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THE EUROPEAN SOIL INFORMATION SYSTEM

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THE EUROPEAN SOIL INFORMATION SYSTEM

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Preface

Soil information has been collected by individual countries for over 100 years, by FAO internationally for nearly 50 years and by the European Union for almost as long. Soil science, soil classification and taxonomy, and information technology have developed enormously over that time. Even more important, the perceived problems for which soil information is an essential knowledge base, and the uses to which it is put, have also changed greatly (and are continually changing). Briefly stated, the original scientific interest in soils and plant growth for commercial crop production has now been joined by numerous concerns of environmental protection, pollution control, carbon sequestration to limit climate change, organic farming and other aspects of multipurpose land use.

Thus, the need for an easily accessible and standardized database of soil information at a scale and detail of information adequate for the requirements of the European countries became apparent and has been partially met in past years. The European Soils Bureau, established in 1996, is now able to consolidate the progress made in establishing and using an improved database.

Proposals for this technical consultation were established following the 21st FAO Regional Conference for Europe in 1998. Attention was drawn to the actual and potential problems of soil degradation, including erosion in many areas, substantial loss of topsoil and loss of good agricultural land to urbanisation and pollution. There was general agreement on the importance of adequate soil information in the prevention of soil degradation and to facilitate crop forecasting. It was noted that the importance of the issues was recognized in the World Soil Charter of FAO and in the European Soil Charter.

The Conference, noting FAO activities in developing a world soil and terrain database (SOTER), accepted a proposal by the EU presidency that it should invite the European Commission to examine the possibility of financing the extension of the existing European Soil Information System (EUSIS) to incorporate information from all countries that are entitled to attend the Conference. Various issues that needed to be addressed were noted.

This Technical Consultation, convened to consider the issues related to soils information systems in Europe, was jointly organized by FAO and the European Commission with the technical support of the FAO Land and Water Development Division. Given the technical nature of the consultation, the participants were experts in the field of soil information. They made brief oral statements on the status of soil information in their respective countries (more detailed country reports are included in these proceedings).

Success in sharing information to mutual benefit depends primarily on an agreement to interface the mapping, monitoring and research activities of the various national and sub-national soils institutions in Europe. Data must be readily available across borders, though not necessarily cost-free: the vast accumulation of data represents a huge investment of scientific effort and money so the copyright holders may not be willing to have it disseminated freely without any return to them and without their control of how it is used. Secondly, success depends on a willingness to harmonize the concepts underlying mapping scales, procedures and classification and then interpretation for solving problems or operating programmes concerning environmental, agricultural or other policies.

The purpose of the meeting was not merely to promote the establishment of a European Soil Information System permitting easy inter-European exchange of data and experience, valuable though that is, but also to facilitate its practical use to solve problems both national and continental, and encourage exchange of experience with such activities.

An important by-product would be the example to other countries, particularly those in the developing world, on how well-utilized soil information can help to solve national and global problems in a rational and cost-effective manner. Practically all countries in the world today have soil resource databases and soil specialists, due to the long-continued development work of FAO, and other aid agencies, and to the intellectual contributions of scientific institutions such as the IUSS and ISRIC. Reaping the full potential harvest from this past work requires continuing international contributions of ideas and in some cases finance.

The exchange of views and the fuller understanding of the needs and potential contributions of each of the countries that resulted from this consultation will facilitate Europe-wide cooperation in the future. The conclusions and recommendations set some priorities for immediate and longer term action.

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Acknowledgements

The support of the European Commission and the European Soil Bureau for this meeting hosted by FAO is gratefully acknowledged. Particular thanks are due to J. Meyer Roux and Luca Montanarella for their contributions in the discussions. The technical reports provided by the representatives of the particular countries are highly appreciated (see list of participants, Annex 3).

Acknowledgement is also due to M Lindau, FAO Regional Representative for Europe, J. Meyer Roux, Deputy Director, SAI, JRC and H. Wolter, Director of the Land and Water Development Division, FAO, for their support and inspirational opening addresses. The contributions of R. Dudal, Professor Emeritus, W. G. Sombroek and N. Blum, Secretary General of the International Union of Soil Science, who expertly chaired the sessions, are gratefully acknowledged.

Special thanks are due to F.O. Nachtergaele (AGLL/FAO) and Ms D. Moro, Regional Office for Europe (FAO) for the organization of the meeting and to M. F. Purnell (FAO Consultant), Ms S. Vrionides (FAO) and Ms C. Smith Redfern (FAO) for the compilation, review and editing of these proceedings.

Acronyms

AGROTOPO	Agrotopographical Database
ARIS-unit	Agriculture and Regional Information System Unit (EU)
B&H	Bosnia and Herzegovina
CIS	Commonwealth of Independent States (Russia)
CNRS	National Centre for Scientific Research, Universities
CPF	Pedological Map of France
DTM	Digital Topographic Maps
EC	Economic Commission
ECE	Economic Commission for Europe
ESB	European Soil Bureau
ETC/S	European Topic Centre on Soil
EU	European Union
EURODB	Digital Cartographic Database of Europe
EUSIS	European Soil Information System
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographical Information System
HUNSOTER	Hungarian Soil and Terrain Digital Databases
ICAM	Integrated Coastal Area Management
INRA	National Institute of Agronomic Research
IRPA	Institut de Recherche en Pédologie et l'Agrochimie
ISRIC	International Soil Resources Information Centre
ISSS	International Society of Soil Science
IUSS	International Union of Soil Science
SAI	Space Applications Institute (EU)
SAI, JRC	Space Applications Institute, Joint Research Centre, European Commission
SIS	Soil Information System
SOTER	Soils & Terrain Digital Database
SPFS	Special Programme for Food Security
WRB	World Reference Base for Soil Resources

Summary report, conclusions and recommendations

This Technical Consultation was a follow-up to the 21st FAO Regional Conference for Europe held in Tallinn, Estonia, 25-29 May 1998, which discussed *inter alia* the uses and benefits of soil information. Among the conclusions and recommendations of its report was the recommendation for further study of soil information systems and the problems and opportunities. In particular, items 24 to 28 of the report from that Conference were as follows:

24. In considering the document prepared by the Secretariat, attention was drawn to the actual and potential problems of soil degradation. Examples of current problems included erosion in many areas, the substantial loss of top soil and the loss of good agricultural land to urbanisation where this was limited.

25. There was general agreement on the importance of adequate soil information systems in the prevention of soil degradation and in assisting in the process of crop forecasting. It was noted that the importance of the issues was recognised in the World Soil Charter of FAO and in the European Soil Charter. A number of databases had been integrated into a single European Information System covering the EU member states, EFTA countries and the countries of Central and Eastern Europe.

26. The Conference, noting FAO activities in developing a world soil and terrain database, accepted a proposal by the EU presidency that it should invite the European Commission to examine the possibility of financing the extension of the European Soil Information System (EUSIS) to incorporate information from countries which are entitled to attend this Conference.

27. This action would be subject to its cost-effectiveness and would take into account parallel activities in various countries and their national and regional bodies, to avoid duplication of effort.

28. The Conference also noted that the issue of scale would need to be addressed but that all participating countries would be invited to take part in the technical consultation process.

The Technical Consultation on the European Soil Information System was therefore convened by The European Commission and FAO with support from the International Union of Soil Science and hosted by FAO in Rome on 2-3 September 1999.

Attendance

Twenty-four European countries out of the forty-two in the Region were represented at the meeting by one or more delegates. Most provided a country report on soil information in their country including some that did not attend. The present General Secretary of the International Union of Soil Science (IUSS) also participated.

The European Commission was represented by the Deputy Director, Spatial Applications Institute, Ispra. and the Secretary from the European Soils Bureau.

The FAO was represented by the Regional Liaison Officer for Europe and three former Directors of the Land and Water Development Division (AGL) as well as the current Director. The FAO organiser of the meeting was present throughout and staff of the Soils Branch of FAO (AGLL) also attended as their other duties permitted.

Observers were also present from the PMS/Soil Campaign of the Alliance pour un monde responsible et solidaire, Paris and from ISRIC, the Netherlands.

A full list of participants, complete with addresses, is given in Appendix 2.

Opening of the Technical Consultation

The meeting was opened on 2 September1999 with welcome statements from M. Lindau, FAO Regional Representative for Europe, A. Meyer-Roux, Deputy Director of the Spatial Applications Institute, European Commission, and R. Florin, acting Director AGL, FAO. These were followed by keynote papers on global and European soil information systems and by sessions on soil mapping scales, issues of copyright, reports on current status of national and sub-national soil information systems and a final general session and consolidation of the conclusions and recommendations.

Country Papers

The country reports on the status of soil mapping and the development of national soil information systems had been distributed and were presented briefly and discussed in relation to the objective of developing a European soil database and information system. Twenty of these reports are included in this document.

Considerable differences of approach and of achievement are evident. Some small countries have detailed soil maps and other information for the whole of their territory, whereas a few countries do not yet have complete coverage below 1:1 000 000 scale. Much of the mapping is quite comparable but some, particularly at larger scales and for specific purposes, does not correspond to modern soil information requirements.

Technical Discussions

The conclusions relevant to this technical meeting of the 21st FAO regional meeting for Europe held at Tallinn 27-29 May 1998, as given above, were recapitulated by Mr Montanarella:

Specific answers concern the scale of the map to be produced, at regional level as well as at country level. Another issue raised by the Regional Conference concerned the applications of such soil maps.

The issue of scale for the SOTER database for Europe. Mr Nachtergaele (FAO) proposed that for SOTER-Europe a 1:2.5 million scale would be retained, reflecting the large amount of data available in the region, allowing at the same time an update of the 1:1 million scale soil map of Europe in those aspects which are somewhat deficient, notably the soil classification, which falls between the FAO legends of 1974 and 1988. Also the completion of the terrain component at this scale would allow the introduction of this factor also at 1:1 million

scale. FAO also noted the limited amount of georeferenced soil profile information in the Soil Map of Europe.

Mr Montanerella (ESB) recalled that the global SOTER exercise is carried out at 1:5 million and that is therefore the scale most appropriate for the development of a SOTER database for the European region. This point of view was endorsed by France (Mr Stengel) and by Germany (Mr Eckelman).

Germany proposed that in the European region, all mapping at scales smaller than 1:5 million should be coordinated by the European Soil Bureau. A view also endorsed by Italy (Mr Costantini).

Mr Nachtergaele (FAO) remarked that the SOVEUR project (Soil vulnerability for pollution in Eastern Europe) will, in the near future (summer 2000), produce a full SOTER coverage for the whole eastern Europe region up to the Urals at 1:2.5 million scale. This project was undertaken with ESB being kept fully informed, but the Bureau was unable to participate because of pending copyright issues at the time. Therefore FAO, ISRIC and the national soil institutes in the region will go ahead with the publication of the material at this scale.

Finally, it was decided that ESB would provide soil and terrain SOTER-compatible information for the whole of Europe to FAO at an equivalent scale of 1:5 million.

