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ATTI DEL WORKSHOP

TOWARD A NETWORK OF REGIONAL SOIL SURVEYS IN THE FRAME OF EU: THE COOPERATION AMONG THE EUROPEAN, NATIONAL AND LOCAL LEVELS

Sponsored by the European Union

D.G. JRC - Space Research Institute - European Soil Bureau

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PREFACE

The workshop has been organised by SISS (Italian Society of Soil Science), with the sponsorship of the European Union, D.G. JRC - Space Research Institute - European Soil Bureau (ESB), and was hosted by the Regional Government of the *Regione Toscana*. The collaboration of *Progetto Finalizzato PANDA* of the Ministry of Agricultural Policies, and the auspices of the *Osservatorio Nazionale Pedologico e per la Qualità del Suolo* are acknowledged. The purpose was to stimulate the debate about the experiences and the future tasks of the European administrative regions and staffs working on soils. The invited speakers tried to emphasise arguments concerning soil databases, applications of soil information, organisation of permanent focal points at regional and local level.

The addresses of Winfried Blum, Secretary General of the International Union of Soil Sciences (IUSS), Luca Montanarella, Secretary of the ESB, and Vannino Chiti, President of Regione Toscana, opened the workshop. The German experiences and problems, showing the organisation and responsibilities at regional (Land) and national level, were presented during the morning, thanks to Wolf Eckelmann, Hans Heineke and J. Kues, Rainer Schweizer, Dieter Kühn, Reinhard Hartwich. Fiorenzo Mancini, the *father* of the Italian Pedology, chaired the session.

In the afternoon two presentations dealt with the international level: ESB strategies were presented by Luca Montanarella, and the FAO World Reference Base for local soil surveys by Freddy Nachtergaele. The following six presentations were devoted to the Italian regions and the national issues, with contributions from Romano Rasio, Nicola Filippi and Andrea Giapponesi, Mario Toteda, Luciano Lulli, Edoardo Costantini, Ghislaine Urbano. Winfried Blum chaired the session.

Jaume Boixadera from the Region Cataluña (Spain) commented the general outline of the workshop and the President of the SISS hold the closing remarks.

Over 150 participants attended the workshop. They received one copy of the "Manual of Procedures of the georeferenced soil database for Europe", edited by the ESB, and the freshly published document

"Guidelines for establishing regional soil services in Italy", edited by the Scientific Committee of the Soil National Observatory, established by the Ministry of Agricultural Policies.

The participation was very satisfactory, and encourages in going ahead with this kind of meetings; this should stimulate all the European regions for a co-operative work, in a network co-ordinated by the European Soil Bureau.

Following the workshop, on November 6th, two ateliers hosted by the ISSDS (The Experimental Institute for Soil Study and Conservation), have been organised; the topics were "The soil map of Italy at scale 1:250,000", and "Toward a database for Alpine Regions".

The initiatives of the Italian Society of Soil Science are going on embracing a wide range of topics to increase the knowledge of soil and the environment at different levels. Some examples are a national advisory board on fertilizers, soil vulnerability and sensitivity, the evaluation of agri-environmental resources through geostatistics and computer applications, a committee for education in soil science. We invite all of you to attend our meetings, and to read the *Bollettino* where all the proceedings will be published.

We wish to thank the invited speakers and their collaborators for their valuable scientific contributions; Manuela de Pace and Barbara De Rosa from the staff of the Experimental Institute for Plant Nutrition of Rome for supporting the organisation of the Workshop. We are very grateful to Marcello Pagliai, Director of the Experimental Institute for Soil Study and Conservation for hosting the ateliers, as well as Olga Grasselli and Miranda Morandi from the same Institute for their contribution. A particular thanks to Marina Natalini for her support also in the collection and the editing of the manuscripts during the review.

Rosa Francaviglia, Romano Rasio and Paolo Sequi

Address of the Secretary-General of the International Union of Soil Sciences (IUSS)

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Distinguished guests, Ladies and Gentlemen,

I thank the organizers of this International Workshop, especially Prof. Paolo Sequi, for inviting me to take part in this International Workshop on " Towards a Network of Regional Soil Surveys in the Frame of EU: The Cooperation Between the European, National and Local Levels", and it is both, an honour and a pleasure to convey to all of you the best greetings on behalf of the International Union of Soil Sciences at this special occasion.

I should like to inform those of you who are not familiar with my Organization, that we are a learned international union, founded in 1924, in Rome, Italy, as an international society, with about 45,000 members in 163 countries, adhering to us through National Societies, as for example the Società Italiana della Scienza del Suolo and individual members from those countries which do not have a national soils organization. Moreover, we have five regional associations, three in Africa, one in Latin America and one in East and Southeast Asia. Since 1993, the IUSS is a full member of ICSU, the International Council for Science. Under this umbrella, we are together with 25 other scientific unions, such as IUPAC, IUPAP, IUGG, IUGS, IGU, IUBS and many others, as well as with 96 national academies or science councils, for example the Consiglio Nazionale delle Ricerche in this country, which also means that soil science is accepted by the scientific community as a basic science.

Coming back to this Workshop, I should like to comment briefly the main goals under the aspect of the importance of soil surveys for the future development on an international level, and especially here in Europe.

Regional soil surveys on a national or local level are very important for steering the uses of soil and the harmonization of different land uses on a given national or local level. However, if we want to compare soil data on a European level, it is absolutely necessary that the methodological approaches under which these surveys have been developed are comparable, because without the harmonization of methods, the data cannot be compared on a higher level.

But there is an urgent need for soil data, not only from the point of view of agricultural and forest production, but also from the point of view of harmonization of different land uses and especially sustainable development, which includes not only agricultural but all other main uses of soil and land, as e.g. the use of soil for filtering drinking water and maintaining biodiversity, the soil as a biological habitat and a gene reserve with enormous importance for future biotechnological and genetic engineering purposes. Besides, soils are used as space for the development of technical infrastructure, such as housing, industrial production, transport, dumping of refuse, sports and recreation, and others. For this purpose, soil materials, such as clay, sand, gravel, water, and others are used. And finally, soils are part of landscapes and as such geogenic and cultural heritage, concealing and protecting archaeological and paleontological treasures, a point which is of special importance for this country. All this has to be taken into consideration when we speak about soil survey, because it is a unique source of information, for harmonizing land uses for the sake of future generations.

Recent examples of such endeavours are the OECD Workshop in York, UK, aiming at defining agri-environmental indicators, the activities in the European Union, defining indicators for sustainable agriculture and other initiatives brought forward be the European Environment Agency in Copenhagen, within the European Topic Centre Soil, and a lot of work carried out by the European Soil Bureau, within the Joint Research Council of the European Commission.

Therefore, this International Workshop today is a very important step forward in the overall development of the use of soil data for steering our future. I congratulate the organizers on this initiative, and I wish all of you a very successful workshop.

Thank you for your kind attention. Grazie

The BGR Federal Soil Information System, a link between State Soil Surveys and BGR's European partners; aspects of the new German Federal Soil Protection Act

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Need for soil information - general outline

The ongoing discussion on soil protection has caused the increasing demand for pedological data and information. Users of soil information are:

- Decision makers in politics, ministries
- Administration mainly on federal and state level
- European administration and institutes
- Agriculture and forestry
- Industry, mainly for agrochemical production
- Planning agencies and similar administrative bodies
- Research and scientific publication

In March 1998, the first German Act on Soil Protection at national level was accepted by both houses of the German parliament (Bundesregierung 1998). This resolution caused additional need for soil information. It has started a detailed discussion on the administrative and technical structures necessary to realise soil protection in Germany. The main aspects and consequences arising from the new German act are:

§ 1: The act shall cover precautionary aspects of soil protection as well as those of contaminated sites.

§ 3: The Act on Soil Protection has to respect 11 already existing directives of different legal level (e. g. directive on sewage sludge).

§ 8: The Federal Government shall define details of soil protection steps (e. g. threshold values) to be introduced into a subordinate ordinance on soil protection, well co-ordinated with the state level.

§ 19: The Federal Government and the *Länder* shall define the need to exchange data between both levels. The Federal Government may establish a national soil information system.

Currently, a number of technical annexes are in preparation to form a subordinate ordinance on soil protection, specifying the German Act on Soil Protection. These annexes will define soil quality criteria as well as 'precaution levels', 'trigger levels' and 'action levels' and procedures to explain how soil protection measures will be processed.

Since the federal act on soil protection has passed the German government, the states (Länder) of Germany are requested to create state level acts on soil protection or to modify already existing versions.

The institutional situation

Responsibilities for soil information and soil protection at the national level in Germany are within the scope of several institutes. The main fields of interest and activities are (examples):

• The Environmental Agency (Umweltbundesamt; UBA) is responsible for all soil protection measures in Germany as well as for developing and updating the ordinance on soil protection.

• The Federal Institute for Geosciences and Natural Resources (Bundesanstalt für Geowissenschaften und Rohstoffe; BGR) mainly deals with geo-scientific information on Germany, e. g. soils, geology, hydro-geology, developing branch information systems, methods and tools e. g. to derive thematic maps.

• A Federal Forest Agency (Bundesanstalt für Forst- und Holzwirtschaft; BFH) provides information on forest soils and co-ordinates the German part of the EU-wide forest soil condition project.

Moreover, numerous other federal institutes provide some information relevant to soil protection or develop concepts or tools.

At state level the organisational structures in the 16 federal states differ widely. The main responsibilities are:

• Soil Survey Institutes: Soil mapping and soil information systems.

• Environmental Institutes: Soil protection measures and contaminated sites mapping, information systems.

In some states the same institute covers soil survey activities and environmental aspects as well. In all cases, only the state institutes are responsible for activities on the "Länder" level, the federal agencies and institutes are responsible for nationwide aspects, co-ordinating state activities throughout Germany and dealing with European aspects of soil information and soil protection.

Soil information in Germany

In Germany, sixteen state geological surveys and the Federal Institute for Geosciences and Natural Resources (BGR) are co-operating to collect information about the soils of Germany and to organise a network of soil information systems (Oelkers, 1991; Eckelmann and Hartwich, 1996). This nested system is intended to contain all information relevant to soil protection. It will then be possible to recall and interpret the data according to scientific or regional criteria. Additionally, methods and criteria are being developed for the recognition and assessment of soil contamination.

BGR´s soil information system structural components need to correspond to analogous information systems of the individual German states as well as to EU organisations, e. g. the European Soil Bureau. This indicates above all the need for compatible data standards (e. g. FAO), data field registers, data sets and methods. The position of BGR between federal state structures and the EU level explains most of the difficulties of a national soil survey.

Recently, Oelkers and Voss (1998) reported in detail on the Lower Saxony Soil Information System, NIBIS and on the development of similar systems in the other federal states.

Objectives, aims and structure of the BGR Soil Information System

The soil information system for Germany, called FISBo BGR, is one of a number of linked geo-information systems, e.g. geology, soils, geomorphology, hydrology. Together they form a geo-information network which enables broad inter-disciplinary evaluation of different topics. The structure of such an information system has been described by Vinken (1992). The principles of the BGR Soil Information System have been described by Eckelmann *et al.*, (1995) and Eckelmann (1996). These and other papers give an overview of current work on information systems in Germany.

FISBo BGR's detailed objectives and aims are:

• To extend and provide a database of soil information in co-operation with the German federal states according to the needs of the federal government.

• To analyse this database to answer requests for information from the federal government (e.g. for preparing presentations of the current situation).

• To aid the compilation of basic and thematic maps for prognosis and for drafting guidelines as required by the new Act on Soil Protection.

• To provide a basis for answering questions submitted by European Union agencies or international bodies.

• To provide a basis for co-operation with other research institutions (e.g. for nation wide analyses).

The following main structural components are being developed at BGR at present, analogous to the information systems of the individual German states:

• a spatial database that maintains a number of already existing soil and related maps including the geometric-topographical data.

• a soil profile and laboratory database that contains both the observations of soil surveys as well as the results of all soil chemical and physical analyses.

• a method database that defines the data processing techniques (for determining groundwater recharge, water retention and filter functions, soil productivity, etc.) underpinning interpretation of soil maps and the relevant principal and supplementary data.

With respect to future co-operation with organisations of the European Union, these structure components need to be adjusted to those of the European Union level. This demonstrates above all the need for compatible data field registers, data sets and methods.

Soil mapping and FISBo BGR spatial database

The German Soil Mapping Guide (KA 4; AG BODENKUNDE 1995) was published in 1995 in its 4th edition. It contains data keys, symbols and all parameters used in soil mapping and site description. Together with the definition of the principles of the soil information system (Heineke *et al.*, 1995), these data keys are assigned to data fields to be used in digital management. As this mapping guide deals only with the German Soil Taxonomy, links to international soil taxonomies, e.g. the FAO Soil Classification System (FAO 1990; FAO-UNESCO 1990) need to be defined; they are presently in preparation. They will become more important in the future, particularly at the European Union level.

For special soil mapping purpose, e.g. mapping of forest sites or city areas, there are other guidelines existing in Germany (Oelkers, 1991). Soil maps compiled using these special mapping guides are integrated into the geological survey's soil maps as far as possible and these soil maps are accessible. Naturally this requires transformation of all available data into the standard form as given in the Geological Survey's German Soil Mapping Guide.

The spatial database established at the FISBo BGR needs to have soil maps in order to fulfil its duty to the federal government as well as for co-operation with the European Union. These maps for national and international needs, and representing the digital soil geographical databases, include the elements, given in fig.1 (Behrens *et al.*, 1998). The main objective in soil mapping nation wide is at least to compile and have available a **nested system of soil maps** at different scales, which can be used for a wide range of applications, for all co-operations between the federal state, the national level and the EU.

Figure 1

Soil thematic elements of the FISBo BGR spatial database

- Digital **Cartographical Database** of Europe (EURODB) to serve as the basic map
- **1:200,000 soil map as the common base map to be compiled jointly with the individual state soil surveys**
- **1:1,000,000 Soil Map** of Germany as the most important geographical database for national requirements (Hartwich *et al.*, 1995)
- **1:1,000,000 EU Soil Map**, representing the German part of the Soil Geographical Database of Europe at a scale of 1:1,000,000
- **Soil Regions map at a scale of 1:1,000,000** to show landscape relations and to give an overall view of soil information
- **1:2,000,000 Soil Map** of Germany, representing a part of the Hydrological Atlas (in preparation)
- **Soil Regions Map of Europe at scale 1:5,000,000**, which has been drawn up in co-operation with the European Soil Bureau
- **Non Soil Data** (climatic, morphologic and land use data)

This approach should help to solve the problem, Zitzmann documented in 1994 soil maps existing in Germany. The information that he obtained, showing the availability of 1:25,000 to 1:200,000 soil maps, emphasised the problem of incomplete coverage. Besides these scales, several state geological surveys published soil maps at scales of 1:5,000 and 1:10,000 and/or soil maps of the entire state at scales of 1:300,000 to 1:500,000. Although some state geological surveys could improve soil information, the availability of soil maps at identical scales and quality is still unsatisfactory with respect to national requirements.

The 1:200,000 Programme

In a recent approach, the individual state soil surveys and the national soil survey of BGR agreed on a programme to compile and publish a joint 1:200,000 Soil Map of Germany. Production of this map is to be co-ordinated by BGR. The first maps have already been published.

In order to co-ordinate the 1:200,000 programme, BGR and the sixteen state soil surveys have prepared a 1:200,000 manual including the following elements:

- Guidelines for soil map units and soil profile descriptions including flow charts showing all steps to be taken by the state soil surveys of Germany as well as those taken by BGR.
- data sheets with 42 data fields for data collection related to the soil units of the 1:200,000 soil maps.
- rules for amalgamating soil survey maps to other scales.
- a general legend for the standardised 1:200,000 soil map.
- a Soil Regions Map of Germany at a scale of 1:1,000,000.

A system of landscape relations has been defined for Germany to ensure that the soil surveys describe similar soil units for the 1:200,000 soil map in a comparable way (see Hartwich in this volume). This hierarchical system classifies landscapes according to geology, morphology, climate, and vegetation. As already proposed by Dudal *et al.* (1993), these principles have been used in the compilation of the 1:250,000 European Union Soil Map Manual.

THE 1:1,000,000 SOIL MAP

The digital 1:1,000,000 Soil Map of Germany (Hartwich *et al.*, 1995) is the most important part of the spatial database of the FISBo BGR Soil Information System. In addition to the characteristic soil profiles ("Leitprofile"), thematic maps dealing with nationwide problems of soil use and soil protection have been derived. The 1:1,000,000 scale makes the soil map especially suitable for evaluating problems at both national and European Union level (Jamagne *et al.*, 1995).

Whilst preparing thematic maps, the needs of some users required improvement in and completition of the 1:1,000,000 spatial database with more precise information on land cover. This work is presently being done using the CORINE Land Cover data set and has led to changes in the description of the variability of soil map units.

Another digital element is presently in preparation using digital geo-morphological data to derive a first geo-morphographic database and map of Germany. This database will include a 50 square meter raster e. g. to run erosion models as well as to derive vector graphics. Moreover, climatic information will be adapted to the FISBo BGR spatial database non soil data sets.

Altogether, the 1:1,000,000 scale contains the most important data set of Germany available to science, administration and industry, using a BGR specific leasing procedure.

Soil Profile and Laboratory Database

The soil profile and laboratory database of the FISBo BGR stores all soil attribute data collacted from point observations of fully described and analysed reference profiles in sets of digital files for later retrieval. Links between the files, that is tables, are maintained through primary keys. Depending on regional or national requirements, the soil database may be set up according to various soil classification systems. In addition to the German system, the FAO soil classification system has been included so far. The latter has been done in order to cater specifically for international co-operation. Similarly, a soil database is presently being developed according to the U.S. Soil Taxonomy (widely used in Asia and the Americas). Up to now, 7,000 sites throughout Germany have been analysed and documented in this database.

One essential purpose of the harmonised, site-specific soil data is to develop representative soil profiles for small scale soil maps for making spatial interpretations on various themes (Hennings, 1994). Additionally, this soil profile and laboratory database can be used to create pedotransfer functions, which relate different soil properties to one another or to soil texture (Bouma and VanLanen, 1987). The pedotransfer functions are essential for creating standardised data sets from inhomogeneous data. This data can be used to analyse the spatial structure of specific soil properties using geo-statistics or to determine the background values of soils for selected inorganic or organic pollutants (Utermann *et al.*, 1996).

With reference to the new German Act on Soil Protection, information had to be improved on heavy metal contents in soils for use in the technical annexes to the act. Therefore, three federal states (Bavaria, Saxonia and Thuringia) supported the BGR soil profile and laboratory database with additional data on heavy metals from their state level. These data sets together gave a sufficient basis for BGR to derive soil quality criteria on heavy metals.

The German Act on Soil Protection defines three categories of soil quality criteria as soil levels:

- "precaution levels" indicating a certain chance of future soil problems which need to be addressed in order to avert upcoming damages;
- "trigger levels" indicating further investigations to ascertain (verify/falsify) whether the soil contamination implies a hazard;
- "action level" indicating as a rule of hazard which has to be warded off; further investigations to ascertain the hazard are usually not necessary.

Based on the BGR examinations on soil quality criteria on heavy metals, the German Federal Environmental Agency subsequently proposed soil levels for numerous elements and compounds. Examples of those levels are given in fig. 2 and 3.

Figure 2

Precaution levels for metals in soils [mg/kg DM] (aqua regia)

soils	cadmium	lead	chromium	copper	mercury	nickel	zinc
clay	1.5	100	100	60	1	70	200
loam/silt	1	70	60	40	0.5	50	150
sand	0.4	40	30	20	0,1	15	60

Figure 3

Trigger levels [mg/kg DM] (inorganic compounds)

Substance	childrens' playground	residential area	parks and leisure ground	industrial and commercial area
arsenic	25	50	125	140
lead	200	400	1,000	2,000
cadmium	10	20	50	60
cyanide	50	50	50	100
chromium	200	400	1,000	1,000
nickel	70	140	350	900
mercury	10	20	50	80

In another approach, a first edition of the "Guidelines for Taking Soil Samples" (Ad-hoc-AG Boden 1996) has been published jointly by the individual state soil surveys of Germany and BGR. Another co-operation between BGR and state soil surveys led to a definition of a joint Soil Laboratory Database, which includes the description of all important analytical methods. This digital database version will be available to the public shortly.

Contents and Use of a Method Database

Processing of pedological data, e.g. to make interpretations of soil maps on various themes or to analyse specific topics, requires not only the availability of the necessary data within an efficient information system, but also well defined methods to be applied from a digital method base. The method database contains methods to derive land qualities from pedological base data (e.g. maps). The methods themselves consist of pedotransfer functions (in modular form). These pedotransfer functions, once established as reliable and accurate, permit key parameters (relationships) to be calculated, thus, greatly simplifying the data required in modelling (Wagenet *et al.*, 1991). Furthermore, the methods collected in such a method database must be programmed according to a single system so that they can be used by both BGR and the German state soil surveys.

Figure 4

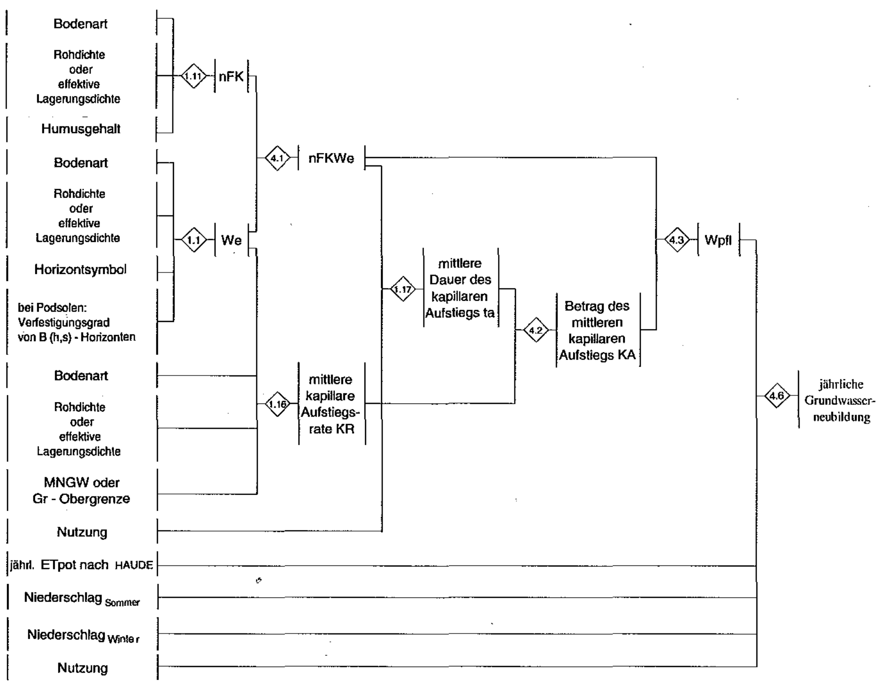
Methods calculating soil properties or the vulnerability of soil to specific hazards

- Groundwater recharge
- Potential agricultural yield
- Nitrate retention capacity
- Retention capacity for heavy metals
- Potential susceptibility to compaction
- Vulnerability to erosion by water
- Vulnerability to erosion by wind
- Vulnerability of forest soils to acidification

An up to date documentation of a large number of methods has been published (Hennings, 1994). The methods are restricted to calculating specific soil properties, parameters or functions and determining the vulnerability of the soil to specific hazards (fig. 4). This set of methods was prepared by a joint working group of the soil surveys of the German individual states and of BGR, set up to study various methods for processing basic pedological data, to assess these methods, and to compile suitable documentation.

Figure 5

Flow sheet diagram of the method documentation "Groundwater recharge" (year)



All of the methods in the method database are deterministic models based on simple empirical relationships (fig 5). Sometimes these models considerably simplify the physical and chemical processes concerned and provide only an approximate estimate of the parameter of interest. Information about the kind of input data needed, the appropriate scales, and whether the result is qualitative or quantitative is given for each method, so that the different methods available in the method database for the same desired parameters can be compared. In addition, this documentation describes methods whose applicability is restricted to certain areas or to maps of a certain scale. Therefore, all of the methods must be checked and developed further (Hennings, 1994).

After publishing the new version of the German Soil Mapping Guide (KA 4), it became necessary to update a number of these methods. This work has been done recently and a publication of an updated version of the method documentation is imminent.

Much emphasis has been given to the optimisation of algorithms for the pedotransfer functions. The EU scientific co-operation network project "Using existing soil data to derive hydraulic parameters for simulation models in environmental studies and in land use planning" (Wösten *et al.*, 1998) is an important step forward. The final report gives notice of the establishment of the HYPRES Database (**Hy**draulic **Pr**operties of **E**uropean **S**oils), which has been supported by copious data, e. g. from BGR and the Lower Saxony Soil Survey. This data was used for the derivation of class and continuous pedotransfer functions. These functions and the Soil Geographical Database of Europe have been combined to generate a map of the availability of water in European soils.

In addition to the above-mentioned method documentation, some methods still need to be standardised. To this end, the individual state environmental agencies of Germany and BGR have agreed on a set of thematic maps, which need to be processed for the purpose of soil protection in near future.

Use of the Soil Information System and perspectives

The BGR soil information system will be used mainly to advise the German federal government and to co-operate with the individual state soil surveys. The needs of the German Act on Soil Protection will require close co-operation of BGR with the environmental agencies of the individual states and the German government. The information systems will be applied to develop pedotransfer functions and fairly complex methods for evaluating soil data. Provided the individual state soil surveys and the BGR are using the same standardised methods, comparable results can be expected. It will also be a basis for co-operation with other institutes at European Union and global levels.

As far as a network of soil information system in a federal state system as well as on the EU level is concerned, the following requirements need to be fulfilled:

1. To organise soil information and soil protection in a federal state system and connected to the European scale, stable structures are of high importance with regards to well-equipped soil survey institutes at regional level (state, "Länder") as well as for the federal state.

2. The existence of a European partner institute is undoubtedly necessary for international co-operation.

3. All soil survey institutes shall agree to one common structure of soil information systems.

4. They shall jointly define guides for soil mapping, sampling, map presentation etc. and they shall all use the same soil taxonomy, hopefully connected to the European system.

5. Regional soil surveys and the national level shall agree on one map scale of common interest (1:250,000 ?).

6. Data exchange between regions and the national level is necessary for both sides. The necessity shall be defined and dealt with trustfully, respecting the aims and tasks of each partners (regional or national) political level.

7. The soil survey institutes will never own the same (and sufficient) budget. To define share work is one of the most effective ways, to be successful and to use the same structures.

8. System exchange should be aimed even at the European scale.

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THE SOIL INFORMATION SYSTEM OF LOWER SAXONY AND ITS USE FOR LANDUSE AND SOIL PROTECTION PROPERTIES

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1. Introduction

The demands made on geological surveys in the context of planning decisions and individual consulting services are increasing. This is partially due to the new laws on soil conservation expected soon (Fieber, Kues and Oelkers, 1993). Differentiated soil information for various planning levels is required, especially for sustainable land use, soil and nature conservation, regional and state planning, agricultural planning and ground water protection (Steiniger and Müller, 1993; NDS.GVBL Nr. 16, 1994; Kühner, 1996, Sächsisches Landesamt Für Umwelt Und Geologie, 1994). The computerised statewide soil information system was developed because manual handling is no longer adequate for the systematic utilisation of the existing data and methods. This information system contains all of the data and methods for regional planning and soil-related planning and is regularly updated and always accessible. These developments are discussed using as an example the Soil Information System of Lower Saxony (NIBIS) (Heineke, 1991; Heineke, Filipinski and Dumke, 1995; Heineke and Eckelmann, 1998) to present in detail its potential areas of application. This system integrates a large amount of information from all of the relevant geosciences either derived from existing references or newly acquired. Because information systems cannot function as more collections of data, the currently available evaluation methods required for the use of the database are organised within a method base (Müller, 1997). Moreover, the instruments for data gathering and methodological development (continuous soil monitoring and research departments) are an integral part of the system.

Taking soil science aspects into consideration during the various planning and approval procedures also requires agreement on the technical requirements for making the relevant soil information available to the technical planning groups in question (e.g. NDS.GVBL Nr. 19, 1994; Sächsisches Landesamt Für Umwelt Und Geologie, 1994; Umweltministerium Baden-Württemberg, 1995). Examples are shown for the following planning areas: state planning/regional planning, drinking water protection and agricultural structure planning.

2. An outline of the soil information system of Lower Saxony (NIBIS)

It is essential that the information base available for making the right decisions at the right time regarding the prevention and minimisation of soil pollution or the remediation of contaminated sites, is as complete, up-to-date and cost-effective as possible. Setting up the digital information system NIBIS was a vital prerequisite for the up-to-date provision of information from a statewide level down to individual parcels of land. The most important characteristics of this system are its user orientation and application flexibility. The information made available is constantly aligned to the technical requirements.

2.1 Conception

Reflecting the concept agreed between the federal German states, NIBIS comprises several technical information systems (TIS) covering the following areas:

- geosciences;
- anthropological impact on the soil;
- nature conservation and landscape conservation.

One of the main elements of the geoscientific aspects is the soil technical information system (TIS BODEN) which is the furthest developed of all such systems in Germany.

The structure of NIBIS TIS-BODEN is strongly oriented to the information needs of measures essential to soil protection. These were determined at the start of the development phase by a needs analysis carried out by the state office responsible for soil protection. NIBIS TIS-BODEN was therefore primarily designed to fulfill the following tasks:

♦ the digital recording and statewide storage of all development information at different scales, including the option of continuous updating;

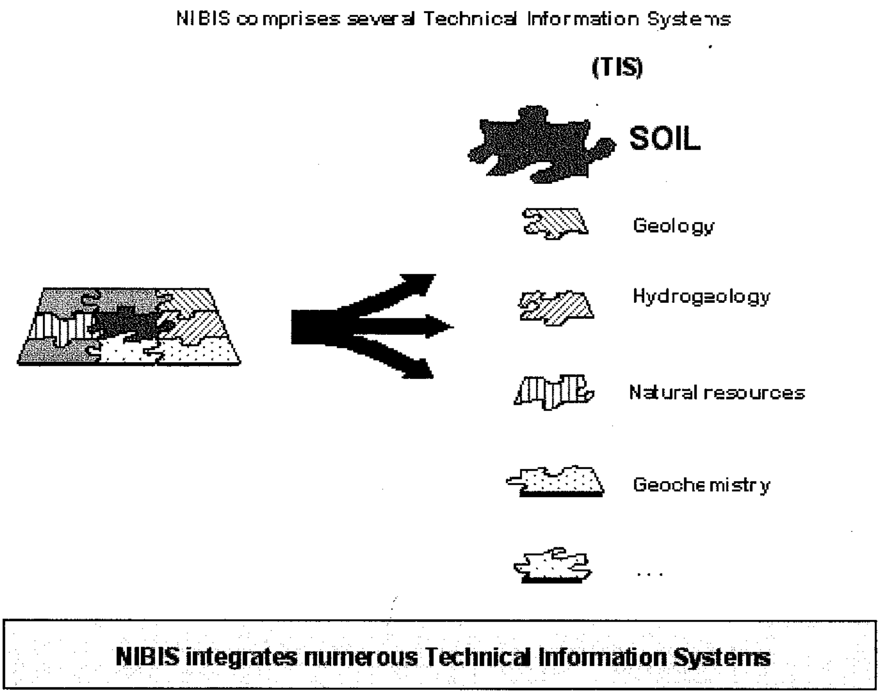
♦ joint and variable further processing of all the data;

♦ problem and user related evaluation with different methods for displaying the results taking into consideration soil science state-of-the-art.

The development of the soil science and computer methods required to implement these objectives was agreed at a state/federal level among geological surveys in Germany headed by the Soil Survey of Lower Saxony - Soil Science Department - (Heineke, Filipinski and Dumke, 1995; Heineke, Eckelmann, 1998; c.f. Schweizer, 1998 in this report). The structure and potential of the system also reflect recommendations of the 1994 Conference of Environment Ministers compiled by the author (AD-HOC-AG Kernsysteme und Methodenbanken, 1994 a+b).

Figure 1

The NIBIS structure



2.2 The contents of NIBIS TIS-BODEN

The following focuses on the soil technical information system within NIBIS. The structure of soil cover as well as their areal distribution are controlled by the following soil formation factors: parent rock, climate, relief and land use history. The distribution of soils and their structure is determined on the basis of individual site surveys, and the classified soils are displayed in maps at various scales. The soil map components form the areal database.

A representative soil sample from these individual site surveys is tested and subjected to laboratory analysis to determine the soil properties. These aspects form the laboratory database.

Another sample from the surveyed sites is then selected to determine long term soil changes dependent on land use and soil exploitation, for long term observation, and for field experiments. Because the soil analysis interpretations can be used to interpret the site surveys, the results in the laboratory database and from the continuous observations can be integrated within the areal database and also displayed on an areal basis.

The methods required for evaluating the data base are listed in a collection of methods in a standard format after relevant development and testing via the laboratory, container and field tests, and then made available in the NIBIS TIS-BODEN methodology base in digital form. The methodology base and the associated specially developed software always automatically guarantees the proper technical linkage between data and methods. The detailed structure of this software is described in Bartsch (1998). Table 1 lists the currently available data and methods.

2.3 Application of NIBIS TIS-BODEN

The information provided by NIBIS TIS-BODEN is oriented to the needs and terms of reference of potential users as determined from the results of the above mentioned survey. Specifically this means that NIBIS TIS-BODEN contains data and evaluations for sustainable and environmentally compatible land use, the protection of soil and peat bogs, as well as nature conservation and water protection.

Table 1

Contents of NIBIS TIS-BODEN (as at 1998)

Area database		
Data stock	**Data stock Applications**	**Areal coverage (in digital form)**
Soil maps at scale 1:500,000 (BÜK 500)	Statewide maps	100 %
1:200,000 (BÜK 200)	Statewide base maps	100 %
1: 50,000 (BÜK 50)	Planning/evaluation at a regional and district level	100 % - available on CD-ROM
Soil map at scale 1:25,000	Planning/evaluations at regional and district level	40 %
Land use from historical topographic maps at scale 1:25,000	Planning/evaluation at regional and district level	30 %
Forestry location map (state forests) at scale 1:25,000	Planning at plot level	100 %
Soil map at scale 1:5,000 (developed from the soil assessment data)	Planning at plot level	60 % (will be available 90 % by 2000)
Climatic zones at scale 1:200,000	Supplementary data for site characterisation	100 %
Climatic data from the German Weather Service and the soil monitoring sites	Supplementary data for site characterisation	100 %

Table 1 (cont.):

Laboratory database/borehole database		
Data stock	**Data stock applications**	**Extent (in digital form)**
Laboratory data, soil samples	Basis for model development, model calibration	approx 100,000 samples
Profile descriptions	Basis for model development, classification of physical, chemical and biological soil properties, model calibration, plot level accurate evaluations	approx 600,000 profiles
Date from soil monitoring sites	Basis for model development, model calibration, plot-level accurate evaluations, site development	70 areas invol ving agricultural land use, 20 forestry areas
Data from field testing	Basis for model development, model calibration, plot-level accurate evaluations, site development and land use alternatives	31 field experiments

Method base		
Method stock	**Applications**	**Extent (in digital form)**
65 modules	Technical evaluation for various purposes and at various scales for administration, industry, associations, etc.	65 modules

This information is used in the context of:

- Statewide planning;
- Nature conservation and landscape planning;
- Agricultural and forestry land use;
- Agricultural structure;
- Water resource management;
- Recycling and waste resource economy;
- Soil remediation and regeneration.

