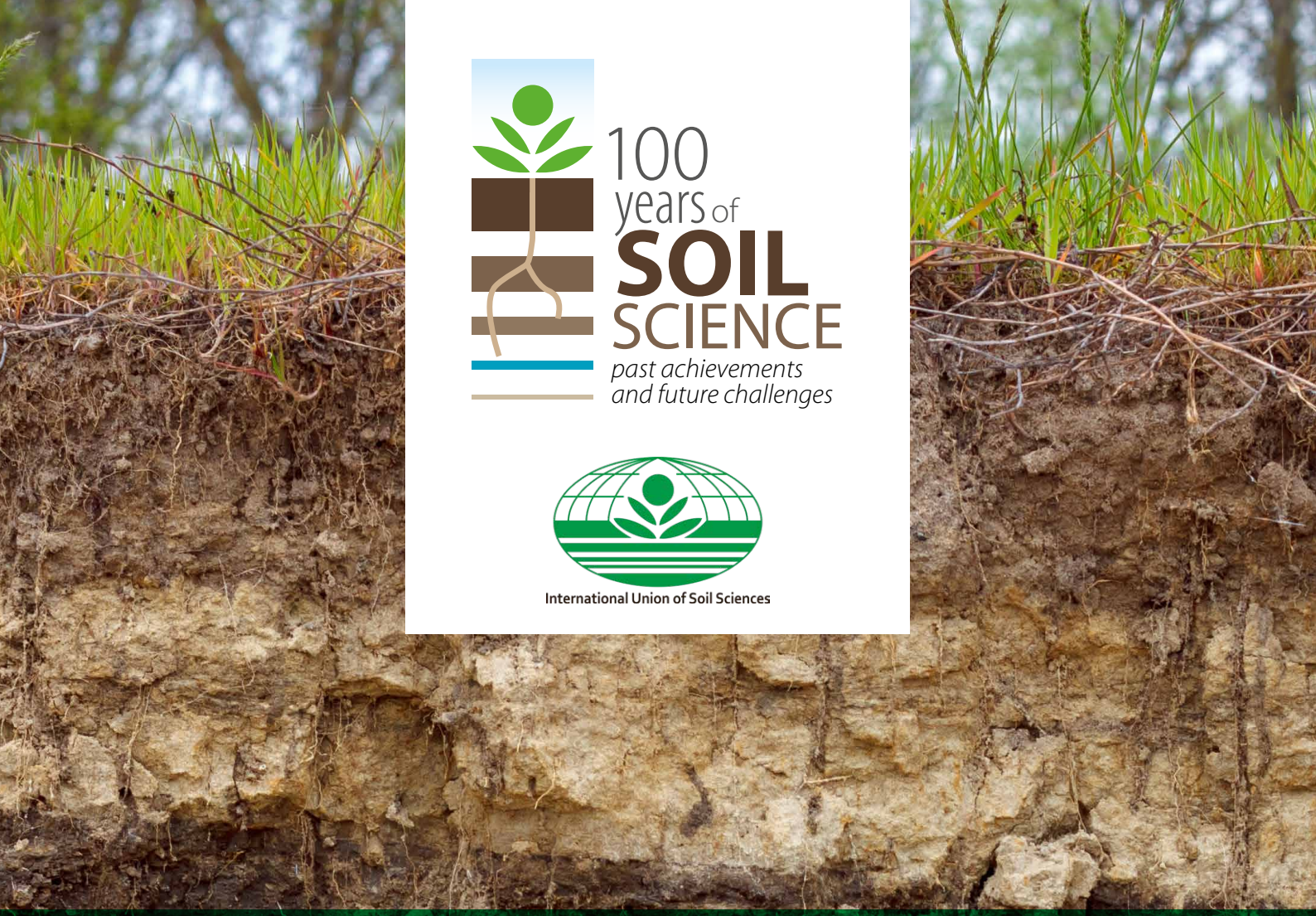

100 years of SOIL SCIENCE
past achievements and future challenges

International Union of Soil Sciences

Centennial Celebration and Congress of the International Union of Soil Sciences

Florence - Italy

May 19 - 21, 2024

ABSTRACT BOOK

ID ABS WEB: 137903

6. Soil in the digital era
6.01 125400 - Applications of proximal soil sensing technologies and beyond

A COMPREHENSIVE REVIEW OF PROXIMAL ELECTROMAGNETIC SENSORS' ACCURACY AND COST CONSIDERATIONS FOR SOIL PROPERTY PREDICTION AND MAPPING

