

Soil classification and mapping in the Alps: The current state and future challenges



Jasmin Baruck^{a,*}, Othmar Nestroy^b, Giacomo Sartori^c, Denis Baize^d, Robert Traidl^e, Borut Vrščaj^f, Esther Bräm^g, Fabian E. Gruber^a, Kati Heinrich^h, Clemens Geitner^a

^a Department of Geography, University of Innsbruck, Innsbruck, Austria

^b TU Graz, Graz, Austria

^c Museo delle Scienze, Trento, Italy

^d INRA – Science du Sol – UR0272, Orléans, France

^e Bavarian Environment Agency, Marktredwitz, Germany

^f Agricultural Institute of Slovenia, Ljubljana, Slovenia

^g Soil and Biotopes, Scharans, Switzerland

^h Institute for Interdisciplinary Mountain Research (IGF), Innsbruck, Austria

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ABSTRACT

As soils are facing considerable changes in climate, land use, land consumption, and degradation, it is vital to understand the characteristics of soils and their distribution, especially for soil management issues. In mountainous regions like the Alps, soils require specific attention as they provide a large variety of ecological functions, but also because of their vulnerability. However, pedological research and the collection of soil data in the Alps are still limited. On the one hand, there are specific methodological problems linked to the surveying, interpretation, and classification of Alpine soils due to their high variability over short spatial ranges and the peculiarities of the Alpine environment in general. On the other hand, the process of collecting soil data and mapping soils, as well as the soil classification systems used, significantly differs among the Alpine countries. The Alpine Convention therefore requires data harmonization as a basis for national and cross-country collaborations, soil monitoring, and sustainable management.

This paper is an initial national expert-based review, which deals with the status of soil classification and soil mapping and related problems in the Alpine region. In the first part we highlight the current state of soil databases and soil maps in the Alpine area, as well as efforts toward soil data harmonization. We summarize the national soil mapping and soil inventory programs, monitoring activities (e.g., Soil Quality Monitoring, Soil Management Survey, Forest Monitoring), and soil information systems available in the main Alpine countries Austria, France, Germany, Italy, Slovenia and Switzerland. Second, we present the soil classification systems which are in use in the Alpine area. It is discussed to what extent these systems can reflect the characteristics of Alpine soils. In this context, we also examine the relevance of organic matter and humus forms. We then outline problems of comparability between the classification systems as well as challenges to classifying Alpine soils in general. In the third part – as soil classification and soil mapping are two different matters from a methodical point of view – we highlight basic challenges to soil surveys in the Alpine environment.

We conclude that Alpine-wide shared soil site mapping and soil classification standards covering the specifics of Alpine soils are lacking. Thus, the main aim for the international management of Alpine soil resources should be to develop a framework for the basic soil information that is to be gathered by means of cross-border collection in the entire Alpine space, and to harmonize the already existing data. The former should include an upgrade of an existing international soil classification, e.g., the World Reference Base WRB (IUSS, 2014).

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1. Soils in the Alps

1.1. Motivation and aims

In general, soils are known to be an essential and non-renewable resource that plays a fundamental role for ecosystems (Arnold et al., 1990) and provides valuable services to humans (Barrios, 2007;

* Corresponding author.

E-mail addresses: jasmin.baruck@uibk.ac.at (J. Baruck), o.nestroy@tugraz.at (O. Nestroy), giacomo.sartori@muse.it (G. Sartori), denis.baize@orleans.inra.fr (D. Baize), Robert.Traidl@lfu.bayern.de (R. Traidl), Borut.Vrscaj@kis.si (B. Vrščaj), estherbraem@sunrise.ch (E. Bräm), fabian.gruber@uibk.ac.at (F.E. Gruber), kati.heinrich@oeaw.ac.at (K. Heinrich), clemens.geitner@uibk.ac.at (C. Geitner).

Clothier et al., 2011; Fisher et al., 2009). As worldwide soil degradation is taking place much faster than soil can develop, this resource requires sustainable management.

Soils in mountainous regions like the Alps, including all sites from the valleys up to the summits, require specific attention as they provide a large variety of ecological functions but are also highly vulnerable to changes (Hagedorn et al., 2010). In the Alps – like in other mountain areas (Munroe, 2008) – comparative soil research and data collection are still rare, especially above the timberline (Geitner, 2007; Kilian, 2010), which leads to several problems, e.g., within soil protection efforts. Specific problems arise when surveying and interpreting soils in the Alpine environment. Those are rarely satisfactorily resolved because Alpine soils are highly variable over short spatial ranges, leading to complex patterns of soil characteristics (Geitner, 2007; Theurillat et al., 1998; Veit, 2002). In addition, the process of collecting soil data and mapping soils, as well as the soil classification systems used, significantly differs among the Alpine countries. Within this setting essential national and cross-border soil initiatives regarding soil monitoring, protection, and management are difficult and still rare.

Against this background, this paper is dealing with three key aspects to give an initial national expert-based review of the status of soil classification and soil mapping and related problems in the Alpine region. First, we highlight the current state of soil data in the main Alpine countries Austria, France, Germany, Italy, Slovenia and

Switzerland, and efforts toward data harmonization in the Alpine area. Then, we deeply focus on the different national and international soil classification systems and their main principles which are in use in the Alpine countries. The expert-based discussion shows to which degree these systems are able to reflect the specifics of Alpine soils. In this context, the relevance and classification possibilities of the forms of organic matter and humus are also briefly discussed as in Alpine environments these are of great pertinence. In conclusion, we outline problems of comparability between the classification systems, as well as challenges to classifying Alpine soils in general. From a methodical point of view, the naming of a soil body based on field profile description and laboratory analysis (classification) and the delineation of a soil unit area (soil mapping) are two quite different matters. Thus, we finally emphasize basic challenges to mapping soil sites in Alpine regions.