For third party use, NIBIS TIS-BODEN has the following technical alternatives (3-step application):

♦ Provision of soil maps, evaluation maps and database extracts:

- As print outs;
- On data carriers of all types;

♦ Preparation of evaluations on a consultancy basis, and if required, including elaboration of new methods;

♦ The use of NIBIS TIS-BODEN data and methods by the user via ONLINE services through the Internet (available within the next three years).

In complex cases, such as the preparation of pedological guidelines for the supplementary agricultural advisory service in drinking water protection areas, cooperation procedures are developed among the interested parties - in this case the water boards, the water industry, agriculture, the consulting engineers and NLfB. These guidelines form the basis for the development of similar projects/contracts (also by third parties) utilising the NIBIS TIS-BODEN data and methods. This coordination guarantees that the work is carried out statewide on a standardised and therefore compatible basis. The following discusses this collaboration and cooperation.

3. Currently supported planning procedures and pedological technical reports

Soil information for technical planning involving soil protection is usually requested statewide at three planning levels (table 2). These planning levels can be assigned to planning procedures whose structure is regulated for each specific state with respect to soil protection (e.g. Sächsisches Landesamt Für Umwelt Und Geologie, 1994; Umweltministerium Baden-Württemberg, 1995) (table 2, example Lower Saxony).

Table 2

Planning procedures and planning levels

Legal framework	**Upper planning level**	**Intermediate planning level**	**Lower planning level**
State planning policy NROG	State regional planning policy	Local regional planning policy	Land use plan / Detailed local development plan
Nature conservation NnatG	Landscape policy	Landscape framework plan	Landscape plan / Green spaces policy / Nature conservation area designation / Landscape conservation area designation
BauGB			Physical development planning
Soil protection BodSchG	subordinate rule books	subordinate rule books	subordinate rule books
Water protection NWG	Water resources management framework plan	Water Law procedures	Supplementary agricultural advisory service / Protection area designation
Fertilizer decree SchuVo Liquid manure decree			Schedules
GAKG FlurbG	Land redistribution policy	Agricultural structure preplanning	Agricultural structure planning Land redistribution procedures Agricultural structural develop ment plans Legally binding planning
NAbfG, BImschG TASi		Landfill management planning District refuse plan	Landfill planning Remediation Contaminated sites
Environmental impact analysis (UVPG)	Environmental impact studies (UVS)	Environmental impact studies (UVS)	Environmental impact studies (UVS)

NROG = Lower Saxony Regional Policy Law, NNatG = Lower Saxony Nature Protection Law, BauGB = Construction Statute Book, NWG = Lower Saxony Water Law, SchVo = Protected Area Decree, NAbfG = Lower Saxony Refuse Law, BImsch = Federal Emission Protection Law, EBodschG = Draft for the Soil Protection Law. TASi = Technical Waste Guidelines, UVP = Environmental Impact Analysis, LROP = State Regional Policy Programme, RROP = Local Regional Policy Programme, FNP = Land Use Plan, B-Plan = Detailed Local Development Plan, NSG = Nature Conservation Area, LSG = Landscape Conservation Area, GAKG = Joint Responsibility Law for "Improving Agricultural Structure and Coastal Protection", FlurbG = Land Redistribution Law.

Different types of pedological information is required for the planning procedures for laws and regulations in Lower Saxony (NDS.GVBL NR. 16, 1994; NLVWA, 1989; NMELF, 1991). The application guidelines, for instance for the Lower Saxony Agricultural Structure and Nature Conservation Office, are currently being elaborated and are to place a high priority on pedological aspects. The planning procedures can be classified according to thematic evaluation areas for specific pedological involvement. This primarily involves the presentation of basic pedological data and the evaluation of possibilities and sensitivities with respect to material tolerance, substance degradation, negative structural impact, cultivation and general site assessments (table 3) (Müller, 1997; NLÖ and NLfB, 1996).

The structural content of planning instruments usually makes it necessary for planning procedures to be carried out interdepartmentally. This is particularly true for overall regional planning policy (Kühner, 1996). This allows different technical aspects to be taken into consideration (figure 2). The procedures and contents need to be documented in a standardised way if they are carried out on a regular basis to ensure that they are comprehensible and compatible. The extent to which these lists are formally elaborated differs from state to state (Sächsisches Landesamt Für Umwelt Und Geologie, 1994; Umweltministerium Baden-Württemberg, 1995). In Lower Saxony, the technical pedological reports for pedological issues in regional planning policy procedures and for groundwater protection have been specified, and a coordinated procedure has been determined (NDS.GVBL Nr. 16, 1994; Kues, Billerbeck and Stelzer, 1996) (see 3.2).

The costs compared to conventional procedures were considerably reduced by the cooperation models and the multiple use of relevant pedological information (figure 3).

3.1 Regional policy and state planning

The objective of regional policy is to coordinate the demand on land made by various users by taking into consideration and mutually assessing all regionally relevant land uses. Regional policy lays down the regional structure which the different planning levels are committed to achieve for each planning region. The objective of state planning is to implement these structures. Soil protection has recently gained a higher priority within this structure. The sustainable protection of soil intended here is not just restricted to "rare" soils or "contaminated" soils, but to all soils based on the principle of damage prevention (NMI, 1994). According to the state regional policy plan (LROP): "preventative principles in environmental protection.... should be given higher priority."

Table 3

Subjects involving pedological evaluation and technical planning classifications

	Material load	Substance degradation and negative structural impact	Cultivation	Site assessment / soil disturbance
State regional policy programme	*	*	*	*
Local regional policy programme	*	*	*	*
Land use Plan	*	*	*	
Detailed local development plan	*	*	*	
Landscape programme			*	*
" framework plan			*	*
Landscape plans	*	*	*	*
NSG-designation			*	*
LSG-designation			*	*
Physical development planning	*	(*)	*	
Soil protection	*	*	*	*
Water resources management framework plan	*		*	
Protection regulations	*		*	*
Fertilizer decree	*		*	
Agricult. planning	*	*	*	*
Forestry planning		*	*	*
Land redistribution plan		*	*	*
Agricultural struct.	*	*	*	*
Landfill planning	*			*
Contaminated sites	*			*

Abbreviations, see Table 2

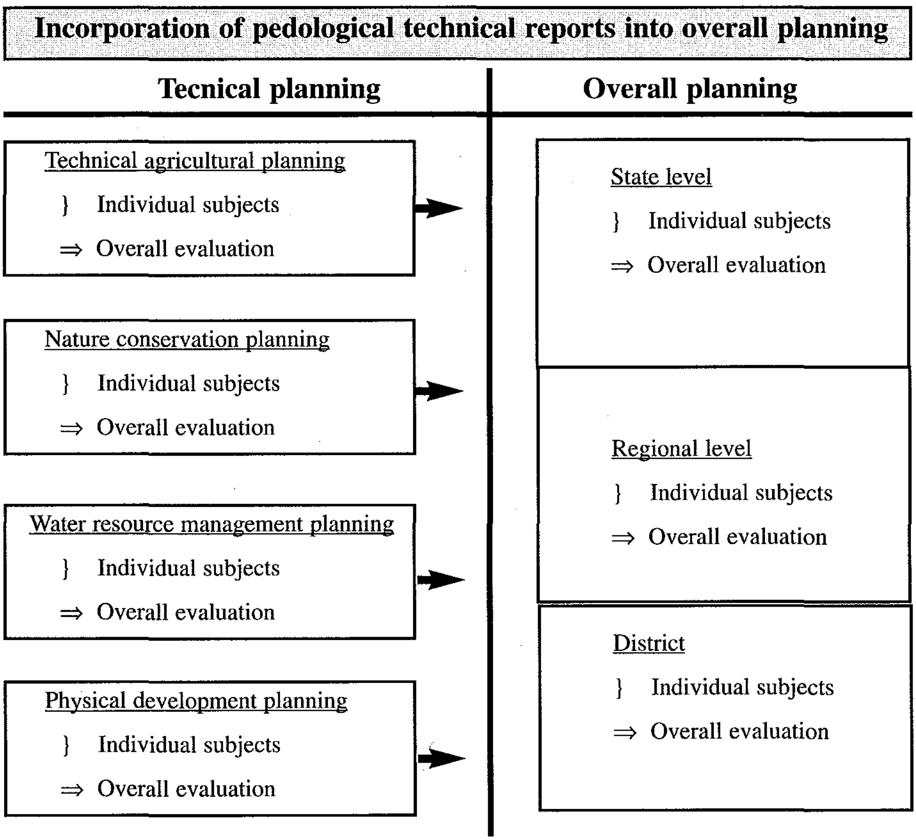
Table 4

Agricultural structure planning level and instruments

Land redistribution programme to determine:	**Agricultural structure development planning** to highlight:	**Land redistribution** implementing:
♦ Land redistribution objectives and priorities ♦ Statewide measures planning	♦ Zones of conflict ♦ Development possibilities ♦ Policy gaps	♦ Improvements in agricultural structure and promotion of general land use culture and land development
Upper planning level	**Intermediate planning level**	**Lower planning level**

Figure 2

Technical reports and overall planning



The LROP should play a part in improving the: “structural conditions for environmental reorientation...”. It “moves away from the predominant approach in previous programmes of site and areal protection... in favour of an environmentally compatible planning approach to protect the environment.” (NMI, 1994). In addition to overall planning, there are also special technical plans e.g. agricultural and technical planning, water resource management planning, and landscape planning (nature conservation planning) according to the Nature Conservation Law in Lower Saxony (NNatG). The results of technical planning (e.g. agricultural planning, landscape planning) then flow back into the original policy programmes and plans. The objectives of regional policy with respect to soil protection are to present soil functions and soil potentials to establish priority areas - and regulated (preventative principles) areas for various uses. In the case of the priority areas there is a compatibility rule (safeguarding aspect). In the case of the regulated areas there is a coordination rule. The objective of this designation is to reduce conflicts between competing user rights. The priority areas laid down for Lower Saxony are: areas for nature and landscape, grassland farming, drinking water extraction, natural resource extraction. Regulated areas are laid down for agriculture, forestry, nature and landscape, recreation, natural resource extraction, grassland farming and drinking water extraction. Soil information from which to derive soil functions and soil potentials are involved when taking into consideration soil protection during the elaboration of regional policy programmes at various planning levels. Some German states have guidelines here for the way this can be realised via technical planning (Sächsisches Landesamt Für Umwelt Und Geologie, 1994; Umweltministerium Baden-Württemberg, 1995; NMELF, 1991). In Lower Saxony, soil information is currently integrated in the technical planning at various planning levels for the selection of regulated areas for agriculture. A guideline agreed between the regional policy and nature conservation planners is currently being elaborated.

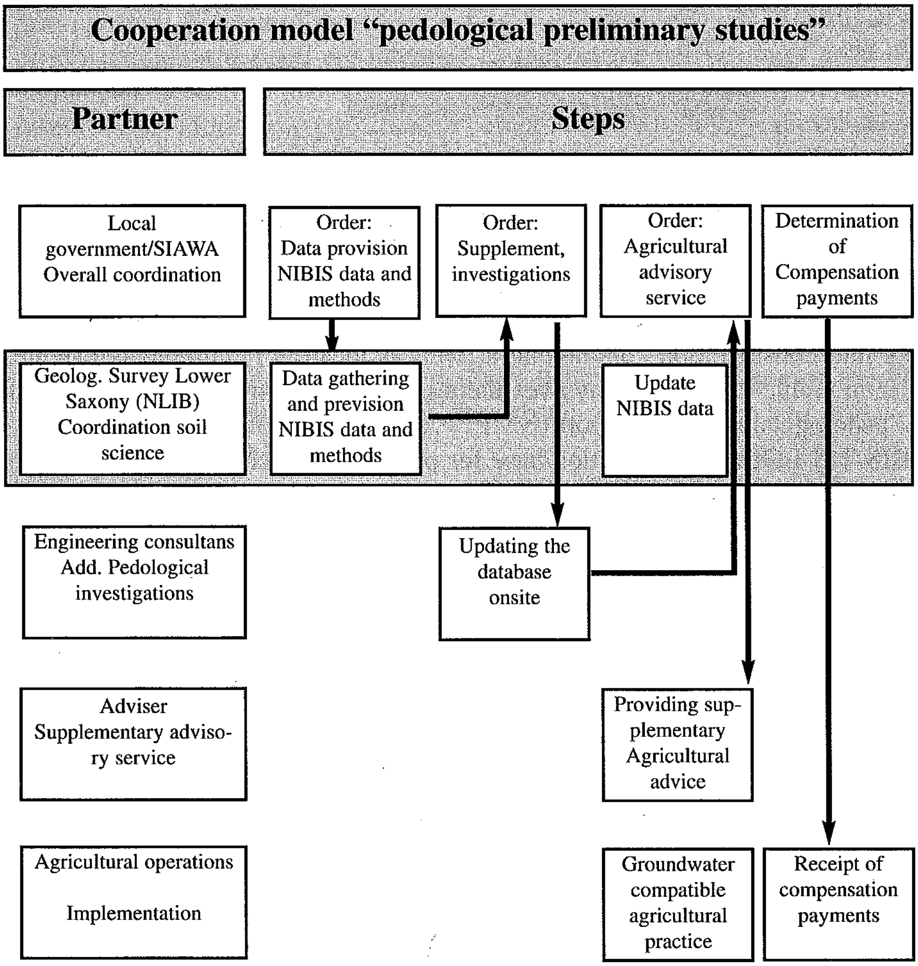
3.2 Drinking water protection

In Lower Saxony, approx. 87 % of the water for the public water supply is extracted from ground water. The priority areas and regulated areas for drinking water extraction occupy approx. 680,000 hectares primarily used for agriculture and forestry (NMI 1994). Increasing pollution of ground water is predicted because of more intensive land use and airborne pollution (Strebel, Duijnisveld and Böttcher, 1989). The Lower Saxony

Water Law was amended (Nds.GVBL Nr 24, 1992) and the protection provisions of the Protected Area Decree (SchuVo) were extended (Nds.GVBL Nr. 11, 1995) to provide the legal and economic framework for preventative (regulated) site-related ground water protection. One of the most important instruments here is the water extraction levy which finances site-related supplementary agricultural advisory services and compensation payments. Basic pedological information is made available here as part of a cooperation model (figure 3).

Figure 3

Cooperation model "pedological preliminary studies"



The Soil Survey of Lower Saxony (NLfB) makes soil data available and produces nitrate leaching risk maps as part of a pedological preliminary study on behalf of the State Bureau for Water and Waste (StAWA). These documents are supplemented by engineering consultants by remapping. The results, as well as some of the basic information, are also issued in digital form to the client and/or the engineering consultants for further processing and integration with other relevant data, e.g. cultivation records, etc. in GIS systems. Studies elaborated in this way can highlight sub-areas down to plot level within the catchment area with different needs for action. This allows the responsible water authorities and agricultural advisers to develop site-specific and cost-effective measures which can be implemented as part of the supplementary advisory service (Kues, Billerbeck and Stelzer, 1995).

3.3 Agricultural structure planning

Agricultural structure planning represents separate technical planning aspects within overall agricultural technical planning (table 4). In addition to agricultural structure planning, the agricultural expert reports are also an integral part of landscape planning and regional policy as well as for the provision of individual advice. Agricultural structure planning has to take into consideration commercial as well as location requirements (Thöne, 1996; Kohl, 1995). This involves the use of soil information in the form of a pedological technical report (NMELF, 1991). The potential use of the NIBIS TIS-BODEN information base for pedological technical reports as part of agricultural structural planning varies according to the policy objectives laid down in legislation and their integration into each planning level. Pedological technical reports are required at the intermediate level (agricultural structure development plans/AEP) for land redistribution measures, and particularly at the lower planning level (land redistribution procedures) (see table 5). This table also highlights the subjects dealt with and the evaluation methods and database required depending on the terms of reference. As a rural regional planning instrument, land redistribution must take into consideration the characteristics and special needs of the regional and local conservation and protection zones and develop differentiated regional development objectives incorporating this information (Thöne, 1996). The soil assessment data play an important role in this context. This data is gathered at a large scale (50 x 50 metre grid) as part of a standardised federal procedure for agricultural land. The most important element is a detailed soil profile description down to a depth of 1 metre and classification of the soil according to geological origin and local potential (around 60 % of this data is already available in digital form for Lower Saxony - table 1). The evaluation of soil as a resource worthy of protection was carried out using this soil assessment data as an evaluation basis using a land redistribution planning process as an example. The NIBIS TIS-BODEN data and methods stock can be used to derive the natural background (pedological properties and potential, material flows, etc.) required for resource-protection land use planning, and can be derived on the basis of thematic evaluations and presented in the form of planning maps. The results determined from the NIBIS TIS-BODEN methodology base (Müller, 1997) are used for the integrative evaluation of several thematic complexes by integrating methods using matrices to generate differentiated assessments (Erdmann, 1996). The spatial identification of priority areas in need of action reflecting the "sensitivity" and "worthiness of protection" of the soil are intended to support the derivation of areal requirements needed to maintain or restore the functional capacity of natural resources. The following priorities for comprehensive pedological evaluation are laid down as the target concept (the "agricultural priority areas" are then outlined underneath):

- Areas of special importance for soil protection

- Areas of special importance for ground water protection taking into consideration the filter and buffer properties of the soil

- Priority areas for agriculture taking into consideration the filter and buffer properties as well as the substance degradation and negative structural impact on the soil

- Determination of site-specific ecological potentials for the redesignation of agricultural land.

The determination of "agricultural priority areas" taking into consideration "site-specific restrictions on use" was carried out by the integrative evaluation of areas of high agricultural significance (middle to high arable yield) alongside areas of risk with high sensitivity. The target areas are defined as follows:

- Areas of very high significance for agriculture (without restrictions)

- Areas with a high significance for agriculture (without restrictions)

- Areas with high to very high significance for agriculture, but requiring regulatory measures for ground water and soil protection

Table 5

The need for basic pedological planning data for agricultural structure planning

Legal framework and planning instruments - agricultural structure planning	Planning levels, scales and databases	Thematic priorities for pedological evaluation	Examples for the provision of various evaluation methods (NIBIS TIS-BODEN)
Law covering the Joint Responsibility "Improvement of Agricultural Structure and Coastal Protection" (GAKG); FlurbG; ROG; UVPG; BNatSchG; NNatG; u.a. **Agricultural Structure Development Plan (AEP)**	Intermediate: 1:50,000 / 1:25,000 BÜK50 BK25 GK25	Material load Substance degradation and negative structural impact	Organic content, heavy metals, nitrate leaching Erosion, silting up, compaction
FlurbG; "Nature Conservation Guidelines"; NNatG; UVPG; u.a. **Land Redistribution Procedures (in particular, Plans according to § 41 FlurbG)**	Lower: 1:10,000 / 1:5,000 Soil assesssment (i.M. 1:5,000)	Site assessments Cultivation	Seepage water flow rate, potential yield, biotope develop. potential Irrigation, treatment

Regulatory (preventative) measures for ground water protection and soil protection are required for areas at risk. The identification of priority areas for agriculture does not restrict agricultural use to these areas alone, but rather highlights the high value of these areas for agricultural use and agricultural resource management. In those areas where agricultural land is to be utilised for planning measures, those agricultural areas worthy of special protection can be much more easily identified and taken into consideration during the planning procedure as a result of the more differentiated classification. A catalogue of soil protection demands to be taken into consideration during planning procedures involving agricultural structure planning in Lower Saxony is currently being elaborated in collaboration with the technical departments involved. Guidelines will then be established to demonstrate how the NIBIS TIS-BODEN soil data can be used and evaluated within the agricultural structure administration planning instruments.

4. Outlook

The time and expense involved in planning procedures can be considerably reduced by using the procedures agreed with the planning authorities and multiple use of the pedological data already available in the Lower Saxony Soil Information System (NIBIS TIS-BODEN). Because the planning maps can be issued in the form of map plots with superimposed grid topography, as well as digital data records for reprocessing in other GIS systems, it is possible to guarantee the integration of digital results into planning process procedures. The pedological technical reports do not represent finished plans of action, rather they are aids to planning decision making. NIBIS TIS-BODEN and its functionalities will be available in the medium term on the Internet, with simplified access to data and methods. The examples discussed above clearly demonstrate that a properly compiled information base containing all relevant pedological data and methods, as well as their interpretation, is vital for planning procedures which involve different technical departments. They provide complete areal coverage as part of preventative soil protection measures. The main deficits are in the evaluation of individual functions and potentials within an overall evaluation. Moreover, the pedological technical reports for each planning instrument are continuing to be firmed up (e.g. Sächsisches Landesamt Für Umwelt Und Geologie, 1994; Kues, Billerbeck and Stelzer, 1995). The most important aspect here is interdepartmental coordination of the contents and statements resulting from technical planning between the ministries and technical institutes involved, with the objective of implementing and integrating the needs of soil protection in a coordinated manner in all of the relevant technical plans and planning levels.

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THE BIS OF BADEN-WÜRTTEMBERG, A GENERAL VIEW ON ITS CONCEPT, STRUCTURE AND IMPLEMENTATION AT STATE LEVEL

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1. Introduction

The BIS (Bodeninformationssystem = soil information system) owes its emergence particularly to the initiative of Mr. Vinken (SAG, 1989), previously employed at the NLfB (geological survey of Lower Saxony) in Hannover. His plan was to develope an extensive soil information system for Germany (at that point without the new Federal States). The following resolutions were drawn up for the BIS:

• - May 31, 1989 resolution of the circle of Directors of the SGD (State Geological Surveys of Germany) and of the BLABO (Bund-Länderausschuß Bodenforschung: Geological Committee of the Federal Ministries);

• - 16./17. Nov. 1989 resolution of the Environmental Ministries Conference.

With regard to the BIS, the SGD extended the term "soil" as follows: In the broader sense of the term we refer to soil as all areas of the earth's surface and the underground, in which the human can intervene. In contrast, the term soil is used in a more narrow sense in correlation with Soil Science/Pedology. This is certainly not the most optimal selection of terms, however there is hardly anything that could be changed due to the resolutions and conversions taken place today.

The SGD regards the structure of BIS as a continuation of the official tasks with modern methods. This means that the BIS should penetrate fully in the activities of the SGD. At the same time, the BIS offers a chance for all institutions involved with the underground to administer their information. Even the existing flood of data cannot be overcome without information systems. It should also be possible, determined by the strived-for systemised storage of information, to deal with the new demands in a flexible manner in the future.

2. Organisation

The organisation to structure the BIS requires enormous efforts. Based on jurisdiction, the BIS in Baden-Württemberg is limited to the essential field of geo-scientific fundamental principles. Further fields such as anthropogenic influence with the technical information system and soil protection are processed by other administrations. Based on the great technical breadth, the field of geo-scientific fundamental principles of the BIS is subdivided into the following technical information systems (FIS):

- Soil Science (Pedology);
- Geology;- Hydrogeology
- Economic Geology;
- Geotechnics;
- Geochemistry;
- Geophysics.

The BIS-coordination workgroup and the FIS-workgroups were appointed nationwide by the BLABO. The FIS-workgroups are assigned to the BIS-workgroup, which I direct. In addition to this organisation, supported by the SGD, there is the workgroup LABO AK 2 (committee of the state soil protection, working group 2: soil information systems), appointed by the State Environmental Ministries). To avoid overlappings, I'm guest in the LABO AK2.

The internal organisation in the LGRB for Baden-Württemberg takes a similar course (Schweizer, 1995): A FIS-representative, who could also be a member of the nationwide FIS-workgroup, was called in for every technical information system. In addition, a BIS-coordinator, also a member of the nationwide BIS-workgroup, was called in. There are the following internal workgroups, developing concepts for BIS as well: the workgroup on geospatial database, the workgroup for the concept inter-disciplinary geo-scientific surveying, and the workgroup on the information system for local planning (IS-BLP).

3. Goals and Implementation

The following main goals are strived for with the structure of the soil information systems:

a) support of internal tasks of our Authority with the help of an information system;

b) inter-disciplinary coordination and employment of concepts;

c) use of concepts of other states; the costs of personal concept development can be saved;

d) processing of geo-scientific information for user-oriented products.

A) Which uses will be achieved with the mentioned goals?

The support of internal tasks of our authority with the help of an information system yields the following benefits:

- work in an economic manner

- data consistency

- stimulation of multi-purpose implementation of data and methods

- digital products

B) The inter-disciplinary coordination and employment of concepts yield, in particular, the following benefits:

- use of general data structures;

- use of general methods;

- reduction of the development phase;

- increased understanding for other fields of expertise and departments.

C) Making use of concepts of other states serves the following purposes:

- the conversion can be effected involving previously developed concepts;

- nationwide standardisation;

- exchange of applications (with similar system requirements).

D) Why should user-oriented products emerge from geo-scientific information?

- geo-scientific fundamental information is often not appropriate for immediate use in other fields of expertise;

- a processing of geo-scientific information allows for more extensive use;

- the expertise for the processing in problem-oriented products is most likely to be found in SGD.

Firstly, basic data documented in geo-scientific basic-maps is developed by means of classification and evaluation of other geo-scientific recording and measurement data (fig. 1). A gradual processing and evaluation towards the user often allows a determination of properties of soil, rocks, and groundwater. Evaluation maps 1st order are developed. Usually with the help of additional external data, potentials or functions can be defined as evaluation maps 2nd order. The latter accommodates the user to a much greater extent than the basic maps. In the scope of cooperation with users, yet higher aggregated evaluation maps can develop possessing the goal of efficiently solving the user's processing tasks. At the same time, the feedback from the user can produce an intensified conforming of the evaluation map to the needs of the user.

I have merely mentioned the most important advantages. These goals and uses must be considered throughout the development of BIS.

A subdivision in projects is necessary for the realisation. For their completion, these projects need priorities set by the directors, as the BIS possesses fundamental influence on the activities of the authority. In keeping the plan feasible, it makes sense to accompany each individual project with the help of modern methods of project management.

4. Components and Concepts

From a conceptual point of view, every technical information system of BIS should consists of the following components (fig. 2):

- database;
- methodbase;
- core system.

Figure 1: Data flow from the LGRB to the user

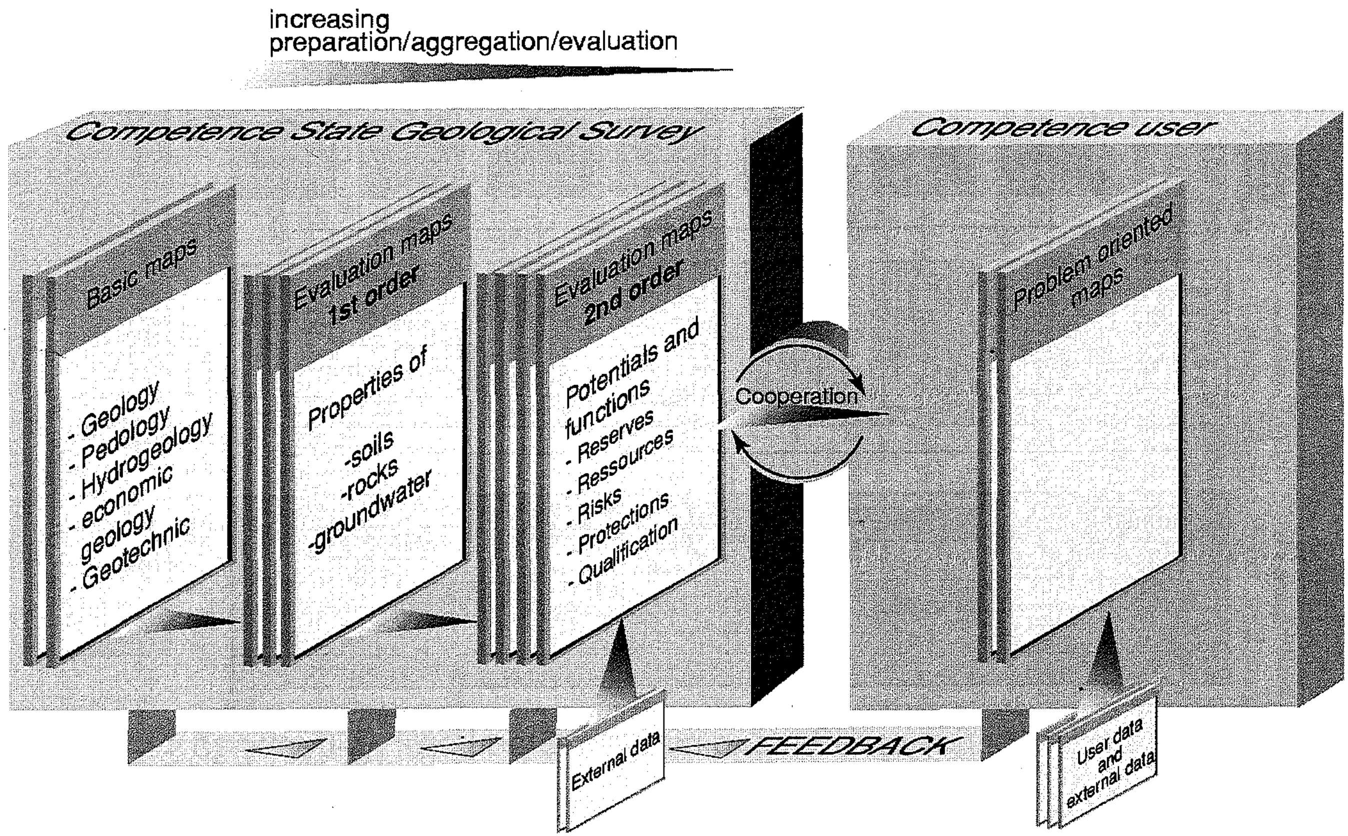
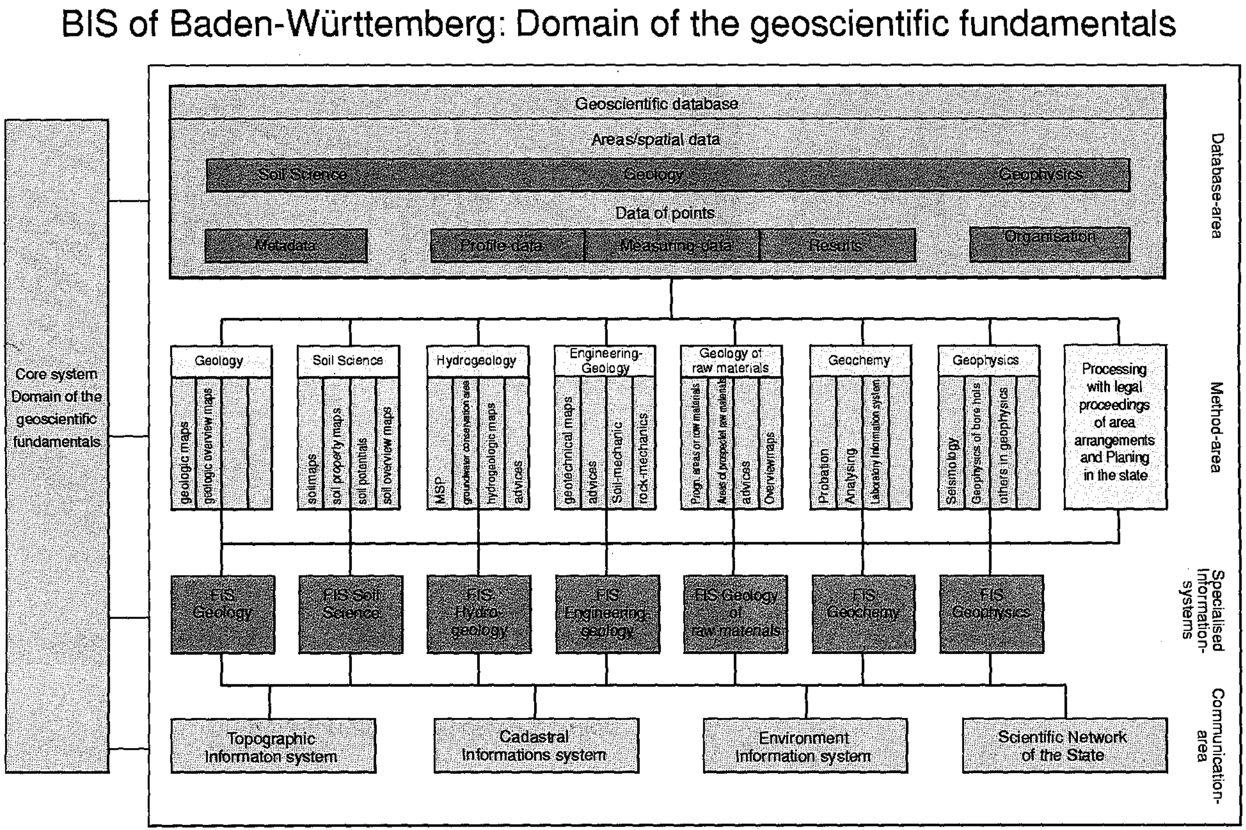


Figure 2: The BIS of Baden-Württemberg: Domain of the geoscientific fundamentals



The database should be implemented on a commercial RDBMS (Relational Data Base Management System). For the most applications ORACLE have been implemented. In the future, one will gradually save the data in object-oriented DBMS. First object-oriented possibilities were created with ORACLE Version 8. Usually, only the object attribute data is saved in the database. The geospatial data, in particular geometry, is often a component of the file system in the employed GIS. In the medium-term, the geospatial-data will be saved together with the factual data in one database. The NLfB has developed the method bank system MEMAS for the management and use of methods (see presentation of Mr. Heineke). - With the core system, an access system for the BIS is created, which should allow a quick access to the information in the BIS by means of technical or spatial meta-information.