The issue of scale for national soil studies in Europe. Mr Montanarella drew attention to the fact that coordinating national soil mapping activities by ESB involved mainly the development of a harmonized methodology, but did not imply financing the national efforts at 1:250 000 scale.

Mr Blum (IUSS) noted that the scale of soil maps is often determined by the intended use and the main users and can therefore vary depending on the applications, be they economic, environmental, or agronomical. This point of view was endorsed by Hungary.

Mr Jarvis (UK), although agreeing that 1:250 000 would be a good compromise for a regional scale, noted that for implementation this is still too coarse and many national and district applications would require 1:50 000 or more detailed scales.

FAO noted that as far as the scale for national soil maps are concerned, the methodology and scale of 1:250 000 seems appropriate for most countries , except the very smallest countries in Europe.

Several countries such as Austria, Estonia, Lithuania, Italy, Poland and Slovenia stated that a national soil map at 1:250 000 or larger scale was already available for their country and integrating them in a 1:250 000 or 1:5 million scale product should be no problem.

France stressed the fact that soil surveys should be carried out in a participatory way and underlined the importance of monitoring soil qualities.

Methodology of mapping and soil classification. Mr Sombroek welcomed the compatibility that existed between the methodology developed by ESB for mapping at 1:250 000 scale and the SOTER approach developed for application at 1:1 million and 1:5 million scale. Mr Varallyay (Hungary) observed that harmonization, standardisation and uniformisation do not have the same meaning and made a plea for harmonization of methods across the region, rather than imposition of a uniform methodology.

Mr Dudal drew attention to the fact that most soil classifications do not include topsoil characteristics as distinguishing criteria, which is certainly a disadvantage particularly in Europe where soils are strongly influenced by human activities. Austria stated that national classification systems did take this into account.

Germany noted that data provided should also allow interpretations for environmental issues, not only agriculture, and suggested that soils should be classified as a function of the major land use under which they occur, a practice being tested by the soil survey in Germany.

The Czech Republic (Mr Nemecek) noted that some taxonomic problems will always remain, but that in general the information required for this exercise is readily available in the country.

Italy and FAO recalled that the World Reference Base for Soil Resources had been adapted as the reference soil classification at the last IUSS congress in Montpellier (1998) and urged ESB to endorse it for the 1:250 000 scale mapping.

Applications of small scale soil maps. Mr Sombroek highlighted the utility of small scale soil maps for supporting International Conventions such as the Convention to Combat Desertification and the Kyoto Protocol. Mr Sombroek underlined the fact that soils contain 2 to 3 times the amount of organic carbon compared to the above-ground standing biomass. Therefore studies concerning carbon sequestration need to draw on soil information. Mr Blum drew attention to a new round of GATT negotiations in which environmental indicators are most likely to play a crucial role. A number of these indicators will have to be derived from soil maps and monitoring soil qualities. Mr Meyer Roux and Mr Montanarella noted that, at present, the European Commission did not attach too much importance to the question of climatic change but considered the soil map an essential tool in crop forecasting.

On the issue of copyright, Mr Montanarella explained that there was a well established procedure for the distribution of the Soil Map of Europe. The map comes with a licence agreeement which allows its use for a limited amount of time and charges a variable amount to the user which ranges from practically nothing for contributors and researchers, to 20 000 Euros per year for commercial enterprises.

Germany (Mr W. Eckelman) made the point that it would be preferable for the global soil data to be distributed under a similar arrangement. Germany expressed great concern about the upscaling of soil maps and gave as an example the FAO-Unesco soil map of the world which has been used by commercial firms in Germany to produce local maps. The UK (Mr Jarvis) stressed that the ownership of soil data remains with the organization that produces them. France (Mr Stengel) stated that local communities are often the owners of the data and those cannot be simply released at a national or international level. A view endorsed by Germany which noted that the Lander are the owners of the data on their region.

FAO voiced concern about this protective attitude and stressed that, at a global scale, data should be freely available to all. FAO soil information products are distributed at production cost and carry a standard copyright text. It is deemed impractical to try to regulate possible misuse of the data. Poland and Hungary joined FAO in supporting a more liberal approach to copyright.

A number of countries noted that they had not paid attention to copyright issues for soil maps in the past but would urge their administration to look into this aspect.

Mr Sombroek explained that the copyright issue did not arise because of the inherent or strategic value of soil data, but rather because most national soil institutes have been privatised and soil data are often the only capital these institutes have. In this respect, the UK implored

FAO to appeal to member governments to support and strengthen national soil institutes to provide the public service of making low-resolution soil information available in support of international conventions and global perspective studies. This sentiment was echoed by many countries, in particular Slovenia.

It was finally agreed that data ownership would remain with the national organizations, but that the SOTER database for Europe at 1:5 million could be released in the public domain under joint FAO-ESB logos with due recognition given to national soil institutes that contributed.

Use of the information

A great variety of old, traditional and modern, innovative uses for soil resources information were quoted, and it is evident that one cannot forecast how material may be used in all the countries or in the European Union. It was emphasized that the material should be stored, and be capable of being supplied, in a form which is required by the users and is easily comprehensible to those who are not soil scientists. More research and experiment, and continuous exchange of experience, is still needed to achieve that. However, various international efforts to harmonize soil scientific practice should help to facilitate understanding by agronomists, botanists, economists and other users. Examples are the standard analytical methods now widely adopted, and their interpretation; common soil description and mapping techniques; the basic elements of the World Reference Base for soils (WRB) which is the soil taxonomic classification approved by the IUSS and by FAO; and the Soils and Terrain Database (SOTER) aimed at providing comprehensive data suitable as a basis for decision-making.

Conclusions and Recommendations

The expert consultation reached agreement on the following main conclusions and recommendations:

1. The extension of the 1:1 000 000 scale European Soil Information System (EUSIS) to the countries not covered at present should be continued.
2. The countries belonging to the FAO European Region should be fully integrated in the current structure of the European Soil Bureau.
3. The European Soil Bureau should contribute to the 1:5 000 000 World SOTER data base by providing FAO with a 1:5 000 000 scale SOTER database for Europe.
4. Copyright issues are related to scale, to density of observations and to the forecast type of data use. The global data at scale 1:5 000 000 or smaller should be in the public domain according to the FAO charter and can be incorporated into the global soil and terrain database.
5. FAO should appeal to its member nations in the region to support and strengthen their national soil institutes in order to make available soil information at low resolution free of charge in support of international conventions and global perspective studies.
6. The geo-referenced soil database at a scale equivalent to 1:250 000 is recognized as appropriate for all European countries and should be actively supported at national level in order to address inter alia the concerns raised by the FAO Regional Conference for Europe (1998), in particular land degradation, land use issues and environmental monitoring.

7. For the 1:250 000 and larger scales there is need to reinforce the Regional and National Soil Survey Institutes. The meeting would welcome an initiative of the European Soil Bureau to co-ordinate national soil information systems in a European-wide soil database.

8. For the 1:1 000 000 and 1:250 000 scale geo-referenced soil data in Europe, the coordinating, harmonizing and advisory body is the European Soil Bureau of the European Commission in cooperation with the relevant national bodies.

Keynote papers

The Global Soil and Terrain Database and the European Soil Information System

Soil data are a crucial input in models that simulate crop growth and calculate anticipated yields and water balance (Alexandratos, 1995), that assess the environmental impact of different land-use practices, and that identify major agricultural potentials and constraints. An overview of the use of soil data in applied research is given in Table 1.

TABLE 1
Uses of soil information in applied research (after Scholes *et al.*, 1995)

Model Examples	Key Soil Parameters Used
Biogeochemical models Plant response models Agricultural models	C, N, P, water retention, depth, acidity, clay, sand and stones content
Sediment yield models	Texture, water retention and transmission, depth c, erodibility
Water balance models	Water retention and transmission
Trace gas models	C, N, texture, pH, redox potential
Landform history	Soil type, isotypes
Geomorphology, morphodynamics	Parent material
CO_2, CH_4 and N_2O inventories	C, bulk density, depth, soil moisture regime
Climate models	Water and heat capacity, surface reflectance
Environmental impact models	Soil fertility, soil erodibility
Agro-ecological zoning	Soil type, texture, slope, soil phase

To summarize and spatially represent this soil information, traditionally soil maps have been produced at national level, since early this century. It soon became obvious, however, that these national inventories should be streamlined in order to facilitate the exchange of research information and the transfer of agricultural technology. At global level, FAO has, since the early 1960s, been involved with developing a common soil classification system (FAO, 1971 – 1981; FAO, 1988; FAO, 1998) which is accepted worldwide, and in correlating the different national maps into a single world soil map, produced by FAO and Unesco between 1971 and 1981.

With the development of Geographical Information Systems and the computer revolution of recent years, allowing a large amount of data to be easily stored and retrieved, FAO has co-operated with other International and National Agencies to upgrade the methodology for making soil inventories as well as the way data are stored in a Relational Database Management System. This culminated in guidelines produced for establishing National and Regional Soil and Terrain Databases, i.e. the SOTER programme (UNEP/ISRIC/FAO/ISSS, 1995a, b and c).

The status of this programme at a global scale is elaborated below, with particular emphasis on the further development of the European part of the database.

F. O. Nachtergaele
Land and Water Development Division, FAO, Rome, Italy

The Soil Map of the World

At the global level, only two relatively large scale soil maps exist: a 1:10 million scale map prepared by Kovda and co-workers (1977), and the 1:5 million scale FAO-Unesco Soil Map of the World (FAO, 1971 – 1981). In addition, a number of simplifications and transformations of the latter map exist (FAO, 1993; Moscow State University, 1993).

It is generally accepted that the 1:5 million scale FAO-Unesco map is the most appropriate source of soil information for studies of a continental, regional or global nature.

The International Society of Soil Science (ISSS) – at its Seventh Congress, at Madison, Wisconsin, United States, in 1960 – recommended that soil maps of continents and large regions be published. As a follow-up, in 1961 FAO and Unesco decided to prepare a Soil Map of the World at 1:5 000 000 scale.

The project started in 1961 and was completed over a span of twenty years. It is the fruit of worldwide collaboration between innumerable soil scientists. Successive drafts of the soil map and of the legend were prepared from a compilation of existing materials, combined with systematic field identification and correlation. The first draft of the Soil Map of the World was presented to the Ninth Congress of the ISSS, in Adelaide, Australia, in 1968. In accordance with the recommendation of the Congress i.e. that the Soil Map of the World should be published at the earliest possible date, the first sheets covering South America were issued in 1971. The results of field correlation in different parts of the world and the various drafts of the legend were published as issues of FAO World Soil Resources Reports (FAO, 1961 – 1971).

With the rapidly advancing computer technology and the expansion of Geographical Information Systems during the 1980s, several attempts were made to digitize the Paper Soil Map of the World. The first effort was carried out by the ESRI (1984) in Vector format and contained a number of different layers of land resource-related information (vegetation, geology), often incomplete and not fully elaborated. This version was distributed until 1991 by UNEP-GRID, when it was replaced by the official FAO Digitized Soil Map of the World, which focused on soil information only and allowed an analysis by individual country. It required an Arc-Info GIS system to be fully exploitable.