C LOZANO FONDÓN [1], M ÖZGE PINAR [2], T SANDÉN [3], S MADENOGLU [4], R BARBETTI [5], G BUTTAFUOCO [6], R LORENZETTI [7], M KNADEL [8, 15], B STENBERG [9], K METZGER [10], F LIEBISCH [11], A GHOLIZADEH [12], E DE JONGE [13], R L NÚÑEZ [14], M FANTAPPIÈ [1], F VAN EGMOND [13], T KOGANTI [8]

[1] Research Centre for Agriculture and Environment, Council for Agricultural Research and Economics, Florence, ITALY
[2] Transitional Zone Agricultural Research Institute (TAGEM/MoAF), Eskisehir, TURKEY
[3] Department for Soil Health and Plant Nutrition, Austrian Agency for Health and Food Safety, Vienna, AUSTRIA
[4] Ministry of Agriculture and Forestry, General Directorate of Agricultural Researches and Policies (TAGEM), Ankara, TURKEY
[5] Research Centre for Forest and Wood, Council for Agricultural Research and Economics, Casale Monferrato, ITALY
[6] National Research Council of Italy, Institute for Agriculture and Forestry Systems in the Mediterranean, Rende, ITALY
[7] National Research Council of Italy, Institute of BioEconomy, Sesto Fiorentino, ITALY
[8] Department of Agroecology, Aarhus University, Tjele, DENMARK
[9] Department of Soil and Environment, Swedish University of Agricultural Sciences (SLU), Skara, SWEDEN
[10] 1Agroscope, Field-Crop Systems and Plant Nutrition, Nyon, SWITZERLAND
[11] Agroscope, Water Protection and Substance Flows, Zurich, Switzerland
[12] Department of Soil Science and Soil Protection, Faculty of Agrobiology, Food and Natural Resources, Czech University, Prague, Czech Republic
[13] Wageningen University and Research, The Netherlands
[14] Instituto de Recursos Naturales y Agrobiología de Sevilla (IRNAS-CSIC), Seville, Spain
[15] Geopark Vestjylland, Vemb, Denmark

Proximal soil sensors (PSS) are used to efficiently characterize soil properties from point to farm/field scale and reduce the need for cost- and labor-intensive soil sampling and laboratory analysis for creating high-resolution maps. They enable rapid means for soil characterization and monitoring of soil properties, providing tools to make informed decisions aiming at the improvement of productivity, soil health conservation, and mitigation of environmental impacts. A framework for selecting the most suitable PSS method for mapping a specific soil property based on expected accuracy and associated costs is lacking. Within the ProbeField project, we are reviewing the accuracy of electromagnetic PSS in estimating specific soil properties and quantifying associated costs. Moreover, we discuss cost and accuracy variation when using multiple techniques simultaneously. The lack of information on costs in the literature caused us to perform a market analysis through questionnaires directed to companies, a unique aspect of this study. Our review hopes to be a guide for professionals, academics, and other end-users in PSS.
We reviewed a total of 209 studies. The normalized root-mean-squared error (NRMSE) was used as a measure of accuracy in estimating soil properties. Among all, diffuse reflectance spectroscopy (DRS) and X-ray fluorescence (XRF) techniques exhibit higher accuracy in estimating soil carbon and nutrients, however, require soil sample contact. Gamma-ray radiometry and electromagnetic induction (EMI) are the most common on-the-go sensor combinations, especially used to accurately estimate water content and soil texture. The Cost of mapping services ranges between a few hundred to several thousand euros per working day depending on the technique and type of sensor used. About 75% of mapping cost is attributed to fieldwork personnel, and data analysis and reporting, while the other 25% is to movement efforts and sample analysis. Several companies report extra charges attributed to fieldwork conditions. Results demonstrate that portable sensors offer accurate and cheaper point estimations, although on-the-go sensors offer better spatial estimations at the expense of accuracy.

Keywords: Cost-effectiveness, Proximal Soil Sensing, Data fusion, Combined sensors, Agricultural soils