At present, the LGRB has set up a series of databases with the accompanying applications in the field of factual data. The procedure of structuring occurs according to the following scheme:

- information analysis;
- rough concept;
- fine concept;
- data modelling;
- programming;
- test;
- production/use.

The information analysis was usually abbreviated and carried out together with the creation of the rough concept. The departments of the LGRB faced a great challenge with the creation of the rough and fine concepts described as an Entity-Relationship-Model (CHEN 1976). The main focus was centred on the specialists of the database management system during the steps data modelling and programming.

The following concepts for databases have been elaborated (Anwendung geowissenschaftlicher Informationssysteme, 1999):

- pedological database of points and areas (Fritz and Waldmann, 1998);
- database of drillings: the possibility offered itself to partly fall back on nationwide-elaborated concepts;

• database of laboratory data, measurement data and results: this data model was developed with the participation on all technical departments;

• database of geospatial data: a rough concept has been developed which has partly been transferred into a fine concept;

• database of raw material companies: The development of this concept emerged for the most part from the LGRB. It was incorporated in the nationwide FIS Economic Geology;

• information system for local planning (IS-BLP) (fig. 3).

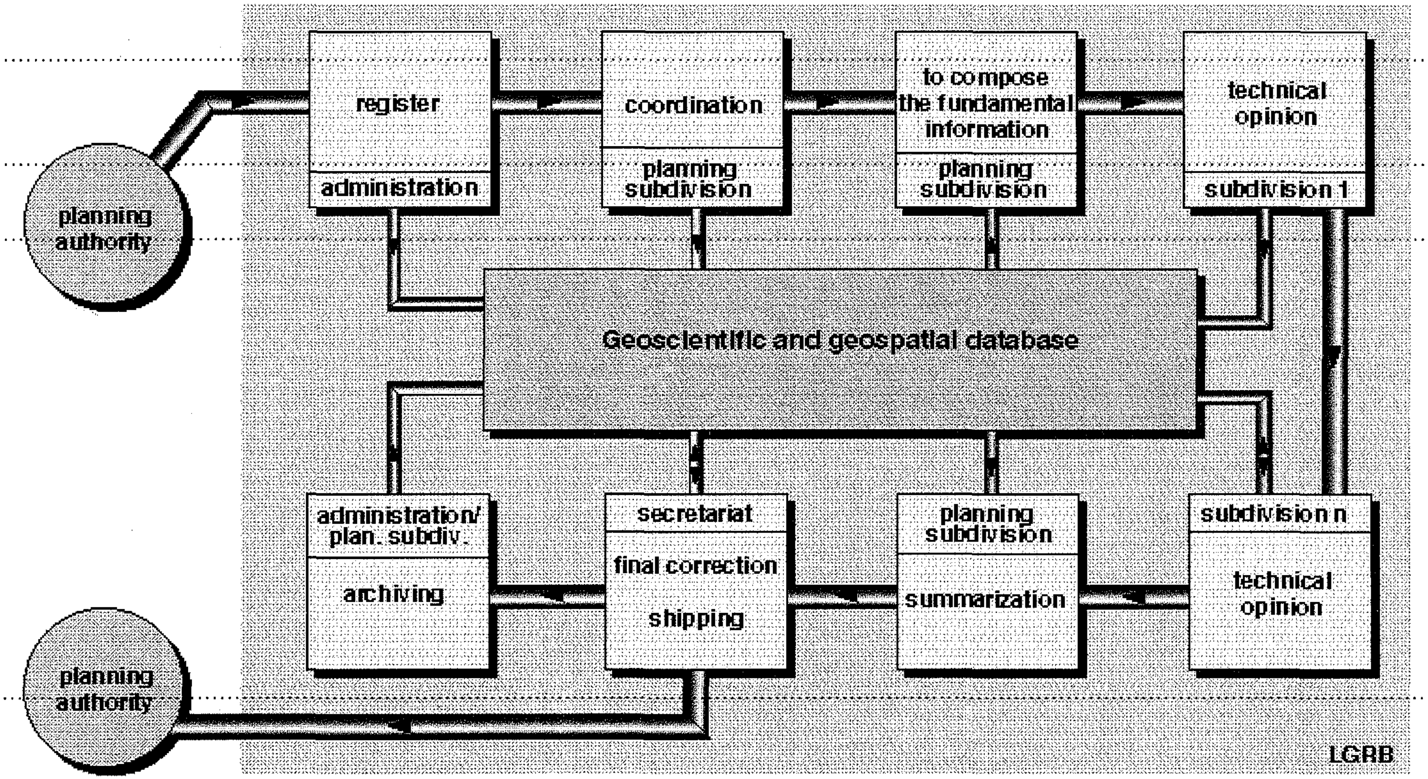
The following is a short commentary on some of the database concepts.

The rough concept of geo-spatial data was elaborated primarily to offer an oversight of the connection between data sources, geo-data, cartographic data and the map. The connection with the conventional map is certainly necessary middle-term, to facilitate special presentations of geo-data.

Using the example of the data-model of laboratory data, measurement data and results, inter-disciplinary working methods are to be briefly explained. The goal was firstly to generalise the complex structure probe, partial probe, several types of analysis, that the system can react flexibly to various demands on the volume of probes and analyses. These demands are overlapped by the various references in the analysis of water, soil and rock. Water probes are primarily taken from very different points, whereas rock probes often occur at one point, however at different depths. A central element for the measurement data is a table containing solely a few columns possessing a variable definition. Regarding its volume, it will certainly contain many data segments making necessary optimal access mechanisms such as those supplied by ORACLE.

The processing of expertise statements for the local planning (IS-BLP) should be effected with the support of a special information system (fig. 3) within the information system of planning as a component of the BIS of Baden-Württemberg. In addition to administrative data, the available geoscientific data is required in digital form for its creation. This absolutely demands extensive stands in the central facilities of the ORACLE-database and the DKA (see 5). A further problem is posed by the processing by means of almost all departments. To ensure that the work is done in a sure manner, honouring all stipulated deadlines, the employment of a workflow system, coupled with database and DKA, is a necessity. For the first time, this system will make experience in integrally supporting entire work processes possible. We plan to program this system in 1999.

Figure 3: Structure of the workflow for the information system of local planning



5. Infrastructure

The structure of information systems demands various components on different levels; these components, in their entirety form the information system.

Level 1 (Base structure)

Servers:

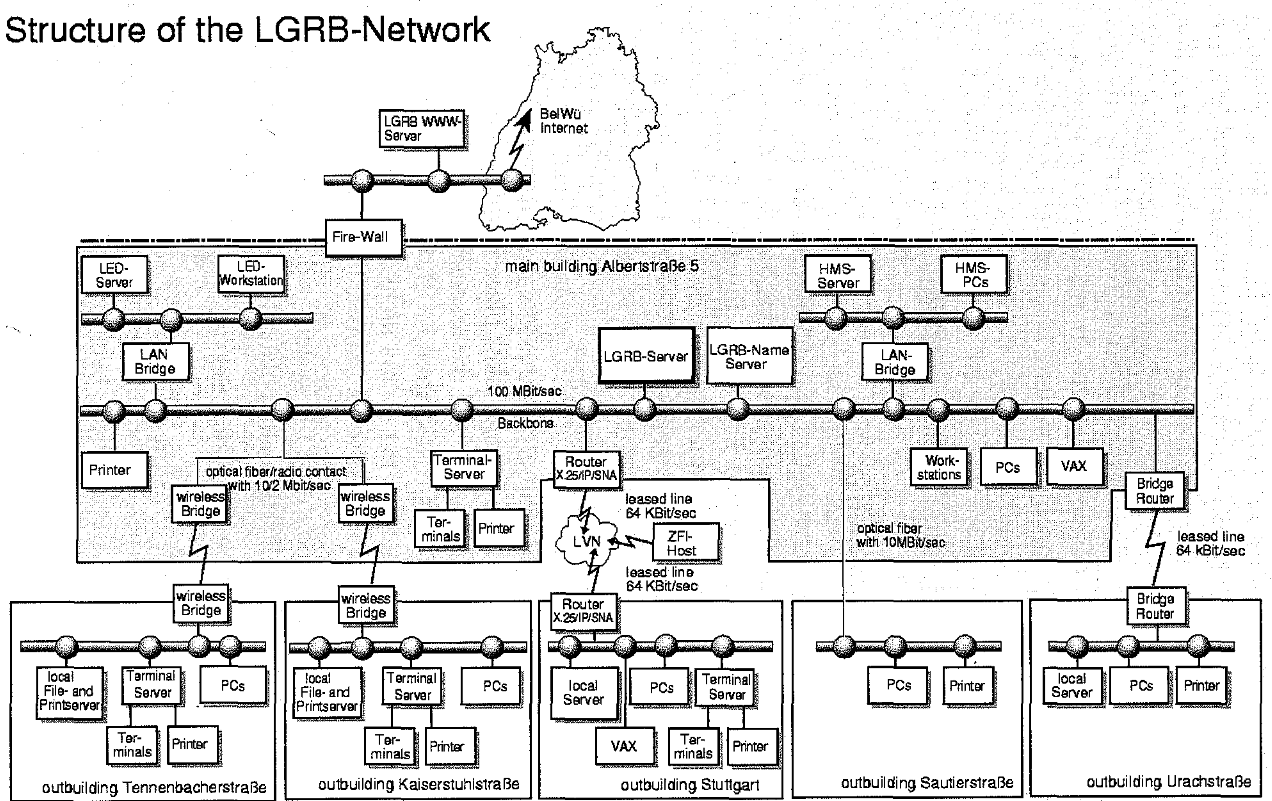
The servers make up the central components for the storage of data and networking. At the LGRB we employ, as a central database-server a multi-processing computer model SGI Challenge L with 512 MB main memory and approx. 50 GB disk-storage. This machine has 2 processors and can be extended to 16. It is running on the operating system IRIX (SGI-Unix). Either the central server or, as is the case in the branch offices, Linux-Server on the basis of the Intel-Architecture (Pentium) are implemented for the central storage of home directories of the users.

Network:

The central part as the backbone of the LGRB-LAN (local area networks) form an FDDI-Ring with 100 Mbit/s speed (fig. 4). The database server (SGI) and two concentrators have been connected to this ring in the first elaboration phase to date. Both concentrators supply the end users and the periphery via Twisted-Pair (10BaseT) or Thin-Wire-Ethernet. Due to the mechanical problems, we plan to greatly reduce the Thin-Wire-Ethernet. An SGI -Workstation with the IRIX-operating system will be implemented as a name server for network operation. Until now, the realization of powerful network connections to the four branch offices in Freiburg and in one branch office in Stuttgart has been very costly.

The Freiburg offices, we have connected one with fiber optic (10 Mbit/s), two via radio connection (2 Mbit/s) and the new additional building with a leased line from the German Telekom (64kbit/s). The building in Stuttgart is connected by the closed network of the Baden-Württemberg state authorities (Landesverwaltungsnetz = LVN) (64kbit/s). In addition, the entire LGRB-LAN is connected (10 MBit/s) with the University of Freiburg via a fiber optic and, thus, with the Internet.

Figure 4: Structure of the LGRB-Network



Clients:

For the most part, the end users work with Pentium-PCs using the operating system Windows95. These PCs are all connected with the LGRB-LAN with OnNet32 (product of FTP Software). All PCs have access to Intranet and Internet. In the field of cartography and the creation of geospatial data, we use SGI-workstations due to the necessarily powerful graphics capacity. Due to limited-availability software, Sun Solaris workstations are employed in the seismological area. In the future we tend more to computers with the Linux operating system, because they are more robust.

Level 2: (services on the servers)

Database system

The database system ORACLE forms the basis for the storage of most data. It is installed on the central database server of the LGRB. The database requests are divided into single threads for the runtime, so that parallel processing is possible on the server by means of the processors. Both of the products ORACLE-Designer and ORACLE-Developer are implemented for development of applications on PC-systems.

DKA Digital Map Archive

The digital map archive serves the purpose of the storage of LGRB geospatial data. The storage takes place in a file system on the database server. The type of storage and the associated structure is very closely oriented to the Product ARC/INFO from ESRI. For every type of geospatial data, a data model is created: the central archiving of the data occurs according to the properties specified in the model.

The currently used file system is designed to be superseded by the product SDE from ESRI, making data storage possible under ORACLE.

LGRB Internal WEB Server

The LGRB internal WEB Server is the basis for the provision of information with the help of the Internet technology. In this technique, some database retrievals have already been offered from the database ORACLE.

LGRB-External WEB Server

The LGRB-External WEB Server is available since the 1st of february of 1999 (URL http://www.lgrb.uni-freiburg.de).

E-Mail Server:

The internal LGRB-Mail server provides for the E-Mail communication within the LGRB. The mails are forwarded on the external mail server for those partners from the Internet.

Level 3: (Services on the Clients)

WEB-Browser

The WEB-Browser Netscape Communicator Version 4 implemented in the LGRB-Clients forms the basis for the info service as a part of the LGRB-Intranet and the use of the Internet. Within the State Administration, single Intranets between the authorities via the closed network of the Baden-Württemberg state authorities (LVN) are being set up, to which there will be access as well. The great advantage of this technology is the independence of the implemented operating system, thus allowing workstation users and slower PCs to benefit in a similar manner.

Database application

The single database applications still function at present with the help of ORACLE Forms 4.5 under Windows95. However, this should gradually be converted to Internet technology, allowing others aside from the Windows95 users, such as those working under Linux, IRIX or Solaris, to use the programs as well in a similar fashion.

GIS Projects

The product ArcView (currently version 3) from ESRI is implemented to a great extent for the use of the geospatial data stored in the DKA. With a consistent manner of work with ArcView and to promote an increase of comfort, ArcView projects were developed with the help of Avenue-Scripts. These are greatly appreciated by the geo-scientists, as they simplify the use and processing of geospatial data to a large extent.

Office Software

For a long time now, the LGRB has implemented Corel Office as an Office package. A changeover to MS-Office has not been necessary today, as the file formats of MS-Word and MS-Excel can be read and written. With the help of Corel WordPerfect it is possible as well to directly retrieve data from the ORACLE-database and process it further for presentations. A changeover to an Office package which works with Internet technology is desirable.

Special Software

The geo-information system (GIS) ARC/INFO is implemented on SGI-workstations in particular for the creation of geospatial data and in the cartographic preparation. The products Adobe-Illustrator and Aldus-Freehand serve the purpose of desktop-mappings and post-processing. There are also a number of further evaluating programs in the geo-scientific field which I will not extensively elaborated on.

One of these is the system for numerical groundwater models, which carry a very great significance. To present, the product FEFLOW from Wasy in Berlin has been put into use as a user-friendly procedure for the FE-Technik (Finite Elements). In addition, there are further programmes which transfer geospatial data from ARC/INFO to FEFLOW. In the same way, it is possible to present results from FEFLOW with the help of ARC/INFO.

6. Application Examples

Due to the extensive volume, just single examples from the various areas of expertise can be depicted here. A detailed report of the most concepts and applications is planned (Anwendung geowissenschaftlicher Informationssysteme, 1999).

6.1 LGRB-Info service

The LGRB-Infoservice as the Intranet-Service possesses a primarily hierarchical structure. Due to the possibilities offered by html, regulated information becomes increasingly linked. In addition to administrative data, the results from workgroups can be presented immediately following a meeting.

The departments have the possibility of quickly presenting information about their work. There is a great link to other information systems such as libraries, telecommunication, traffic systems and the WEB sites of other geological services.

6.2 Database Applications

Example 1: Database of laboratory and measurement data and results

This database is being gradually tested within the development (prototyping) and has already partially been put into operation. To date, the recording of water samplings and water analyses has been made reality (fig. 5). Applications required for the other types of samplings are adopted by copy and altered slightly, thus producing a number of database applications whose development costs, however, are greatly reduced by means of a common data maintenance concept. In this way, we hope to make a great number of applications available to the users in a much more expedient fashion.

Example 2: Database of raw material companies:

The concept was first tested under MS Access. A transference to the ORACLE-Designer was possible with the help of CASE-Tools. The currently employed application runs under ORACLE-Forms 4.5 on PCs with Windows95. The data maintenance takes place centrally in the database server.

The application serves the purpose of data storage of raw material businesses and the exploitation of surface mineral raw materials. Due to the progressive exploitation of raw materials and new plannings, the data must be constantly carried on. In addition, aged survey stands must be archived to promote a time-dependent evaluation. Further evaluations are carried out with the help of reports and immediate database research.

6.3 GIS Projects

The GIS ArcView is implemented as GIS projects for geoscientific maps for landscape planning, pedological and geological maps, hydrogeological maps and for the disclosure-system for economic geology. Figure 6 shows a screen shot of the ArcView application for geology and soil science.

The geological map and beneath it the soil map are visible in the upper and lower half of the left-hand window. The associated factual data are presented in the tables on the right-hand side. There is an interactive coupling between the factual data segment and the polygons on the map.

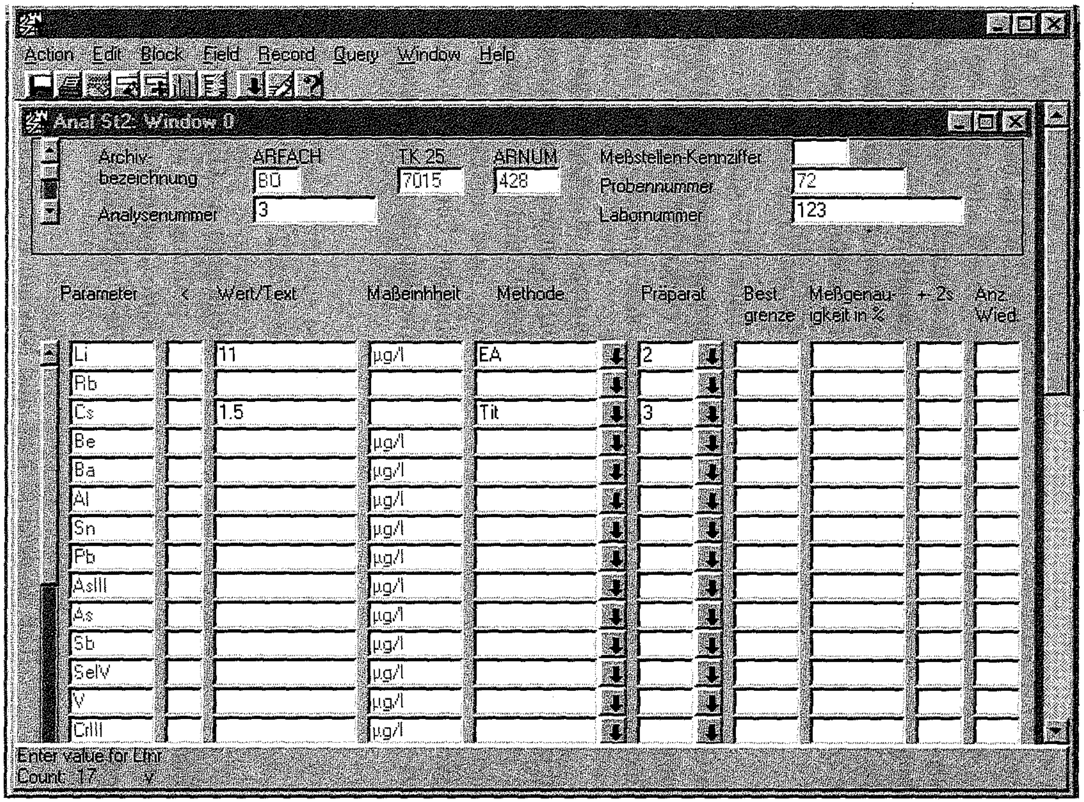
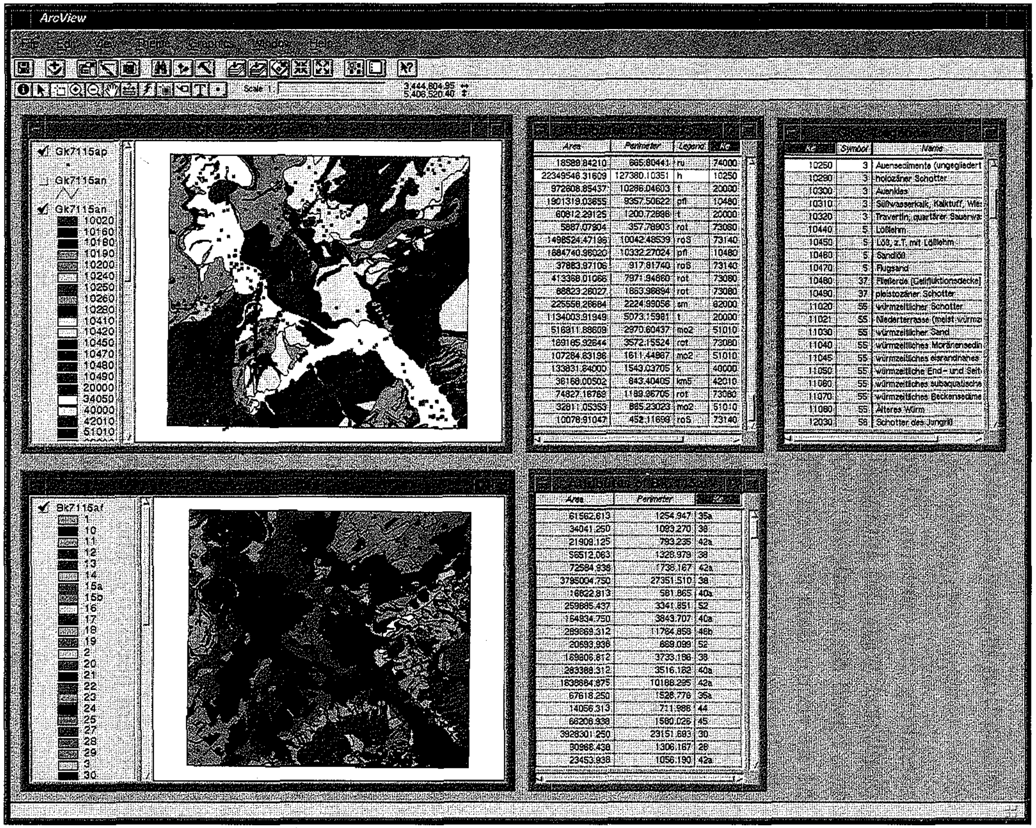


Figure 5: Example of the form for the data input of laboratory data

Figure 6: Example of an ArcView-Project for geologic and soil maps



6.4 Products

The existing geospatial data at the LGRB are available for sale for a fee. Unfortunately we have no experience in the marketing of geospatial data. As, based on an inquiry, the creation of an individual data segment brings about certain costs, a CD-ROM was produced above all for commercial promotion of geospatial data.

The CD-ROM Geo-scientific overview maps of Baden-Württemberg and contains 20 geo-scientific maps as raster files, which can be displayed with the included Netscape-Browser with factual data. The themes based on a scale of 1:300,000 are available accordingly on the CD-ROM as vector data as well. They are stored in the shape-File format and can be further processed together with the factual data with the included ArcExplorer of the ESRI enterprise. The associated meta data is oriented to the european norm prEN1267. For the purpose of reaching an extensive user circle, the price was set at a low DM 49 - (approx. 25 EURO).

7. Perspectives

The existing expansion of the BIS of Baden-Württemberg is just at intermediate state. In view of increasing user demands, the changing tasks and the transformation in information technology, it has become absolutely necessary to continuously further develope the systems, in the process of which the uniform basic concept and the commercial approach are of great importance. The setting-up of methodbases, the expansion of geo-spatial data-processing to the third dimension (Schwezer, 1996), and intergrated data maintenance of factual and geo-spatial data in one system are additional particularly challenging tasks. Moreover, a constantly tightening connection of the systems with the administrative component, up to Workflow systems will be of urgent necessity. The LGRB will certainly make the greatest of efforts to gradually turnover future demands on the BIS.

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Soil survey in a Land of the former GDR: the case of Brandenburg

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1. The tasks of the Geological Surveys in the New Federal States of Germany after reunification

In the first time after the German reunification the main task of the Federal Institute for Geosciences and Natural Ressources (BGR) was to safe soil data collected from different soil science institutes of the German Democratic Republic (G.D.R.). In the New Federal States institutes of geological surveys had been established at different times. The last of these foundations was the Institute for Geosciences and Natural Resources of Brandenburg on 4/9/92. The working group of soil science exists since 1/1/95.

The new institutes of geological surveys received the data which had been safed by the BGR. But the new surveys also were endeavoured to safe other data which mainly had been collected locally. Today these data are in hand of several local offices and firms. For all the New Federal States most of the older soil mapping data are uniform. The following mappings are mainly used for tasks of the new geological surveys especially today:

Medium scaled mapping of agricultural sites (Mittelmaßstäbige Landwirtschaftliche Standortkarierung [MMK] - covers the whole agricultural area of the former G.D.R.);

⇒ Forest site mapping (Forstliche Standortskartierung [FSK] - covers the whole forest area of the former G.D.R.);

⇒ Landscape mapping (Naturraumtypenkarte [NTK] - covers the whole area of the former G.D.R.);

⇒ State soil taxation (Bodenschätzung [RBS] - covers nearly the whole agricultural area of Germany);

⇒ Geological mappings (all of them cover the whole area at different scales and with different contents of the maps, e. g. hydrogeology, quaternary geology);

⇒ historical mappings (mainly topographical mappings; all of them cover the whole area);

⇒ special mappings, e. g. peat mapping, mapping for land improvement or reclamation (single local maps), local mapping with new investigations served to modify state soil taxation in standard of TGL 24300;

⇒ soil maps mostly in atlases and other maps with similar contents at smaller scales.

In the following the bases of some older mappings are presented in details.

2. Mapping bases - data and maps

2.1 State soil taxation with the purpose to tax farmland

The state soil taxation of farm land was realized for a more just tax-valuation of agricultural land. The materials of the soil taxation are existing nearly for the whole area of the Federal Republic of Germany. The mapping had taken place since 1934 and was carried out by drilling with sticks to 1 meter depth in a grid of 50m to 50m. So called homogeneous classified areas were delimited and designated with a symbol. These symbols include a valuation from 7 to 100. Today these numbers are the basis for the taxation of farmers land by state. In each area classified as homogeneous a typical soil profile to a depth of 1 meter was exactly examined and described. The symbol of a classified area explains for instance the average texture to a depth of 1 meter, the most important attribute. The locations of the typical soil profiles are marked in maps with scales of approximately 1:2,000. All boundaries and symbols of the classified areas were marked in topographical maps at scale 1:10,000 for the farming land of the G.D.R.. Only in Brandenburg approximately 90 % of this documents were transferred to topographical maps at scale 1:25,000. In these maps the classified areas had been coloured. The colours are determined by the medium texture which is explained by the symbol of classified areas. The mapping sheets at both scales are an essential basis for the development of new maps.

2.2 Geological mappings

Even older than the State Soil Taxation of farmland are some geological mappings or geologic-agricultural mappings. Often they are of the last century. 90% of the sheets at scale 1:25,000 are existing for the Brandenburg. Most of them contain drilling descriptions with stratum sequence and thicknesses. Other and new mappings are existing in smaller scales, but they don't cover the whole territory. Most of the territory of Mecklenburg-Vorpommern is mapped at scale 1:100,000 only.

Newer edits are the lithofacies maps for quaternary sediments at scale 1:50,000 (Lithofazieskarte Quartär). Some new geological sheets are mapped since the reunification at scale 1:25,000. They complete the so called "white" areas of the territory. Now all geological surveys are working on nation-wide geological maps at scale 1:200,000. All these maps are very useful for the soil mapping in Germany at the same scale. The maps at scale 1:25,000 are an essential basis for estimating the conditions and sequences of substratum especially at the depth between 1 and 2 meters below surface. This layer was not investigated by the State Soil Taxation. The geological information are completed by data from hydrogeological mappings at scales 1:50,000 and 1:200,000.

2.3 Medium scaled mapping of agricultural sites (short called MMK)

This mapping only exists for the agricultural soils of the New Federal States of Germany. Farmland covers less than 60% of the whole area of the former G.D.R.. The result of this mapping were overview maps at scale 1:100,000. The efforts for the field work were very different and depended on the knowledge of the surveyor and on mapping areas complexity. The mapping included approximately 6,000 typical soil profiles described by the standard of TGL 24300. Most of these data are digitally saved. The objectives of the field works were to evaluate the State Soil Taxation of farmland (see 2.1). Furthermore they were used for the évaluation of the information derived from geological mappings, most at scale 1:25,000. All digital data of this mapping are part of the geographical information system in each New Federal State.

The method of the MMK was based on a medium scale. This map was the first one of its kind because the general legend units (so called regional site types) has defined typical associations of dominant and subdominant soil forms (soil bodies). This mapping describes most of the mapping units as heterogeneous. A soil form is a combination of units of soil classification and substratum classification system (defined in the standard TGL 24300/07 and /08). The last mentioned units are defined by typical vertical substratum sequences. In the case of this standard the main feature is the soil texture.

The abstracted characterisation was directed to agricultural use and not on to a single field. The mapping was much more a planning tool applied to large farms being typical for the G.D.R. and their superior authorities. The aim of the agricultural production in the G.D.R. was self sufficiency but also the export.

2.4 Forest Site Mapping 1:10,000

Forest mapping of the G.D.R. was aimed at forest use and its planning. Therefore, the field observation by drilling was carried out on distances of approximately 100 m to 300 m between each bore hole (without regular sampling) and down to a depth of 3 m. A single map doesn't follow topographical map sheets but it shows the occurrence of forest on the territory of a former forest firm. The mapping units mostly include data of one local soil form. Partly some units of heterogeneous locations (units with changes of sites) connect 2 and more rarely 3 local soil forms. Simply a local soil form is a combination of a soil form according to MMK (see 2.3) with a regional name, usually the name of a settlement nearby. These names were used to classify differences within one soil form (for instance sandy Cambisols). There are some important differences between this forest site mapping and the medium scaled agricultural mapping. The symbols are not conformable to standard of TGL 24300.

The forest site mapping covering the whole forested area was completed after the reunification. The maps are not digitally available. But, they are an essential basis of soil mapping at medium scale. Because of its different nomenclature and its island character (maps of forest firm areas) the interpretation of forest site maps of the former G.D.R. is rather expensive. 35 separated forest site maps were the base for the first soil map at scale 1: 50,000 in Brandenburg. We received our information for that map only for the forest area.

2.5 Landscape Mapping 1:100,000

This mapping exists for the whole area of the former G.D.R. It is derived from experiences of the forest site mapping, the MMK-mapping and also the different geological mappings. The single maps were not printed. Numbers in each map unit code some characteristics of the so called mosaics, characterizing texture, hydrological conditions and relief. These information can be used as basis for soil mapping at scale 1:200,000. The strongly abstracted data didn't deliver additional information to the MMK but for the forested land this mapping is useful.

2.6 Special mappings and abandoned mappings

The above mentioned mappings were mostly realised before the German reunification. But the quality of information received from these maps were very different because they treated different aims which mostly depended on scale and land use. In most cases the relatively small scales didn't fulfill the requirements of users. Many peat soils were degraded in the last decades for instance by intensive drainage. Therefore, the peat soils were mapped again at larger scales by drilling on a narrow grid. A main result was the exact registration of the peat soils thickness. Agricultural amelioration mappings were the bases for the planning of improving measurements (e.g. drainage or irrigation). Site mappings also exist for former agricultural companies. Soil-geological mappings of the G.D.R. started at scales 1:100,000 and 1:25,000 and had been stopped by the government in the end of the sixties. Only some sheets were printed and are available. A map of substratum at scale 1:100,000 was compiled after the second world war for territory of the Federal State of Thuringia.

The special maps and other single sheets are used to prepare the new basic mappings in each New Federal State.

3. New mappings in the New Federal States

3.1 State-wide overview maps

On the basis of the mappings mentioned above and on the experiences collected in earlier times by mapping (mostly special mappings such as redeposited soil in dumps, peatland or areas of agricultural firms) were elaborated state-wide soil maps at scales 1:300,000 up to 1:500,000.

They represent a first attempt to create area covering maps in the New Federal States. Partly the former nomenclatures had been used. The map of Brandenburg will be the last one in this sequence and it will be completed within 1999. The map will be elaborated as the first state-wide overview map of a New Federal State according to the nomenclatures of the German Soil Mapping Guide, 4th edition (further short called KA 4). The legend and delineations will be based mainly on the guidelines of the overview map at scale 1:200,000. The mentioned guideline includes also a new system of soil classification and of substratum classification units. The last called system mainly bases on experiences of agricultural and forest site mapping in the G.D.R.. It shows typical vertical substratum sequences which describe feature combinations mainly of geogenesis, texture, parent material, calcium carbonate content.

3.2 Nation-wide soil overview mapping 1:200,000

All Federal States elaborate this soil overview map of the Federal Republic of Germany in co-operation with the BGR. The basis of the map for the New Federal States are the above mentioned documents which will be included in the manuscripts by different methods. Mostly the delineations of the existing maps at scale 1:100,000 will be adapted for the scale 1:200,000.

In the case of Brandenburg the bases are prepared at scale 1:25,000. The contents and the delinations are marked according to the guideline (KA 4). Therefore, a translation of the legend units of the mentioned medium scaled agricultural site mapping or landscape mapping is omitted. The contours will be stronger orientated on the new contents according to the guideline (KA 4), such as boundaries of geogenesis or parent material units. These contents played a lower role in the old mappings because of their orientation on land use. Nevertheless the former mappings at scale 1:100,000 are used to determinate the contents of mapping units in order to estimate the spectrum of existing soil forms. The methods to delineate the boundaries of mapping units, to describe contents of these units and to define mapping units of a legend are similar to the ones for the scale 1:50,000 in Branden-burg (see 3.3).

3.3 Basic mappings of New Federal States

In the New Federal States the basic soil mappings started at scale 1:50,000. Only in Mecklenburg-Vorpommern the scale 1:25,000 is used. According to the personal capacity in the soil science groups most surveys decided to use the scale 1:50,000. The first map sheets are printed and further sheets are in print or in elaboration.

The bases for mapping are named under 2.1 - 2.6. Extensive field works are necessary to evaluate and complete the information of the bases according to the requirements of the guideline (KA 4). Furthermore it serves for the correction and sometimes to draw boundaries in field. Look at the method description below.

3.3.1 The Soil-geological Mapping of the State of Brandenburg 1:50,000

This mapping is also digitally stored. The manuscript sheets are developed by the analogous combination of basic information and new experiences in field works. The documents mentioned above except the MMK are not digitally stored. The skilfulness of the new institutes is not enough to digitize the bases at present. The digital contours of the MMK 1:100,000 are unsuitable because of their inaccuracy. The contours are delineated analogous at scale 1:25,000 after combining the different information. The essential rules to define boundaries are:

1) the possibility to present areas at a given scale (approximately 25 hectares, line distances approximately 2 millimetres);

2) areas of different soils are demarcated according to the recurrent distribution pattern and of the relationship between their area proportions;

3) important specifics can be depicted larger, however the marking must consider the included soils.