A first rasterized version of the soil map was prepared by Zöbler (1989) using the ESRI (1984) map as a base and using 1º x 1º grid cells. Only the dominant (FAO) soil unit in each cell was indicated. This digital product gained some popularity because of its simplicity, particularly in the United States.

In 1993, FAO and the International Soil Reference and Information Centre (ISRIC) combined efforts to produce a raster map with a 30'x 30'cell size in the interest of the WISE (World Inventory of Soil Emissions) project (Batjes *et al.,* 1995). This database contains the distribution of up to 10 different soil units and their percentages in each cell. In 1996, FAO produced its own raster version which had the finest resolution with a 5'x 5'cell size (9km x 9km at the equator) and which had a full database completely corresponding with the paper map in terms of soil units, topsoil texture, slope class and soil phase. This version is available on CD-ROM and contains, in addition to the Vector Map mentioned above, a large number of databases and digital maps of derived soil properties (pH, OC, C/N, soil moisture storage capacity, soil depth, etc).

An overview of the publication stages of the paper Soil Map and its digitized version is given in Table 2.

TABLE 2
Important dates in the development of the Soil Map of the World

1960	ISSS recommends the preparation of the soil maps of Continents
1961	FAO and Unesco start the Soil Map of the World project
1971	Publication of the first sheet of the paper map (South America)
1981	Publication of the last sheet of the paper map (Europe)
1984	ESRI digitizes the map and other information in Vector format
1989	Zöbler produces a 1° x 1° raster version
1991	FAO produces an Arc /Info Vector map including country boundaries
1993	ISRIC produces a 30'x 30'raster version
1996	FAO produces a 5'x 5'raster version with derived soil properties
1998	FAO produces CD ROM with Digital Soil Map and derived soil properties

The Global Soil and Terrain Database SOTER

SOTER is another initiative of the ISSS, the approach of which was adopted at the 13th World Congress of Soil Science in 1986. Under a UNEP project, the SOTER methodology was developed in close cooperation with the Land Resources Research Centre of Canada, FAO and ISSS. After initial testing in three areas, involving five countries (Argentina, Brazil, Uruguay, United States, Canada), the methodology was endorsed by the ISSS Working Group on World Soils and Terrain Digital Database (DM). After further refinement, the Procedures Manual for Global and National Soils and Terrain Digital Databases was jointly published in 1993 by UNEP, ISSS, FAO and ISRIC, thus obtaining international recognition. The Procedures Manual is available in English, French and Spanish (UNEP/ISRIC/FAO/ISSS, 1995a, 1995b and 1995c).

The Soil and Terrain Digital Database (SOTER) programme provides an orderly arrangement of natural resource data in a way that these data can be readily accessed, combined and analyzed from the point of view of potential use and production, in relation to food requirements, environmental impact and conservation. Basic in the SOTER approach is the mapping of areas with a distinctive, often repetitive pattern of landform, morphology, slope, parent material and soils at 1:1 million scale (SOTER units). Each SOTER unit is linked through a Geographic Information System with a computerized database containing all available attributes on topography, landform and terrain, soils, climate, vegetation and land use. Thus, each type of information or each combination of attributes can be displayed spatially as a separate layer or overlay or in tabular form.

The SOTER concept was primarily developed for application at country (national) scale and national SOTER maps have been prepared, for Uruguay (1:1M), Kenya (1:1M, Kenya Soil Survey, 1995), Hungary (1:500 000), Jordan and Syria (1:500 000). Other countries in which the methodology has been applied include Bolivia, Ethiopia, Argentina, the Gambia and Myanmar; moreover, there are a number of proposals for an expansion of this application to many more countries.

The original objective of SOTER was to develop the system worldwide at an equivalent scale of 1:1 million in order to replace the paper Soil Map of the World (Sombroek, 1984). However, it soon became obvious that the resources were lacking to fully tackle and complete this huge task in a reasonable timeframe.

In the early 1990s, FAO recognized that a rapid update of the Soil Map of the World would be a feasible option if the original map scale of 1:5 M were retained. Together with UNEP, FAO began to fund national updates at 1:5 M scale of soil maps in Latin America and Northern Asia. At the same time, FAO tested the physiographic SOTER approach in Asia (Van Lynden, 1994),

Africa (Eschweiler, 1993), Latin America (Wen, 1993) and the Former Soviet Union and Mongolia (Stolbovoy, 1996).

These ISRIC parallel programmes were merged by UNEP and FAO in the mid 1990s following a meeting in Rome during which the three major partners agreed to join all resources and work towards a common world SOTER approach covering the globe at 1:5 M scale by the 17th ISSS Congress of 2002.

An operation plan was agreed upon, but progress suffered when UNEP, for budgetary reasons was from 1998 no longer in a position to support continental SOTER studies, in spite of the success of the South American database.

At 1:1M scale, the world SOTER database contains several layers of information.

At 1:5 M scale, the information particularly on Terrain Components is reduced.

The ongoing and planned SOTER activities are summarized in Table 3.

TABLE 3
Operational plan for the global SOTER: 1995 – 2002

Region	Status	Main Agencies Involved	Publication
Latin America and the Caribbean	Finalized	ISRIC, UNEP, FAO, CIP, national soil institutes	1998
Northeast Africa	Finalized	FAO	June 1998
North and Central Eurasia	Draft Ready	IIASA, Dokuchaev Institute, Academia Sinica, FAO, ISRIC	December 1999
Southern Africa	Ongoing	FAO, ISRIC, National Institutes	2000
Eastern Europe	Ongoing	FAO, ISRIC, National Institutes	2000
Southeast Asia	Project Proposal submitted	Awaits funding (FAO, ISRIC, IBSRAM)	?
Near East	Ongoing	FAO (Saudi Arabia, Yemen, Jordan, Lebanon, Morocco, Mauritania)	2001
West Africa	Project Proposal submitted	Awaits funding (ISRIC, CGIAR)	2002
Europe	Proposal	EU /FAO	?2000
United States and Canada	Own Effort	United States confirmed interest	?
Australia	Own Effort	-	?

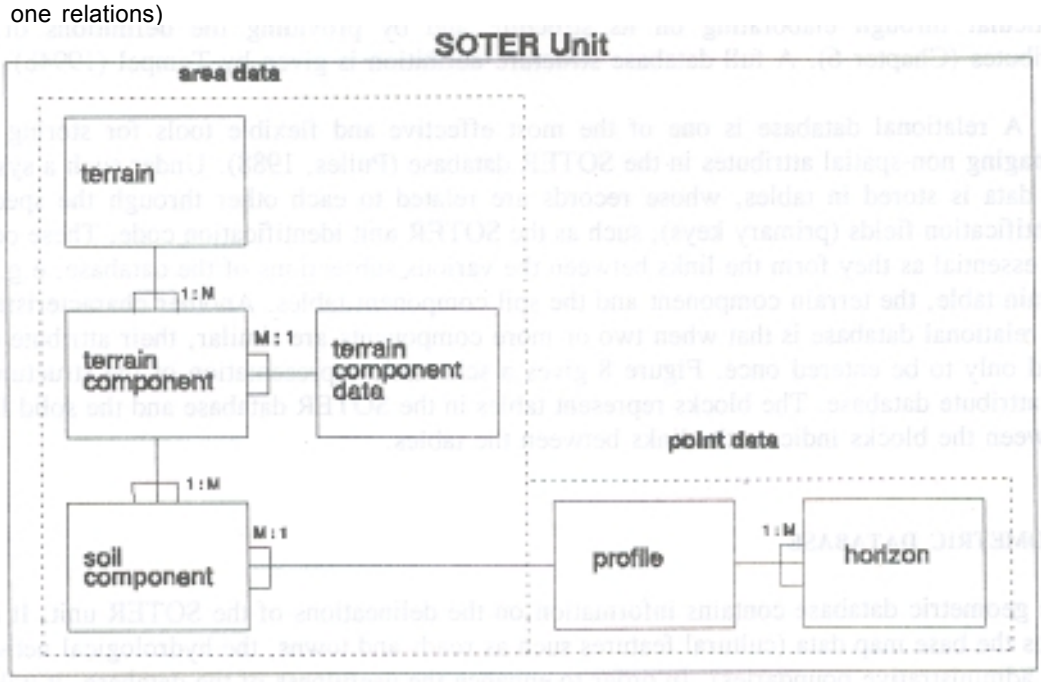
The scales of the various regional SOTER products vary from 1:5 million in Latin America and the Caribbean, 1:2.5 million in Eastern Europe (SOVEUR project) to 1:1 million in North-eastern Africa.

History of Soil Mapping in the European Context

Systematic surveys were started in most European countries during the 1950s against the background of an urgent need for increased agricultural production.

On the initiative of a number of European soil scientists, a meeting was organized in Gent, Belgium in 1952, with the purpose of harmonizing methodologies and classification systems. As a result of this meeting, a request was submitted to the Director General of the Food and Agriculture Organization of the United Nations (FAO) to sponsor the harmonization within the framework of the FAO European Working Party on Land Utilization and Conservation. In response to this request, FAO established a Working Group on Soil Classification and Survey, later affiliated with the Sub-Commission on Land and Water Use of the European Commission.

FIGURE 1
Soter Attribute Database structure with area and point data (1:M = one to many M:1 = many to one relations)



This work resulted in a first draft of the soil map of Europe at a 1:2.5 million scale presented at the second meeting of the Working Group held in Oxford, United Kingdom, in September 1959. From 1959 to 1964 several drafts of the map and text were presented and discussed at successive meetings of the Working Group and at the Seventh and Eighth International Congresses of Soil Science. The map and its explanatory text were published by FAO in 1966.

A further step towards a common European inventory was the preparation for the 1:5 million Soil Map of the World, jointly undertaken by FAO and Unesco. The project was initiated in 1961 and publication started in 1971. The two map sheets covering Europe were issued in 1981. The FAO -Unesco Soil Map of the World incorporated the European systems of soil classification into an internationally recognised legend that enhanced cooperation and enabled a harmonised overview of the soil characteristics, both at continental and global level.

The broad composition of the soil associations at scales 1:2.5 million and 1:5 million was considered as a basis for more detailed land resource management and planning. Conscious of its responsibilities with regard to the practical application of soil data, the Working Party on Soil Classification included the preparation at 1:1 million scale in its programme in 1965. This map was published as the EC Soil Map by the Directorate General (DG) of Agriculture in 1985, and was later digitized under the CORINE (Coordination of Information on the Environment) project.

