

THE SOIL DATABASE AND FOREST SOIL SAMPLE COLLECTION OF THE NATIONAL CENTRE FOR SOIL MAPPING (CRA-ABP)

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Update and management of the soil database of Italy is one of the core activities of the Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria (CREA). The database is related to the soil samples collected by the soil archive of the National Center for Soil Mapping and interests all main Italian agricultural and forestry soilscapes. Analyzed and georeferenced soil observations from surveys carried out between 1950 and 2013 have been stored in the national database. Sampling and analytical procedures were performed in accordance with national and international standards. Both organic and mineral horizons were sampled. Main analyses were: particle size, pH, organic carbon, nitrogen, bulk density, and lime content. The soil samples were archived and their placement digitized, so that they allow further wet or dry analysis. At present, the database stores 5,384 analyzed observations (soil profiles, minipits or auger holes), sampled in forest environments, and 1,306 on permanent grassland. Stored samples amount to 16,466. Forest environments of soil samples are described in 16 forest categories.

Keywords: geomatics, forestry, carbon, soil samples archive, forest categories.

Parole chiave: geomatica, foreste, carbonio, pedoteca, categorie forestali.

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1. Introduction

The Italian National Center for Soil Mapping (Centro Nazionale di Cartografia Pedologica - CNCP) is a research group maintaining the national soil spatial data infrastructure and collection.

CNCP has been established in 1998 within the project "Soil Methodologies: definition of criteria and specifications for the construction, maintenance, updating and consultation the 1:250.000 scale soil map of Italy". CNCP is part of the Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria (CREA) a National Research Organization operating under the supervision of the Italian Ministry of Agriculture (MiPAAF) and is located at the Agrobiolgy and Pedology Research Center, Florence. Currently, CNCP is funded by CRA and two international projects (EU 7th Framework Programme agINFRA www.aginfra.eu; LIFE+SOILPRO www.soilpro.eu) and belongs to the networks of other projects (INQUA Aeomed; CostAction Deserthub; Italy-Israel Ringo). CNCP maintains the soil database of Italy and a collection of several thousand of soil samples taken all over Italy, in Peloponnesus (Greece), and Israel, and interests all main Italian agricultural and forestry soilscapes.

CNCP has been involved in the EU INSPIRE Thematic Working Group on Soil (Arnoldussen *et al.*, 2012).

CNCP has for many years developed soil survey, mapping, and informatization methodologies. Several thousands of soil observations have been stored on a Ms Access database. This Information System was the starting point to develop the Soil sample collection. In

2007 CNCP published the "Linee guida dei metodi di rilevamento e informatizzazione dei dati pedologici" (Guidelines of the methods for soil survey and data informatization) a volume (Costantini, 2007) with an attached CD-rom "CNCP 3.0, Database for soil observations and pedological units storing, correlating and geo-exploring" (L'Abate *et al.*, 2007). The software was developed according to the European Soil Bureau Handbook (Finke *et al.*, 1999) and the "Metodologie pedologiche" project (Costantini and D'Antonio, 2001). Several Italian regional soil services (Regione Sicilia, Regione Lazio, Regione Liguria, Regione Puglia, Regione Toscana, Regione Calabria) adopted the software as soil information system so that it can be considered the Italian "de facto" standard for soil database architecture. The first attempt setting up a National Forest Inventory is dated on '90 (Castellani *et al.*, 1988). Tosi and Marchetti (1998) verified that the extremely differentiated, inhomogeneous and variable reality of Forest Statistics, makes the data available from local authorities and projects incomparable and almost not useful at national level.

Information are generated by different experiences concerning standards, localization and time of completion of regional, interregional and national projects. Further improvements of Forestry monitoring were achieved thanks to Riselvitalia (Bianchi, 2004) and INFC (National Inventory of Forests and forest carbon reservoirs) (CFS, 2005) projects. This last cited project in particular focused on the forest contribution to Italian carbon sink. The third phase of the project included soil survey to estimate forest soil carbon sink (MiPAAF, 2008). CNCP

has been involved into the National Inventory of Forests and Forest Carbon reservoirs survey of additional attributes, phase 3+ managing soil analysis and soil sample collection (MiPAAF, 2008).