The single delineation area is designated mapping unit. Each mapping unit is described individually. Field works will be realised to derive and register the contents according to the guideline (KA 4). Criteria for location of soil profiles are:

1) representative position in a mapping units or of a special soil form;

2) determination of typical soil sequences (Catena);

3) clear up contradictions which were determined by former bases;

4) representative spatial position in a larger area, e. g. to have enough measurement values.

Soil profile descriptions are prepared also to evaluate former mappings. Former profile information up to a depth of 2 m are transferred in the new nomenclature. Description translations are differentiated according to the actual guideline. The systematic classification of soil forms is in agreement with the actual system of soils and typical substratum sequences. Description level of soil forms (soil bodies) should be as low as possible. The soil form characterization existed also according to the standard TGL 24300/07 and /08 in the G.D.R..

The following example shows the translation possibilities between both nomenclatures on the respective type level:

nomenclature:	TGL 24 300	Ka 4
standard/guideline symbol:	sbB	BB : p-s(Sp)/f-s(sdr)
standard/guideline description:	Bändersand-Braunerde	Braunerde aus Sand (aus Geschiebedecksand) über Fluvisand (aus Sandersand)
interpretation:	Cambisol with banded sand by clay eluviation	Cambisol consisting of periglacial sand overlyin melt-water sand.

This classification level can be differentiated on a lower level according to the guideline (KA 4):

guideline symbol:	lBB : pky-ss(Sp)/pky-ss//fg-ss(sdr)
guideline description:	lessivierte Braunerde aus Kryoturbatreinsand (aus Geschiebedecksand) über Kryoturbatreinsand über tiefem Schmelzwasserreinsand (aus Sandersand).
interpretation:	Cambisol with low level clay eluviation consisting of cryogenic sand (with eolian components and partly with glacial drifts) lying over cryogenic sand consisting of melt-water sand overlying deep melt-water sand.

This classification level is used often to classify soil profiles in field works. Only the symbols are saved digitally.

The soil science of geological survey in Brandenburg decided to describe mapping units and units of this legend in the lower level for soil forms (see above). This idealized soil forms of mapping units are saved individually in a so called digital database for soil forms which are used to describe areas. The databases include soil form symbols and the typical horizon data. Last will be needed on nation-wide standardized evaluation methods.

In opposite to the other Federal States the soil survey of Brandenburg creates different soil maps in a new way. With the description of each mapping unit (individual area) are saved all area soil forms with their estimated proportion and distribution pattern. The mentioned soil forms are linked with the databases of area soil forms which consists of idealized soil profile data. All individual data of mapping units are related to units of a general legend at first and further to map legend. The general legend level can be understood as a large extent objective summary according to expert knowledge. The general legend units are defined after a classification in 5 steps with special keys. These units are more detailed as the map legend units. The following classification steps are realized to get general legend units:

1) sort to a main geogenesis group;

2) sort to an area type of dominant textures (includes associations with vertical texture sequences);

3) sort to an area type of dominant soils (includes associations);

4) sort to further subordinate pedological attributes (e. g. of a lower soil typological unit level or a lower proportion of the area);

5) sort to special attributes which are essential and not mentioned by steps above (e. g. gravel content).

The classification key system is easy expandable in opposite to traditional methods.

Usually experts define a general legend in advance. General legend units are defined by experiences. After this step the demarcated areas are assigned to these units. Problems with the comparison are a result of this. Demands to create new general legend units are raised and retroactive changes are difficult. The general legend units of this traditional method are more common. That's the reason why most of these units are differentiated in a specific printed map legend. An example for this method is the MMK.

The example for the new method is the sheet Potsdam with different natural conditions (e. g. areas of ground moraine, melt-water sand, valleys, peatland, dunes, devastation or expanded settlement). It shows the aggregation stage of separate mapping units up to a map legend: about 1700 mapping units are aggregated to about 400 defined general legend units, and these to 56 map legend units.

The descriptions of general legend units are stored in an area database for external users. They should be used for the standardized evaluation methods. The soil forms of general legend units are also linked with the area soil forms archives. With the use of general legend units a anticipated comparable aggregation and evaluation is connected.

In order to print a map are to be kept editorial premises. Not all general legend units can be marked with individual colours and different rasters. On the map border can be placed only a limited number of legend units. Each map uses specific similarities to aggregate general legend units. Thereby also are to consider the proportions of soil forms on the map area. The colours and rasters are assigned by approximately equal criteria for each single map sheets. Thereby the colour assignation is according to the colour prefixed for dominant soil typological units by guideline (KA 4). The rasters are used to symbolize dominant textures, texture associations and their vertical sequences. A clear map lay-out is based on the close correlation of soil units and substratum sequences. It is not necessary to manipulate the map appearance. It is also corresponding with the landscape distribution, because it is reflecting the distribution of geogenesis and parent material conditions.

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The 1:200,000 soil map of Germany and the related Soil Information System (SIS)

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Organisation of soil mapping in Germany

In Germany, soil surveying is influenced by the federal character of the republic. The geological surveys of the component states of Germany are responsible for soil mapping and publishing of soil maps at medium and small scales. According to a list, compiled by Zitzmann (1994), in the beginning of the nineties there were the following official soil maps in Germany (Table 1).

Although the number of soil maps meanwhile has increased by a few medium scaled maps - especially from Baden-Wuerttemberg (Rilling and Waldmann, 1993) and the East German states (Laender) - the availability of soil maps at identical scales up to now is not satisfactory facing the national requirement. Moreover, all these maps are elaborated by different methods and, therefore, presenting varying soil parameters. To solve this problem, a few years ago the state soil surveys and the national soil survey of the Federal Institute for Geosciences and Natural Resources (BGR) have started a programme to compile and publish a nationwide 1:200,000 soil map of Germany (Finnern, 1993). The compilation of such a common 1:200,000 soil map was also a request of the Department of Environment of the Federal Government, because soil protection on national level requires harmonized information and comparable soil data. The methods used for the evaluation of soil data were documented by Hennings (1994).

Table 1

Soil maps in Germany

At medium and small scales		At large and medium scales	
Scale	Number of soil maps	Scale	Number of soil maps
1: 200,000 =	16	1: 5,000 =	about 1,100
1: 250,000 =	1	1: 10/20,000 =	„ 70
1: 300,000 =	3	1: 25,000 =	„ 400
1: 400,000 =	2	1: 50,000 =	„ 250
1: 500,000 =	11	1: 75,000 =	2
1: 600,000 =	2	1: 100,000 =	„ 30
1: 750,000 =	6		
1: 1,000,000 =	4		
1: 2,000,000 =	3		

For the preparation of the new 1:200,000 soil map a very close co-operation among the single soil surveys is necessary. In practice the co-operation is realized by working groups. The most important working group consist of the heads of each state soil survey and the national soil survey of the BGR. This body of experts, set up for the co-operation in all matters concerning the pedological work of the individual states (as soil mapping and soil information systems), had decided as well on structure and contents of the 1:200,000 soil map as on the corresponding database. This group of experts meets twice a year for the exchange of information about the state of progress on the map and on the database. The varied working steps connected with the elaboration of the 1:200,000 soil map require also a good co-ordination. which is realized by BGR.

Basic documents of the 1:200,000 soil map

Prerequisite for a common soil map and its related database are standardized guidelines for map design, for structure and contents of the legend as well for the description of the soil parameters. For that purpose several papers were elaborated from the working groups mentioned above:

- German Soil Mapping Guide,
- Guidance for the elaboration of the 1:200,000 soil map,
- Rules and methods for standardized soil descriptions, and for the aggregation and generalization of mapping units,
- General Legend of the soil mapping units.

The **German Soil Mapping Guide** (AG Boden,1994) includes the German soil taxonomy as well as all data keys, symbols and all parameters used in soil mapping and site description. To ensure that the soil surveys describe similar soil units on the 1:200,000 map in a comparable way, this guide also contains a framework legend with seven hierarchical levels (aggregation stages) for a systematic combination of soil map units (SMUs) which can be represented on soil maps at different scales (Table 2).

Table 2

Hierarchic aggregation stages represented on soil maps (very simplified scheme)

Aggregation stages of different levels	**way of delimitation**	**application scales**
1. homogeneous soil bodies	mapping in the field	> 1: 10,000
2. associations of similar soil bodies	mapping predominantly in the field	up to 1: 50,000
3. associations of dominant soils with associated soils	elaboration of draft maps, checking in the field and mapping where necessary	up to 1: 200,000
4. associations of dominant soils	derived from other larger scaled maps	up to 1:1,000,000
5. smaller soil landscapes	derived from medium or small scaled soil maps, from geological-morphological maps, and climatic maps or vegetation maps	< 1:1,000,000
6. main soilscapes	derived from small scaled soil maps, from medium or small scaled geological-morphological maps	< 1:1,000,000
7. soil regions	predominantly derived from geological maps and climatic maps	< 1:5,000,000

For the preparation of the 1:200,000 soil map the aggregation stages 7, 6 and 3 are important because the soil typological units (STUs) are described on the aggregation level 3 as dominant soils with associated soils, and the aggregation levels 7 and 6 (soil regions and soilscapes) form the basis for the structure as well for the legend of the map as for the database. Twelve soil regions and 38 soilscapes are described in the German Soil Mapping Guide. Some examples for the soil regions and soilscapes in Germany are shown in Table 3.

Table 3

Examples for the soil regions (level 7) and soilscapes (level 6) of Germany

Soil Regions	Soilscapes
- Holocene coastal plains	- Tidal-flat areas of the North Sea coast - Marschland and bog soils of the coastal area - Estuary areas
- Major floodplains	- Floodplains and lower terraces - Older terraces
- Glacial drift areas	- Loamy ground and end moraines in Northern Germany - Sandy glacial deposits in Northern Germany - Moraine deposits in the foreland of the Alps - Lowlands and ice marginal valleys
- Loess and sandy loess areas	- Foreland of the loess areas with thin loess cover - Loess areas ("Boerden") - Loess covered mountainous areas
- Mountain and hill areas with different parent materials, their weathering products, and redeposited material	- Mountain and hill areas with predominantly calcareous sedimentary rocks (limestone, marlstone) - Mountain and hill areas with predominantly non-calcareous sedimentary rocks (sandstone, siltstone, claystone) - Mountain and hill areas with predominantly volcanic rocks - Mountain and hill areas with predominantly magmatic and metamorphic rocks
- The Alps	- Flysch and molasse of the Pre-Alps - Calcareous rocks of the Alps - Silicate rocks, sand - and marlstones of the Alps

Very important for the soil description of the 1:200,000 soil map is another table of the Soil Mapping Guide which shows the proportion of the soils units in a certain area. These proportions can be differentiated by six classes (Table 4).

Table 4

Proportion of the area covered by a soil unit

Name of the class	Proportion (%)
rare	< 10
less spreaded	10 - 30
wide spreaded	30 - 50
dominant	50 - 70
highly dominant	70 - 90
nearly exclusive	> 90

The **Guidance for the elaboration of the 1:200,000 soil map** (Hartwich *et al.*, 1995) contains

- schedules for the working cycle,
- forms and tables for the description of the soil mapping units,
- instructions how to fill in the data in the columns,
- notes about the legend,
- rules for the arrangement of the map sheet.

Moreover, it defines the criteria to fulfil the mapping objectives, e.g. the minimum size for a polygon (100 hectares), minimum distance between two arcs (2 mm), etc.

When drafting the 1:200,000 soil map, soil scientists have to ensure that landscapes of similar soil forming factors have similar soil inventories. How we delimitate comparable SMUs is described in the **rules and methods for soil descriptions and for aggregation of mapping units** (Altermann, 1995; Schmidt, 1995; Billen *et al.*, 1997; Schmidt *et al.*, 1997). These guidelines include information about the regional assignment of soil associations and serve for check up whether all soil parameters are evaluated in the same way: e.g., do we find comparable soils combined in a mapping unit? Are the delimitations realized according to the same criteria? To achieve these aims the documents propose the following working steps:

(i) Definition of soilscapes with comparable soil associations. Connected with it is a determination and a comparison of such soil parameters as parent material, water conditions, relief, land use, etc.

(ii) Determination of the typical soils of the soilscapes and, therefore, a regional assignment of the soil associations,

(iii) Delimitation of the area covered by a defined soil association and check up where it occurs how is it spreaded in the landscape,

(iv) Determination of characteristic reference profiles for the dominant soils and check up of the profile data.

For many landscapes of Germany the occurring soil associations are already well known. Therefore, it was possible to produce a first version of a **General Legend of the soil mapping units**. This General Legend shows the links between soil landscapes with special parent material and water conditions or a typical relief and the soil associations resulting from these soil forming factors. The soil mapping units (SMUs) of the 1:200,000 soil map in general are composed of soil typological units (STUs) and subtypes of parent material. As mentioned above, the STUs corresponds with the soil associations of the aggregation level 3 (dominant soils with associated soils) whereas, the parent material information are genetic or lithological subdivisions of parent material types (e.g. weathering products of marly limestone mixed with loess).

All soil mapping units, which are stated in the General Legend, are described considering dominant soils and associated soils, parent material, soil texture and the proportion of the area covered by a soil unit. An example for the description of a soil mapping unit is given below. It consist of a short text, where the most important expressions are characterized in bold letters, and a second part with significant symbols from the database. The information stated by symbols are more detailed than the information in the text part.

> Predominant **Calcaric Regosol** to **Rendzic Leptosol**,
> less spreaded Calcaric Cambisol from clayey **loess**
> with gravels, overlying redeposited loamy and clayey
> material derived from **limestone weathering**
>
> 4 RZn, RRn; 2 BBc: p-(z,n)tö / pfl-(z,n)l, pfl-(z,n)t(^k)

The SMUs are grouped as well in the legend of the map as in the database to the corresponding soil regions and soilscapes. The structure of the General Legend corresponds with the list of soil regions and soilscapes given in the German Soil Mapping Guide (see Table 3). The soil mapping units are assigned to these landscape areas following the German soil taxonomy which prescribes that the soils have to be arranged according to the soil development (from the less developed to the more developed soils) and to the hydromorphic conditions (from the dry, non-hydromorphic soils to the wet, hydromorphic soils).

The structure of the 1:200,000 soil map

The 1:200,000 soil map of Germany is compiled and published by the Federal Institut for Geosciences and Natural Ressources (BGR) in co-operation with the geological surveys of the component states. The compilation is a teamwork with special duties for each partner, e.g.: the pedological data as well for the printed map as for the database are provided by the federal states but editing, cartographic work and preparation for printing is done by BGR.

The main part of the map sheet takes up the soil map with the single SMUs, but the printed map sheet consist of many other components as shown in figure 1.

The 1:200,000 soil map related database

The database of the 1:200,000 soil map (Krug and Kleemann, 1998) is a part of the spatial database of the soil information system of the BGR (FISBo BGR). According to the above mentioned procedure the data come from the federal states of Germany. These are data of different origin, e.g. data investigated in the field or derived from large scaled soil maps, estimated data by expert knowledge or by using statistical methods, measured data of individual soil profiles which are considered representative for a Soil Mapping Unit. All these data will be stored and maintained in a relational database and managed by the database system ORACLE.

At the moment, during the test period, the database system MS Access is used. The structure of the database is consistent with the structure of the General Legend of the 1:200,000 soil map. The data columns are organized by four hierarchic levels as indicated in figure 2.

Figure 1

General structure of the 1:200,000 map sheet

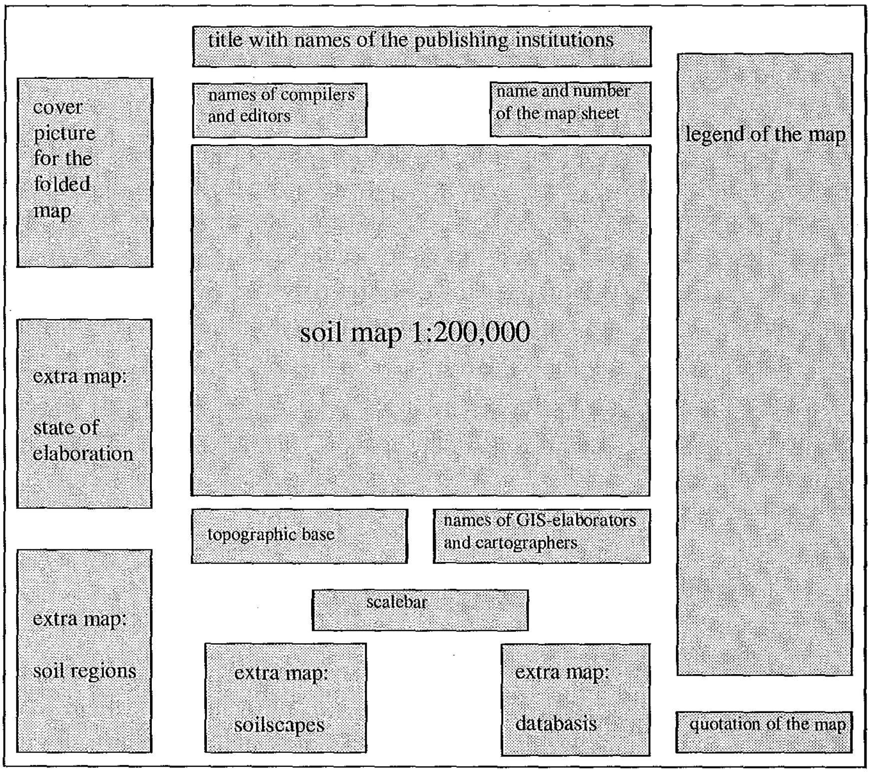
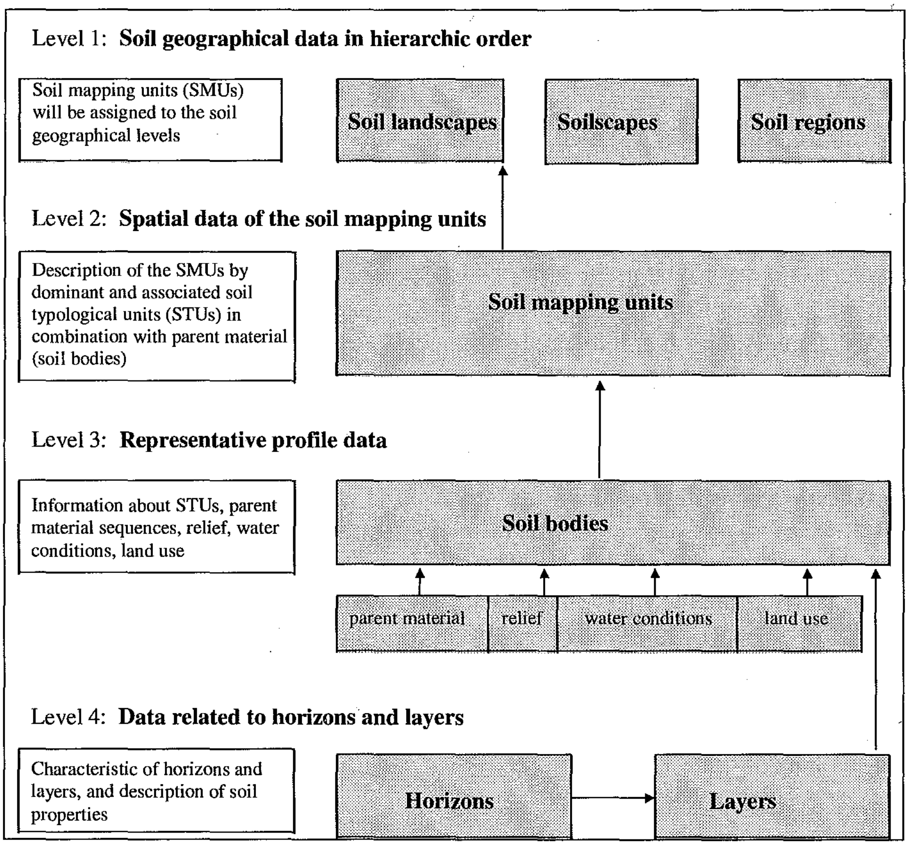


Figure 2

General structure of the 1:200,000 database



(i) The first level contains the soil geographical data with columns for the description of the soil regions, the soilscapes and the smaller soil landscapes (Table 2). The data of level 2 will be assigned to these soil geographic units.

(ii) The second level is characterized by data for the spatial organization of soils in the soil mapping units. A general description of the soil mapping units is indicated and the associations of dominant soils with associated soils are registered here.

(iii) The data columns of the third level gives information about the local soil parameters represented by individual profiles. There are stated e.g. the local sequences of parent material, soil texture or depth of water table.

(iv) In level four the data related to the horizons or layers are listed, e.g. symbols of the horizons, content of carbonate or organic matter.

In practice, for the 1:200,000 soil map the data input can start with the soil geographical units because the soilscapes and soil regions of Germany are already defined. But, data collection starts in general with level 4 and later aggregation lead to the higher levels. To fill in the data in the appropriate columns of the database a lot of masks, or forms, can be opened and the input take place corresponding to data availability or data supply by the federal states. The main form, or front mask, serves to open the forms for the soil geographical data, the General Legend and the soil mapping units. On the other hand these forms can be opened as well and forms appear for parent material, soil types and other parameters.

The database contains 42 different parameters for soil description but, being many parameters used at different levels and numerous combinations possible, more then one hundred columns are present in the database. Most of the parameters belong to the soil profiles and offer representative information about horizons and layers. These basic parameters are predominantly related to the pedogenetic and geogenetic characteristics of the soils but also to relief and water conditions. For the preparation of the 1:200,000 soil map many database columns do not contain the real numerical data but the information are arranged in classes. This facilitates the comparison of the data which are acquired by different methods.

State of completion

After the basic documents were finished off, in 1997 publishing of soil maps has started and, up to now two map sheets, Munich and Brunswick, are printed. In 1998 the production of draft maps was intensified by the geological surveys of the federal states so that at this moment the BGR is preparing nine map sheets for editing. By the end of 1998 the print of the sheet Neumuenster shall be realized and, two further sheets shall be published in the first months of 1999. Most geological surveys already possess the basic data necessary for preparing the 1:200,000 soil map and, therefore, the compilation of the maps makes rapid progress. Some federal states have the purpose to finish soil mapping at scale 1:200,000 up to the end of the year 2000.

As mentioned above, the common database is available for all geological surveys of Germany. This database belonging to the 1:200,000 soil map will be filled in the same quickness as the print makes progress. Now, at the end of 1998, the data of four map sheets are feeded into the database. After translation into the regulations of the "Georeferenced Soil Database for Europe - Manual of Procedures" (Finke *et al.*, 1998) these data can be used for the new European 1:250,000 soil database as well.

Summary

For nationwide questions concerning soil and environment protection the national soil survey and the state soil surveys of Germany have started the publication of a 1:200,000 soil map. The compilation of this map is carried out digitally and follows standardized guidelines and methods. Structure and content of the legend but also the delimitation of the soil mapping units are defined in these documents. The represented soil associations form an extract of a relational database belonging to the map. This database includes 42 parameters suitable for soil description at different hierarchic levels and necessary for the pedogenetic and geogenetic caracterization of spatial soil units. The database can be used for the preparation of the European 1:250,000 soil map as well.

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THE ROLE OF THE EUROPEAN SOIL BUREAU AND THE PERSPECTIVE OF A "NESTED" SOIL DATABASE

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Introduction

Soil is one of the essential elements of the biosphere, which necessitates a global policy for management, evaluation and conservation (Borlaug and Dowswell, 1994). To implement such a policy, it is necessary to have information harmonized both in space and time (ISSS, 1988).

The Commission is the originator of several programs aiming to acquire soil data (CEC-JRC, 1995). Associated with other sources of information (water, air, land management) these data are a valuable aid for decision support processes, in particular for the control of agricultural production (Vossen and Meyer-Roux, 1995), land management and environmental protection (Blum, 1990).

One of these programs, MARS (Monitoring Agriculture by Remote Sensing) initiated the development of a geographical database for soil cover at an accuracy of 1:1,000,000 scale (Meyer-Roux, 1987). The Support Group "Soil and GIS", bringing together experts from different EU countries, proposed a methodology and created a scientific network for the acquisition and exchange of information (Burrill and King, 1993). The advantages of this Group included their contact with the abundance of national and international studies. This experience also highlighted the absence of co-ordination not only between countries, but equally, and to the same degree, between different Directorates-General of the Commission.

Soil Information Focal Point

The Soil Information Focal Point (SIFP) was therefore created at JRC Ispra in 1994. Following the work and initiatives stimulated by the EEA Task Force, its mission was, on the one hand, to manage information elaborated at the 1:1,000,000 scale and on the other, to organize thinking on the Commission's future needs for soil data.

Three initiatives were identified:

1) The creation of a coordination group from the Directorates-General of the Commission (Inter DG Group) which includes the European Environment Agency (EEA).

2) Support for a second meeting of Heads of Soil Surveys and those responsible for management of databases in the EU (CEC, 1991a).

3) The creation of a working group termed "Soil Information System Development" (SISD) bringing together experts in soil science and information systems.

The Inter-DG Group produced a report identifying the demand for soil information from the Commission (CEC-JRC, 1995). The report highlights the large requirement for soil information, both within the Commission and in external institutes and organizations. The requirement is presently expanding due to an increased focus on environmental issues and sustainable planning. However, much of this need is presently unmet. The required information is either non-existent, exists only at an unsuitable resolution, or is available only as incompatible and/or incomparable datasets from national (or regional) organizations.

The second meeting of the Heads of Soil Survey and those responsible for management of databases in the EU was held in Orléans in December 1994. Main recommendations of the meeting where (EC, 1996) the support for the ongoing process of updating the European geographical and analytical soil database corresponding to the 1:1,000,000 scale, the establishment of the Soil Information System Development working group, the need for a more detailed database in Europe at scale 1:250,000 and the creation of an European Soil Bureau.

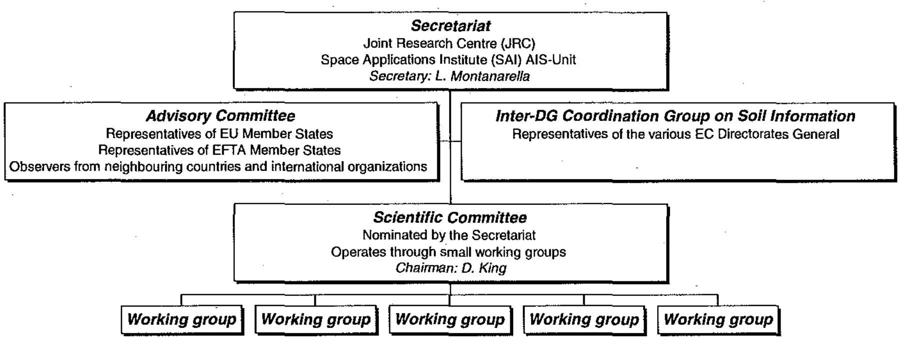
The Soil Information System Development working group produced in 1996 an important policy paper titled "European Soil Information Policy for Land Management and Soil Monitoring" (King and Thomasson, 1996) that sets guidelines for the future European soil information policy. It recommended the creation of an European Soil Bureau.

European Soil Bureau

The **E**uropean **S**oil **B**ureau (ESB) was created in 1996 as a network of National soil science institutions. It is currently managed through a secretariat that is located at the **J**oint **R**esearch **C**entre (JRC), Ispra, Italy, and is part of the **A**griculture and **R**egional **I**nformation **S**ystems Unit (ARIS) of the **S**pace **A**pplications **I**nstitute (SAI). Its aim is to carry out scientific and technical duties in order to collect and harmonise soil information relevant to Community policies, its relevant General Directorates (DG's), to the European Environment Agency (EEA) and to concerned Institutions of the EU Member States. Its current organisation is represented in figure 1.

Figure 1

Current organisation of the European Soil Bureau.



The activities of the ESB are essentially driven by the demands of soil information by the EU Member States and the European Commission. The needs of these two large user communities are gathered trough two committees, the Advisory Committee and the Inter-DG Coordination Group on Soil Information.

Official delegates from the 15 EU Member States and from the EFTA countries form the Advisory Committee. Observers with no voting rights are also admitted from the major International organisations (FAO, UNEP, etc.) and from the EU neighbouring countries. The committee insures the necessary link between the activities of the ESB and the relevant policies and activities concerning soil in the single EU Member States.

The Inter-DG Coordination Group on Soil Information is a inter-service working group with participants of all the relevant services of the European Commission involved directly or indirectly with soil related issues. Particularly DG VI (Agriculture) and DG XI (Environment) are heavily involved in soil related policies. Recently, a surge of interest in soil information has been observed also by other Commission services: DG XVI (Regional policy) in relation to the **E**uropean **S**patial **P**lanning **P**erspective (ESDP) and DG I and DG VIII in relation to soil information in non-EU countries. The extension of the European soil databases to non-EU countries has indeed been stimulated by the needs of these General Directorates. Recently, the United Nations Convention to Combat Desertification entered into force, and the European Union, as one of the parties of the Convention, will have to strengthen its support to adequate soil information systems in the affected regions. Extension of the current coverage of the soil databases available within the ESB is therefore foreseen after 1999.

The needs identified by the two bodies, the Advisory Committee and the Inter-DG Co-ordination Group on Soil Information, are collected by the Secretariat of the ESB and transmitted to the Scientific Committee.

The Scientific Committee is in charge of implementing the necessary activities in response to the needs for soil information. It is formed by relevant European experts in soil science and operates through small *ad hoc* working groups in charge of performing the single tasks requested by the soil information users.

Currently (1999) there are five working groups active within the ESB:

1. The **1:1,000,000 European soil database group** is operating already since many years, well before the creation of the ESB. It has been the driving force of a European joint effort of many soil scientists from different countries. Chairman of the group is Dr. M. Jamagne (INRA - SESCPF). The geographical extension of the Soil Geographical Database of Europe (fig. 2) covers currently (Ver. 1) the EU Member States, the Central and Eastern European countries (Poland, Czech Republic, Slovakia, Hungary, Romania and Bulgaria), the Baltic States (Lithuania, Latvia and Estonia), Norway, Switzerland, former Yugoslavia and Albania. In its final version, expected to be ready in 1999, it will include also Iceland. The final version will also incorporate the **S**oil **P**rofile **A**nalytical **D**atabase of **E**urope (SPADE) and a soil hydraulic parameters database linked to the 1:1,000,000 soil database of Europe, named HYPRES, which stands for **Hy**draulic **Pr**operties of **E**uropean **S**oils. It will also include an expert system for the

estimation of several additional parameters, from the variables presently stored in the database. Therefore the final version will consist of a geographic dataset, a semantic dataset, a soil profile analytical database, a soil hydraulic parameters database and a knowledge database in a fully integrated system (fig. 3), named **Eu**ropean **S**oil **I**nformation **S**ystem (EUSIS).

Figure 2

Current extension of the European Soil DataBase Ver. 1.

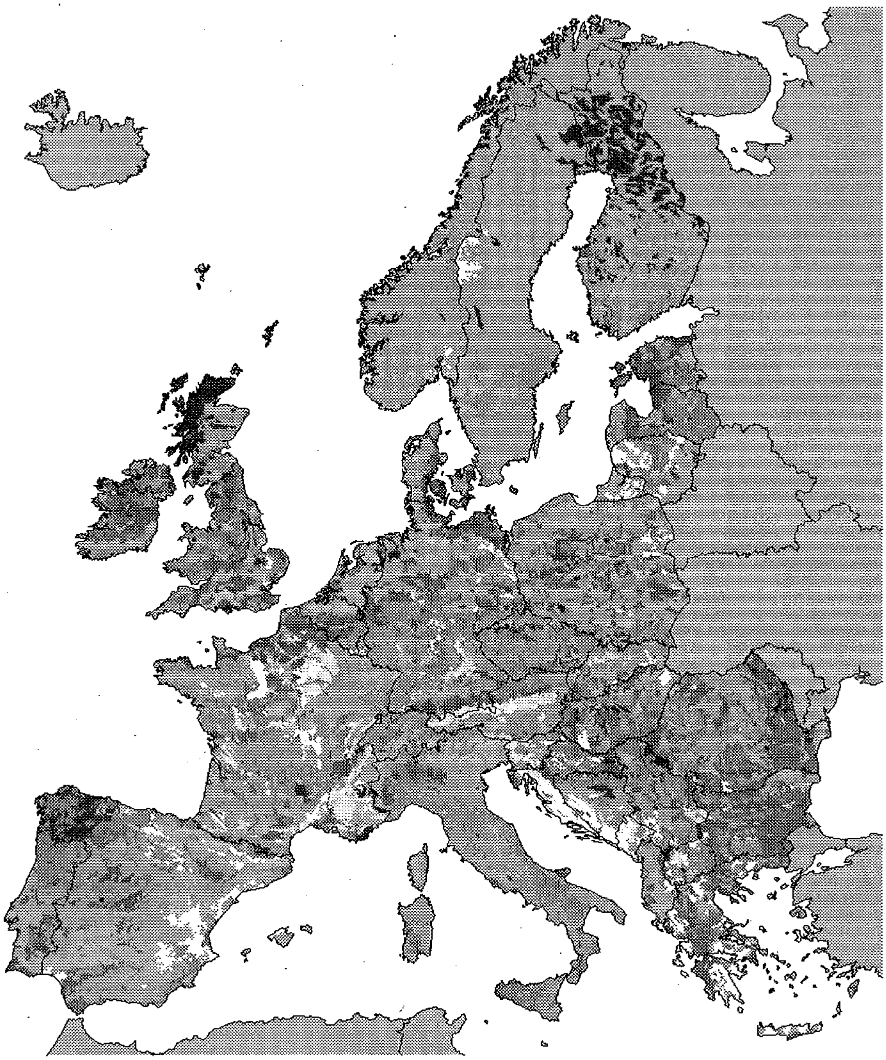
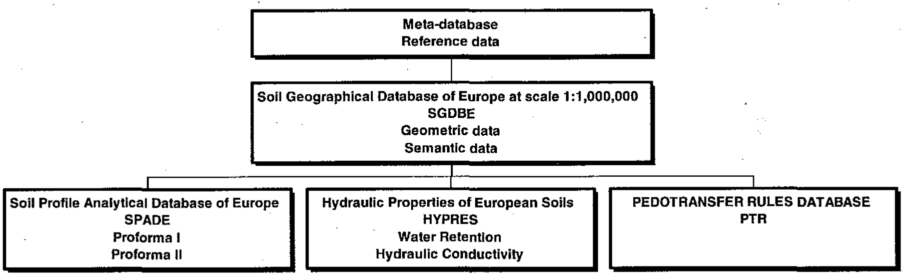


Figure 3

Simplified structure of the European Soil Information System (EUSIS).