In 1987, the European Commission launched a programme to Monitor Agriculture using Remote Sensing (MARS). This programme required an improved version of the CORINE database in order to provide soil parameters needed to model and forecast agricultural production in the EC. This task was initially undertaken by a soils information focal point, and later, in 1996, the European Soil Bureau (ESB) was established as a new body within the European Commission as part of the Agricultural Information Systems Unit (AIS) of the Space Applications Institute

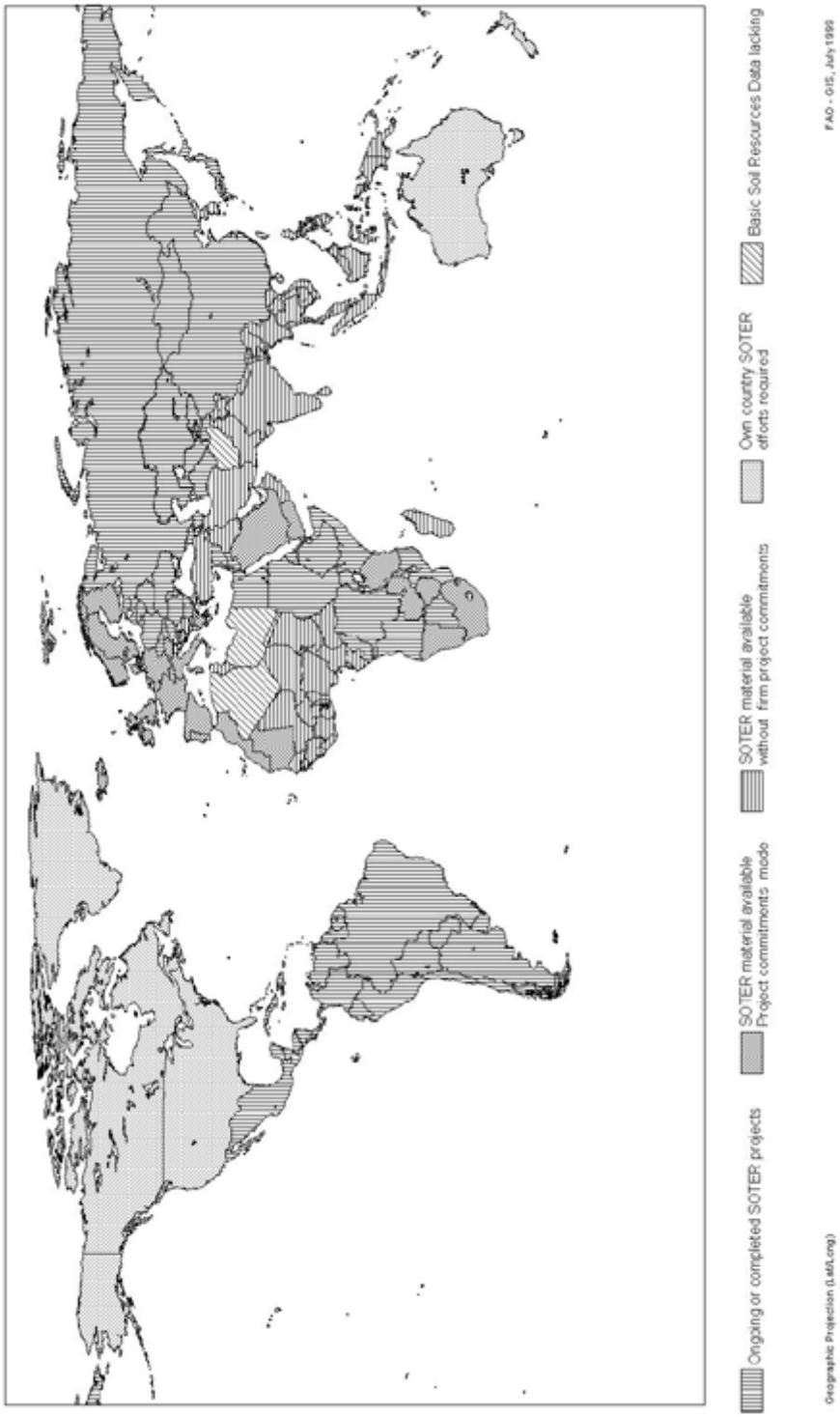


FIGURE 2
Status of global SOTER database in September 1999

(SAI). Its role is to collect and harmonise soil information for policy formulation for the European Community.

More recently, and in response to a growing demand for more detailed soil information, ESB has launched investigations in the design and implementation of a future georeferenced soil database of Europe at 1:250 000 scale. This more detailed scale is of particular interest for smaller countries of the Region to allow more meaningful mapping of soil factors and for environmental applications.

Past and Current FAO Activities in European Soil Mapping

FAO is preparing a soil and terrain database under a regional project (SOVEUR: Soil vulnerability to pollution in Central and Eastern Europe) at an equivalent scale of 1:2.5 million to serve as a base for mapping the vulnerability to soil pollution in fourteen countries in Central and Eastern Europe, including the Baltic States, Belarus, Moldova, Ukraine and the European part of the Russian Federation.

FAO has been closely associated with the preparation of soil maps in Europe through guidelines and methodology development. FAO has developed guidelines and methodologies on soil profile description (FAO, 1990), soil classification, the Framework for Land Evaluation (FAO, 1976), the guidelines for preparing soil and terrain databases as discussed above, or for undertaking land-use planning (FAO /UNEP, 1998) and agro-ecological zoning (FAO, 1991a).

At national level, for instance, FAO has *inter alia* assisted Slovenia in land valuation and Lithuania in setting up a land information system.

In land degradation mapping, FAO was an active participant in and contributor of information to a global inventory undertaken by UNEP and ISRIC (Oldeman *et al.*, 1991). FAO is also involved in an international programme of detailed degradation mapping of the coastal zone in the Mediterranean countries through its participation in the Mediterranean Action Plan.

The Need for Harmonized Soil Data Access in Europe

In the European context, policy decisions, communications, trade and technology exchanges would need harmonized and compatible soil data information. The demand for this harmonised soil information is already high in the European Union and would eventually include and serve the rest of Europe and the Maghreb.

Harmonized land resource information throughout the Region would allow a much more rational transfer of agricultural technologies, management practices or knowledge of selected crop varieties and research results that could be transferred from one region to another, or between counties with similar physical land resources. Such information would prove to be a sound reference base to facilitate communication among those involved in planning, decision making and implementation. The problem of which scale to adopt is obviously a major one as the requirements of small countries are different in this respect from larger ones. Therefore it is proposed that the global scale to be adopted, which will be in the range of 1:2.5 million to 1:5 million, should be complemented for small countries with a compatible mapping effort at the more detailed scale of 1:250 000 as proposed by the EU and already undertaken for instance by Italy.

A good example in this respect is the traditional cooperation between the Nordic countries and the Baltic States in matters of research into crop-soil interactions.

The existence of harmonized soil data sets would also facilitate the task of lawmakers and enable policy makers in the environment domain to set norms and standards for the whole Region. It would also allow the agricultural crop modelling and forecasting as developed under the MARS programme to be rapidly expanded to the whole Region. This in turn would assist agro-economists and policy-makers throughout Europe. Other possible uses are linked with applications in early warning or climatic change models and scenarios, which would also require harmonised soil data sets.

Obstacles to harmonized soil data at the EU level are related mainly to priority setting in individual countries and to administrative copyright procedures. This may, however, have significant consequences for the development of programmes at regional and international level, as data would remain unexploited or could not be used in other programmes, including the proposed joint FAO -ESB undertaking of preparing a pan-European soil and terrain database.

Another concern related to the harmonization of soil data sets and methods, is that soil laboratory procedures differ for historical reasons between Eastern Europe and the rest of the Region. This leads to difficulties in interpretation of results and could be tackled by more intensive collaboration in method comparison and correlation. There is a significant amount of soil information that is available in paper format and there is a dire necessity of transformation into digital format. Digitalization of soil maps into a GIS would facilitate the exchange of information and make these data compatible with the rest of Europe. FAO and ESB are jointly working in the production of a georeferenced soil database that would also cover the European part of the States of the Commonwealth of Independent States (CIS) for their national needs. However, to do so at the same scale of 1:1 million as for the EU Member States, will require considerable efforts and resources, but the potential applications and benefits to users of this soil information system would likewise be of great significance. Sound and harmonized soil information would allow an integrated approach to the sustainable use of land resources in the CIS countries. This would imply considerable improvement of land use planning in the Sub-region and thus constitute a step forward in the creation of a fully integrated pan-European land resource management system.

Recommendations

- On the basis of the existing European soil map at 1:1 million scale, a new European soil database should fit the major requirements of the global soil and terrain database. This implies an expansion of the map with a physiographic layer covering the whole of Europe, a revision of the soil legend to fully fit the 1990 Revised Legend, and a review of soil mapping unit boundaries where required. In addition the measured soil profile analytical database would be expanded to fit SOTER requirements, including classification of soil profiles in the World Reference Base for Soil Resources.

- The scale to be adapted would be 1:2.5 million for the whole region to make full use of the pre-existing information and to avoid copyright issues which may arise at larger scales.

- The Regional database would be complemented for selected smaller countries with a similar database at the larger scale of 1:250 000 in order to ensure that their specific national requirements are met, while they would remain compatible with the overall database.

- The operational and budgetary execution of such an undertaking would remain with the European Union with technical assistance of FAO and the respective national soil institutes in each of the countries concerned. The final result would be incorporated within the Global Soil and Terrain database and published under the logos of all contributors.

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The European Soil Information System

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 aimed at acquiring 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 coordination not only among countries, but equally, and to the same degree, among 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:

- The creation of a coordination group from the Directorates-General of the Commission (Inter DG Group) which includes the European Environment Agency (EEA).
- Support for a second meeting of Heads of Soil Surveys and those responsible for management of databases in the EU (CEC, 1991a).
- 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.

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European Commission, European Soil Bureau, Ispra (VA), Italy

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 or non-comparable datasets from national (or regional) organizations.

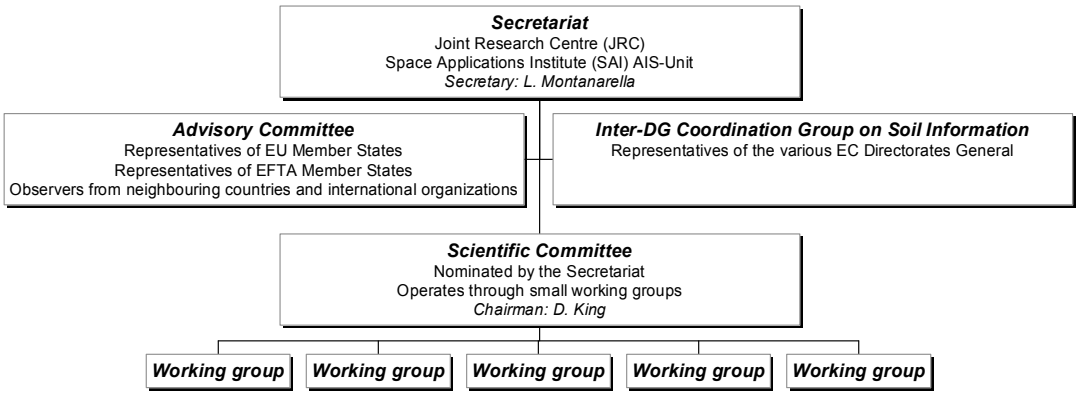
The second meeting of the Heads of Soil Survey and those responsible for management of databases in the EU was held in Orléans in December 1994. Main recommendations of the meeting (EC, 1996) were support for the ongoing process of updating the European geographical and analytical soil database corresponding 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 a 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 a European Soil Bureau.