2. Material and methods

Sampling and analytical procedures were performed in accordance with national and international standards. Soil analysis followed Italian official analytical methodologies: *Metodi di Analisi Chimica del Suolo* – Methods of Soil chemical analysis (MiPAAF, 2000) and *Metodi di analisi fisica del suolo* - Methods of Soil Physical Analysis (MiPAAF, 1997) and international standards ISO/TC 190/SC 1 - Evaluation of criteria, terminology and codification; ISO/TC 190/SC 2 - Chemical methods and soil characteristics; ISO/TC 190/SC 5 (13.080.20) - Physical methods; ISO/TC 190/SC 7 - Soil and site assessment.

International Soil classifications are adopted Soil taxonomy (SSS, 2006) and World Reference Base for Soil Resources (IUSS–ISRIC–FAO, 1998; IUSS, 2006). Among the spatial data infrastructure maintained by CNCP, the Soil Information System of Italy (SISI) is the most important (SISI, 2013). SISI is a web-GIS application for online soil data consultation. The web-GIS application was developed for use related to agriculture, agro-industry, food, forestry, natural and geological science.

The application offers both soil and climatic information, related to 1:500,000 scale geography. In addition to the free access through the agINFRA Science Gateway, the registered access allows consultation of soil profiles, different formats data download and several service capabilities. Soil observations from surveys carried out between 1950 and 2013, analyzed and georeferenced are stored into the national database.

Disturbed and dried soil samples are collected at the Fagna experimental farm, Scarperia (Florence), in accordance with the following technical protocol:

- 1) All collected data and the analyzes results are computerized. A listing in digital format (MS Excel and \ or MS Access), showing analytical data and codes, is delivered to the CRA-ABP along with samples.
- 2) All the samples locations are georeferenced.
- 3) It is essential that the collection of soil samples for storage in the archive is done with the utmost care, according to Sampling standard ISO/TC 190/SC 3 Soil quality - Sampling - Part 105: Packaging, transport, storage, preservation of samples; Part 106: Quality control and quality assurance; Part 107: Recording and reporting; ISO 18512:2007 - Soil quality - Guidance on long and short term storage of soil samples.

Approximately 1 Kg of air-dried, milled and sieved to 2 mm ground, placed in a PVC rigid, airtight, and with cap liner container is stored. Containers are marked with the following: survey lot code; type of observation; number of observation; number and genetic code of the horizon; upper and lower horizon limits in cm; effective depth of sampling; day, month and year of the sampling.

Land cover is described in 6 categories at the CORINE second level (EEA and OPOCE, 2007) and in some

cases further detailed in 50 subcategories up to 6 levels (Costantini, 2007). Forest environments of soil samples are described in 16 categories (Del Favero, 2001; Costantini, 2007; Petrontino and Fucilli, 2013) adapting National Forest Inventory classes (CFS, 2005) to CORINE forest categories (EEA and OPOCE, 2007).

3. Results

Not agricultural soil observations are well distributed across the country (Fig. 1) with a slight lack of data in the Alpine regions (39% in Southern Italy, 35% in Central Italy, and 26% in Northern Italy). Monitored environments (Tab. 1) resulted 58% forests, 27% shrub and/or herbaceous vegetation associations, less than 10% pastures and permanent grasslands, and permanent crops (timber plantations), less than 5% mine dumps, and open spaces with little or no vegetation. In relation of surveyed forest formations (Tab. 2) resulted 51% deciduous broadleaved formation, 15% meso and microthermic narrow leaved formation, less than 10% evergreen broad-leaved formation; herbaceous formation; thermoxerophile shrub formation; thermophile needle leaved formation, and less than 5% hygrophilous broadleaved formations; microthermic arbustive formation; mesothermophile arbustive formation. Investigated forest environments (Tab. 3) were: 38% broad-leaved forests, 12% forest dominated by deciduous oaks, less than 10% shrub and/or herbaceous vegetation associations; poplar wood, willow grove and other broad-leaved plantations; larch and/or cembra pine forests; White and/or red fir forests, less than 5% holm oak mixed forests; chestnut forests; forests dominated by beeches; mine dump and construction sites; forests dominated by hygrophilous species; mediterranean pines forests; not native broad-leaved forests; mountain pines forests; not representative holm oak and cork oak forests; coniferous plantations.