It is expected that the development of this soil information system will continue well beyond 1999 with the extension of the coverage to the Commonwealth of Independent States (CIS) and to the Mediterranean basin. The main aim is the establishment of a common framework at continental scale for the sustainable use of the soil resources in Europe. The already well established European Soil Information System of the EU is recognised by the participating countries, and by the European Environment Agency (EEA), as a reference for reliable soil information. Its participatory approach allows full integration of already existing knowledge at local level into a European framework. The wealth of information available in the Eastern European countries on their soils can therefore be fully recovered and integrated into a European context. Indeed, one of the major aims is to give to the soil scientists of the New Independent States (NIS) the possibility to see their work recovered and valorised in an European context. These countries, being the birthplace of soil science, can give a very valuable contribution to the quality and content of the European Soil Information System.

The existing EU European Soil Information System (EUSIS) has given to Europe a tool of comparable importance of other well established systems in the United States (National Soil Information System, NASIS) and in Canada (Canadian Soil Information System, CANSIS). EUSIS, the European system, is fully compatible with the FAO's World Soils and Terrain database. The scale is of course different, as the European system is much more detailed, with information at scale 1:1,000,000.

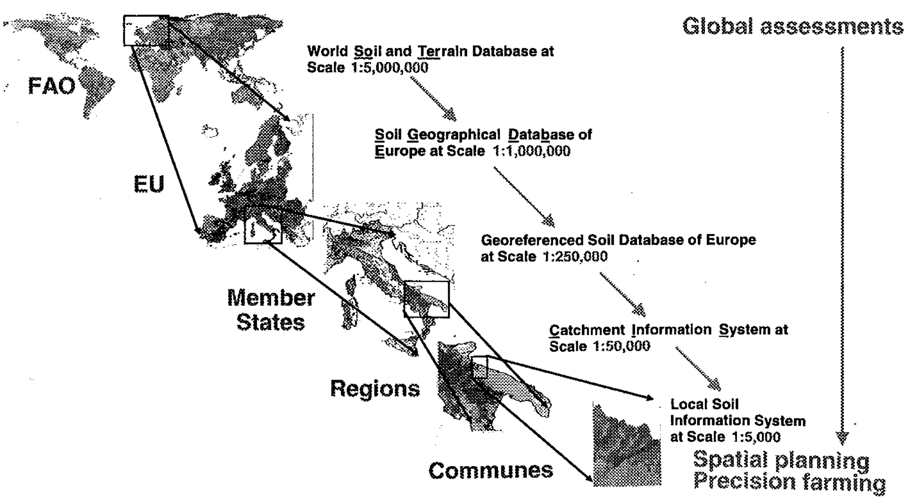
2. The **Information Access Working Group (IAWG)** turned

out to be one of the most important within the ESB, as it is in charge of the development of an European policy for the access to soil databases. The general aim of the group has been to develop guidelines that insure the maximum protection of the data ownership together with regulated access for all the potential data users. This is developed in conformity with the EU policy as regarding the access to relevant environmental information in Europe. Chairman of the IAWG is Dr. R.J.A. Jones (Silsoe College, Cranfield University). The Information Access working group developed the guidelines that are a major breakthrough in European data access policy. The key statement is that data ownership and copyright remain with the Contributor. This means that the data supplied to the ESB by the Contributors for the creation of the European soil database are owned by the Contributors and not by the Commission. On the other hand the principle of regulated access to the data by everybody is reinforced. The combination of these two statements produces a data access policy that maximises database access and use and safeguards the intellectual property by the Contributors. Licenser of all the soil data is the European Commission through its European Soil Bureau that becomes focal point for data licensing and distribution. Data are leased for a limited time and not sold. Charging is according to a price matrix. The adopted price matrix differentiates the cost of lease of data according to the use. Minimum charge (cost of handling) is applied to Contributors and non-profit organisations for internal use. Charging is required in the case of external use by these organisations. Maximum charging is applied to full commercial uses by private organisations.

The **1:250,000 working group** represents the future of the ESB. It works at the design and construction of the new European soil database at scale 1:250,000. It has been established following a feasibility study by the DG XI (Environment) of 1993, which recommended the creation of such a database for future environmental applications within the EU. Chairman of the group is Dr. Peter Finke (SC-DLO, Wageningen). The 1:250,000 Georeferenced Soil database of Europe project started after a feasibility study by the Directorate General XI (Environment) prepared by R. Dudal, A. Bregt and P. Finke in 1993. This study was commissioned to meet the still growing demand for soil parameters in environmental context - for which assessment on levels of regions or watersheds seems most appropriate - and to support the databases already developed by CORINE, e.g. on land cover and biotopes at a 1:100,000 scale. Direct contact to national soil surveys and land research centres of the former 12 EU Member States demonstrated that the national coverage of soil mapping at scale appropriate for a more detailed soil map ranged from 10% to 100%. However in all countries, some areas where found with coverage sufficient to be converted into a 1:250,000 soil map through generalisation, eventually complemented with some additional fieldwork. Special attention was paid to soil and terrain attributes that need to be recorded in term of environmental protection. Given the low availability of soil data suitable for preparing a more detailed soil map of Europe, it was determined that " a wall to wall soil map" or soil database could be accomplished only in the long term, but a recommendation was made to carry out studies in small pilot zones with a high coverage of data, with the aim to develop a methodology, a common legend and a common database useful for the final database at scale 1:250,000. This principle was endorsed also by the European Environment Agency (Scoping study on establishing a European topic Centre for soil, DGGU Service Report no. 47, 1995). In order to start the project, a working group was created within the ESB. It was charged with the preparation of the Manual of Procedures (Doc. EUR 18092 EN), the delineation of the pilot areas and the overall scientific supervision of the project. From the operational point of view the database will be created in selected pilot areas co-ordinated by regional co-ordinators for territorial correlation of each project. The selection of the first pilot area already started with the delineation of an area covering the North-Italian quaternary plains and tertiary low hills. Project leader for that area is Dr. R. Rasio (ERSAL-Lombardia). New areas followed recently, covering Central and Southern Italy and the Alps. This new soil database will be fully integrated in the future nested European Soil Information System EUSIS (fig. 4).

Figure 4

The nested European Soil Information System (EUSIS).



This nested European Soil Information System will on one side fully integrate Europe within the future World Soil and Terrain (SOTER) data base of FAO, expected to be ready by 2002, and on the other end link up with the existing National and Regional soil information systems within the EU. It will address needs by soil information users at different scales, ranging from global change studies at global scale (1: 5,000,000 scale) down to very detailed information for spatial planning and precision farming applications (1:5,000 scale). Intermediate scales of spatial soil information will respond to the needs of the European Union (1:1,000,000 scale), to the EU Member States (1:250,000 scale) and to Regional and Local authorities (1:50,000 scale). The system will be fully integrated with the soil monitoring activities of the European Environment Agency and with the World Soil and Terrain Database of FAO.

4. The **soil erosion risk assessment** working group, chaired by Prof. Dr. N. Yassoglou (NAGREF, Greece), is in charge of the elaboration of a new Pan-European Soil Erosion Risk Assessment. The project will concern the establishment of a new georeferenced database of the potential and actual erosion risks in Europe. The assessment of the potential and actual erosion risk in Euro-pe will be made at a scale of 1:1,000,000. This scale is chosen because it is the one in which soil erosion related databases are available for the whole of Europe. The methodology will be based on the concepts used in the previous CORINE *Soil Erosion Risk and Important Land Resources in Southern Europe* project. There will be, however, significant improvements in the quality of the data to be used. Full advantage should be taken from the newly available European GIS coverages, like the Soil Geographical Database at scale 1:1,000,000, the completed CORINE Land Cover database, new DTMs, etc.

The geographical extension of this new soil erosion risk assessment will cover the EU Member States, the EFTA countries, the Central and Eastern European countries including the Baltic States, former Yugoslavia and Albania.

Additionally, two more detailed studies will be performed at scale 1:250,000 covering Italy and Albania, respectively.

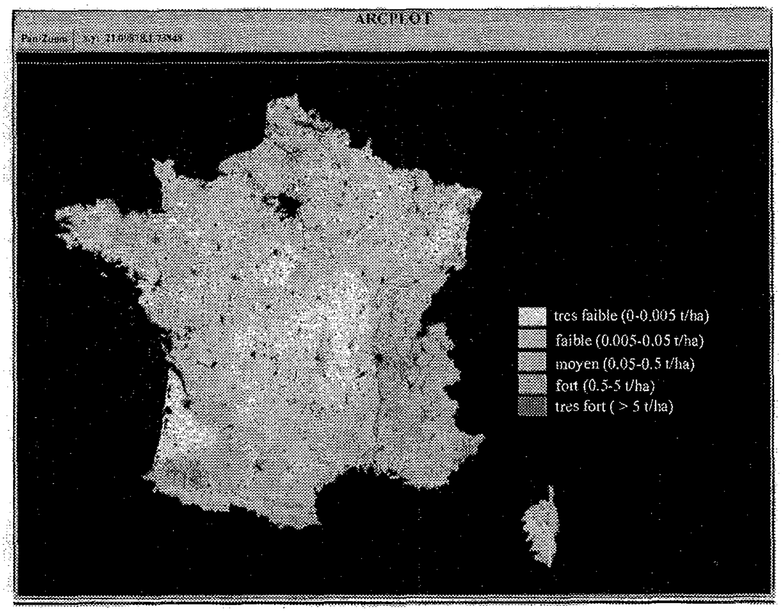
Currently the group has produced a preliminary test on France (fig. 5), in order to establish the most appropriate methodology for such a new pan-European soil erosion risk assessment.

5. The **soil analytical methods** working group is chaired by Prof. Dr. E. Van Ranst (Univ. of Gent, Belgium) and is in charge of soil analytical methods harmonisation in the framework of the development of

the European Soil information System (EUSIS). The group is closely linked to the new activities of the JRC within the Soil and Waste unit of the Environment Institute (EI). It has produced an inventory of computer models using soil data that allows to clearly identify future needs for soil data as input to existing interpretative models. This is a key issue, as there is often a mismatch between data available within existing soil information systems and data needed by the relevant models for the production of the derived information needed by the relevant decision makers.

Figure 5

Soil erosion risk in France using a new Pan-European approach.



Conclusions and perspectives

During the last two years there has been a surge of requests to the European Soil Bureau for data on European soils. This increase in activity is due to a number of reasons:

- the establishment of the European Environment Agency and of its European Topic Centre on Soils requires a large amount of soil related information;

• the growing concern about the impacts of agriculture and other human activities on soils has triggered a number of policies and regulations that need soil information for their implementation;

• specific EU policies, like the Common Agricultural Policy, the 5th Environmental Action Plan, the European Spatial Development Perspective and others, require harmonised soil information within the European Union;

• internationally binding agreements, like the UN Convention to Combat Desertification (UNCCD), call for detailed soil information at a regional scale (specifically annex 4 of UNCCD requests comparable soil information for the countries of the Mediterranean basin);

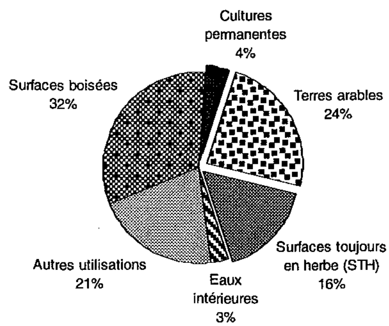
• severe environmental disasters (landslides, flooding, etc.) in some EU Member States have raised the issue of adequate soil information for disaster prevention.

These growing demands go far beyond the actual capabilities of the European Soil Bureau and require a much larger and efficient organisation. There is indeed a growing need for such a common forum, as society becomes more and more aware of the many functions soils are performing for the human wellbeing. It is the multifunctionality of soil that has always prevented to address soil as a medium worth conservation and protection. Many stakeholders hold a share on this complex environmental compartment. Agriculture has been traditionally the major stakeholder and the driving force of appropriate soil conservation measures. In the new context of a reformed Common Agricultural Policy (CAP) as delineated in the Agenda 2000 of the European Union, there is a need to create the "common ground" that allows the new stakeholders that are starting to profile themselves in Europe (environmentalists, rural communities, spatial planners, urban communities, tourism, etc.) and that have relevant interests on soils due to its multifunctionality (cultural heritage, filtering of water, source of biodiversity, building ground, etc.) to confront their needs with the "traditional" soil users, the farmers. This gets particularly obvious if we consider the current (1997) land use within the EU (fig.6).

In this new context, the European Soil Bureau needs to enlarge its scope in order to take into account the new needs for relevant soil information by these new actors. The issues related to soil protection and to the development of suitable indicators for the assessment of soil degradation phenomena will become a priority. The current databases respond mainly to soil fertility issues in the framework of the past need for a more productive European agriculture.

Figure 6

Major land uses within EU 15 (1997).



Source: Eurostat/ZPA1

The new needs are on the contrary focusing on the relationship between soil and quality of agricultural products and the impact of agriculture (and other human activities) on soils. The links existing between the quality of agricultural products and soil properties are well studied, even so we are still missing assessments at small scales for EU policy needs. Fewer data are available on the degree of soil degradation due to un-sustainable agricultural practices. The same is true for other forms of soil degradation due to industrial activities (sealing, contamination, etc.). A new effort is needed for the collection of updated and relevant information on European soils in order to implement more effective soil protection policies at EU level.

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New developments in Soil Classification and implications for the European Soil Survey Programme with special reference to WRB

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1. Introduction

Soil classification, for long frozen in time, and at one point declared dying if not dead (Nachtergaele, 1997), has recently received a number of new impulses most notably by the publication of the World Reference Base for Soil Resources (ISSS Working group RB, 1998a and b; FAO/ ISRIC/ISSS, 1998). The World Reference Base (WRB) was originally an initiative of FAO and Unesco, supported by UNEP and the International Society of Soil Science which dates back to 1980. The intention of the project was to work towards the establishment of a framework through which ongoing soil classification could be harmonized. The final objective was to reach international agreement on the major soil groups to be recognized at a global scale as well as on the criteria and methodology to be applied for defining and separating them. Such an agreement was meant to facilitate the exchange of information and experience, to provide a common scientific language, to strengthen the applications of soil science and to enhance the communication with other disciplines and make the major soil names into household names. Several meetings of the ISSS subgroup were held, starting in 1982 in New Delhi with unfortunately very little progress being made, until it was realized in 1992 in Montpellier, France, that there was no justification to develop a completely new nomenclature very different from the Revised Legend published by FAO in 1988. Therefore it was decided that the FAO Revised Legend was to be adopted as the Framework for WRB's future work and that it would be the task of the working group to further develop its definitions and linkages to the existing FAO units, in order to give them more depth and validity.

The first draft version of WRB was presented at the 15th World Congress of Soil Science at Acapulco, Mexico (ISSS/ISRIC/FAO, 1994) and since then it has been subjected to testing on consistency during meetings in Germany (1995), Russia (1996), South Africa (1996), and Argentina (1997). In November 1997, the last meeting was held in Vienna, Austria, and a final text was adopted which was consequently presented at the 16th World Congress of Soil Science in Montpellier, France in August 1998.

The WRB publications comprise:
1. World Reference Base for Soil Resources: Introduction (ISSS Working Group RB,1998a);
2. World Reference Base for Soil Resources: Atlas (ISSS Working Group RB, 1998b);
3. World Reference Base for Soil Resources: (FAO/ISRIC/ISSS, 1998).

All three publications carry the logos of the three main organizations involved in their development: The International Society for Soil Science (ISSS), The International Soil Reference and Information Centre (ISRIC) and the Food and Agriculture Organization of the United Nations (FAO).

The first volume describes the thirty Soil Reference Groups and is well illustrated with colour pictures of soil profiles, landscapes in which they occur, and a brief overview of their soil management implications. The volume is aimed at (under)graduate students and people who use soil science in their profession, as such it is aimed to make the major soil groups well known to the general public. The second volume gives the distribution of the Soil Reference Groups throughout the world, based on correlations made with the 1974 FAO Legend and the FAO-Unesco Soil Map of the World. (FAO, 1971-1981) and includes a selection of pictures and analyses of the monoliths present in the Soil Museum in Wageningen. The last volume gives the technical description of diagnostic horizons and properties, the key to the classification at the highest level, and the definitions of the subdivisions that are foreseen. This volume is aimed at soil scientists and soil correlators.

Note that these publications are based on contributions of hundreds of soil scientists throughout the world. Their contents were only arrived at after sometimes long and hard negotiations among very different schools of thought on soil classification. The text was fully endorsed by the

ISSS who also recommended during its last world congress that the "...system should be used as reference base of ISSS and as a standard in peer-reviewed soil science journals".

2. Differences between the FAO Legends and the WRB Soil Classification

The first and major difference between the different FAO Legends (1974; 1988-90) and WRB is the fact that the FAO legends were originally conceived exactly as what their name implied, namely to be a legend for a specific map. As such it was important that soil units were recognized that had a significant extent and could be represented on a map at a specific scale (1:5 million in the case of the original Legend). As a legend, there was less need to be fully comprehensive and it was recognized that certain soil profiles could not be classified in it. Provided these profiles represented no large units, this was not seen as a major flaw. At the same time, because of the limitations of scale of the map, it became necessary to group certain related characteristics under one unit, while in fact different processes were at work. An example of this is type of shortcoming is that the Calcic Gleysols (FAO,1974) also included Gleysols with a gypsic horizon.

In addition a number of criteria were introduced in the FAO legend, such as texture and slope, to enable the legend to give sufficient information to users. Normally these attributes would not be used at such a high level , in a legend intended to be a classification system.

However, the success of the legend was such, that soon it became accepted as the higher two levels of an international soil classification system. Over time the FAO "classification" was adopted rather than the Soil Taxonomy as the worldwide reference system, first in Europe, then in Eastern Africa and in Northern Asia. Some countries adapted it to the extent that their national classification systems were based on the FAO legend: Bangladesh (Brammer *et al*, 1988), Botswana (De Wit and Nachtergaele, 1989) and Kenya (Kenya Soil Service, 1985) are examples. Nevertheless, Soil Taxonomy remains the preferred correlation system in most of Asia and the America's.

The development of WRB, which is a replacement for the FAO legend as a classification system will certainly confuse some users as most differences are small and the nomenclature of both is very similar. The major changes and modifications are discussed and illustrated below.

2.1 Modifications at the highest level: Reference Soil Groups

At the highest level 30 Reference Soil Groups are recognized. These include three new ones compared to the FAO Revised Legend: CRYOSOLS, DURISOLS and UMBRISOLS. The **Greyzems**, present in FAO Legends since 1974, are deleted at the highest level and are merged with the Phaeozems.

Cryosols are soils subjected to intense thawing and freezing, and show signs of cryoturbation. **Durisols** comprise the soils in semi-arid environments which have accumulations of secondary silica (duripans). **Umbrisols** cover soils with umbric horizons or soils with a mollic horizon with a desaturated subsoil.

The Leptosols have been diminished by "losing" soils that have indurated pedogenetic horizons at shallow depth which are considered in WRB as Plinthosols (with shallow petroferric horizons), Calcisols (with shallow petrocalcic horizons), Gypsisols (with shallow petrogypsic horizons) and Durisols (with shallow Duripan).

Podzoluvisols have been renamed "**Albeluvisols**", because the cheluviation process typical for Podzols is not prominent in these soils and it was thought better to draw attention to the presence of the eluvial or albic horizon tonguing in the argic one.

2.2 Modifications of Diagnostic horizons and properties

Of the 16 diagnostic horizons of the Revised Legend only the fimic horizon has not been retained, because it covered too wide a range of man-made surface layers. It is replaced by three different horizons: hortic, plaggic and terric horizons.

Minor modification of horizon definitions were made for the histic, mollic, umbric, albic, ferralic, argic and natric horizons.

Major alterations are made in the definition of the spodic horizon, which is brought in line with the recent modifications in the Soil Taxonomy (Soil Survey Staff, 1998).

In addition to the existing 15 diagnostic horizons, 20 new ones are proposed. Most of these are adopted from FAO's diagnostic properties and soil phase indicators, others are newly formulated.

The newly defined diagnostic horizons are the *andic*, *anthropedogenic*, *chernic*, *cryic*, *duric*, *ferric*, *folic*, *fragic*, *fulvic*, *glacic*, *melanic*, *nitic*, *petroduric*, *petroplinthic*, *plinthic*, *salic*, *takyric*, *vertic*, *vitric* and *yermic* horizons.

Newly defined diagnostic properties and materials include: *albeluvic tonguing*, *alic* and *aridic properties*, and *anthropogenic*, *calcaric*, *fluvic*, *gypsiric*, *organic*, *sulfidic* and *tephric soil material.*

Gleyic and *stagnic properties* have been reformulated. Slight changes have been proposed in the description of *abrupt textural change* and *geric properties.*

Most changes are minor, perhaps with the exception of the definition changes for the spodic and andic horizon and the approach taken in Anthrosols.

2.3 Modifications related to the Classification approach

Three fundamental changes have been proposed in addition to the ones discussed above. These relate to the standardization of a classification approach as different from a legend.

The first one is the use of standard depths: no other depth limits than 10, 20, 25, 30, 40, 50, 75, 100, 150 and 200 cm have been used. Although still less than satisfactory this is considered an improvement over the Revised Legend which contains various depth limits.

The second, more fundamental, change is the exclusive use of standardized definition for each subdivision name (modifier) of the soil Reference Groups used. For instance, while in the Revised Legend the term "dystric" had several meanings (less than 75% base saturation in Vertisols, less than 50% in different depth-control sections in Cambisols and Planosols.), in WRB "dystric" has a unique meaning, which is: "having a base saturation (by 1M NH_4OAc) of less than 50 percent in at least some part between 20 and 100 cm from the soil surface, or in a layer 5 cm or more thick directly above a lithic contact in the Leptosols".

The third, and most important, innovation is the building-block approach taken. The building blocks are the uniquely defined modifiers as described above. There are 121 of these, which compares favourably with the 152 different soil units in the Revised Legend. An overview of all modifiers is given in Table 1. An example of their definitions is given in Box 2.

These building blocks are used to define the lower level sub unit as illustrated in the following example:

Example

In Vertisols the following modifiers have been recognized, in order of priority:

1.	Thionic	intergrade with acid sulphate Gleysols and Fluvisols
2.	Salic	intergrade with the Solonchaks
3.	Sodic	intergrade with the Solonetzes
4.	Gypsic	intergrade with the Gypsisols
5.	Calcic	intergrade with the Calcisols
6.	Alic	intergrade with the Alisols
7.	Gypsiric	containing gypsum
8.	Pellic	dark coloured, often poorly drained
9.	Grumic	mulched surface horizon
10.	Mazic	very hard surface horizon; workability problems
11.	Chromic	reddish coloured
12.	Mesotrophic	having less than 75 percent base saturation
13.	Hyposodic	having an ESP of 6 to 15
14.	Eutric	having base saturation over 50%
15.	Haplic	

To classify a reddish coloured Vertisol with a calcic horizon one would follow the priority list and note that modifiers 5 and 11 apply. Therefore, the soil is classified as Chromi-Calcic Vertisol. If more information on depth and intensity of the calcic horizon is available, one may specify this by classifying the soil as Chromi-Epicalcic Vertisol, indicating the occurrence of the calcic horizon within 50 cm from the soil surface.

When more than two modifiers can be used, they can be added within brackets after the standard name. If, for instance, the Vertisol discussed also has a very hard surface horizon (modifier 10), the soil would be named Mazi-Calcic Vertisol (Chromic).

Table 1: General alphabetical list of modifiers

Abruptic	Ferralic	Lixic	Rhodic
Aceric	Ferric	Luvic	Rubic
Acric	Fibric	Magnesic	Ruptic
Acroxic	Folic	Mazic	Rustic
Albic	Fluvic	Melanic	Salic
Alcalic	Fragic	Mesotrophic	Sapric
Alic	Fulvic	Mollic	100 Silic
Alumic	Garbic	70 Natric	Siltic
Andic	40 Gelic	Nitic	Skeletic
10 Anthraquic	Gelistagnic	Ochric	Sodic
Anthric	Geric	Ombric	Spodic
Anthropic	Gibbsic	Oxyaquic	Spolic
Arenic	Glacic	Pachic	Stagnic
Aric	Gleyic	Pellic	Sulphatic
Aridic	Glossic	Petric	Takyric
Arzic	Greyic	Petrocalcic	Tephric
Calcaric	Grumic	Petroduric	110 Terric
Calcic	Gypsic	80 Petrogypsic	Thionic
Carbic	50 Gypsiric	Petroplinthic	Toxic
20 Carbonatic	Haplic	Petrosalic	Turbic
Chernic	Histic	Placic	Umbric
Chloridic	Hortic	Plaggic	Urbic
Chromic	Humic	Planic	Vetic
Cryic	Hydragric	Plinthic	Vermic
Cutanic	Hydric	Posic	Vertic
Densic	Hyperochric	Profondic	Vitric
Duric	Hyperskeletic	Protic	120 Xanthic
Dystric	Irragric	90 Reductic	Yermic
Entic	60 Lamellic	Regic	
30 Eutric	Leptic	Rendzic	
Eutrisilic	Lithic	Rheic	

Where relevant, the names can be defined further using prefixes, for example Epigleyi-, Protothioni-. The following prefixes can be used:

Bathi	Epi	Orthi	Thapto
Cumuli	Hyper	Para	
Endo	Hypo	Proto	

Table 2: Example of unique modifier definitions

Carbi-	having a cemented *spodic* horizon which does not contain enough amorphous iron to turn redder or ignition *(in Podzols only).*
Carbonati-	having a soil solution with pH > 8.5 (1:1 in water) and $HCO_3 > SO_4 >> Cl$ *(in Solonchaks only).*
Cherni-	having a *mollic* horizon more than 30 cm thick, having a strong granular structure and a Munsell colour value and chroma, moist, of less than 2 throughout the upper 15 cm (or immediately below the plough layer). Bulk density is generally between 0.9 and 1.3.
Chloridi-	having a soil solution (1:1 in water) with $Cl >> SO_4 > HCO_3$ *(in Solonchaks only).*
Chromi-	having a B horizon which in the major part has a Munsell hue of 7.5 YR and a chroma, moist, of more than 4, or a hue redder than 7.5 YR.
Cryi-	having a *cryic* horizon within 100 cm of the soil surface.

For each reference soil group there is a defined list of which modifiers may be used and in which a priority order is given. This is illustrated in Table 3.

Table 3: Priority listing of lower level units of reference soil groups

ALBELUVISOLS	ALISOLS	NITISOLS	ACRISOLS	LUVISOLS
Geli-	Verti-	Andi-	Plinthi-	Lepti-
Gleyi-	Plinthi-	Molli-	Gleyi-	Verti-
Ali-	Gleyi-	Ali-	Andi-	Gleyi-
Umbri-	Andi-	Umbri-	Umbri-	Andi-
Fragi-	Niti-	Humi-	Areni-	Calci-
Stagni-	Umbri	Veti-	Stagni-	Areni-
Endoeutri-	Areni-	Alumi-	Geri-	Stagni-
Abrupti-	Stagni-	Rhodi-	Albi-	Albi-
Ferri-	Albi-	Ferrali-	Humi-	Hyposodi-
Hapli-	Humi-	Dystri-	Veti-	Profondi-
	Abrupti-	Eutri-	Abrupti-	Ferri-
	Lamelli-	Hapli-	Lamelli-	Lamelli-
	Profondi-		Profondi-	Rhodi-
	Ferri-		Ferri-	Chromi-
	Hyperdystri-		Alumi-	Hyperochri-
	Rhodi-		Hyperdystri-	Dystri-
	Chromi-		Rhodi-	Hapli-
	Hapli-		Chromi-	
			Hyperochri-	
			Hapli-	

3. Proposals for further expansion of WRB

In the context of developing legends based on WRB, it is of particular importance to note that special attention is paid to the development of a topsoil characterization compatible with the WRB nomenclature.. The development of such a system would allow a more practical approach to problem solving for agronomic or urban development related problems.

Further activities of sub-committees within the Working group RB include translations of the three books in several languages (including French, Spanish, Chinese, Arabic, Italian, and German), further field testing of the proposed subdivisions and definitions, the preparation of a handbook on laboratory and field tests, the creation of a special study group on Anthrosols, further testing and documentation of the WRB classification scheme etc...

4. Implications of WRB for European Soil Inventories and small scale surveys

It is somewhat ironic that when FAO first released the FAO/Unesco Legend back in 1974, immediately voices went up to call it a soil classification. Now in 1998 when we collaborated to create a soil classification, I have the impression there is a certain cry to use it as a legend instead!

Although there are examples where soil classifications have been used as pure legends, it is generally accepted that, although related, the two issues of classification and map legends should not be confused. Soil surveys, and particularly large scale regional soil surveys, perhaps at 1:200,000 or larger, require legend criteria which can not be covered to the last detail by even a very comprehensive soil classification. Some examples of these factors are: slope, drainage criteria, precise colour ranges for certain horizons, classes of stoniness, pH, precise texture ranges including sand classes etc…These "soil series" criteria have by necessity to be developed by the local surveyors within a nationally agreed system. What should be aimed at is the possibility to incorporate, or at least attach, these "local soil series" within an international system at a higher level. This in turn requires that at the highest level of the national classification, a soil classification system is used that is compatible with WRB. The FAO revised legend, Soil Taxonomy and the Référentiel Pédologique Francais have relatively little problems with this approach, but more purely pedogenetic classification systems such as the Russian or old French CPCS system may pose more difficulties for soil correlation. An example for a similar correlation is the one undertaken by Galligani and Magaldi (1997) for the Soil map of Europe.

In the European context it is also appropriate to draw attention to the fact that it is a challenge and an opportunity for a number of regional soil services within single countries in Europe to transcend their differences and adopt WRB as a common national approach to soil classification in line with, and endorsed by the IUSS.

The other issue involved in local soil surveys is the way soil information can be stored and represented. The recent advances in computer and database management and Geographical Information Systems, coupled with the enhanced resolution of satellite images, allows for a more natural ordering of soil and related information than what was possible in a classical soil map. There is a general agreement that a land system approach is to be preferred, in which at the highest level large natural landscapes are recognized, at a lower level parent material and other terrain criteria can be brought in, while the soil information sensu stricto can be stored at a third level in which the soil associations are put in their natural context each identified by a typifying pedon. It is obvious that not all soil units can be represented by profiles, and that each typifying pedon may stand for a number of similar soils in different units in a country or region. This kind of arrangement of soil information has been promoted at national scale for instance by Mitchell and Howard (1978) and CSIRO in Australia, and by the landscape approach of the French school. At regional level a similar techniquer is proposed by Finke *et al* (1998) for the European Soils Bureau (ESB), while at international level the SOTER (UNEP/ISSS/ISRIC/FAO,1995) approach as endorsed by the International Union of Soil Sciences (IUSS), UNEP and FAO is the norm. Although the details between these methods differ, the major difficulty in unifying them, appears to be more political and commercial than scientifical.

In addition copyright rules on soil data and maps have become an issue in the European regions. The harmonization of these different approaches and the free accessibility of soil and terrain data remains a priority for FAO. Progress is being made in this context in a joint undertaking by ESB and FAO for the creation of a European Soil Data Information system at small scale.

The concern of many computer scientist to deal with measured observations, rather than with expert opinions, has led to a more systematic inclusion and use of soil profile data in thematic databases. It has also led to a rather unwarranted faith in pedostatistics and pedotransfer functions. Although, ideally, each mapping unit is characterized by an actual soil profile (or an association of profiles) occurring in it, for economic reason the number of soil profiles actually described and measured remain often very limited, and the reliability of extrapolating these results remains debatable. In this context the problem of the format and content of different soil databases can be raised. It is indeed remarkable how many database structures deal nearly exclusively with laboratory data, at the exclusion of morphological profile data. The ESB profile dataset is a good (or rarther to be more precise: "bad") example of this approach. This may limit the possible applications of these inadequately conceived data structures. Therefore the use of broader and more open data storage systems as proposed in SOTER or in the FAO/ISRIC/CSIC multilingual soil profile database (FAO, 1995) is recommended.

Another warning in this context concerns the blind faith often expressed by computer modellers in laboratory analyses. Various studies on within- and between- differences of laboratory results have shown a high variability in the results obtained and to base sophisticated computer models on these may only result in more error propagation.

5. Conclusions

A change to a new soil classification system is always difficult, even with the strong endorsement of the IUSS. It is recognized that no classification system will ever be final nor perfect. However, the flexibility of the modifier approach used in WRB, should allow to deal better with new insights in soil science, than the rigid hierarchical systems used up to now.

It is also a challenge and an opportunity for a number of regional soil services within single countries in Europe to transcend their differences and adopt WRB as a national classification system as a national approach in line with, and endorsed by the IUSS.

Fundamental differences between map legends and soil classification systems should not be confused, while trapfalls related to an unwarranted faith in (pedo) statistics, laboratory results and computer modelling should not be pursued at the cost of less field observations.

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GUIDELINES FOR ESTABLISHING SOIL SERVICES (SURVEYS) AT REGIONAL LEVEL

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Foreword

At the moment in Italy there is a great interest for soil survey at local level; in different parts of the country, probably as effect of technical courses and experimental works done during the beginning nineties, local centres for acquisition and implementation of soil information are becoming reality. These centres are settled in public bodies, generally involved in agricultural matters, belonging to regional governments.

The general purpose of this presentation is to support the "entering in force" of these centres, aiming to the organization of one centre for each region; so this work is primarily devoted not to soil scientists, but to decision – makers. Now decision - makers, and have to decide about the opportunity of transforming a general interest about soil resources and their sustainable use in a permanent effort of knowledge and application of this knowledge: this effort should bring to what we call here the "Regional Soil Service".

A scientific Committee, to support the Italian Ministry of Agricultural Policies for the creation of the National Observatory for Soil and Soil Quality, is active in our country since January 1996. The activity of the Committee is organized through plenary meetings and working groups. One of these working groups was established in July 1996, almost at the beginning of the activities, and was charged of the general task described with the following communication: the elaboration of a booklet containing the guidelines for organizing Regional Soil Services.

The working group involved four members of the Committee; three more soil scientists prepared specific parts of the document.