European Soil Bureau

The European Soil Bureau (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 Joint Research Centre (JRC), Ispra, Italy, and is part of the Agriculture and Regional Information Systems Unit (ARIS) of the Space Applications Institute (SAI). Its aim is to carry out scientific and technical duties in order to collect and harmonize soil information relevant to Community policies, its relevant General Directorates (DGs), to the European Environment Agency (EEA) and to concerned Institutions of the EU Member States. Its current organization is represented in Figure 1.

FIGURE 1
Current organization 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 through 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 organizations (FAO, UNEP, etc.) and from the EU neighbouring countries. The committee ensures 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 an inter-service working group with participants from 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 European Spatial Planning Perspective (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 for 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 Coordination Group on Soil Information, are collected by the Secretariat of the ESB and transmitted to the Scientific Committee.

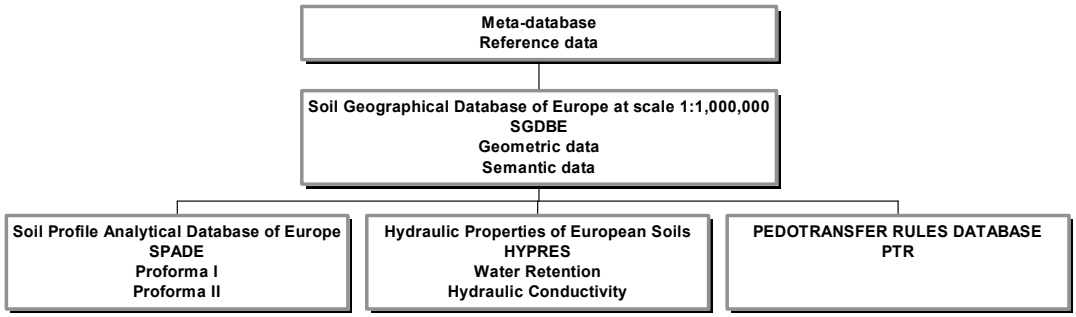
The Scientific Committee is in charge of implementing the necessary activities in response to the needs for soil information. It is formed by relevant European experts in soil science and operates through small *ad hoc* working groups in charge of performing the tasks requested by soil information users.

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

1. The 1:1 000 000 European soil database group has already been operating for many years, since 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 (Ver. 1) currently covers 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 also include Iceland. The final version will also incorporate the Soil Profile Analytical Database of Europe (SPADE) and a soil hydraulic parameters database linked to the 1:1 000 000 soil database of Europe, named HYPRES, which stands for Hydraulic Properties of European Soils. It will also include an expert system for the estimation of several additional parameters from the variables stored at present 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, named 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 recognized 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

FIGURE 2
Simplified structure of the European Soil Information System (EUSIS)



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 valorized in a European context. These countries, which were 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 Europe a tool of comparable importance to other well established systems in the United States (National Soil Information System, NASIS) and in Canada (Canadian Soil Information System, CANSIS). The European system, EUSIS, is fully compatible with the 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 access to soil databases. The general aim of the group has been to develop guidelines that ensure the maximum protection of data ownership together with regulated access for all the potential data users. This is developed in conformity with EU policy regarding access to relevant environmental information in Europe. The Chairman of the IAWG is Dr R.J.A. Jones (Silsoe College, Cranfield University). The Information Access working group developed 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 maximizes database access and use and safeguards intellectual property ownership by the Contributors. Licenser of all the soil data is the European Commission through its European Soil Bureau which 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 alters the cost of lease of data according to the use. Minimum charge (cost of handling) is applied to contributors and non-profit organizations for internal use. Charging is required in the case of external use by these organizations. Maximum charging is applied to full commercial uses by private organizations.

3. The 1:250 000 working group represents the future of the ESB. It works on 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 with national soil surveys and land research centres of the former 12 EU Member States demonstrated that the national coverage of soil mapping at scales appropriate for a more detailed soil map ranged from 10 percent to 100 percent. However in all countries, some areas were found with coverage sufficient to be converted into a 1:250 000 soil map through generalization, 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 of developing a method, 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 coordinated by regional coordinators 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. 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.

This nested European Soil Information System will fully integrate Europe within the future World Soil and Terrain (SOTER) data base (FAO), expected to be ready by 2002 and, at the other end of the scale, 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.

4. The soil erosion risk assessment working group, chaired by Prof. Dr N. Yassoglou (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 Europe 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 made at scale 1:250 000 covering Italy and Albania, respectively.

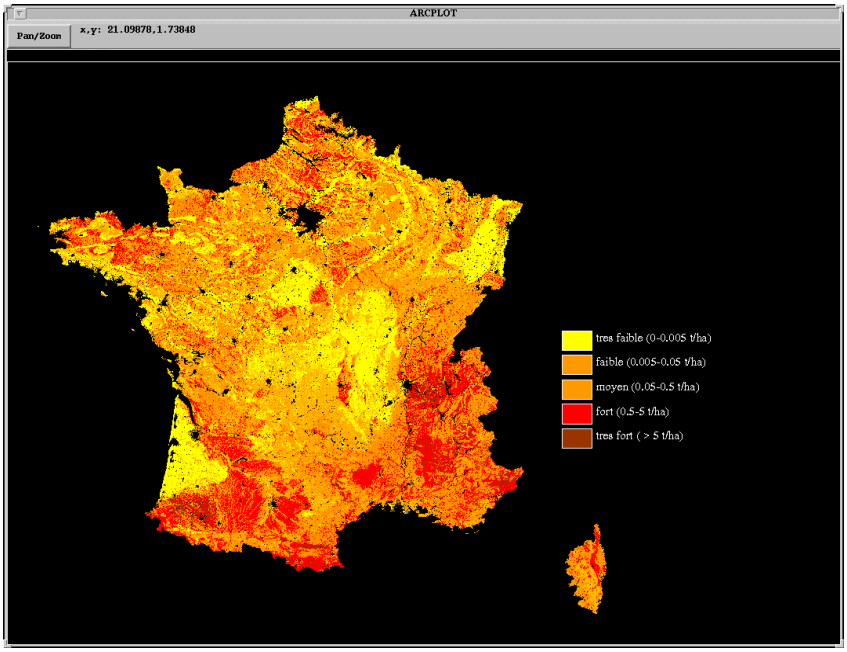
Currently the group has produced a preliminary test on France (Figure 3), in order to establish the most appropriate methodology for such a new pan-European soil erosion risk assessment.

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 harmonization 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 us 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.

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;

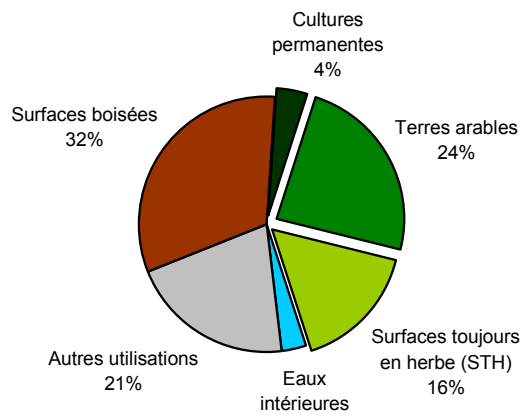
FIGURE 3
Soil erosion risk in France using a new Pan-European approach



- 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 harmonized 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 or mitigation.

These growing demands go far beyond the actual capabilities of the European Soil Bureau and require a much larger efficient organization. This has been also among the conclusions of the recent meeting in Bonn "Soil Protection Policies within the European Union" (Bonn, 9 to 11 December 1998) calling for a European Soil Forum among high-level officials and decision-makers to develop a "common ground" for soil protection policies in Europe. 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 human wellbeing. It is the multifunctionality of soil that has always prevented soil being treated as a medium worth conservation and protection. Many stakeholders hold a share in 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 in soil 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 becomes particularly obvious if we consider the current (1997) land use within the EU (Figure 4).

FIGURE 4
Major land uses within EU 15 (1997) (Source: Eurostat/ZPA)



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. 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 unsustainable 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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Country papers

Some aspects of land information in Albania

Land Information.

The territory of Albania is 28 748 km^2, out of which 7 000 km^2 are arable land, 10 400 km^2 are forests, 4 000 km^2 pastures, 500 km^2 are urban areas and the rest is lakes, rivers, canals, roads, seaside beaches, rocky areas etc. Albania is mainly a mountainous country and the arable land is scattered all over it, but most is in the western lowland, alongside the rivers and in the south-eastern plateau.

As a result of soil reclamation in the western part of Albania 52 000 ha arable land has been treated by swamp drainage and 200 500 ha arable land has been improved. Thus, prior to the land privatization there was an average of arable land of 1.2–1.4 ha per person.

There are considerable data on existing maps as regards to both their quality and availability. This information is being utilized to speed up the design and production of new maps (where there is previous experience).

Prior to the land reform in 1991, Albania had a system of physical cadastre under the Ministry of Agriculture, Soil Department, and 26 cadastral offices were set up in the 26 districts. These offices collected the relevant documentation as to the geographical position and the size of the parcels according to the topographic boundaries (canals, roads etc) but not including the ownership titles. They also had data on the kind of parcel; this was necessary for the planning of the centralized economy by the state. The map provided information based on the divisions of the agricultural cooperatives or state farms not on the cadastral village. The maps were kept and maintained by the cadastral offices in the districts, while the originals were mainly kept at the agricultural map service at the Institute of Soil Research. This system is still operating but nowadays it deals with the privatization process.

The cadastral maps are produced using traditional methods (tachiometry) at the scale 1:2 500 and 1:5 000. During about 45 years, 1 070 000 ha have been surveyed with this method, which represents one third of the entire country. It includes 629 000 ha arable land or 90 per cent of the total agricultural land. The survey is mainly carried out in the lowland and the hilly parts of the country and the findings have been used not only for the production of the cadastral maps but also for different research projects, drainage and irrigation systems, land management and agricultural planning etc.

The situation of the maps for the agricultural lands:

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Cadastral Maps 1:5 000		Bassel Maps 1:2 500		New Survey 1:50 000	
Sheets	Area (ha)	Sheets	Area (ha)	Sheets	Area (ha)
2050	890 000	353	180 000	500	300 000

In addition, the Army Topographical Institute has produced maps at a small scale which are of no use in agriculture though some of them at scales of 1:1 000 and 1:25 000 are used in forestry and pasture management.

