive feature.
 The landform flat is dominant amongst the profile sites with a graded poten-
 tial of 5, which is accordingly connected to minimal curvature values around
 0. The landform slope is most common for profiles with a potential of 4,
 100 whereas spurs and hollow can present profile locations with a potential score
 of 2 and, as expected, have increasingly negative minimum curvature values.
 A support vector classifier using these two predictor variables results in a
 cross-validated prediction accuracy of 47%, where the most common error
 is that a large number of sites are mistakenly classified as having grade 4.
 105 Nevertheless, the general implications of the feature selection are plausible,
 as flat areas can be expected to have higher field capacity values than sloping
 regions with negative curvature values.

3.2. Potential as a habitat for moisture-tolerant species

4. Conclusion

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