The main steps of the work were:

1. activation of the Working Group - WG (Rome, July 1996): identification and subdivision of the main subjects, plan of the booklet;

2. first progress meeting (Cagliari, February 1997): general outline, examination of the first chapters and common presentation of the three main parts of the booklet;

3. first circulation of drafts, general discussion and re – orientation of contents (Rome, summer 1997);

4. second progress – meeting (Florence, January 1998): refinement of chapters, coherence among Parts;

5. third progress – meeting (Milan, February 1998): insert of specific contributions, final release for general circulation;

6. approvals of the Committee and by the Conference of Experts nominated by the Regions (Rome, Spring 1998);

7. editing of the booklet (Rome, Summer 1998).

The booklet is organized in the three following "Parts":

I. why a regional soil service;

II. state of the art in the different Italian administrative regions;

III. general guidelines for establishing the service at regional level.

The cover of the booklet (figure 1) was studied by a soil scientist to show the twenty different regions composing our country (marked by administrative boundaries) and the underlying soils, basic resources that should be known and managed in a co-ordinate and sustainable manner.

1. Why a Regional Soil Service

The Part I is subdivided in six chapters, and has the general purpose of introducing and explaining the usefulness of a regional soil service; facing the problems each region has (agricultural development, land use planning, environmental resources protection), the single chapters outlines and to describes how such a service should support the regional government and local decision - makers.

Figure 1

The cover of the booklet

So the focus of the Part I is on:

- the acquisition of knowledge about regional soil resources;
- the application of this knowledge for practical problems.

The Part I underlines the role of soil resources in ecosystems and thus the usefulness of inventorying these resources for proper and sustainable management. The main subjects of the Part I are:

1. soil functions;

2. soils as basic environmental components;

3. soil bodies as basic references for land use planning;

4. roles and functions of a Regional Soil Service (RSS);

5. disseminating the RSS activities and opportunities.

2. State of the art in the Italian administrative regions

The Part II is subdivided in eight chapters and has the general purpose of:

- supporting the evaluation and reporting of the current situation in the regional soil centres;

- describing the current demand of soil information at regional level;

- reviewing the degree of knowledge on soil resources locally acquired;

- outlining the amount of resources actually implemented;

- supporting the evaluation of the gap between the current situation, in different centres, and the purpose and proposals described in the booklet (particularly in the Part III).

A more complete understanding of the state of the art for the regional soil surveys needs to be implemented with the results of the "Moncapri Project", reviewed and reported in these Proceedings by Lulli and Gardini in the presentation "Soil map monitoring of Italian regions".

The eight chapters of the Part II describe the current status of regional soil surveys and centres, their application and dissemination activities, focusing on:

1. a synthesis of cartographic outputs available;

2. an overview on the technical offices and centres currently established;

3. the human resources really employed (permanent) in soil sur-

vey activities;

4. the available support services (e.g.: laboratories for soil analysis);

5. the amount and quality of HW and SW;

6. the co-operation network connecting each centre;

7. the financial resources (excluding salaries and general costs) yearly available for increasing knowledge about regional soils.

We can easily review and comment some aggregates in the conclusion from the Part II:

1. in 90% of the twenty Italian administrative regions there is a nucleus of permanent soil scientists (pedologists), potentially increasing for organizing a local soil service;

2. these nucleus are constituted by at least two pedologists, even if in seven cases there are at least four pedologists;

3. twelve laboratories for soil analysis are part of the local soil surveys, and could support the routinary service activities;

4. fourteen cars are available for field activities;

5. not less than 2.5 million euros are yearly available for survey and mapping activities.

3. Guidelines for establishing the service

The Part III of the booklet is subdivided in six chapters, and has the general purpose to identify and describe the main steps (not chronologically ordinate), leading to the institution of the Regional Soil Service (RSS). Five chapters are devoted to the description of the RSS itself, while Chapter 6 deals with the relationships of that service in a nation-wide and continental-wide perspective; the last chapter of the booklet, being crucial in the meaning and tasks of this meeting, is specifically discussed in the last paragraph of this presentation.

Chapter 1 and 2 may be summarized by the sentence "who will do what?". Chapter 1 deals with the basic education and the professional standard of SRR staffmembers, as chapter 2 deals with the main fields of activity of the service. Even if we believe that the service activity is based on common projects and condivision of responsibilities, we propose as main sectors of organization the following:

- soil survey and mapping – analysis?;
- soil interpretations;
- (soil analysis) soil conservation – protection? ;
- soil database management;
- dissemination of soil information.

The Chapter 2 is strongly related to the themes reported in the Part I, answering to the question “why a soil service?”.

The contents of chapters 3 and 4 can be summarized by the sentence “how and where?”. Chapter 3 deals with methodological and technical standards characterizing the different areas of activity , in a nation-wide a continental-wide streamline. So basic matters of co-ordin gement; the dissemination of soil information and its application to practical purposes. Chapter 4 deals with a very delicate subject, that is the organization of RSS facing with Italian public bodies regulations; also the location of this service, compared with its administrative orientations and priorities (agriculture, soil protection, soil remediation) and the financial support, are briefly outlined in chapter 4.

Chapter 5 is devoted to the quantification of the different resources implemented in RSS activities, and can be summarized by the sentence “how much?”. So the chapter 5 deals with the quantification, according to a regional surface module of about 600,000 hectares, of at least the following arguments:

1. how many pedologists have to compose a “minimum size” RSS, in the first steps of its activities?

2. what’s the reason to expand this “minimum size” staff?

3. how many untrained persons should be added to the pedologists, to improve their effectiveness and efficiency?

4. what’s the minimum equipment supporting the service activity?

5. what’s the minimum amount of financial resources allowing the RSS to gain, year by year, a significant and useful “know how” about regional soils?

We summarize here some answers to the questions reported above, in the same order:

1. the minimum size of the service, for its effective "entering in force", is of at least 4 – 5 pedologists; even in the smallest regions, such as Valle d'Aosta, Molise, Umbria, we believe that this group should ensure the covering, with satisfactory quality standard, of the different work areas requiring the RSS routinary activity;

2. the staff should be expanded in the widest regional surfaces (we estimate one person more each 400,000 hectares) or where the RSS has to solve particular, urgent or specific tasks;

3. we believe that the pedologists should be supported by two persons for each pedologist, dedicated to support services, field operations, laboratory maintaining, data entry activity, and so on;

4. the service should dispose of a basic equipment, such as at least one car for survey, one laboratory for routinary analysis, library and basic literature to consult, archives of aerial photographs and maps, basic HW and SW for storing and manipulating soil information;

5. the financial support, to improve and maintain the basic knowledge on regional soil resources, is yearly estimated in 300,000 euros for the minimum size staff, expanding since at least 75,000 euros for each additional staffmember (pedologist).

4. A first balance: at which point of the walk?

The real possibility of establishing RSS has to be faced comparing, the current situation in the different Italian regions, and the organization presented in the booklet, described in the Part III and summarized in the previous paragraph of this paper.

Basically we use here two elements for evaluating how far we are from a generally distributed model of RSS, at regional level:

1) the amount of human resources actually involved compared to the amount estimated for activating the RSS on a nation-wide perspective;

2) the amount of financial resources actually implemented in regional soil surveys compared with the minimum budget for each RSS proposed in the booklet.

Starting from the first point of view we can conclude that instead of one hundred pedologists requested in order to apply the organization model of RSS nation-wide, we dispose now of not more than fourthy pedologists.

With regard to the second point of view we can easily estimate about 7.5 millions euros per year are globally necessary for RSS activities, instead of the 2.5 millions currently available.

Following these data we should estimate that we are not far from the half of the walk, but we do not know how many years we will need to complete this walk (at least the first part of the walk), nor how much "undulated" it will be.

Of course a glimpse of optimism is necessary: we must interpret as a key of this optimism the very recent availability of about 6 millions euros for elaborating, in fifteen Italian regions (more than the 80% of the national land) the first approximation of the soil map of Italy, at scale 1:250,000, in the frame of the European Soil Bureau continental-wide project (see other presentations in the Proceedings for more detail, such as the paper by Costantini "Preparing the soil survey of Italy at scale 1:250,000").

We can assume that if we are able of showing the effectiveness and efficiency of using this money for inventorying soils, a great part of the financial resources requested for applicating the model here presented, will be provided by the same source of financing during the next four years, in the framework of the so called "Interregional Programs". From this perspective the walk will be completed very quickly.

5. Last chapter of the booklet: one of the reasons for this meeting

In this presentation we dedicate a special attention to the chapter 6 of the Part III. When this chapter was elaborated the reasons of this meeting were not so evident, nor urgent, and the meeting itself was not in our agendas.

We must remember the conclusions of the previous paragraph, underlining the quite recent perspective of organizing a network of at least fifteen Italian regions working together on the same common task, financially supported: the first approximation of a soil map of Italy at scale 1:250,000.

Now we can easily introduce the general theme of the Chapter 6 – Part III, answering to the sentence "with whom are we walking?". The meaning of this chapter focuses on the following basic concept: the RSS itself, its quality and users orientation, will decrease rapidly if it is non connected in a network at interregional, national and European level.

At national level we think that this network should have at least two references:

1. the projects and tasks practically involving different regions: we cited the map at scale 1:250,000, but we can add: the SINA project, financed by the Italian Ministry of Environment and co-ordinated by the Regione Emila – Romagna; the ecopedological map at the same scale, for the whole national land (see the presentation of Montanarella, "The role of European Soil Bureau and the perspective of a 'nested' soil database"); or the program plans elaborated by interregional authorities, such as the Po Basin authorities;

2. the activity and role of the National Observatory for Soil and Soil Quality, on the behalf of which was created the Conference of Regional Soil Experts; this is a the moment the natural point of confluence of the different regional activities, it stimulated the financing of the soil map at scale 1:250,000, and it will stimulate once more the allocation of funds available in the so called "Interregional Programs". The network of RSS will be greatly helped with the approval of a proposal of Decree, discussed and elaborated within the Observatory; the matter of this Decree is the "Nationally Distributed Soil Service", dealing with a network of RSS with a national co-ordination.

At European level we already mentioned, so many times, the recurrent co-operation with the European Soil Bureau; just to summarize the main points of this co-operation:

1. the first Pilot Zone of the Georeferenced Soil Database at scale 1:250,000 is settled in Northern Italy, on the behalf of the co-operation of ESB and five Italian administrative regions;

2. the ecopedological map of Italy will hopefully engage during next two years the twenty Italian regions and the ESB;

3. the ESB is officially involved in the program of the soil map of Italy at scale 1:250,000.

Closing this presentation we will promote the role of RSS in a European perspective: in fact in UE we can observe different policies impacting on soil management; we can mention here the agri – environmental regulations, the reform of rural policy contained in Agenda 2000, the Documents "European Space Development Planning", "Toward sustainability" and "Revision of regulations for rural development". On the other hand we see that the soil is also interested by different policies at regional level, many of which influenced by UE regulations: the sewage sludge treatment and spreading on soils, the nitrate vulnerability, the space planning at municipality level, the soil protection at catchment level.

Being the soils not so moving as air and waters, their sustainable management is a matter of regional/local evidence, but we need a common framework to inventory European soils and interpret their properties for practical purposes, and for different departments and agencies of regional government (Agriculture, Forestry, Environment, Public Health, Public Works).

After the meetings in Silsoe (1989) and Orleans (1994), devoted to the state and perspective of soil surveys at national level in Europe, and joining the meeting held in Hannover (1996) within which many presentations dealed with regional subjects, we believe that the time is coming for a closer co-operation among European regions of UE. With the umbrella of the ESB and the standing protocols (e.g. Convention of Alps, Four Motors of Europe, Alpen Adria – Arge Alp), this co-operation should link efficiently and effectively the demand of soil information at local level with the vision of a sustainable development all over the continent.

We thank to Dr. Carlo Riparbelli for the final revision of the document.

DEMANDS AND PROBLEMS FOR A REGION SKILLED IN SOIL INFO

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1. General description of the Emilia-Romagna region

The Regione Emilia-Romagna has a population of slightly less than four million people and a total surface area of roughly 22,000 km^2. Soils surface area is about 94% of the regional territory; the other part, not covered by soils, is mainly rock outcrops, fluvial beds, water bodies and urban areas (this estimation is based on the 1:200,000 regional land cover map). Approximately half of the regional soils is in the fluvial plain and the other half is in the Apennines.

Soils is in the fluvial plain cover a continuous area, from the Po river and the Adriatic sea coastline to the first Apennine reliefs. The elevation typically ranges from -3 to 100 m. The temperature regime is mainly temperate subcontinental. Values of water surplus are about 50-300 mm per year; water deficit occurs especially in the summer, with mean values around 150-250 mm, which are mitigated by the high relative humidity of the air and, locally, by ground water supply.

Main present land uses: arable, fruitgroves, vineyards, commercial vegetables, rice fields. Main soils: Calcaric Cambisols, Gypsic Vertisols, Haplic Calcisols, Eutric Vertisols, Chromic Cambisols, Calcaric Arenosols, Thionic Histosols (according to the FAO legend).

Note: The opinions expressed by the authors are of a personal nature and do not necessarily reflect the views of the Regione Emilia-Romagna and of the regional Prevention and Environmental Agency (ARPA).

Soils in the Apennines cover a continuous area from the first hills at the plain border to the Apennine ridge. The elevation typically ranges from about 100 to 2,000 m. The temperature regime varies from temperate sub-continental to cold temperate and, on the highest peaks, to high mountain regime. Water surplus and water deficit vary, respectively, from 800 and from 150 mm (in the low Apennenine border facing the plain) to more than 1,200 mm and to less than 10 mm per year (in the high Apennines). Main present land uses: arable, vineyards, fruit groves, oak-dominated woods, beech-dominated woods, pastures, parks. Main soils: Calcaric Cambisols, Calcaric Regosols, Eutric Cambisols, Dystric Cambisols, Umbric Leptosols, Haplic Luvisols, Ferric Luvisols, Vertic Cambisols (according to the FAO legend).

2. The system of regional services which deal with the multiple functions of the soil resource

In Emilia-Romagna there are numerous regional services which are active in many fields involving soil information issues, e.g . Land Economical Planning Service, Agricultural Planning Service, Landscape Bureau, Forestry Bureau, Agro-Meteorological Service, Soil Conservation Service and Catchment Authorities. The main soil data collection has been carried out by:

- the Pedological Bureau, which is a part of the Geological and Cartographical Service;

- the Agronomical methods team, which works within the Food and Agriculture Development Service;

- the Soil Chemistry Specialistic Analytical Areas of Department Sections in Piacenza and in Ravenna, which work within the regional Prevention and Environmental Agency (ARPA).

2.1. Pedological Bureau

Its aim is to serve as a point of reference for the numerous regional and local services and external bodies which are active in land planning and management, to provide them with comparable geographical soil information and to facilitate the participation in the decision making process.

Its main areas of activity are:

(i) soil survey, soil mapping and the implementation of the soil information system;

(ii) cooperating in the broad interdisciplinary use and dissemination of soil information.

The permanent staff consists of four pedologists, assisted by numerous professionals, private companies, research and experimental institutions and universities. Being a part of the Geological and Cartografical Service facilitates the integrated approach to problems with other specialists (namely geologists, geomorphologists, hydrologists, agronomists and specialists in forestry, vegetation, satellite image processing and geographical information systems), so that individual and collective capacities are increased.

The regional soil survey programmes were initiated in the mid 1970s. They were set up as a permanent process, which is still going on. Without the intention of describing the soil in a definitive manner, soil information is collected through a series of subsequent approximations. So, as in the past years, the present approximation to the knowledge of the soil is a means of cooperating with the different regional services dealing with the application of soil data to specific topics. This joint effort, which facilitates the dealing with of the problems incountered by the final users of soil data and the collection of feedback from the users and other specialists, is a concrete starting point to future approximations to the soil knowledge, so taking into account urgent matters and priorities. Aimed at more and more "demand driven and results oriented" soil survey projects, soil information is improved by its integrated and intersectorial use.

Soil information is collected at three complementary levels of detail:

- at the reconnaissance level it is available in the whole region (e.g . 1:250,000 soil map, edited in 1994);

- at the semi-detailed level it is available in the whole plain and in a few reference areas in the Apennines (e.g. 1:50,000 soil map of the plain, 1998);

- at the detailed level it is available only in small reference areas (e.g. 1:10,000 soil map of agricultural experimental fields; benchmark sites with measurements for specific topics).

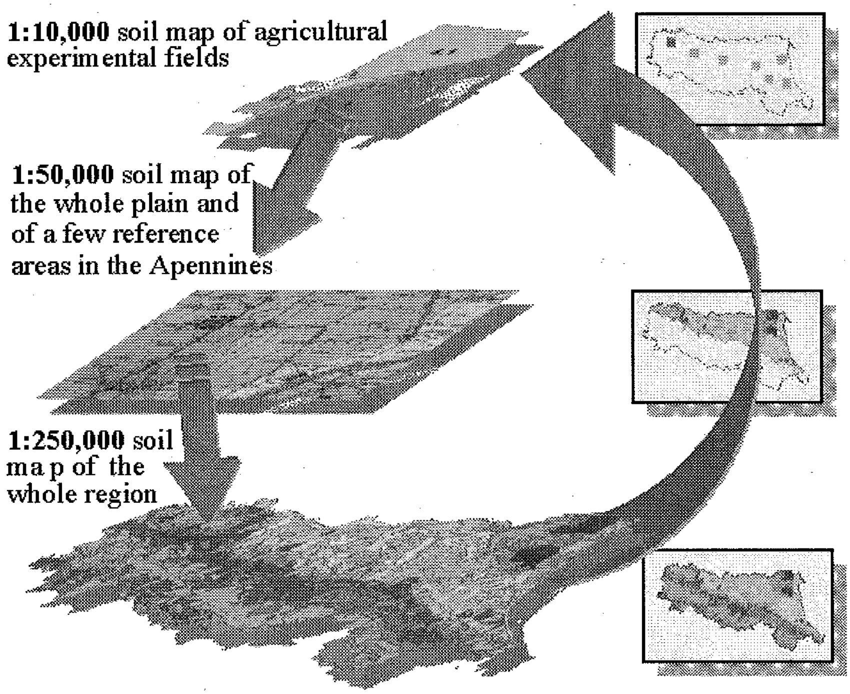
The coherence and the linkage of the soil data which are available at different levels of detail facilitates their use as a flexible reference network (figure 1), e.g. to:

- generalize local experimental results by extrapolating the information to similar soils;

- support the choice of benchmark sites according to their representativeness.

Figure 1

The coherence and the linkage of the soil data which are available at different level of detail facilitates their use as a flexible reference network



The next step in the efforts of making soil geographical information broadly accessible to the general public will be taken at the end of this month via Internet. But for the effectiveness in communicating soil information, to make it more comprehensible and appropriate to target groups, cooperating with the users remains crucial; until now, the main efforts in cooperating and improving communication language have been in the agro-environmental sector (see 2.2).

Interregional cooperation has increased in the past years, to improve comparability of soil data and criteria in their use for applications. In particular, within the activities of the interregional project "SINA-Carta pedologica", financed by the Italian Ministry of Environment, and in agreement with the European Soil Bureau, the Pedological Bureau is cooperating with other Italian regional soil services and with research or experimental institutions (e.g. Istituto per la Genesi e l'Ecologia del Suolo, Istituto Sperimentale per lo Studio e la Difesa del Suolo) to (i) define a common georeferenced soil database in a way which best ensures compatibility and comparability with the Manual of Procedures for the European soil database (European Soil Bureau, 1998) and (ii) evaluate the local performance of models and pedotransfer functions for water vulnerability assessments.

2.2. Agronomical methods team

The agronomical methods team is included in the Food and Agriculture Development Service. Its activities are aimed at cooperating in the determination of the agro-environmental programs and providing tools for their fulfilment, with reference to:

(i) fertilising: the extension service started in 1979 in order to provide farms with a rational fertilising plan, which is based on soil knowledge; it aims to facilitate the application of the integrated production guidelines;

(ii) manure, sludge and other organic materials management, in collaboration with the regional environmental department;

(iii) providing farms and extension technicians with the necessary soil information, which is integrated with the pedological bureau soil information system, in order to support a proper farm management and implementation of EU agricultural regulations; currently the soil database is supplied with the "Global Information Agricultural System", a software integrated system which is available to all farmers and extension technicians and to anybody who is connected to Internet;

(iv) elaborating and divulgating thematic maps, derived from the pedological bureau soil maps, in order to support agro-environmental and forest technical assistance at farm and larger area levels:

- agricultural practice guidelines map, based on the 1:50,000 soil map, is available on Internet at:

http://www.regione.emilia-romagna.it/ass_agricoltura/newass.htm;

- regional catalogue of main Apennines agricultural soils, based on the 1:250,000 soil map;

- regional catalogue of soils in the plain, based on the 1:50,000 soil map; a first version is available in Internet at the official site of "GIAS" project: http://www.gias.net;

(v) agricultural research and experimentation: tending first to create a soil evaluation grid in order to provide assistence in the choice of crops based on their nutritional requirements;

(vi) the control of the effectiveness of the measures, by monitoring:

- the agricultural practices in the farms included in the programs of the extention service;

- the effects of the adopted criteria for nitrogenous fertilization on water bearing stratum and on the unsaturated layers of soil;

- the validity of the practices of fertilization in experimental farms.

2.3. Prevention and Environmental Agency (ARPA)

Being one of the main environmental factors, in addition to air and water, soil is one of the principal topics in question by the ARPA. The activities conducted regarding soil can be distinguished as follows:

(i) surveillance activities, regarding actual or potential soil pollution, conducted by specific ARPA department sections, through territorial services, which are themselves almost always divided into districts (i.e. areas containing one or more municipalities which are similar in terms of environmental and/or production features);

(ii) Monitoring and control of contaminated soils, as well as their reclamation, carried out by the ARPA department sections, through the various "analytical areas". In particular, the department section in Ravenna holds the title of "excellence" with reference to the topic "reclamation of contaminated industrial sites";

(iii) Characterization of the soils by their physical-chemical analyses, evaluation of their agronomical characteristics, in order to support the agricultural activities, the monitoring and the evaluating of agricultural use of sludge, compost and manure. These activities are carried out by the soil chemistry "specialistic analytical areas" of department sections in Piacenza and in Ravenna.

This draft shows that within ARPA, which is structured as a network system, different soil issues are pertaining to the various knots of the network.

3. Demands and problems

The Emilia-Romagna integrated system of regional services which co-operate in the soil data collection and in the broad interdisciplinary use of soil information seems to be sufficiently well structured and flexible, so that:

- excessive duplication of effort and dispersion of activities are avoided;

- practical results are adjusted to priorities and achieved.

In order to improve the effectiveness of this system it would be opportune to consolidate the existing services by exploiting their specificities and to promote a closer collaboration among them. Main priorities are listed below.

(i) Training of the personnel

Of utmost importance is the strengthening of soil management training programs for technicians who carry out environmental monitoring and for technicians who provide assistence to agricultural companies.

(ii) More continuity in the cooperation with professionals and private companies

With regard to the soil survey and soil mapping activities, top quality professionals and private companies are already available, even if specific professional training opportunities would be welcomed. On the other hand, since the trend is to reduce public technical services, the small nucleous of the Pedological Bureau's permanent staff demands for more continuity in the cooperation with professionals and private companies. Soil maps and soil data bases can express only a part of the knowledge acquired in the field during survey; the other tacit knowledge remains in the minds of soil surveyors (e.g. local experience, with feedback from land managers, and the defining of alternative untested hypotheses on local models in order to extrapolate point data or to describe specific soil functions). It is therefore opportune to find a way to exploit human resources in order to adeguately deal with the increasing quantity and variety of requests of the application and dissemination of data.

(iii) Communicating information

New technology (e.g. Internet) is facilitating public access to soil information. However, in order to communicate information effectively, cooperating with the final users of the data, involving land managers and improving interdisciplinary comprehension remain crucial, because information needs to be properly interpreted and converted to each target group.

(iv) Closer linking of soil databases

The georeferenced soil database, whose definition is in progress within the activities of the three year interregional project "SINA-Carta pedologica", seems to be a good reference in order to get a closer linking of soil databases.

(v) Interregional harmonization

The need for closer cooperation among regions requires coordinating bodies at a national level. It goes without saying that, in order to avoid the duplication of regional and nationals activities and data, the auspicious national institutions should be responsible for soil data appropriate for nationwide analyses.

The Regional Environmental Agencies (ARPA) have the National Agency (ANPA) as a coordinating body; yet its effectiveness is limited by the fact that many regional agencies are in the process of being set up. Offical standard methods for chemical and physical soil analyses are in existence and applied accordingly (Comitato per l'Osservatorio Nazionale Pedologico e per la Qualità del Suolo). However it is important to improve inter-laboratory cooperation for quality control, not only of soil data but also of the various materials which are spreaded over the soil (sludge, compost and manure).

With regards to the criteria of the use of soil data by the extention services in fertilisation and in manure and sludge use in agriculture, it is necessary to follow up on and encourage the coordinating carried out by the Comitato per l'Osservatorio Nazionale Pedologico e per la Qualità del Suolo which enabled the editing of the Code of Good Agricultural Practice, in the hopes of bringing toghether soil chemists, agronomists and pedologists who work in regional services in order to define a working protocol to direct extention sevices to farms.

The development of guidelines and procedures aimed at improving the comparability of soil survey and soil mapping data collected by various Italian regional services is facilitated by the broad conceptual coherence of soil information, which is a consequence of the either direct or indirect links with the same pedological school (University of Florence). Furthemore, the well-targeted Manual of Procedures of the Georeferenced Soil database for Europe (EUR 18092 EN), which was published a few months ago, is an important reference. However, beyond the manuals, the role of the field soil correlator is indispensable to effectively harmonize the data. Given the importance of the local experience of the correlator, it is crucial to guarantee the continuity of the soil correlator's work on specific projects.

Perspectives for a Region at the Kick-off of its Soil Survey Program: the Case of Calabria

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Foreword

In all productive activities, knowledge is the basis for decision - making. In agricultural activities the available technologies, and the current scenarios deriving from CAP, make evident and urgent the knowledge of relationships between production and physical resources.

So it should be possible on one hand to give answers to demands of quality and tipicity, on the other to support the environmental protection for a sustainable use of land resources.

Besides, the correct management of land can not ignore a deep and articulated knowledge of soils.

Pedology, studying the genesis, the classification and the mapping of soils, is a basic tool to know, interpret and estimate the potentialities and limitations of each tract of land.

Particularly the soil resources, overutilized and thus degraded for so many years, ask for more attention. Organic matter decrease, erosion, pollution, overfertilizing, are in conflict with the demands of environment and consumers protection, and make difficult the possibility of a diffused "Quality" aim.

Being soils limited resources, the sustainable land management is a current and very urgent task for our societies; it is very expensive to renew soils and to restore them from erosion, salinization, pollution, compaction, urbanization, desertification.

Besides, it is very obviuos that "Quality" is the result of precise agrobiotechnologies, but they have to be well related to physical resources. In specific agricultural compartments, such as in viticulture, this assumption is acquired and accepted by consumers. The quality of wine is the performance of grapes and cave – work, but the effect of the territory is fundamental. Thus every approach to quality and tipicity of agriculture products has to be based on the knowledge of environmental resources and, among them, soils are for us the most important.

The zoning of the territory is proposed here as a basic tool to plan agrotechnologies and to orient them to the best relationships existing between physical environment and quality of products. On the contrary the risk is to exclude the policy of quality label from rationale, without supporting the specificity of these products.

This is the reason of the ARSSA program: the agricultural development has to be based on the sustainable use of environmental resources. The specific program on soil survey, excellently elaborated, has the purpose of acquiring knowledge about soils and their distribution, to support effective land use planning and to organize extension services efficiently related to demand of producers.

The new CAP and the GATT agreements

The previuos agricultural policy created overproduction of goods in many sectors, with consequent difficulties for the EC budget.

Thus the new CAP aimed to the extensivation of agricultural production and to the sustainable development, to obtain quality yields and protection of environment throught the adoption of decoupled incentives.

Thanks to the GATT agreement the global exchange of agricultural products is rapidly increasing, as the subsidies, the support to the production and the commercial barriers are decreasing.

If agriculture is devoted to the production of quality and the protection of environment, and, in the same time, is market oriented, for competing at a global level this kind of agriculture should be supported by extension services well organized, particularly engaged in knowing the different tracts of land and the occurring soils.

The policies connected to general support services oriented to agricultural production are, on the other hand, included in the GATT "Green

Box", and they are going to be financially supported during the agreements of the next Round.

The agricultural extension services in Calabria

In 1993 the Region Calabria, with Act n. 15, charged the ARSSA with the mission of promoting the agricultural developmet by:

- initiatives of reallotment, to enlarge the size of farms and promote the cooperation among farmers;

- experimentation, dissemination of knowledge, applied research, professional qualification, education, diffusion of low input technologies, using experiemental farms and fields;

- organization and coordination , preparing one- and three-year programs, of regional extension services;

- experimental agricultural activities at local level;

- different types of extension services (specialized and generalized);

- coordination, through the CESA, of organization and realization of techinical courses, managed by qualified and certified bodies;

- responsibility and management of Technical Support Services;

- preparation of middle – term (three years) and short – term (one year) programs for Rural Development Services.

The Region Calabria, with the above mentioned act, charged ESAC at first, and ARSSA afterwards, with the task of planning, organizing, coordinating and managing the Rural Development Services. This act gives a fundamental, significative role to extension services, as structural component of an integrated system of services: research, experimentation, information, dissemination, consulting. This act officially created the role of "extensionist", assigning and financing 170 of these positions to ARSSA and 64 of these positions to Professional Organizations, in order to create the UDA (Rural Extension Units). The same act requested the distribution of extension services on a regional basis, creating 22 Centres, called CESA, each one covering homogeneous areas for integrated development.At every 2 – 3 centres there is a coordinating and aggregating administrative point (named CEDA).

At the moment 150 extensionists are engaged at ARSSA: 115

of them have a University degree, as 35 have a secondary technical school diploma. In the main Professional Organizations 56 extensionists are working.

We can say that the Region Calabria has done its duty to prepare the agricultural extension services at a regional level: it selected and professionally formed the extensionists, promulgated an act specifically devoted to this matter, created an Agency for managing these services, relating them with other institutions operating on the same sector, particularly Professional Organizations and farmers associations.

Specificity of ARSSA soil survey experience

Soil survey activity in ARSSA started as a regional program within the Agricultural Development Services, supporting extension activities. Thus the main task of the soil survey is devoted to applications for agrotechnologies optimization and for sustainable land use. Soil survey outputs are oriented to support choices of different crops and rootstocks, fertilizing plans, water management, soil conservation and prevention of erosion. The soil maps are expected to show the agricultural limitations and potentialities.

Soil survey applications bring to the opportunity of a semi – detailed survey intensity, just a compromise between the availability of usable and applicable tools and the scarcity of time and financial resources. Great attention is devoted to interpretative maps, for specifical and well defined land uses, such as soil suitability maps, or maps showing single soil factors, such as pH, texture, lime content.

Acquiring and disseminating information about soil properties should support and introduce innovative soil management models into a farm level, finalized to sustainable land management and agricultural products qualification and certification.

Thus, even if a great amount of attention is devoted to matters of soil genesis and taxonomy, we ask researchers and their soil research institutes for more outputs on themes of soil – plant interactions, particularly on questions of the quality of agricultural goods. We believe that soil formation is very important, but ARSSA action in soil survey is mainly devoted to soil qualities and properties related to different land use options.

Soil survey program of ARSSA

On a middle and long term perspective, the main lines of planning for soil survey activities are:

- soil survey of the whole regional land, at scale 1:250,000, to make available a general tool for land use planning at regional and infra – regional (provincial) level, in the different productive and land management compartments. This map gives an overall picture of the main soil typologies occurring in the regionl land, allowing the correct application of CAP guidelines. Those who are responsible of soil survey in the fifteen administrative regions with ordinary statute have prepared a preliminary project, under the examination of the Italian Ministry for Rural Policies. The soil map will be compiled using unified methods and procedures, and it will be harmonized with the general project leaded by the European Soil Bureau, finalized to a Georeferenced Soil Database of Europe at scale 1:250,000. We hope that this program will start as soon as possible, using the financial resources available from the Interregional Program "Agriculture and Quality";

- soil survey of intensively cultivated agricultural areas (coast – plains and inland – plains), for optimizing agro – technologies, particularly the choice of different crops and the preparation of fertilizing plans. The main applications will be finalized to manage the impact of agricultural activities on environment, having in mind economical tasks;

- soil survey of hilly areas, being these the wider agricultural component of regional land, supplying goods of high qualitative value. The sustainable management of hilly land is a strategical issue, both for high capabilities (having goods high bioproductive value) and for high vulnerabilities, such as those related to desertification risks;

- soil survey of areas supplying typical agricultural goods (red onion of Tropea, bergamot, vineyards in certified belts). In these areas there are immediate soil survey applications for agrotechnologies; besides, there are great opportunities for agricultural zoning, defining subzones and showing different levels of tipicity. At the moment these subzones are confused in the general belt, but the consumers should be helped to look for each subtipicity and each subzone. The land description supports the research of a renewed appeal for tradictional and typical goods, it is the base for diversifying their quality, it is the basic tool for preparing and approving "production protocols" related to soil qualities and oriented to the quality of products;

- detailed soil survey of ARSSA experimental farms, to manage experimental programs on a soil basis, enhancing possibilites of agrotechnology transfer to similar soils.

Available soil surveys

We outline here the main results reached and deliverable at the moment:

- the soil map at scale 1:50,000 of the coast - plain of Vaticano Cape – Vibo Marina area, with interpretative maps of soil suitability for Tropea red onion. The surveyed area extends on 8,000 hectares; soil map is finalized to agrotechnology transfer to extension services (sustainable land use, fertilizing and liming plans, cultivar choice). The survey outputs should support the projects to promote the Tropea red onion and to certify the "Geographically Protected Indication (IGP)";

- the soil maps at scale 1:50,000 of the Crati River Middle Valley and of the S. Eufemia - Lamezia Plain. The surveyed areas extend on 40,000 hectares, intensively cultivated with orchard, olive – trees, horticulture. These areas were surveyed within the Soil Mapping Program promoted by the Italian Ministry of Agricultural Policies, co – financed by European Union and the Region Calabria in the framework of the Measure 4 – Task 1 – EEC Regulation n. 2052/88. These areas are representative of the regional soilscapes, including different situations from a geologic, physiographic and anthropic point of view. Beside the soil survey activities there were a specifical training for the whole team of soil scientists; the overall staff acquired a specifical orientation to soil survey and its applications, with a specifical procedure and methodological framework, applicable to future projects;

- soil survey of the Experimental and Educational Centre settled in Molarotta – Camigliatello Silano. The survey was realized thanks to the cooperation between ARSSA and the Experimental Institute for Soil Study and Conservation, and it is a methodological reference for the detailed soil surveys of the remaining experimental farms. The survey concerned an area 260 hectares wide, that we could see as a representative "window" of the geomorphological and pedological peculiarities for the Sila Plateau. Three maps were compiled: soil, land capability, current and potential erosion risk;

- land use map of the Middle Ionian area in the Catanzaro Province, at scale 1:50,000. The map shows an area 100,000 hectares wide, extending on the ionian coast range and plain, from Botricello to Squillace, including part of the Sila Piccola Mountain. It represents just one of the different information layer to approach an integrated inventory, but it is useful for the preliminary orientation of the extension programs and, on a broader perspective, for land use planning. The results were disseminated among the different potential users, in public and private sectors;

- two monographies, dealing with "fertilization guidelines" and "irrigation management" for the published soil survey areas. These information, even if limited by the scale of the reference soil maps, are directly applicable, in the different mapping units, by extensions, operators and farmers.