The land privatization process has brought about a high parcel fragmentation, which is difficult to portray on the cadastral maps at the scale of 1:5 000. Therefore, it was decided that for all the agricultural areas the cadastral maps will be of the scale of 1:2 500 while for the urban zones of the cities and the villages they will be of the scale of 1: 500 and 1:1 000. The conversion of the maps from scale 1:5 000 to 1:2 500 is carried out through the photographic enlargement of 1:5 000 sheets, dividing them into four parts.

Alongside the use of the existing maps, new cadastral maps are being produced for the zones that are not covered by such maps.

It is planned to make air photographs of the most important zone of the country, the western lowland (4 000 km^2), at scale 1:10 000, so that they can be used for the design of the new photomaps and maps at 1:2 500, as well as for the city maps at 1:1 000, that are part of this zone. The existing maps of this area are very old, while this is the most intensive part in terms of agricultural production and potential for the future development of infrastructure and tourism.

In the mountainous zones, not covered by the cadastral maps, the arable lands are as much as 70 000 ha. For the survey of this area, it is necessary to make a survey of the whole physiographical area of 300 000 ha. The production of the maps for these zones will incorporate the use of the field methods, tachiometry using either theodolites or total stations. The latter is also a new technology for our country.

The areas actually covered by maps, will be digitized using digitizing or scanning methods. These technologies are not very well known in Albania. Therefore, it is essential to first provide the relevant equipment and train the staff.

In the other areas of the country, that are not included in this treatment and for which there is no need to produce large scale maps because there is little agricultural land and large forests with no future in terms of urban and industrial development, the forestry cadastral maps and those of the scale 1:25 000 or 1:10 000 will be used.

Soil Information

The first studies on land in Albania date back to 1938 – 1950. They provide limited data, strongly influenced by the then agro-geological classification trends. The Pedology Chair of the Agricultural University carried out profound studies on the basis of a unified methodology in 1950–1970. Based on such studies carried out in 1971–1973 and 1980–1986 and before the pedological map of Albania was designed at scale 1:200 000 and the administrative pedological maps at the district level at the scale of 1:50 000. For specific areas (hydromorphic lands, etc.) pedological maps were produced of scale 1:10 000.

In the nineties, the opening of the country to the west created opportunities to further deepen the studies in the field of land evaluation and for the conversion of the pedological map according to the legend of FAO-UNESCO and the Soil Taxonomy. For the first time we produced a pedological map at 1:1 000 000, following the above mentioned methods. This map was presented in the 16th World Congress of Soil Science held in Montpellier, France in August 1998. In parallel a group of experts in the Land Protection Section at the Institute of Soil Research in Tirana is field studying the lands according to the FAO-UNESCO methodology and is preparing the pedological map at scale 1:200 000 for the western lowland. With the present poor funding by the Albanian government, it is foreseen that it will be completed only after 20 years.

The basis for the land evaluation in Albania has mainly been the pedological map at scale 1:50 000 and partly that at scale 1:10 000 made after the Russian methodology and the classification that comes from it. This classification has as evaluation base the soil zones (horizontal and vertical zones) and is denominated as a genetic-agronomic classification. It is based primarily on the conditions of soil formation, which account for agronomic features favourable for agricultural cultivation. This classification has been accepted as the national classification. After 1990 the FAO-UNESCO legend and the Soil Taxonomy were applied for the national classification. Hence, the pedological map at the scale of 1:1 000 000 has been produced and the production of the map at the scale of 1:20 000 has been started.

Conclusions and Recommendations

The maps of 1:1 000 000 and 1:200 000 provides only a generalized information while the Albanian territory is relatively small and there is a rich variety of lands. It suffices to mention that in the most recent publication of the Soil Taxonomy 12 soil orders are recognized while in Albania at least six of them are identified: Histosols, Vertisols, Mollisols, Alfisols, Inceptisols and Entisols. Hence the indispensability of producing maps of a large scale.

During recent years, the European Community helped introduce GIS technology in Albania. The project foresaw the establishment of a centre for training staff, and pilot projects for the technology in a limited area. Having accomplished all the objectives, the project ended in 1998. Due to the lack of financial means, no further steps have been undertaken. The Ministry of Agriculture and Food of Albania has submitted proposals to FAO and the European Community for the continuation of this effort through the funding of a new project which mainly consists in the use of GIS technology in other districts and their networking with the centre.

The status of soil mapping in Austria

The present status of soil survey and soil data in Austria has recently been reviewed by Blum *et al.* (1999). According to this review, there are three systems of soil survey in the country, namely:

- the Forest Soil Survey, carried out by the Federal Forest Research Centre
- the Austrian Agricultural Soil Survey, carried out by the Institute for Applied Soil Science Federal Office and Research Centre for Agriculture
- the Soil Taxation Survey, also mainly dealing with soil used for agriculture, carried out by the Financial Administration.

These systems produce soil maps of different scales and covering different percentages of the surface area of the country.

Furthermore, available soil information is completed by a large set of data referring to distinct sampling points. Most of these points are arranged in grids of different densities, covering almost all of the country. Results referring to soils under forests have been reviewed by Kilian *et al.* (1992) and those referring to agricultural soils by Danneberg *et al*. (1997). The Federal Environment Agency is developing a computer-aided information system to collect these data (Schwarz *et al.*, 1994, 1998), with several other systems making use of them.

Forest Site Mapping

Forest site mapping started in the early 1960s and since then, some 400 000 ha or 100 percent of forest land has been mapped, predominantly at scales 1:10 000 or 1:25 000. Mapping has been focussed on state-owned forest land, the floodplain forests of the Danube and the Vienna Woods.

The mapping uses the "combined method" developed in Baden-Wüttemberg with some minor variations. The goal is the definition of site units, fitted into a hierarchical framework. Climate, geology, pedology and vegetation are used for site classification. Recently, guidelines for forest site mapping in Austria have been completed, considering also modern techniques (Kiliam and Englisch, 1998). A large forest soil database has been developed, containing about 5 000 descriptions of soil profiles and 26 000 analyses of individual soil horizons.

Soil Taxation Survey

The taxation of agricultural land is carried out by the financial administration in cooperation with the Federal Surveying Office since 1947. The first taxation – mainly based on the German Soil Taxation Act of 1934 – was completed in 1973. The Austrian Soil Taxation Act of 1970 provided

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a new legal basis, regulating the continuation and updating of soil taxation data and their integration into the Austrian Cadastre. Since 1974, the data have been updated and reassessed, taking into consideration changes in important environmental factors.

Soil parent material, texture, humus horizons and structure are used to define the soil unit (Klassenfläche). Maps are produced at scale 1:2 000 or 1:2 880 (scale of old cadastre). Soil assessment data exists in analogue form for approximately 2.8 million hectares of agricultural land, which corresponds to 33 percent of the total area of Austria. The digital capture of soil assessment data is planned.

The Austrian Agricultural Soil Survey

A systematic mapping of soil under agricultural use is being carried out since 1958 by the former Federal Institute of Soil Survey, now Institute for Applied Soil Science, Federal Office and Research Centre for Agriculture. Up to now, almost 98 percent of the area to be mapped has already been surveyed in the field. Out of 220 districts, 150 districts have been published as soil maps at 1:25 000 and a further 50 districts as manuscript maps at 1:25 000; 15 districts remain for editorial work and 5 for field survey.

Soil surveying is done from both a pedological and an agricultural point of view. It also considers geological, geomorphological and climatic conditions. Soil units are defined as areas of identical soil type and similar site conditions. For each soil unit at least one soil profile is described, samples are collected and analysed originally for pH, texture, soil organic matter and lime-content (old scope of analysis) and later on additionally for exchangeable cations, electrical conductivity, plant available nutrients and a series of heavy metals (modern scope of analysis). Thus, more than 20 000 profile descriptions exist, complemented by analytical data.

For the digital capture of these soil data, a GIS-based soil information system was installed using the GIS software, ArcInfo, and the databank system ORACLE. The databank structures have been built up within the framework of the EU project Interret IIC. The geometric and attribute data of a project area consisting of 5 districts are being converted to a digital form; the first of these districts is already completed. A three year programme to convert the great bulk of geometric and attribute data to a digital form has commenced.

Scale and classification system used in the national maps

As already mentioned, most Austrian soil maps use the scale 1:25 000. Normally, the scale of the field maps is larger, the Austrian Agricultural Soil Survey, for example, uses a scale of 1:10 000 for the field maps. The Soil Taxation Survey uses the scale of the Austrian Cadastre, i.e. 1:2 000 or 1:2 880 (old cadastre).

The Austrian System of Soil Classification dates back to 1968 (Fink, 1968). It was prepared by a commission of the Austrian Soil Science Society and adopted by this society. Since then, it is used by all Austrian institutes concerned with soil survey. The system is a genetic one and is mainly based on the ideas of Kubiena (1953). It will be used at least until the Austrian Agricultural Soil Survey is finished, to avoid a system change within work that is not yet completed.

However, due to the long time elapsed since 1968 and to the large progress of pedological science within this time, the need for a more modern system of soil classification exists. The Austrian Soil Science Society therefore appointed a commission chaired by O. Nestroy, Graz, to

prepare a new system of soil classification. This system should consider the almost complete knowledge about Austrian soil distribution, which has accumulated during the last decades, the latest developments in international soil science and the state of discussion on soil systematics especially in the neighbouring countries. It should, however, keep in mind that it must be possible to translate from the old system to the new one, (preferably by computer-aided procedures) in order to avoid a devaluation of the existing information. This work will be finished in the near future as preliminary results have already been published (Nestroy, 1998).

Problems envisaged for adaptation of the national and regional maps to a global methodology

The newly prepared Austrian systematics consider the need for a translation of soil types into WRB. This, however, is not always possible. Several soil types, especially those of the alpine regions, are not adequately classified by the WRB system (Nestroy, personal communication).

Suggestions for a regional mapping scale and applications

Nestroy (1999) published a soil map of Austria as part of the European soil map at 1:1 000 000. It is planned to further develop this map to a scale of 1:500 000, using the new Austrian soil systematics (Nestroy, personal communication). All kinds of application of such small scale maps should be treated with extreme care.

Eventual national copyright considerations

All organizations carrying out soil survey hold the copyright for their respective sets of data. The copyright status of the newly built computer-based datasets need decisions by the official Austrian authorities. Up to now, no official consideration of this subject has occurred.

Conclusions and recommendations

From an Austrian point of view, the completion of the programmes to build up national soil information systems will need priority. These systems will enable the construction of regional maps without the insufficient precision which up to now is inherent in such a construction.