At present, 12,894 analyzed soil observations (soil profiles, minipits or auger holes) are stored in the database. Both topsoil and subsoil layers or organic and mineral horizons have been sampled to 30 cm or more. Several relevant parameters are stored to allow models developments and environmental investigations. The most representative collected properties (Pritchett, 1979) are: Soil site: Elevation; Aspect; Organic matter cover; Grass cover; Soil depth; Bedrock depth; Horizon/Layer; Coarse fragments; Effervescence; Bulk density; Roots quantity; Routinary Analysis: Nitrogen; Organic carbon; Carbonates; pH; textural analysis: Clay; Silt; Sand. Among genetic horizons, the most representative are: OA (16%); A (15%); Bw (6%); A1 (5%); less than 5% are described also Ap; A2; C; AC; Bt; Bw1; AB; R; Ap1; and E. The collected soil samples have been related to analytical data.

15,498 analyzed soil samples of Italian forestry soil-scapes were physically stored and archived.

At present, the database stores 5,384 analyzed observations (soil profiles, minipits or auger holes), sampled in forest environments, and 1,306 on permanent grassland. Total stored samples amount to 16,466.

4. Discussion and conclusions

The periodical repetition of forest inventories is necessary for the accurate and continuous updating of information and it is also fundamental for checking biodiversity changes into the natural ecosystems, particularly in the forest (Gasparini and Tosi, 2000). This archive could contribute with historical soil information to define soil carbon stock variation during the last decades (UN, 1998). The collected and stored soil information is used for several kinds of forest research activity, as well as for calibration of new instruments and analytical methods.

Aknowledgments

Update and management of the soil database of Italy is one of the core activities founded by the projects: MiPAAF (2009-2013) COLLEZIONI E A-OR, BIO-DATI, and 7° FP agINFRA. BADASUOLI, AGRO-SCENARI, SOILPRO

O and INFC3+ projects contributed collecting relevant amount of data and samples. Contributions to soil sample collection: Giorgio Moretti, Stefania Simoncini, Daniele Amoroso, Maria Fantappiè, Enrico Gregori, Marcello Pagliai.

Table 1. Monitored environments (EEA and OPOCE, 2007).

<i>Code</i>	<i>Class</i>
13	Mine dump and construction sites
22	Permanent crops
23	Pastures
31	Forests
32	Shrub and/or herbaceous vegetation
33	Open spaces with little or no vegetation

Table 2. Forest formations (Costantini, 2007).

<i>Code</i>	<i>Class</i>
A	Evergreen broadleaved formation
B	Deciduous broadleaved formation
C	Hygrophilous broadleaved formation
D	Needle leaved thermophile formation
E	Meso and microthermic narrow leaved formation
F	Thermoxerophile shrub formation
G	Mesothermophile arbustive formation
H	Microthermic arbustive formation
I	Herbaceous formation

Table 3. Forest categories.

<i>Code</i>	<i>Class</i>
13	Mine dump and construction sites
22411	Poplar wood, willow grove and other broad-leaved plantations
22412	Coniferous plantations
311	Broad-leaved forests
3111	Holm oak and cork oak forests
3112	Forests dominated by deciduous oak
3114	Chestnut forests
3115	Forests dominated by beechs
3116	Forests dominated by hygrophilous species
3121	Mediterranean pines forests
3122	Mountain pines forests
3123	White and/or red fir forests
3124	Larch and/or cembrus pine forests
3125	Not native broad-leaved forests
31311	Holm oak mixed forests
32	Shrub and/or herbaceous vegetation associations