Current activities

Within the soil survey program, the priorities are assigned to areas cultivated with vineyards, not only because it is economically crucial at a regional level, but also for the existing relationships between environment and grapes and wine, as these relationships are well recognized by consumers.

Following the indications of the National Act n. 164/92, dealing with the geographical identification of wines, the ARSSA priority is to finalize soil surveys to "zonation" of the main "wine belts". The mentioned act allows to qualify and typify the products (the wine) through the identification, within the already delimitated "wine belts", of "subzones" or "microzones", showing specifical environmental features, as reflected in the wines quality (articles 2, 4 and 6 of the Act). These subzones, or microzones, can be printed and promoted on the labels of bottles, and must be identified on topographical maps by scientifical, not political or administrative, criteria. The criteria should be completely different by the ones used in the delimitation of "wine belts" (areas with certified origin denomination, DOC).

The "wine belts zoning" is seen as the technical tool useful to define suitable zones and to exclude unsuitable ones, starting from homogeneous ecosystems, characterized with typical soils and climate conditions, with peculiar interactions between vineyards and environment.

At the moment the soil survey of "Cirò wine belt" is the priority of the program, being the most important wine belt of the region. The wine here producted is presumed to be, following the World Vineyard Encyclopedia, the oldest among the spirits in the world; it occupies a satisfactory market position, in Italy as abroad.

Perspectives

Within the re-organization processes of ARSSA, a strategical task is the organization of a "Regional Soil Service"; this service, moving from existing units and resources, will be oriented to manage the current soil survey programs, augmenting the organization capacity and the finalization of inputs. Such a service, autonomous enough for organization and management subjects, is much more urgent looking at the task of preparing the soil map of Italy at scale 1:250,000. The soil service functions should be the following:

- definition of soil survey scales, classification criteria, operational and methodological standards;
- definition of protocols for soil survey contracts;
- coordination and quality control of soil survey contracts;
- interpretation of aerial photographs;
- soil survey;
- laboratory analysis;
- soil classification;
- preparation of maps, legends and reports;
- identification of specifical land use problems, compiling the related thematic interpretation maps;
- soil data management and updating, using database and GIS;
- dissemination or results.

English version by Romano Rasio, with the cooperation of Maria Luisa Gargano

Soil Map Monitoring of Italian Regions

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Introduction

The Moncapri project contemplates a monitoring activity of nation-wide soil maps to realise an updated and also updatable database on principal information about realised and occurring soil surveys in Italian Regions. Furthermore in late 1999 a database of representative soil profiles of Italian Regions is expected to realise.

The soil map monitoring belongs to Regional Bodies with a their own regional officer experts on soil science capable of compiling some prepared cards about maps and soil surveys of their own Region.

The 'Istituto Sperimentale per lo Studio e la Difesa del Suolo' di Firenze, by Luciano Lulli, director of Soil Genesis, Classification and Cartography section, is in charge of the whole project and collaborates with Costanza Calzolari of the Soil Genesis and Ecology Institute of the CNR in Florence and with Gilmo Vianello of the Soil Experimental Center in Bologna, to collect and to computerise soil maps sent from the regions.

The planning, realisation and database maintenance are done by Lorenzo Gardin.

Objective 1

The first Project's objective has been the creation of a computerised cartographic repertoire, realized on the information collected by every region

Such objective is of great importance for the followings reasons:

- we have tried to acquire, and then to spread, the greatest number of soil map information either of the past (distant and recent), or of the immediate future, with a monitoring criterion for a continuous transfer of information in both directions;

- many are the users that can utilise such information, not only experts, but also those who work on the territory study and management or on environment, including activities related to the landscape, to environmental engineering, et cetera;

- we think that such a project can also constitute a first embryo of information management on a national level, and it can also be an information reference for community, national and inter-regional projects.

The creation of a computerised soil map inventory has foreseen the following work phases:

a) arrangement of a card useful to collect information about every pedological map from the National Soil Observatory;

b) compilation of the cards by Regional Soil Experts, or by delegates with specific competence in the pedologic field;

c) realisation of a database of all received information by the Experimental Institute for Soil Study and Defence;

d) diffusion of a computerised inventory to the Regions and other potential users.

<u>The available information</u>

For every soil map the followings data are reported:

1. geographical and environmental location of the soil map, principal lithologic and morphological characters of the surveyed surface;

2. survey characteristics (author, date, scale, surface, number of observations, number of profiles, type of adopted classification);

3. description of possible derived thematic maps;

4. data accessibility: availability, data dimension, data publication.

The software

For an easier consultation of the information included in the database, a working application has been realized by MS Access allowing to ask for the original data of single regional cards and to access to a series of answers to the most frequent applications. The data are organised in a geographical context (related to the national, regional or provincial territory) and also according to their content (data related to the soil maps, data related to the punctiform observations, data related to the derived thematic maps).

Every application is shown on the screen and you can directly print it. The application will also be spread short-term by Internet.

Objective 2

The second objective, in progress of realisation, foresees the making of a first catalogue of representative soils pedons, carried out with the information provided by every Region

The benchmark is a soil having a certain extension in the Region, that is consistent of well identified and recurrent landscapes in the regional land, whose data about characters and behaviours are known. The benchmark also has a specific importance in the agro-silvo-pastoral, environmental, ingegneristic field.

A benchmark soil may represent other similar soils. So that, the knowledge of the characters and the behaviours of a benchmark soil is important to be able to understand and to interpret other soils with analogous properties.

The aim of a first inventory of the representative soil profiles of the Italian Regions is to show the characters and the qualities of soils that have a certain importance in the territory, often indicated by different names or symbols in different Italian Regions. A first database of benchmark soils becomes therefore a helping tool in understanding, interpreting and appraising pedological information for surveyors and administrators of soil data; it is also useful to favour the comparison between the different regional experiences in the pedologic field; and finally it forms the basis for a first soil correlation outline at an inter-regional and national level.

This first exploration of soils of the Italian Regions aims to collect some profiles of the more diffused soil typologies in the regional territory; subsequently, when the level of knowledge of the soils will be more homogeneous, it will be important to pass to a real cataloguing of the soil typologies (be they soils bodies, soil series, taxonomic units, or benchmark soils).

For the realisation of this objective, defined and approved by the Advisory Committee of the National Pedological Observatory, the phases of development are the following:

1. the regional experts select the descriptions of the representative soil profiles of their own Region and send them to the Istituto Sperimentale per lo Studio e la Difesa del Suolo;

2. the Institute acts out the realisation of a special database, the computerisation of the received data and their divulgation.

We consider that this objective can form the basis for a "bird's eye view" on soil information at a national level.

• such objective more effectively respond to the need of training Italy to map soil at the scale of 1:250,000;

• it can constitute an integration of data for the soil map of Europe (1:1,000,000) that is nowadays an important community tool for soil resource management;

• it may become an interesting initiative to let data and pedological information flow into the Analytical Database of the project MARS of the European Union.

A brief remark about first data

The soil maps present in Italy are different for their methodology, system of classification, scale because the purposes and aims of the various surveys have been different. Nowadays the data report 433 soil maps in Italy.

In figure 1 we can see the number of soil maps realized in Italy (divided in three macro-regions) since the 1950's to now; we can see a rapid departure in the macro-region where there was a soil school, a peak in the 1970's due to the birth of the Regions, and subsequently due to the Community financing.

In figure 2 we can see the surfaces covered by soil maps in hectares in the three macro-regions. The maps are divided in detailed (scale denominator less than or equal to 25,000), semi-detailed (scale denominator from 25,000 to 100,000) and of recognition (scale denominator from 100,000 to 250,000).

Figure 1

Soil maps realised in Italy through ages

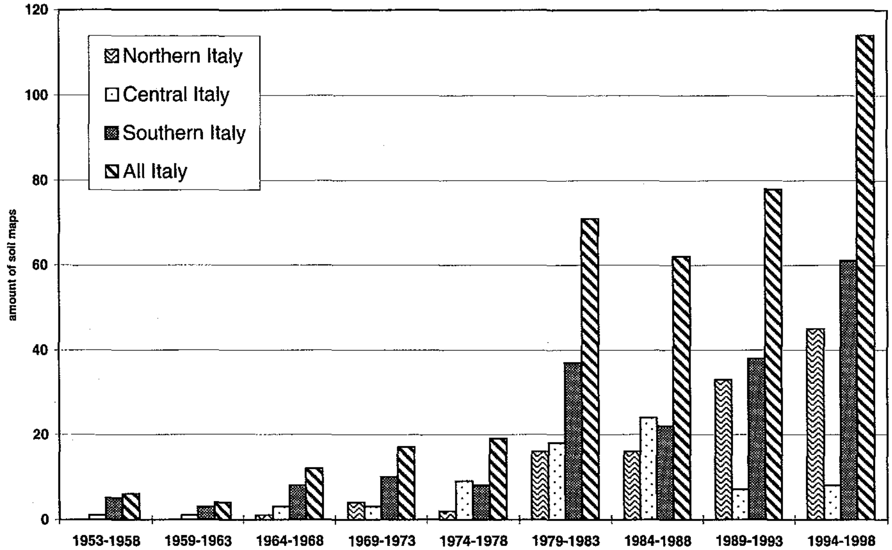


Figure 2

Soil maps coverage

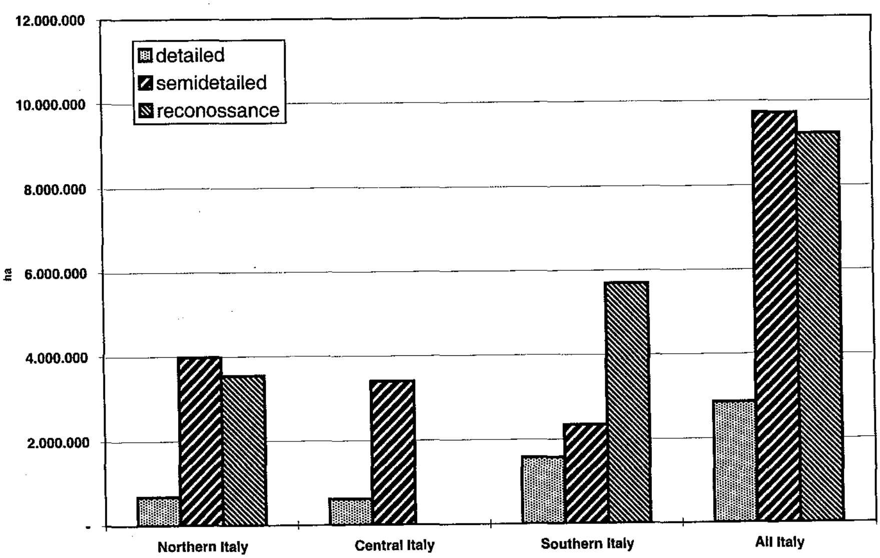


Figure 3

Percentage of soil map coverage on surface coverage

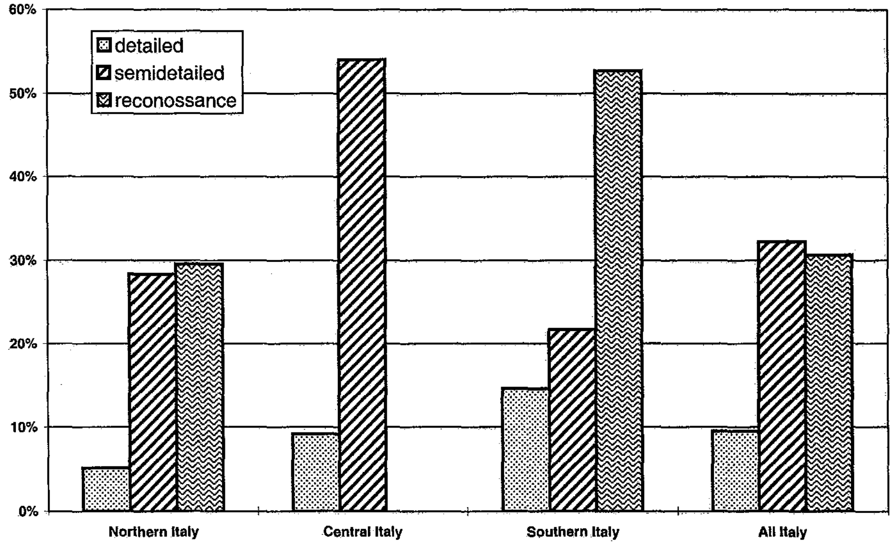
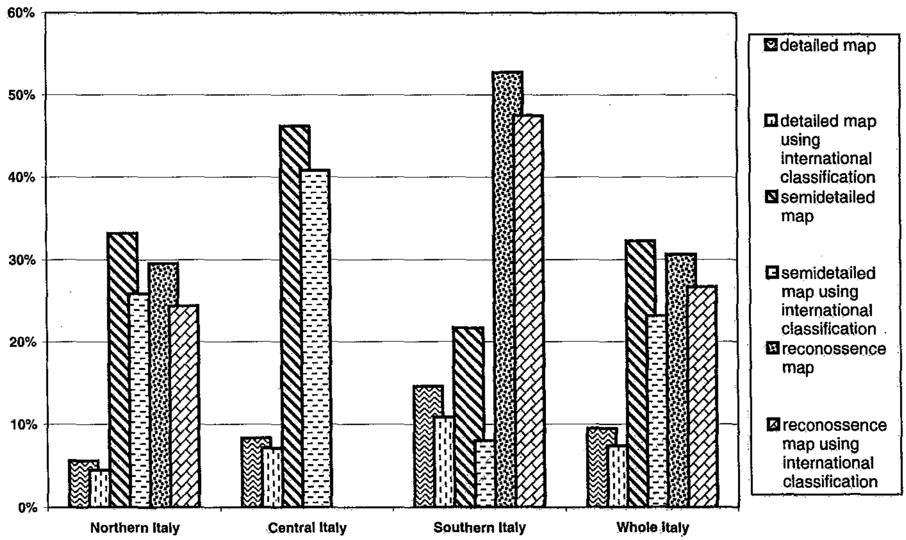


Figure 4

Comparison between all soil maps coverage and using international classification soil maps coverage (percentage of macroregional surface)



In figure 3 we have the percentage coverage values of soil maps of the whole of Italy. In Italy there is still a lot to survey; values around 30% of surface covered by semi-detailed and recognition soil maps appear very low.

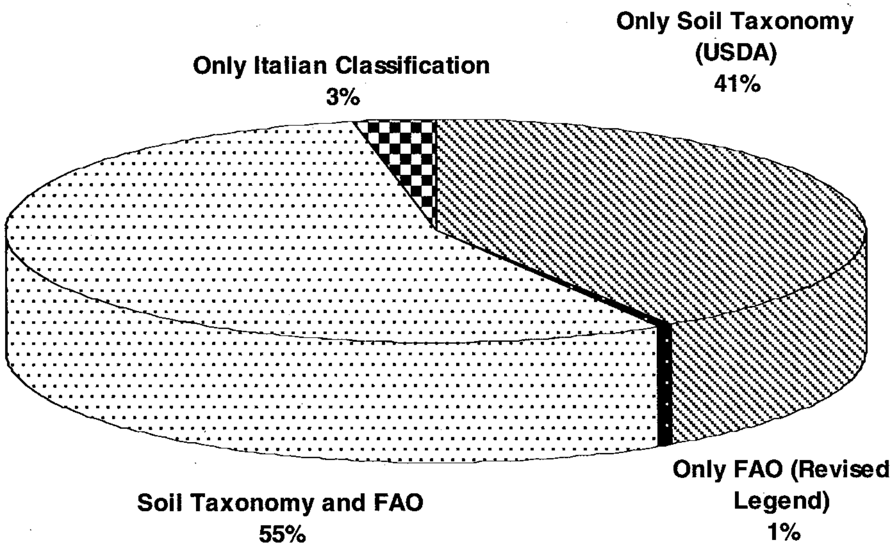
Most of the soil surveys realized in Italy have adopted international systems of classification (FAO and/or Soil Taxonomy). In the following graph (figure 4) there are the coverage percentages, related to the total surface, of all soil maps and of those used by international systems of classification.

As regards to punctiform observations, profiles and borings are around 200,000 in Italy; the profiles are about 20,000 of which 16,877 (84%) geo-referenced.

In figure 5 the distribution of the geo-referenced profiles according to the classification system is shown.

Figure 5

Georeferenced soil profiles classification systems



The applications

The applications of the soil surveys are very numerous and diffused in Italy; among the different types the Land Capability is the most common, but in recent years we have witnessed an orientation toward dark specific evaluations instead of general evaluation models. Following, in table 1, the principal application typologies, their extension and the coverage percentage related to the national territory are reported.

Table 1

	ha	% national land
Land Capability Classification	12,800,969	42.5
	12,800,969	***42.5***
Agriculture evaluation		
arboreal crops suitability	99,959	0.3
grass crops suitability	245,295	0.8
horticulture suitability	7,596	0.0
viticulture suitability	133,654	0.4
	486,504	***1.6***
Forestry evaluation		
Forestry crops suitability	60,424	0.2
Mechanisation suitability	7,126	0.0
	67,550	***0.2***
Sheep-breeding evaluation		
pasture suitability	158,297	0.5
	158,297	***0.5***
General agronomic evaluation		
Soil management and utilisation	1,724,503	5.7
Soil fertility	475,720	1.6
Soil use limitations	2,799,418	9.3
Soil vulnerability	73,219	0.2
	5,072,860	***16.8***
Environment evaluation		
industrial mud spreading suitability	1,376,572	4.6
zoo-refluent spreading suitability	1,736,018	5.8
Protective capacity Vs pollution agents	1,592,317	5.3
	4,704,907	***15.6***
Water management evaluation		
Soil moisture balance, AWC, water deficit	823,208	2.7
Landslides and water erosion	611,900	2.0
Irrigability (USBR, FAO)	1,638,335	5.4
	3,073,443	***10.2***
Other		
Specific interpretations	531,382	1.8
Engineering suitability	15,628	0.1
	547,010	***1.8***

Preparing the soil survey of Italy at scale 1:250,000

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Introduction

The soil survey of Italy at scale 1:250,000 should be considered as an opportunity for setting up or reinforcing existing Italian regional services, as well as for creating a national centre for soil cartography. Furthermore, it will provide an opportunity for supporting pedological activities in Europe, in particular those co-ordinated by the European Soil Bureau (ESB) and, all in all, a chance to enhance soil culture in Italy and in Europe.

Technical motivations are related to the practical applications of the contemplated database, i.e. the ones stated in the ESB manual: the assessment and georeference of groundwater vulnerability, soil pollution, drought and erosion hazards, land capability, land suitability for crops and agricultural practices, etc.

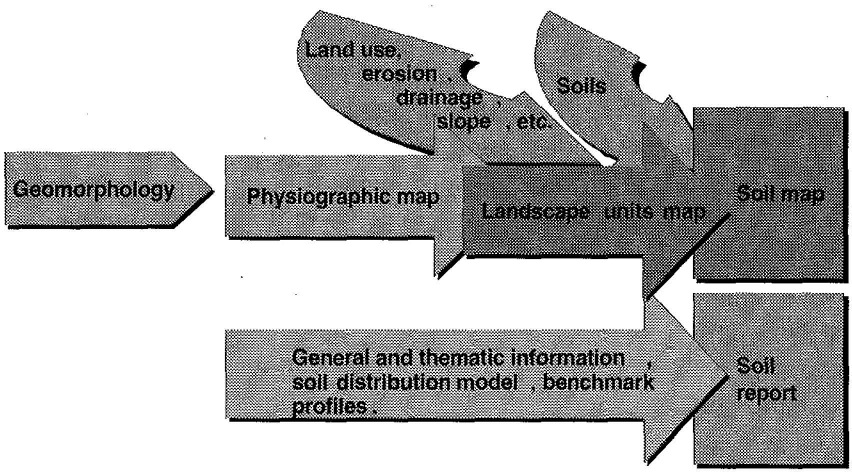
On the other hand, methodological motivations concern the progress made over the last few years with the diffusion of information systems, which has led to considerable innovations.

Traditional and innovative soil data gathering and organisation

In traditional soil surveying and mapping, all information is summarised within the closed system constituted by the soil map and the report (fig 1). The survey activity begins with the subdivision of the studied territory into different macroscopic physiographical environments, based, when possible, on of a geomorphological map. This is followed by a further subdivision of the territory into landscape units, as the relations between soil and some land characteristics, such as lithology of the parent materials, slope, erosion, land use, anthropic works (e.g. terraces, ditches) are only discovered during the field survey. The singling out and delimiting of soil and landscape variations produces the soil map, in which each unit contains information on soils and landscapes at a given scale. The information is summarised in the map legend and in the soil report, where general and thematic information, the soil distribution model and benchmark profiles are illustrated.

Figure 1

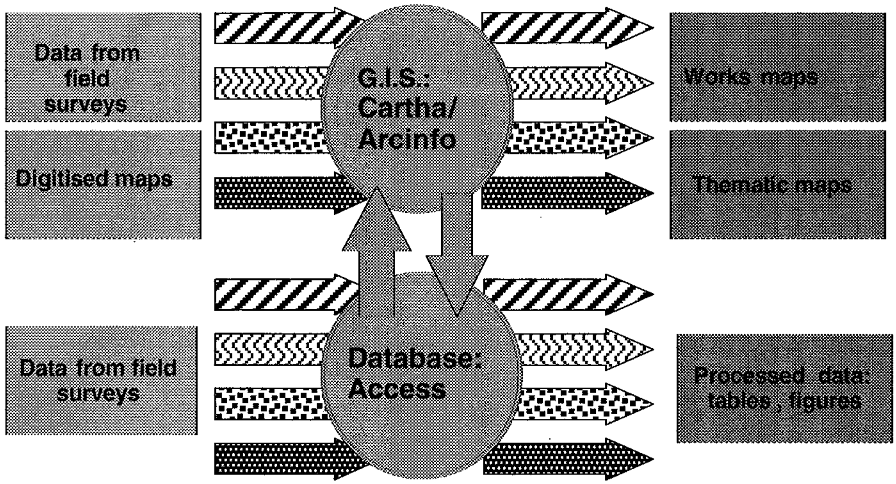
Information gathering process in traditional soil survey and mapping.



The advent of soil information systems has allowed us to store a greater amount of the surveyed data, and has also enhanced the possibilities of data processing, up-dating and retrieval. A major characteristic of the system is that geographical and typological information are jointed, thus creating a unique integrated database that can produce several outputs, which also include the soil map. For this reason, we no longer speak of cartography in terms of "soil map" production, but rather in terms of "georeferenced soil database" creation. The state of the art of most soil information systems is at present constituted by two software units, namely a GIS connected to a database (fig.2).

Figure 2

Soil Information System architecture and software



Basic concepts

Moreover, from a conceptual point of view, soil mapping activity has remained the same, i.e. it is based upon the deterministic approach formulated by Jenny in the early forties. In his famous equation, Jenny stated that soil (S) is the result of five forming factors: climate (c), organisms (o), rock (r), topography (m) and time (t).

$$S = f(c, o, r, m, t) \quad \text{(Jenny, 1941)}$$

The same equation can be rewritten as follows:

$$Sm\ (r\ (c, o), t)$$

which means that the soil we observe in a determined morphological position (Sm = the pedon) is the result of rock weathering and time, where rock weathering (r (c, o)) is itself a function of pedoclimate and organisms.

Geographically speaking, the polypedon (PP) is the union (U) of soils whose forming factors are so similar that they give morphological and functional characteristics which fall into specific ranges.

$$PP = \bigcup_{i=1}^{n} Sm_i\ (r\ (c, o), t)$$

On the other hand, the pedolandscape (or soilscape PL), which in a broad sense can be defined as the landscape with pedological meaning, is the set of climatic, lithological, morphological, soil (s) and land use (us) elements which characterise a tract of the earth surface at a given time.

$$PL = \{c, r, m, s, us\}$$

The pedolandscape may coincide with the polypedon at the detailed scale, when all the soil forming factors are approximately constant, but it is nearly always different at the reconnaissance scale.

$$PP \equiv PL \quad \text{when} \quad c, r, m, us = K \quad \text{(detail)}$$

$$PP \neq PL \qquad\qquad \text{(reconnaissance)}$$

Obviously, at the 1:250,000 scale we map pedolandscapes which do not coincide with polypedons.

Pedolandscapes are usually singled out by thematic mapping, photo-interpretation and free survey. We all know very well that the last two techniques introduce a high level of inference and uncertainty. The interpretation may, or may not, correspond to the reality, but the main problem is that the stakeholders have essentially a unique objective index of confidence: the observation density.

Standards in soil survey

The advent of GIS and databases has meant that information on soil map units and polygons can easily be differentiated from data regarding typological units (Gardin *et al.*, 1996). It is therefore possible to distinguish the "geographical" intensity of pedological observations (auger holes, profiles, etc.), from the "typological" intensity. For this reason survey standards should be considered both in terms of "observations by surface unit" (n/ha) and "observations by soil unit" (n/n) and, when possible, "observations by polygon" (n/n) and "observations by pedolandscape" (n/n).

Moreover, with the aid of information technology, it is possible to deal with typological units such as soil series, or soil bodies, at both detail and reconnaissance level (Finke *et al.*, 1998; Napoli *et al.*, in press). In other words, the two approaches differ essentially in the way they spatialise information, not necessarily from the point of view of the information typology.

For this reason, it is evident why soil geography assumes a prominent role in the creation of a Soil Information System.

Procedures to be tuned and formalised in soil geography

In the ambit of the 1:250,000 soil database, we need to tune and formalise a number of procedures, especially in the field of soil geography. First of all we have to standardise the geographical bases on which to operate, such as aerial photographs, raster and vectorial images, as well as geographical reference systems. Then it is necessary to become skilled in the use of geographical tools such as DEM and satellite for pedological purposes.

For example, at the Soil Science International Congress of Montpellier, Dobos and other Hungarian geographers showed the easy use of satellite and DEM to obtain a quick small scale soil map (Dobos *et al.*, 1998). Although their approach cannot be utilised as such, especially in countries like Italy, which have a great deal of paleosols and a strong anthropic influence, it seems unrealistic that the 1:250,000 soil map should not use these tools.

Thus, the field soil survey should follow not only the photo-interpretation, but also the DEM and remote sensing analysis phase: basically, in the field we should gather information on soils occurring in pedolandscapes which have previously been defined in terms of their constituting elements. Moreover, field borings should allow us to defining the short distance differences, i.e. the internal variability of the polypedon (or soil body), as well as its geography in terms of form, dimension, distribution and relations.

As to the standards in soil uncertainty assessment, it is well known that total observation density follows a set of variables: cartographic scale, soil distribution complexity, site accessibility, remote sensing, financial budget, thematic maps and information technology available; nonetheless, the same quantity of observations can be used either to improve soil typological knowledge, or to assess their geographical distribution. Thus, the fewer the observations, the higher the uncertainty about soils, in terms of the number and kinds of soils which are really present and relevant for the study area, and/or the precision of the soil limits, and/or the soil map purity (i.e. inclusions inside the polygons). As it will not be possible to survey all the soilscapes, the choice between the different strategies has important implications for the selection of the windows in which the detailed surveys are to be carried out (cp. Finke *et al.*, 1998).

A consistent approach could be to start from the Soil Region and arrive at the soilscape through different pedolandscape levels, thus giving a preliminary overview of geographical variability. On this basis it would be possible to carry out a preliminary field soil survey, aimed at defining the number of significant soils in each study area and the number and dimension of windows for the different pedolandscape levels.

In this phase, as well as in the phase of ascertaining the soil map purity, the use of geostatistic, and in particular of non-parametric tests, seems to be possible.

Soil correlation among the different databases

Soil correlation is another activity which concerns soil geography. It is possible to deal with different subjects of correlation, as well as distinct levels of correlation. In particular, we have to bear in mind that we are going to build up databases at three geographical levels: Europe, Italy and Regions, where soil typologies should be comparable in terms of classification and management.

In order to make this correlation activity possible, the information gathering process and the creation of the database must be well organised, and common, sound, robust and easy to use operative tools must be acquired.

The soil survey manual is certainly one of the most important of them.

At the moment we have several soil manuals in Italy. There is not much difference between them, for they all refer to the same international references, but they are different enough to make digital data circulation impractical. As this is also the case at the European level, the European Soil Bureau has promoted the creation of a "Manual of Procedures of the Georeferenced Soil Database for Europe".

The Manual of Procedures of the Georeferenced Soil Database for Europe

The manual is a good first attempt at reaching a standard procedure in soil data acquisition and organisation. It is useful for the international circulation of this data and its processing at European level. Since 1:250,000 is a regional scale, mandatory attributes regard only a minimum number of characteristics, while most of the pedological information is optional. The choice of the different options has to be made in relation to the scope and nature of the applications.

The manual takes up classical pedological assumptions, but also introduces new methodologies. The principles for distinguishing the main soils of a given region are their morphology and characteristics, as results of the soil genesis factors, as well as their behaviour in the landscape context. This means that the subject of the survey is the soil body, i.e. a natural body defined in terms of genetic processes and functional qualities; precisely for this reason, most of the manual is dedicated to the definition of soil body attributes.

Special attention is also given to the description of the pedolandscape, defined as a portion of the soil cover which groups together soil bodies having former or present functional relationships, and of the Soil Region, which represents a part of the soil cover characterised by a typical climate and parent material association; in other words, the "natural" regional unit to which soil bodies and pedolandscapes are primarily related.

The manual recommends a further hierarchisation of landscapes at national level, i.e. the creation of other levels between Soil Region and soilscape.

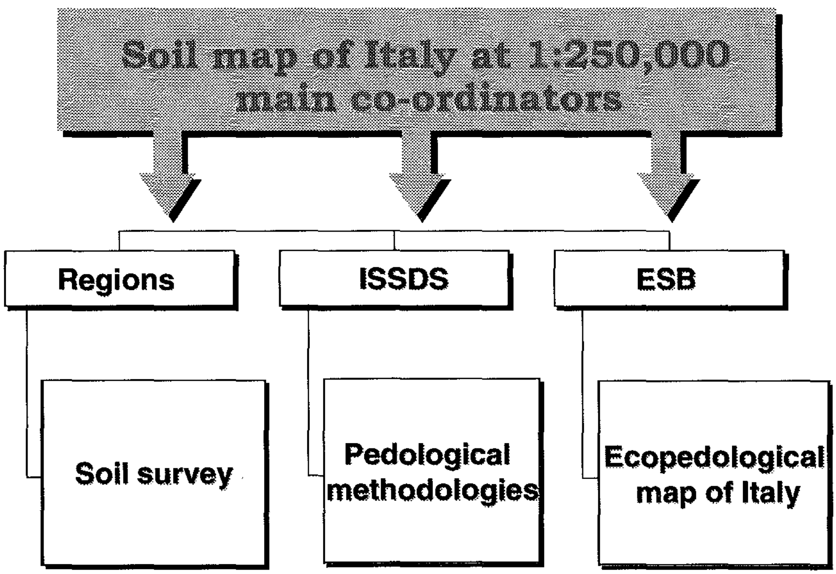
Besides the question of landscape hierarchisation, in order to use the ESB manual in Italy a translation of the document and harmonisation with Italian conditions and methodologies are necessary. These activities will firstly assess the mandatory and not mandatory attributes of the database, then a validation of the structure and parameters will be carried out, with possible modifications to the attributes, survey methodologies and standards.

Subjects of the soil map of Italy at 1:250,000 scale

Although the project should aim at involving the entire community of Italian soil cartographers, the bodies having the main co-ordination tasks are the Regional Administration, the Experimental Institute for Soil Study and Conservation (ISSDS) and the European Soil Bureau. The main task of the Regional Administrations should be to lead and supervise soil surveys within their administrative boundaries; the ISSDS has the duty of co-ordinating the methodological standardisation, while the ESB's job is to give the project a European framework and to co-ordinate the work related to the so-called "Ecopedological map of Italy" (fig.3).

Figure 3

Soil map of Italy at 1:250,000 main co-ordinators



The Project "Pedological Methodologies": criteria and procedures for the creation and up-dating of the soil map of Italy (scale 1:250,000)

The project aims at providing methodological standard for the creation, management and utilisation of georeferenced soil databases. Standards will be in the form of procedures, manuals, file-cards and software and they will be calibrated and validated on pilot areas. They should take into account the national and international state of the art, in particular in the case of the European manual. Moreover, they will have to deal with the actual operative reality of the regional services. One of the objectives of the project is the creation of a soil cartography centre, aimed at gathering and processing soil information at a national level, with the collaboration of Regional centres.

The Italian National Observatory for Pedology and Soil Quality of the Italian Ministry for Agricultural Policies is the advisory committee for the project. In addition to the collaboration with the Regional administrations and European Soil Bureau, the project is integrated with the "Moncapri" project (soil cartography monitoring in the Italian Regions), the northern Italy pilot area of the European database, co-ordinated by the ESB and the Lombardia Region, and the "SINA" project (soil database for areas at risk of pollution) led by the Environment Ministry and the Emilia-Romagna Region.

Framework of the project

The project has been organised in eight sub-projects, the co-ordinators of which belong to the ISSDS and the Regional Administrations (fig. 4).

As previously stated, the project aims at involving all national experts on soil cartography with three participation levels:

- "operating": constituted by the co-ordinators of each sub-project, as well as invited experts,

- "participating": formed by those who want to actively take part in the sub-project and group work,

- "consulting": which includes all those interested in following the work, without the obligation of attending the meetings or providing contributions.