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Rapport sur l'état de l'information sur les sols en Belgique

Etat de la cartographie des sols, échelle et système de classification

Le levé systématique de la carte des sols de Belgique a débuté en 1947 et s'est terminé en 1990. Les relevés de terrain ont été réalisés à l'échelle du 1/5000 sur plan cadastral selon une maille de 75 mètres de côté, soit encore une densité de sondages jusqu' à une profondeur de 1,25 m de 1,7 à l'hectare. La cartographie de l'ensemble du territoire a été réalisée sous forme de planchettes couleurs au 1/20 000 représentant chacune une superficie de 8 000 ha. Un total de 457 planchettes ont été ainsi publiées. La plupart de ces planchettes sont accompagnées d'un texte explicatif qui reprend des informations sur l'oro-hydrographie, la géologie, la climatologie, le type de paysage, l'occupation des sols et le contexte socio-économique de la zone couverte. Une systhèse de la carte des sols a été réalisée par Marechal et Tavernier (1974) en réunissant les différentes unités taxonomiques de la carte au 1/20 000 en zones cartographiques similaires appelées associations de sols.

La classification adoptée pour établir la légende de la carte des sols de Belgique distingue les séries ou unités principales qui sont caractérisées par trois ou quatre facteurs identifiables sur le terrain :

- la nature de la roche mère ou texture de l'horizon de surface ;
- l'état de drainage naturel ;
- le développement du profil (horizons diagnostiques) ;
- la nature de la charge caillouteuse lorsqu'elle est présente.

Les cartes comportent également des informations complémentaires sur des variantes ou des phases de sols particuliers (nature de la charge caillouteuse, variante de développement de profil, phases de profondeurs).

Parallèlement au travail de cartographie proprement dit, la caractérisation détaillées des unités pédologiques a été assurée par la description et l'analyse de profils réalisés à raison d'un profil environ tous les deux kilomètres carrés. La plupart de ces informations ont été ont été rassemblées dans une base de données géo-référencée (Van Orshoven *et al.*, 1988) qui comporte plus de 13 000 profils et un total de 69 000 horizons associés.

La digitalisation partielle des cartes au 1/20 000 a été réalisée depuis de nombreuses années dans différents institutions de recherche. Il n'existe malheureusement aucun inventaire des travaux qui ont été réalisés. D'autre part, il n'y a aucune garantie quant à la cohérence des documents numériques existants (absence de norme).

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La Belgique a également participé de manière active à la préparation de la carte européenne des sols au 1/1 000 000 et notamment à la base de données analytiques de profils représentatifs constituée pour caractériser les différentes unités typologiques de sols (STU) (Van Ranst *et al*, 1994) .

Problèmes d'adaptation à une méthodologie mondiale

Dans le cadre de travaux préparatoires à l'élaboration d'une carte des sols au 1/250 000 pour les communautés européennes, des travaux ont montré (Vander Poorten, 1993) que la conversion des unités du système belge de classification des sols utilisé pour la carte au 1/20000 vers le système de classification de la FAO pouvait être envisagée sans problème majeur compte tenu de l'ensemble des informations disponibles. Cette étude a également fait ressortir que la prise en compte d'un niveau de classification supplémentaire correspondant à la texture, associée à une description des caractéristiques de la région pouvait s'avérer nécessaire.

La carte au 1/20 000 n'étant pas disponible sous forme digitalisée pour l'entièrité du pays, il n'est pas possible d'automatiser sa conversion vers une carte qu 1/250 000 à l'aide d'un SIG. Une procédure manuelle a été proposée par les auteurs de cette étude. Celle-ci est basée sur la réduction des planchettes au 1/20 000 à une échelle de 1/100 000 et la délimitation puis la digitalisation des associations des sols reportées sur ces nouveaux documents afin d'être transposées par une procédure informatique à une échelle 1/250 000. Etant donné que la quantité d'information qui peut être représentée sur une carte est limitée, il est apparu indispensable de rassembler dans une base de données des paramètres complémentaires relatifs à l'ensemble des unités cartographiques qui ont été retenues.

Proposition pour une échelle et applications régionales

Le Ministère belge des Classes moyennes et de l'Agriculture ainsi que les Services Fédéraux des Affaires Scientifiques Techniques et Culturelles (SSTC) soutiennent un projet de recherche dont l'objectif est l'adaptation du système de prévision des productions agricoles établi pour la Communauté européenne (MARS project) aux conditions spécifiques du pays.

L'outil qui doit être mis en place estime l'état des cultures et les productions agricoles en utilisant une approche combinée faisant intervenir un modèle agrométéorologique (CGMS) et la télédétection. Les données pédologiques nécessaires au fonctionnement du modèle sont déduites de la carte des associations de sols au 1/500 000 digitalisée au format vectoriel.

Chaque unité cartographique est associée à une base de données de caractéristiques décrivant les propriétés des différents horizons. Une certain nombre de paramètres caractérisant les propriétes hydriques des sols ont été estimées à partir de fonctions de pédotransfert adaptées aux conditions régionales (Vereecken, 1988). Il est prévu que le modèle puisse fonctionner sur la base d'une simulation établie sur des mailles élémentaires de 1 km x 1 km. La précision pour chaque point de simulation est liée au choix des unités de sols réprésentatives.

Pour l'instant, l'échelle utilisée pour la carte pédologique ne permet pas de délimiter les zones de production avec toute la précision souhaitée. dans ce contexte particulier l'utilisation d'informations disponibles à une échelle de 1/250 000 pourrait constituer une amélioration substantielle du système dès que celui-ci entrera dans sa phase opérationelle.

Le développement dóutils pour la gestion des terroirs et l'aménagement de l'espace rural dans le sud-est de la Belgique (gestion des zones humides, des sécheresses, des productions fourragères, cartographie des aptitudes agricoles et forestières, diversification de léspace agricole est aussi un domaine de recherche et de développement qui réclame des informations sur les sols de plus en plus précises et variées. Dans ces conditions régionales particulières, il est généralement admis que des documents à une échelle au 1/50 000 devraient constituer une base indispensable pour la réalisation de ces travaux.

L'utilisation de la carte des sols pour établir un référentiel agro-pédologique destiné à améliorer le paramétrage des normes de fertilisation dans le cadre des analyses de terres qui sont réalisées à la demande des agriculteurs (Laroche et Oger, 1999; Vandendriessche *et al* , 1993) constitue un objectif pour plusieurs équipes de recherches. Dans ce cas également une échelle au 1/50 000 constitue un minimum nécessaire. Cette démarche est également à replacer dans le cadre du développement d'une agriculture de précision.

La délimitation des zones à risques ou de protection spéciale vis-à-vis des problèmes posés par le lessivage des nitrates et des pesticides dans le sol est devenue une préoccupation prioritaire pour les pouvoirs publics en matière de protection de l'environnement.

L'intégration des données sur les sols dans des systèmes d'information détaillées à des échelles de l'ordre de 1/50 000

Considérations sur les problèmes de droits d'auteurs

Comme dans la plupart des pays européens le levé de la carte des sols de Belgique, ainsi que les programmes de récolte de données qui y sont attachées, résulte d'un parténariat entre l'Etat (Ministère de l'Agriculture) et différentes institutions d'enseignements ou de recherche (Rijksuniversiteit Gent, Katholieke Universiteit Leuven, Faculté Universitaire des Sciences Agronomiques de Gembloux). Selon les termes de la plupart des conventions de recherches signées avec l'Etat belge et en particulier avec le Ministère des Classes Moyennes et de l'agriculture, celui-ci reste en principe propriétaire des résultats de recherches. D'autre part, le bénéficaire s'engage à informer l'Etat des possibilités de valorisation qu'il identifie, y compris celles relatives à d'éventuels partenaires extérieurs. Tout contrat relatif à la valorisation des résultats de la recherche subsidiée doit être soumis à l'accord préalable de l'Etat. Il s'agit d'un accord de principe qui néxclut donc pas *à priori* la diffusion des informations dans le cadre d'un projet européen à plus grande échelle.

Les problèmes de droits de propriété intellectuelle de ces données ont déjà été abordé dnas le cadre de la mise en place de la base européenne des sols. Une attention toute particulière doit cependant être accordée à l'identification du "contributeur" au niveau de chaque pays, surtout lorsque plusieurs institutions sont impliquées dans la fourniture des données. Au niveau national, il semble plus logique de ne mandater qu'une seule institution pour remplir ce rôle, à charge de celle-ci d'informer les autres de l'état d'avancement des travaux et de l'utilisation qui est faite des données.

Conclusions et Recommendations

En dépit de la quantité d'informations disponibles pour le territoire de la Belgique, l'evolution des politiques et des systèmes de gestion de l'environnement et de l'espace rural a fait apparaître de nouveaux besoins qui ne peuvent être rencontrées qu'à la condition d'enrichir les bases de

données nationales par des campagnes systématiques de mesures des paramètres physiques et chimiques du sol en particulier les caractéristiques hydro-dynamiques. Les variations spatio-temporelles de ces paramètres devraient pouvoir être prises en compte afin de servir de support à des études portant sur la dégradation des sols aux changements climatiques.

D'une manière générale les besoins évoluent vers des échelles de travail de plus en plus fines, ce qui implique de pouvoir caractériser de manière précise un plus grand nombre d'unités cartographiques.

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Soil mapping in Bosnia and Herzegovina

Bosnia and Herzegovina (B&H) covers an area of 51 129 km^2. Agricultural land covers 25 253 km^2 or 49.4 percent, forests 23 684 km^2 or 46.3 percent, while 2 192 km^2 or 4.3 percent is barren land. Orthomorphic soils cover 84.5 percent, while hydromorphic soils cover 11.2 percent of the area. The remaining area of 4.3 percent is settlements, rivers, lakes, etc. A major part of Bosnia and Herzegovina, 87 percent, is mountainous with altitudes above 300 m and terrain inclination is over 13 percent in 84 percent of the region.

The Basic Soil Map of B&H at scale 1:50 000 displays the distribution of soil types with their basic terrain features as well as morphological, chemical, physical and biological properties of the soils. Up to now, this is the only map made of the whole country that displays a representation of soil types, including their lower systematic units wherever the scale allowed. The Basic Soil Map includes 116 sheets that are arranged according to a polygonal net. We have verified 36 basic soil types and a large number of subtypes, varieties and forms. A total of 1 176 different mapping units were specified, in 3 176 mapped units. Some 39 476 profiles were opened, 6 152 of them primary (full) and 33 321 secondary (semi-profiles).

Soil Mapping Conditions in B&H

The mapping system in B&H is arranged in two groups:

- Soil mapping system
- Land mapping system

Soil mapping (taxonomic maps)

B&H maps at different scales are in three groups:

a) Global soil maps (small-scale maps) that cover the whole of B&H, are grouped as:
   - Orientation Maps at scales 1:1 000 000; 1:750 000 and 1:500 000
   - Basic Map 1:50 000

b) Regional, survey and soil maps (medium-scale maps) at scales of 1:25 000 and 1:10 000, made for specific regions in B&H at the time of construction of traffic arteries, water reservoirs, city planning etc.

c) Local, detailed soil maps (large scale maps), at scales of 1:5 000, 1:2 500, 1:1 000 and 1:500, made for certain local places in B&H for land cultivation, preparation of regulating plans, reclamation of devastated soil, cemetery construction, etc.