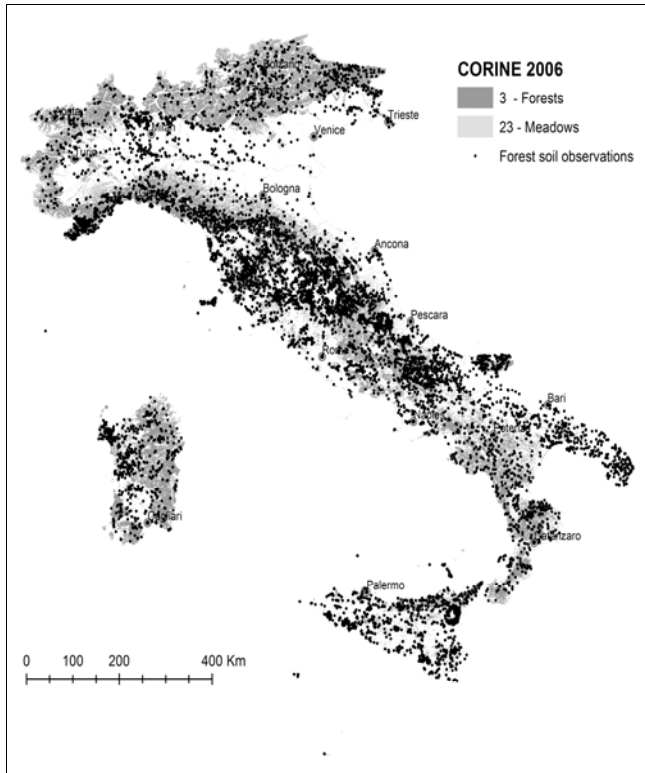


Figure 1. Distribution of soil observations within the country.

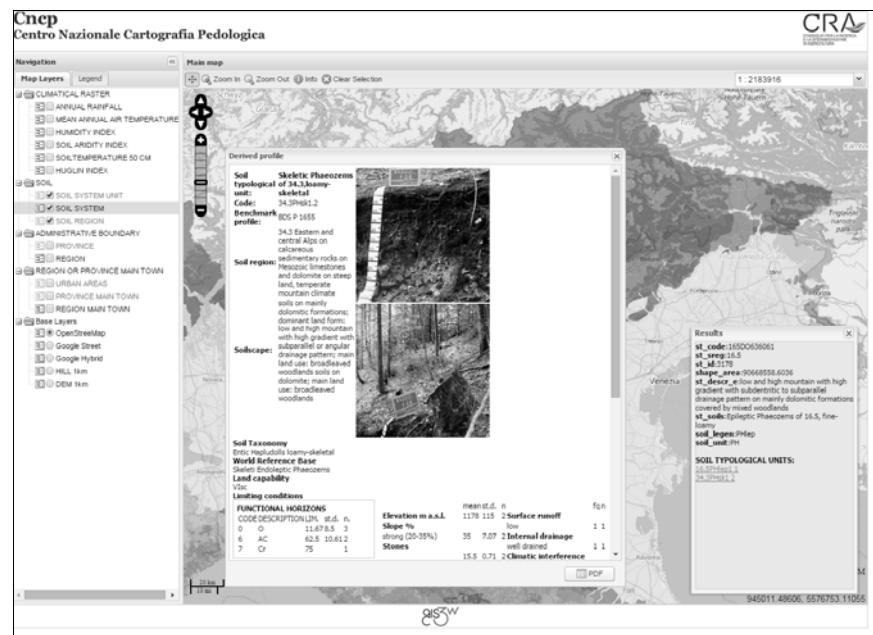


Figure 2. The SISI WebGIS application for online soil data consultation.

RIASSUNTO

La banca dati e la collezione di campioni di suolo forestale del Centro Nazionale di Cartografia Pedologica (CRA-ABP)

L'Aggiornamento e gestione della banca dati dei suoli d'Italia è una delle attività principali del progetto "Biodati" del Consiglio per la Ricerca e la sperimentazione in Agricoltura (CRA). Il database è collegato ai

campioni di terreno conservati presso la pedoteca del Centro Nazionale di Cartografia Pedologica (CRA-ABP) e interessa tutti i principali pedopaesaggi agricoli e forestali italiani.

Le osservazioni georeferenziate ed analizzate rilevate tra il 1950 e il 2013 sono state memorizzate nella banca dati nazionale. Le procedure di campionamento e di analisi sono state effettuate in conformità con gli standard nazionali ed internazionali. Il campionamento ha interessato sia l'orizzonte organico che quello minerale. Le

principali analisi sono state: granulometria, pH, carbonio organico, azoto, densità apparente, effervescenza. I campioni sono stati archiviati e la loro collocazione informatizzata, in modo da poter consentire ulteriori analisi o test di nuovi sensori. Allo stato attuale, il database contiene 5.384 osservazioni analizzate (profili pedologici, minipits o trivellate), campionate in ambienti forestali, e 1.306 su prati permanenti. I campioni memorizzati ammontano a 16.466. Gli ambienti forestali dei campioni sono descritti in 16 categorie forestali.

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