1.2. The Alps and the characteristics of Alpine soils

The Alps are the highest mountain range in Europe, located in the transition zone from temperate to Mediterranean climate. They extend over eight countries (Austria – 28.7%, France – 21.4%, Germany – 5.8%, Italy – 27.2%, Liechtenstein – 0.08%, Monaco – 0.001%, Slovenia – 3.6%, and Switzerland – 13.2%) (Fig. 1). With nearly 14 million inhabitants, the Alps are densely populated.

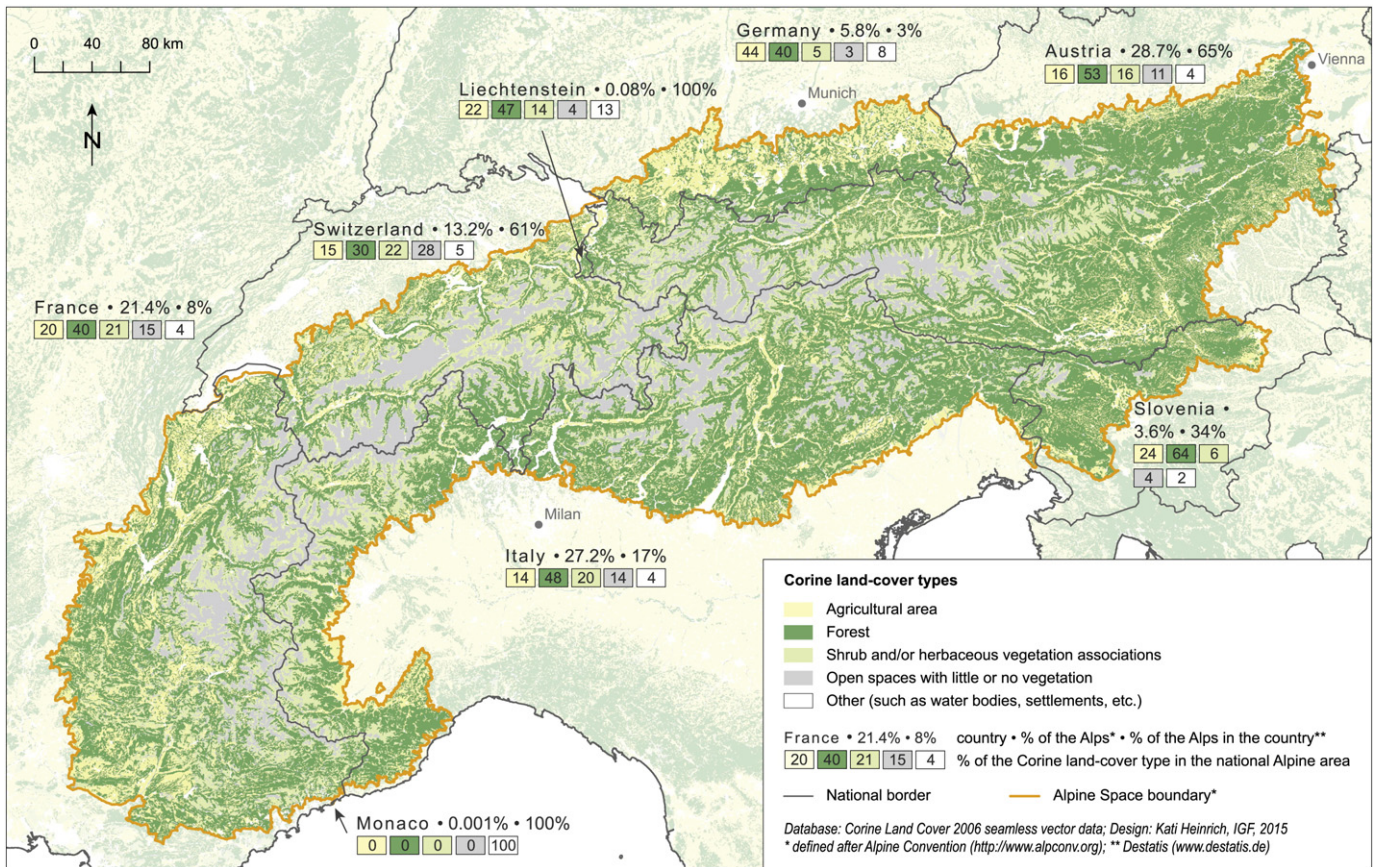


Fig. 1. Map of the Alps indicating the percentage of the Alpine countries within the Alpine area and the percentage of the Alps in each country as well as the Corine land-cover types in the national Alpine area (calculated using the Corine land-cover 2006 vector data of the European Environment Agency). Four soil-relevant classes were selected: 2. 'Agricultural areas', 3.1 'Forests', 3.2 'Shrub and/or herbaceous vegetation association' (vegetation above the tree line), and 3.3 'Open spaces with little or no vegetation' (nival zone). The classes 3.1 to 3.3 are sub-classes of the Corine type 3. 'Forests and semi-natural areas'. All other non-relevant classes were designated as 'Other'.

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