Figure 4

Sub-projects structure and co-ordinators

Sub-project	Sector of activity
1	Definition of the general concepts and glossary; individuation of the Soil Regions, Pedolandscapes and intermediate landscape levels. General co-ordination of the project. *Co-ordinator: Experimental Institute for Soil Study and Conservation.*
2	Standardisation of the soil database attributes; publication of the soil survey manual and field file-card; definition of methods of information broadcasting. *Co-ordinator: Emilia-Romagna Soil Bureau.*
3	Standardisation of methodologies for the gathering and management of geographic data into the GIS; guidelines for the use of aerial photos, satellite and DTM. *Co-ordinator: Experimental Institute for Soil Study and Conservation.*
4	Standardisation of the controls for the data quality check; criteria of contracts definition with the companies. *Co-ordinator:*
5	Methodologies calibration and validation in the pilot area "plains and low hills of northern Italy". *Co-ordinator: Soil Service of the ERSAL (Lombardia Region).*
6	Methodologies calibration and validation in the pilot area "central Italy Regions". *Co-ordinator: Soil Section of the ARSSA (Abruzzo Region).*
7	Methodologies calibration and validation in the pilot area "southern and insular Italy". *Co-ordinator: Soil Section of the SeSIRCA (Campania Region).*
8	Realisation of a national co-ordination centre for the soil cartography and regional soil services support. *Co-ordinator: Experimental Institute for Soil Study and Conservation.*

It is possible to determine four project knots, corresponding to same number of goals.

Activation: the first objective of the project is to define the guidelines that will be developed in each sub-project.

Initial drafts: the second step is the production of an initial procedures draft from each sub-project group, which will then be discussed and approved in an ad-hoc meeting.

Validated drafts: in the third phase validation activity will allow the calibration of the previously drawn up procedures; if necessary, a preliminary proposal of a second set of standards will be put forward.

Final drafts: the last meeting will be devoted to the approval of the calibrated and validated standards and procedures.

The project scheduled time is two years, but it is to be hoped that the activities will go on longer, as a logical continuation of the pedological network which is currently being set up.

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OPERATION "SOIL INVENTORY, MANAGEMENT AND CONSERVATION"

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The Soil Inventory, Management and Conservation operation (IGCS from the French Inventaire, Gestion et Conservation des sols) was launched in 1990 by both the Ministry of Agriculture and the National Institute for Agricultural Research (INRA Institut National de la Recherche Agronomique).

The objective is to create soil data bases at a regional level managed by a geographic information system, so as to have a spatial tool for soil management and conservation, thereby achieving consistent management of space (agriculture, forests, equipment, urbanisation).

IGCS was designed for practical applications. It caters for the needs of politicians, experts and economists. It consists of two levels which are complimentary to each other:

- the regional level: regional soil inventories for planning of soil use by all sorts of decision makers;

- a more local level: reference sectors to meet soil management concerns voiced by agricultural practitioners and suited to holdings and parcels.

The technical aspects

IGCS is based on the use of existing soil data as well as the collection and collation of additional information. The operation consists of 4 actions:

1) The regional soil inventory is based on the concept of the soil landscape and that of the small natural region. It contains the description of the main types of soil and their location in a large area of land which corresponds to an administrative management unit ("département", region) or a natural unit (river basin). It is designed to enable rational management of space and also provides a tool which helps decision-making in areas related to agriculture, environment, land planning and urbanisation. Its resolution which is the equivalent of a map on a scale of 1/250,000 allows for definitions of suitability and regional hazard zones(cf. examples given later of thematic extrapolations derived from the data).

The inventory is drawn up on the basis of a summary of existing studies and on new data acquisition for one of three levels of label which correspond to the quantity and quality of the data:

- minimum label: one site is described (boring)/800 ha; 1 site is described and analysed (profile)/8,000 ha;

- medium label: 1 site is described (boring)/400 ha; 1 site is described and analysed (profile)/4,000 ha;

- upper label: 1 site described (boring)/200 ha; 1 site described and analysed (profile)/2,000 ha.

The regional management committee chooses the label level. It may specify certain special technical specifications (CCTP: cahier des clauses techniques particulières) which include other data (e.g. heavy metals).

The creation of the regional soil inventory marked the beginning of a dynamic process of thematic enhancement and data enrichment.

A list of general technical clauses (CCTC : Cahier des clauses techniques générales) specifies the scientific and technical conditions.

Costs

In an area where there is no or virtually no soil survey, the prices are:

for a minimum label: between 1.20 F/ha (= 0.18 euros) and 1.40 F/ha (0.22 euros); for a medium label: 1.80 F/ha (0.28 euros) and for an upper label: 3 F/ha (0.46 euros). These prices include surveying, reporting, file drafting, analyses and data digitisation costs. These are average prices which change depending on how complex the environment is and whether or not soil studies already exist.

2) Reference sectors are chosen within a small natural region: Exhaustive and detailed inventories of the types of soil and their location are drawn up on sample areas (roughly 1,000 ha) which are representative of small natural regions. They are carried out on a large-scale (1/5,000 to 1/25,000) and are focused on a technical problem: reclamation, irrigation, sludge spread, conversion of vineyards etc. Technical references are acquired and extrapolated at the level of thesmall natural region.

The reference sector is achieved from studies, analyses and surveys and leads to the definition of soil types and a determination key. The extrapolation of specific knowledge on soil enables the further refinement of the resolution in the regional soil inventory.

The cost of a reference sector of 1,000 ha is about 500,000 F (76,923 euros).

A list of general technical clauses (CCTG) specifies the technical and scientific conditions.

3) Data management: The information obtained from the regional soil inventories and the reference sectors lead on to geometric and semantic data which is managed digitally. The computing is done on DONESOL format. The IGCS operation provides a structure for the semantic data by means of DONESOL which is designed to adapt to different levels of precision.

4) Methodological studies: They enable models to be worked out for soil data processing and the crossing of the data with those from other sources obtained from multidisciplinary studies.

Some examples of thematic output based on soil data along with other data (topography, climatology, land use, holdings):

-for regional soil inventories these interpretations cover areas such as sensitivity to nitrate leaching, run-off, erosion, forest or crop suitability, potential for sludge spread, denitrification, knowledge of water storage capacity, landscape characterisation.

-for reference sectors: the first interpretations deal with crop potential.

How IGCS is organised

How it works

At national level:

National co-ordination allows for harmonisation of work done at national level and involves drafting framework-documents (general technical clauses and conditions, code of conduct for the organisation of the operation, data property, dissemination of data#) as well as co-ordinating European work. It ensures that the data are checked, and formatted in the same way for the computer (DONESOL) and it provides technical back up to local teams.

There is a scientific council, consisting of representatives from the Ministry of Agriculture and the INRA as well as other authoritative people representing different areas of competence and users (Ministry of the Environment, farmers, specialised research organisations, environment institute, meteorology). Its role is to keep up with the evolution of methods and tools in order to guarantee the scientific quality of programmes (study of projects, their follow-up and evaluation of results), to propose the attribution of labels as well as to help highlight results.

At regional level:

A regional management committee consisting of joint contracting authorities and local partners is in charge of the running of the regional programme. It also follows the evolution of tasks over time and in terms of the geographic area covered.

A contracting authority representative is in charge of establishing, managing and using the data base. He must also provide information from his holding. He is responsible for soil data content and the computer programme and must ensure consistent management of technical content. He is responsible for the reliability of the regional soil data and must either possess the necessary qualifications (soil science and computer science) and the actual equipment to manage the data base or sub-contract one of the two parts. In the latter case, he remains liable for the whole operation.

The regional scientific and technical committee consists of regional representatives in charge of research, higher education, agricultural development and experts in associated disciplines.

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this area is currently under review to take the evolution of technology and ideas on information systems into account.

It assists the regional management committee in a number of areas, especially in drafting special technical clauses and conditions (CCTP), harmonising the drafting of regional summaries and working out engineering services. It works in conjunction with the National Scientific Council.

Those in charge of the survey collect, summarise and download the information onto the data base etc. These operations are carried out in compliance with the specific and general technical clauses and conditions.

How the network works

A one day technical meeting and a two day seminar which brought together regional and national scientific and technical experts led to the establishment of the network. Participants were given the opportunity to take stock and make full use of what had already been achieved (several thematic applications, experiments carried out with partners in the field) and to address data processing problems. These meetings enabled partners with very different areas of competence coming from a variety of institutes to come together. They gave a good indication of interest and motivation for the operation and helped foster a very fruitful exchange of views.

Working groups consisting of national and regional managers are currently thinking about the following subjects:

* labelling
* data processing, models and themes
* access to data and partnership
* acquisition and use of references at parcel level

Memorandum of Understanding

* A multiannual Memorandum of Understanding between the Ministry of Agriculture and the INRA stipulates the practical arrangements for co-operation and specifies the tasks of the signatories.

* An agreement between the regional management committee and the national promoters (Ministry of Agriculture and INRA) provides a broad outline of the regional project, the role and responsibility of partners and their relations with each other.

* An agreement on regional partnership between the joint re-

gional contracting authorities defines the general organisation of the regional programme, how it is run and what the rules are.

* A contract on the provision of data which is entered into by the contracting authority representative and the customer defines the nature and the extent of the rights granted as well as how the data is transferred, financial conditions and the respective responsibilities of the signatories.

* An agreement on surveys is reached between the contracting authority representative and the person in charge of surveys. It defines the type of study requested and its operational conditions.

State of the art of IGCS and some of its features

The operation started in fifteen regions. Work began either at "département" level or in a pilot zone, or on a river basin. This depended on opportunities available to regional partners and their motivation.

Even if the work carried out is on a smaller scale, the regional level remains non the less an important level for co-ordination.

Allocation of funds: the Ministry of Agriculture has provided about F.15 mn over seven years for the running of the IGCS operation. It financed the work done and provided support for its running (scientific managerial staff). As for regional programmes, these subsidies are supplemented by funds provided by the regional authorities, farmers' associations and the European Union.

The contracting authority representatives vary and can come from the chamber of agriculture, land planning companies, schools of agricultural science and regional associations.

What we can say now and the lessons we have gleaned from the past. Towards a future which will take greater account of demand

A few years down the road since starting the IGCS operation, we see that there is a greater awareness among soil scientists of the need to take users' requirements into account and that they should be very much involved in regional programmes. Nowadays more attention is paid to enhancing data, and the fact that people are now working on the basis of the requirements of the users who are most involved appears to be one of the keys to the success of such an operation. Moreover, new requirements appear linked to new problems such as the spreading of sewage for which knowledge of the soil is necessary. Finally, as far as methods are concerned, questions concerning data processing (overlaying data, changing scale etc.) provide plenty of scope for further research and thought.

Conclusion

The need for information on soil is increasing. A variety of areas need to be covered such as land management, the risk of degradation and the impact of different types of pollution. More and more partners are emerging. The advent and development of new technology will allow for the necessary adjustments to be made for applications (such as models and evaluations).

The quality of this operation as well as the fact that it provides structure to the system seems to be recognised. It does seem to fully meet expectations. Special attention will be paid to highlighting data and promoting discussion. This is why the intention is to create an IGCS site on the Web thereby broadening the scope of discussion between data producers and users.

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THE FUTURE OF SOIL SURVEY IN ITALY: SOME THOUGHTS ABOUT ITS CONTEXT

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1. Introduction

I have been asked to make some reflections about the mapping exercise 1:250,000, which is going on in Italy. The following is written taking into account the presentations and discussions during the Workshop, but it was felt important to deal with several questions not specifically raised in the meeting and which are, according to the author's view, to the foremost interest.

The announcement of the launching of the 1:250,000 soil map of Italy are very good, very welcome news, especially if we consider the grey paths soil survey seems to follow in recent years. It seems to invert the present trend of very few new surveys, which seems to be the rule at the moment.

Sustainable land use is a key issue for sustainable development. Soils play a very much important role in the suitability of a certain part of land for a land use. In European countries land use intensity is, in general terms, very high although some areas are facing important problems of desertification due to abandonment, especially in southern countries. These very intensive uses create many conflicts among present and potential users of soils; acceptance in Europe of the soil functions other than the classical production function, that is, water filtering, ecological (nutrient) function, etc, which have been enhanced by the environmental crisis.

Land use planning is the classical tool to cope with land use conflicts, but to take full advantage of it, among many others, soil information is needed. Bartelli (1978) reviewed the role of soil information for land use planning, but the present demands about soil information go much further. The introduction of the concept of soil protection as opposed to soil degradation and its functional link with land use induced soil degradation means the need of tremendous amount of information. So the answer of Bartelli is not valid anymore, because it was directed mainly to agricultural (productive) uses as well as to their conflicts with other uses, non productive ones, which today are more important than the productive ones; and also because the model of Bartelli applies to classical soil surveys based on a soil-landscape model and again this is not enough to answer the questions raised by the modern land use problems.

The building of the united Europe has shown the lack of enough soil survey information at different levels, with a very uneven picture all over Europe. From the European Commission point of view was felt (King *et al.*, 1996) that a soil database at scale 1:250,000 could fit both the needs of the Commission and the region at global scale. The construction of such a database has already taken its first steps (ESB, 1998) but it represents a tremendous challenge.

Soil has a much lower profile, specially in the media, than other environmental compartments as for instance water, and people are very little aware of the meaning of soil degradation in terms of its impact in space and time. Soil survey has suffered from this fact and a lot of time and effort has been devoted in the last years to discuss the so called crisis of soil survey; technical and conceptual developments in other fields specially in communications, computing and modelling have apparently exacerbated such crisis. All this, in addition to the above-mentioned increasing demands in soil information, has lead to a full disorientation of the professionals involved in it. The discussion on the subject will go on still for some years.

2. The information available (extractable) from a soil survey

People are in many cases dissatisfied with the use of soil information. The amount of soil information existing is – in many cases – limited and large-scale soil maps – the more suitable for the detail and amount of information they have – are the exception rather than the rule. This must not surprise anybody familiar with land surveys; it would be useful to compare the amount of resources devoted to soil surveys and, for instance, to geological surveys.

The amount of information requested from a soil map is not, in some cases, realistic. Most soil maps do not contain enough quantitative information, because they are rather semi quantitative. Computer facilities have stressed this fact, but the cost of collecting such information could be in many cases too high. There seems to be large room for improving current survey methods, but it should be kept in mind that this would mean, at the end, higher costs.

Ways of linking physical entities (mapping units) with their attributes should be improved giving meaningful information in terms of easily usable statistic parameters.

Recently, with the aim of developing a policy of soil protection, soil survey has been regarded as a source of information for soil monitoring. I am sure that in the future this will be the case, but old surveys are not designed for this purpose. Classical soil surveys are different from soil monitoring.

Our capability of adversely affecting the environment is continually increasing and we use it regularly (soil pollution by heavy metals or nitrate) or from time to time (Chernobyl).

Classical soil surveys are well suited to provide information to run models, to make predictions (land evaluation) etc. But are very poorly suited to monitor soil changes, even in case of large improvements in the way to gather and present information.

They are as well very well suited to serve as a basis to locate monitoring schemes and extrapolate the information coming from such schemes.

However soil monitoring claims for a proper, differentiated approach. Besides earth satellite information several approaches are dominant:

- A more or less dense network of point observations precisely referenced and linked to main land use types. The density of such a network will be dependent on land use intensity (environmental damage and change), soil spatial variability, etc. Precise sampling and measurements of the area will be necessary. Some land degradation processes may call for a separated approach (i.e. erosion, salinity, soil compaction, …);
- Small catchments;
- Long term experiments in field plots.

Although it seems obvious, many users are not aware of the implications of the scale. This is always relevant but it is more important for small scales, as 1:250,000 is, for two reasons:

• Its usefulness is limited to regional level, calling for a nested approach to fulfil the requirements at local level;

• The feeling of the decision makers that the soil information needs are fulfilled once the 1:250,000 map of the country is completed.

3. The sources of information for the "new" soil data base

The information assembled for the 1:250,000 should be considered a soils data base. The German 1:200,000 is very keen on keeping in separated places the soil map and the associated data base (Hartwich, this issue) but this splitting will narrow in the future.

People very often want to build up a geographical soil database almost exclusively from already existing data. This is hardly possible for very small-scale databases and a good example is the 1:1M EU soil database. Many reasons stand for that: amount of available information, accessibility, reliability, usefulness (usually the information was collected with other aims), completeness (usually soil physical data are lacking and even more often field measured soil physical data), comparable methods of data acquisition (both field and lab methods), feasibility to link point observations with geographical entities, etc. In most cases the conclusion is: better start over, go to the field again and use the existing information just as a starting point.

Using pre-existing data to rearrange information has been in some cases standard practice. When the amount of existing data was very limited this practice has lead to very poor quality products.

Updating soil surveys is a well-established practice in countries with the more advanced soil survey methodologies (i.e. USA, the Netherlands).

A "new" soil data base 1:250,000 will have to rely, of course, on old information, but if some progress has to be achieved, it will be specially important:

• A good characterisation of soil mapping units;

• Better characterisation of soil-water relationships;

• Explicit information on the soil-landscape model used.

3.1. Characterisation of soil mapping units

Soil surveys need to improve their quality and this is a must although the costs will increase.

One of the most common pitfalls, especially at small scale but also at large scale, is the lack of quantification of the soil parameters inside a mapping unit. Both classical statistics and spatial internal variability parameters will be needed.

3.2. Better characterisation of soil water relationships

Besides (or as a part of) field measurements of soil physical properties, better characterisation of the soil-water relationships is needed. This should include better descriptions of soil structure in terms of functioning. Although attempts to compare approaches and methodologies have been made still large differences are observed among countries and different emphasis is given to the same property.

Many soil physical properties need to be measured in the field. Most old soil surveys have a complete lack of information on soil physical properties, which stands as well for many of the modern ones.

These facts rend soil surveys unusable for many modelling exercises where transfer of water and solutes through the soil takes place.

Soil physical properties exhibit a large variation, larger than chemical ones. There is a large amount of information in the literature, which supports the view that this variation is linked to the size of the sample used to make the measurements, being the presence/absence of macropores critical. Also in many cases measurements are made in sieved and grounded samples i.e. texture dependent. This allows extrapolation of information but masks fully the field (true) effect of soil structure. In addition to this the horizonation of the profile also plays a major role in water flow.

Soils with large amounts of calcium carbonate or gypsum in their matrix exhibit a different behaviour than "normal" soils. This fact, together with structure (related to land uses), should be considered when extrapolating.

Because of the very high cost of making such determinations a proper conceptual framework to make them during the soil surveys and to use later on such measurements should be developed.

Pedotransfer rules or functions should be derived from these gathering exercises and are of the foremost importance. Currently the use of the functions remains still highly speculative because not enough data are available to build them, especially data gathered at field scale.

3.3. Explicit information on the soil-landscape model used

The present model of soil mapping is, largely, unchanged and based in the soil-landscape model. Jenny formalised the ideas about soil distribution that in fact may be traced back to Dokuchaev and the birth of Pedology. Technical advances in remote sensing, soil measuring equipment, data gathering and treatment have tremendously widened the speed, amount and type of data feasible to be collected in a soil survey but soil survey still is a soil landscape based paradigm discipline (Hudson, 1992) and full use of modern technologies is still restricted and its use is not a routine in many soil surveys organisations.

That model is somehow in contradiction with suggested models of building soil databases, where in fact each soil property is stored in a separated layer and combined according to the needs. This approach is not the most efficient – at least for the soil properties which fit better in the soil-landscape model distribution – because usually it has very high sampling requirements.

Quite a lot of work has been done at national level for standardisation of methods, especially in the laboratory methods. However when we look across Europe the differences are outstanding.

Mapping methods is the field where less work has been done. During decades the Soil Survey Manual has been the reference. However methods are not standardised enough and may be described as "expert judgements" with too much room for discretionarity; in fact many of the current systems used are unable to resist a thorough examination using a GIS. Especially important is to formalise – if a standardisation is not possible because of the state of the art – how the soil-landscape relationships are depicted in each survey; construction of legends – at any scale – where the soil-landscape relationships are shown is necessary in all cases.

Especially important is to standardise the description of the landscapes and the parent materials (geogenesis). In that sense the ESB

1:250m Manual (ESB, 1998) should be regarded only as a starting point which in three to four years should be tested across Europe and properly reviewed after being used at all scales.

Such standardisation has to reach all the parts of the mapping exercise. Soil correlation is a well-established activity, but too much emphasis has been in soil classification as the only carrier of soil information.

A key research issue may be identified in the characterisation of the soil-landscape relationships. This cannot be accomplished during routine soil surveys and very large multidisciplinary teams have to undertake such projects in a systematic way across Europe.

4. The human capital for soil survey

Besides the low profile of soils in the appreciation of society, another main problem soil survey is facing is its human capital. Soil survey should be regarded as a long-term activity focused on achieving enough information at a reasonable cost to ensure sustainable land use. Needs of soil information do not follow a flat line and they have peaks following main technological changes (inside or outside the discipline) as well as social needs and perceptions; we may say we are at the beginning of one of such peaks.

The end product of current soil survey methodologies (a paper soil map or a digital soil data base) contains only a small amount of the information gathered during the soil survey activity, remaining the rest remaining in the mind (and field notebook or computer) of the soil surveyors. A lot of improvement on this may be achieved through standardisation – not sterilisation –, formalisation and comprehensive reports and database. However it is doubtful whether such a situation will change at medium term and, under this perspective, the main capital of the soil survey organisations are their soil surveyors.

Routine soil survey can not be considered research work and in fact it is not in any research program, from the EU level to the region level. It is however a hard work because much of it should be done in the field, so it is not very appealing for young professionals.

Current policies, low social appreciation, lack of real possibilities of promotion and the feeling "the survey is finished" spread in some cases among the decision makers has lead to the weakening of soil survey organisations, where few new fellows are recruited.

But on the other side it requires highly skilled people to do the work (situation of the observations in the field, covariant properties associated with soil morphology, soil-landscape relationships, functioning of the soil, soil-land use relationships), specially for co-ordination, where well trained people are needed to match the complex intellectual processes involved.

The overall situation derived from the facts outlined above is the inability to launch new programmes of soil survey in many areas facing urgent needs (nitrate problem; soil contamination), the human capital having been lost and having to start again.

Soil survey activities have to rely on core teams properly located (regional, national and EU level), with a multidisciplinary initial background (agronomy, forestry, geology, chemistry) with continuity in their activities. Otherwise soil survey will be just a lost dream.

5. Soil survey organisations and its role

5.1. Proper setting of soil survey organisations

Soil survey, as a technical routine work aiming at providing ample information of the soil resource, needs to be properly placed.

Soil survey organisations are currently sited in very different administration bodies: agriculture, environment, economy ministries, research organisations, geological survey organisations, development organisations, universities, etc. Uniformity does not mean more efficiency, but it is time to call for a proper situation at the same level, for instance, than the geological surveys and separate if possible from a specific field of activity (i.e. agriculture) but in an environment the most suitable to develop the works (i.e. general survey organisations).

5.2. Soil survey is mainly a technical activity but also a field of research and both facts should not be confused

Very often soil survey is presented as a research activity when it is not in many cases. A small scale soil map where a large synthetic effort is needed could be an example of when technical routine work needs a large input of scientific input in order to assemble the information of large scale maps.

Medium to large-scale soil maps have a large part of technical routine work and only a small part of pure scientific work. Planning, executing and co-ordinating soil surveys calls for a systematic approach, very complex but which can not be described under the heading of research or scientific work. Thus soil survey organisations should be – in their larger part – technical organisations, with highly skilled people, well trained, open minded and able to integrate in its scheme the new technological and conceptual developments coming from outside; only in large soil survey organisations a great effort in research could be envisaged, aiming to solve their own problems, but it seems more logical to use a proper feedback from research organisations to solve those problems.

A lot of research in soil survey is needed to put this discipline in the proper place. Some research subjects have been mentioned before: soil-landscape relationships, characterisation of mapping units, measurement techniques, etc. Research centres have to ensure the development and transference of such improvements but they have to avoid the mistake of considering the full soil survey activity as a part of a research activity; this is – partly – one of the reasons of the present crisis.

Young (1980) discusses who has to carry out soil surveys and gives reasons in favour of organisations, universities and consultants. In the context of the EU, having a vast richness of information with a large coverage, the answer has already been given: each part has its own role but critical aspects are the size of core groups in soil survey organisations and the proper allocation of activities.

Research organisations can hardly undertake large soil survey efforts because funds are not provided for that and because people become frustrated when promotion is hampered, when they work in such an activity is not properly acknowledged and at the end all the process is bastardised.

The role of research centres in soil survey activities should be redefined, otherwise there is no future. Participation, co-operative surveys, seems more reasonable and proper feedback through research projects. The absorption of the leaving months (or allowable time) of the research staff is a poor basis to launch a soil survey programme.

Consultants or private owned companies are another solution. This may be so provided that:

• Sufficient standardisation is available;

• Enough private experts are available, with good knowledge of the area;

• Enough manpower in the contracting soil survey organisation is available to control the mapping activity and to absorb and integrate the knowledge derived from the mapping activity.

• It is difficult to reverse the trends in society and science. They are calling now for competitivity and market oriented approaches in all activities. However, the following should be keep in mind:

• Competitivity or efficiency should be measured in some way other than in terms of costs and short-term aspects. In the case of the soil survey the measure should consider the long term need of information and the quality of the products gathered;

• Sustainable land use calls for an ample view in the process of gathering soil information, especially when monitoring is involved.

6. Concluding remarks

The achievement of a EU soil database 1:250,000 calls for a well structured flow of information from the regions to the EU level as well as back to the regions. Such a scale is only of limited interest for the regions, thus the EU bodies as well as the states have to think of a substantial contribution to this database and not only in terms of co-ordination.

However, much more important than the former, is to identify key aspects needed to be tackled with to ensure the overall feasibility of the process. The comparison of the situations in Germany and Italy will be very helpful in such exercise as they represent in some way contrasting situations, but not only from the organisational point of view.

The scheme outlined by Eckelmann (this issue) from the ESB to the landers looks logical but proper positioning of the soil survey organisations is very important. Although room should exist to accommodate each situation, the basic nature of the soil survey as a resource inventory should be kept in mind.

Timing of the 1:250,000 EU database is critical if social needs have to be met. The German experience with the 1:250,000 map is very clear in this sense: in the best case a large span of time is needed even for a partial, windows-oriented approach.

Soil survey is a costly exercise, and a compromise should be achieved between the amount of money invested and the expected returns (amount of available information). Users, including soil scientists, tend to ask too much from soil maps. Also environmentalists are among the ones who put exaggerate expectations in conventional soil surveys. Soil surveyors are not always able to explain the limitations of their products. With the use of databases, GIS and simulation models the above mentioned situation is even more dramatic.

All the facts outlined above create disappointment among users and this should be avoided.

Recent technical and conceptual developments in soil survey have been very important. But the question is, how many of these tools and concepts could be implemented throughout the soil map of Italy?

More important than the scientific capabilities are the organisational aspects to include in routine surveys those advances; in fact, the major changes of such developments is how the soil survey is organised.

I am not sure if the time is ripe to take full advantage of such existing conceptual and technological advances. In any case the 1:250,000 soil map is a very good opportunity to test many of them, and for sure the final result will be an impressive soil data base.

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MINUTES OF ATELIER "TOWARD A DATABASE OF ALPINE SOILS AT SCALE 1:250,000"

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PROGRAM

Participants: delegates of Italian alpine regions (Valle d'Aosta, Piemonte, Lombardia, Trentino–Alto Adige, Veneto, Friuli–Venezia Giulia), French and Italian Ministry of Agriculture, Rhône–Alpes Region, European Soil Bureau, Environment Ministry, ANPA, Florence University, Experimental Institute for Plant Nutrition, Experimental Institute for Soil Study and Conservation.

Communications:

Rita Calicchia, Roberto Caponigro: Alpine Observatory, SOIA and the theme 'soil'.

Alessandro Villa, Luca Montanarella: ESB actions for a database of alpine soils.

Paolo Giandon: Working Group on soils of Alpe Adria.

Ugo Wolf: Experiences in harmonisation of the 1:1M database in alpine areas.

Roberto Salandin: Acquisitions and perspectives in alpine areas in Piemonte experience.

C. De Siena, G. Bragato, Experiences in Provincia di Trento.

J.M. Vinatier: Experiences from the soil information system of Rhône–Alpes.

Objective: to define the way for an interregional co-ordination finalised to the organisation of a meeting of all the alpine regions of Europe (Autumn 1999 at the JRC Ispra) to launch the project.

COMMUNICATIONS

A. VILLA

Interest of the European Soil Bureau for a co-ordination of the activities; opportunity of the organisation of a meeting (Autumn 1999) with the participation of regional delegates or of an already defined working group.

Problem of time: before the end of 1998-begin of 1999 ESB will send a letter to all Italian regions involved asking for the formal designation of a referent for the project; to the letter a proposal of convention will be joined.

F. MANCINI

Europe is the only continent with an augmentation of forest surfaces, to the detriment of mainly pasturelands.

Signalling of the existence of the "Fondazione per l'Arco Alpino" and of the association "Interprevent" for the study and prevention of alpine disasters.

A possible problem regards the involvement of Swiss experts.

P. GIANDON

Existence of three Working Communities: COTRAO (Western Alps), ArgeAlp (Central Alps), Alpe Adria (Eastern Alps).

Alpe Adria is a Working Community with 19 European regions (5 from Italy, 5 from Austria, 5 from Hungary, 1 from Croatia, 1 from Slovenia, 1 from Switzerland and 1 from Germany) involved and finalised to information and technical exchange between members; costs are in charge of the members.

Different themes, between those selected in phase of statute redaction, are related to soil. Two out of five Technical Commissions formally established are related to soil ("Tutela Ambientale" and "Agricoltura e Foreste").

Every commission constitute working groups; one of those, inside the Commission "Agricoltura e Foreste", is involved in soil protection. The themes developed by the working group (organised in sub-groups) are related to contamination problems, information on existing normative, monitoring activities, cultivation techniques and their impact, evaluation of the presence of polluting substances.

The commissions organise a plenary meeting once a year, normally with a two days program: one for activities presentation and one for operative decisions. During last meeting of the Commission "Agricoltura e Foreste" has been decided to create guidelines for a homogeneous soil information system.

A document is presented.

U. WOLF

Signalling of the existence, for the alpine area, of interregional and transnational convention, also if generally not finalised to soil studies.

Some consideration from the experience of the collaboration with ESB for the harmonisation of European soil database at scale 1: 1,000,000. This database should be utilised to derive information on possible location of principal soil typologies; however, necessity of the organisation, for the future database at scale 1:250,000, of a working group for the definition of some a priori criteria.

The new database should not be intended as operative instrument but as a correlation at level of pedo-landscape; the reference unit, for a real operative instrument, must be a unit at much more detailed scale (ex. 1st order watersheds). The manual should be enriched with information finalised to pedo-landscapes and to forest and mountain uses.

Italian delegates have a privileged position in that project thanks to their geographic position; are the only ones in contact will all the others countries involved.

R. CALICCHIA

The Convention for Alps Protection was born at the end of years '80 between environment ministries of alpine area countries; Italy and Switzerland are the only two countries that have not already ratify the convention. The presidency turns and stays in charge 2 years.

A series of working groups are active; the one denominated "Osservatorio delle Alpi" is composed by a Co-ordination Unit, localised at JRC Ispra (Environment Institute), and by Communication Centres, managed by the different Environment National Agencies.

Observatory activities are defined by the approval of protocols (ex. territorial planning, tourism, natural protection, mountain agriculture, forests, soil protection); only three of them are actually ratified by all involved countries. The objective is to obtain a good representation of alpine system through the definition of a series of indicators.

The program is not on schedule due to disagreements on produced documentation rights; for that reason the activity program, expiring at the end of 1998, has been delayed to 1999. At the same time a new program for the period 2000/2002 will be launched.

ANPA (the Italian national agency for the environment) is responsible for a report on environment condition in Italy that will be arranged collecting and conforming data from different institutions. ANPA organisation structure follows the one of the European Environment Agency; creation of regional agencies and constitution of six Thematic Centres: water, waste, soil, physic elements, air and nature conservation. The Thematic Centres will act in strict collaboration with Excellence Centres (universities, research institutes, etc.) that will be selected by ANPA.

R. SALANDIN

Presentation of pedological cartographic material at scale 1: 250,000 of the Regione Piemonte; pedo-landscape systems and soil protective capability maps. Agronomic/forest value maps to answer to the need of territorial management and planning and required mainly by architects.

Those elaborations are a valid connection element with neighbouring national experts.

Regione Piemonte has an active project for the realisation of regional forest plans at a very detailed scale (1:10,000).

C. DE SIENA

The "Centro di Ecologia Alpina" participate to research projects regarding interactions humus-vegetation-soil referred to different montaneous areas in Europe (Alps, Pyrenees, British Highlands).

Studied areas are small in extension but mapped at a very detailed scale and following a common methodology and terminology.

J.M. VINATIER

One third of Rhône-Alpes region is inserted in the alpine area.

There are no regional services working on soils; there are research and agricultural institutions financed by provincial and national administrations or by agricultural taxes.

The activities of the Chambre Agricole Rhône-Alpes are mainly finalised to solve the problem of cohabitation among agriculture and forest; pedological data are one of the studied elements. The structure is composed of five people in total; field work is carried out by professional bureaux.

About soil information is actually available, but not for the entire regional territory, cartography at scale of 1:100,000 (INRA) and at scale 1:250,000 realised following IGCS system.

For the new activities the scale 1:250,000 has been chosen because the requests came mainly from territory management responsible. The followed standards are those correspondent to the level "label moyen" of the system IGCS, a little more detailed in vineyard regions.

The database contain about 15 different attributes, mainly referred to landscape and geology, per each cartographic unit and other 15 per soil typology. Moreover is present a series of quantitative and qualitative data referred to the unit 'stratum' (group of horizons) following what requested in DONESOL.

The selected scale is not adequate to solve agronomic problems; for that purpose financing for systematic and more detailed studies are not available. The proposed solution is to select reference sectors to be investigated at very detailed scale with the aim to build evaluation keys to generalise properties in space.

A document is presented.

R. BONFANTI

A document is presented.

FINAL PROPOSITIONS

Participants confirm their interest in working, in a collaborative way, for the realisation of a database of alpine soils, following the Manual of Procedures and contributing to its improvement, mainly for the definition of particular criteria for the description of alpine ecosystem, very important for our continent.

Participants all agree on the opportunity of a consolidation of mutual relations, in perspective of a common way for the activation of an international collaboration in autumn 1999.

ERSAL undertakes to prepare detailed minutes of the atelier, complete of participant list and addresses, and to propose the date for a next meeting of Italian regions involved, to be held at Ispra (European Soil Bureau) approximately in the month of February 1999. In that occasion the financial situation ("Carta Ecopedologica", "Programmi Interregionali") should be more clear and should be possible to better define Italian component in the international project.

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