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Land mapping (applied maps)

The purpose of land mapping is recording and evaluation of the situation in the field by:

a) *Cadastral Land Classification* (large scale maps), cadastral plans of Municipalities, classed as cadaster municipalities (KO), were made with marked land lots for the purpose of cadastral income and taxation policies in B&H. A cadaster was established in all municipalities in B&H and is regulated by the Law on Surveying and Cadaster in B&H as:
- close city area 1:1 000
- broad city area and suburbs 1:2 500
- rural area (grassland and forests) 1:5 000

b) *Bonity Categorization* has no significant application in B&H as yet; the reason being the very complicated bonity categorization system proposed in Bonity Categorization Guidelines (1986).

c) *Land Capability Map* (survey map), made for the purpose of city planning in B&H municipalities (109 municipalities) at scale 1:25 000. Land capability categories were distinguished (I-VIII) for the purpose of preservation and rational utilization of land in B&H. At present, this map exists for 60 percent of the B&H area.

d) *Soil Erodibility Map* at scale 1:25 000; this map was made by a Belgrade Institute, however it was destroyed in the Waterworks Company building in Sarajevo during the war of 1992-1995.

e) *Agricultural and Forest Land Map;* these maps were made at various scales from 1:500 000 for the whole of B&H to 1:10 000 for particular areas in B&H totalling 40 percent of the territory.

f) *Production Areas Map* (survey map); such maps were made for certain regional areas at 1:25 000 scale. Three zones were distinguished:
- I zone (I-IV category) land designated exclusively for agricultural production;
- II zone (V-VI category) land designated for agricultural production and other purposes;
- III zone (VII-VIII category) land for all purposes.

g) *Land Zonation Maps* (global and orientation maps); various land zonation maps were made with appropriate designs:
- Vertical Zonation Map of B&H at scales 1:1 000 000 and 1:500 000 with zones according to altitude (0-200 m, 200-400 m, 400-600 m, 600-800 m, 800-1000 m, 1000-1500 m and above 1500 m),
- Regional Map of B&H at scales 1:1 000 000 and 1:300 000
  - early type - 6 regions (lowlands, mountainous, mountainous-alpine, alpine, sub-Mediterranean and Mediterranean)
  - recent type - 4 regions (lowlands 0-300 m, mountainous 300-700 m, alpine above 700 m and Mediterranean below 700 m)
- River Basins Map, scale 1:300 000. There are two river basins in B&H:
  - Black Sea river basin - 76 percent of B&H - Danube (Sava tributaries)
  - Adriatic Sea river basin - 24 percent of B&H - Neretva and Trebisnjica.
- Production Regions Map, scale 1:200 000. There were 23 production regions in B&H before the war (Bihac, Prijedor, Banja Luka, Doboj, Modrica, Brcko, Bijeljina, Zvornik, Tuzla, Sokolac, Sarajevo, Visoko, Zenica, Travnik, Jajce, Drvar, Livno, Bugojno, Konjic, Gorazde, Mostar, Capljina and Trebinje).

Scale and Soil Classification Systems in B&H

In the previous period two classification systems were used:

- General System of Soil Classification (Taxonomic classifications)
- Special System of Land Classification (Applied classifications)

Taxonomic Classifications - Soil Classification

In former Yugoslavia and in B&H the following classifications were in force for designing soil maps:

- Stebut A. (1926): Schematic classification of soil in Yugoslavia. A map of Yugoslavia at 1:750 000 was made according to this classification.
- Gracanin M. (1950): Genetic classification of soil in Yugoslavia. An improved map of Yugoslavia at 1:750 000 was made according to this classification.
- Neugebauer V., Ciric M., Filipovski G., Skoric A., Zivkovic M. (1963): Classification of soil in Yugoslavia (genetic classification). A Basic Soil Map of B&H at 1:50 000 was made according to this classification by the Institute of Agropedology, Sarajevo (1989).
- Skoric A., Filipovski G., Ciric M. (1973): Novel classification of soil in Yugoslavia. A soil map of B&H at 1:500 000 was made according to this classification by the Faculty of Forestry, Sarajevo (1980).
- Skoric A., Filipovski G., Ciric M. (1985): Classification of soil in Yugoslavia. Commonly in use today; certain soil maps in B&H were made according to this classification.
- Skoric A. and Resulovic H. (1990): Soil classification in B&H. At present this is the prevailing soil classification in B&H (see table).

Applied Classifications - Land Classification

Amongst significant land classifications we can single out the following:

- Cadaster land classification (Book of Regulations, 1986), cadaster of all municipalities in B&H was made at 1:5000 - 1:1000.
- Bonity Categorization (Guidelines, 1986), a little was done in the area of Semberija at 1:5 000 and 1:2 500.
- Land Capability (Jaksic *et al*., 1983), maps were made for individual municipalities at 1:25 000 in B&H.
- Land Regionalization (Law, 1988), a map of Regions in B&H was made at 1:300 000.
- Land Zonations (Resulovic, 1996), maps were made for individual regions at 1:25 000, Sarajevo & U-S Canton.

Brief descriptions of individual technical classifications

Cadaster Land Classification is regulated by the Law (1984) and Book of Regulations (1986). Land is classified in eight groups (fields, gardens, orchards, vineyards, meadows, pastures, forests, and swamps). Each group is arranged in eight classes (I to VIII), the first (I) being the best and the eighth (VIII) the worst quality. Income tax was based on these classes.

Land Bonity Categorization. Land is classified in bonity classes and its production capacity and other natural resources are evaluated regardless of the mode of its present utilization (Kovacevic 1975). Land is evaluated in the scale 0 to 100 points and classified in eight categories (I to VIII).

Land Capability Classification. Jaksic *et al.* (1983), designed a classification using the Slovenian classification designed by A. Stritar. Land is classified in eight categories (I-VIII), the first being of the best and the eighth of the worst quality.

Land Zonation - means land classification in three relevant production zones (Resulovic, 1996):

- zone I - the best quality areas (I - IV categories)
- zone II - average potential areas (V - VI categories)
- zone III - areas of inadequate production (VII - VIII categories)

Land Utilization divides the land into relevant zones followed by the definition of the production areas for agriculture, forestry, urbanism, industry, exploitation of minerals, waterworks etc. Classification of agricultural land utilization for farming, cattle breeding, production of fruit, forest breeding etc., as suggested by Antunovic et al (1976), still needs to be designed for each of these types of production.

The Problem of National and Regional Maps Adaptation to Global Methodology

Considering that soil maps were made up to now according to different classifications and methods, it is essential to establish a soil classification system in B&H for application in future. Concurrently, the existing maps will be updated according to the agreed classification, i.e. adjusted to the new classification system.

In order to achieve high quality design and processing of the new adjusted maps it is necessary to establish a Soil Information System in B&H (SIS B&H). Within the process of establishing SIS B&H it will be necessary to develop original software that will convert existing maps into the new classification system. This will require provision of significant financial resources (a rough estimate is US$ 2 - 3 million).

Amongst significant problems we can point out the following:

- lack of a soil information system in B&H;
- insufficiency of competent experts for operating the soil information system;
- lack of adequate equipment (hardware and software) as well as other auxiliary equipment (scanner, plotter, network etc.);
- non-possession of satellite images and air photos;
- nonexistence of adequate vectored geodesic substructure, i.e. non-existence of GIS B&H.

Considerations of Scale and the Level of Application

In accordance with the available geodesic maps, the scale for designing the global soil map of B&H is 1:25 000. As is well known, due to war devastation the Government of B&H is not able to finance designing of this map, therefore the realization of this project should be initiated at regional level with the aid of the international community.

Regarding mapping at the local level, because of the structure of the terrain and the existence of a large number of lots (approximately 10 000 000 lots in B&H) the optimal scale is 1:5 000.

At this level it is possible to display terrain distribution and establish a database for each lot examined, while the soils may be presented at the level of variety or even form.

Map Surveillance and Access Rights in B&H

According to earlier regulations that are, unfortunately, still in force, the Basic Soil Map of B&H at 1:50 000 scale has the status of secret record.

That same level of secrecy is imposed for topographic maps at 1:25 000, the so-called four-coloured maps that display rivers, lakes, roads, settlements, agricultural land, forests and topography (contours), with major peak elevations and geodesic triangulation points.

Land cadaster and geodesic plans are under the authority of the office for geodesy and cadaster service of each municipality, while the land register is within the jurisdiction of the court.

Distribution of other global maps is not limited and they can be procured from the relevant institutions where they were produced.

Conclusions and Recommendations

Considering the geographical position of B&H, the fact that our country is a part of Europe and that in the near future we can expect integration in the EU, we propose the following:

1. We support the approach of establishing a single soil information system at the level of the whole of Europe (EUSIS) that would include B&H.
2. Should such a unique soil information system be established, it would be necessary that all system members agree on appropriate methods and one unique classification system.
3. In B&H, the basis for establishing the unique soil information system (EUSIS) might be Basic Soil Map of B&H at 1:50 000, which must be adjusted to the agreed soil classification.
4. The Basic Soil Map of B&H 1:50 000 is the most detailed map of soil distribution in B&H made up to now. It was drawn on the basis of accurate field and laboratory research. According to rough estimates it contains over 7 000 000 items of data on internal and external properties of soil in B&H.
5. We propose a subsystem of the Global European System, a Centre for Southeast Europe that would include developing countries, countries in transition and all the countries of former Yugoslavia.
6. We propose that EUSIS member countries should have their own system that would be a part of EUSIS network. That system would be further developed by monitoring and additional research.

SOIL CLASSIFICATION OF BOSNIA AND HERZEGOVINA
(Škorić A. and Resulović H., 1990)

Division, class and soil morphology	Soil type
A. ORTHOMORPHIC SOILS	
I - Undeveloped soils (A) - C	1. Litosol 2. Regosol 3. Arenosol 4. Koluvium
II - Humus-accumulation soils A – C A - R	1. Kalkomelanosol 2. Rendzina 3. Ranker 4. Vertisol
III - Cambic soils A - (B)v – C A - (B)rz - R	1. Eutric cambisol 2. Dystric cambisol 3. Kalkokambisol 4. Terra rossa
IV - Eluvial - illuvial soils A - E - Bt - C A - E - Bt - R	1. Luvisol 2. Podzol 3. Brunipodzol
V - Anthropogenic soils P - C	1. Rigosol 2. Hortisol
VI - Technogenous soil (A) - I - II	1. Deposol 2. Recultisol 3. Flotisol 4. Combustosol
B. HYDROMORPHIC SOILS	
I - Undeveloped hydromorphic soils (A) - I - II	1. Fluvisol
II - Pseudogley soils A - Eg - Btg - C A - g1 - g2	1. Pseudogley
III - Semigley soils A - C - G	1. Humofluvisol
IV - Gley soil A - G	1. Pseudogley – gley 2. Humogley 3. Eugley
V – Histosol T - G	4. Low peat 5. Peat-moss

The status of soil mapping in Cyprus

In Cyprus, systematic soil studies and soil classification started in 1957, aiming at collecting information and data about the physical and chemical properties of soils.

The first soil classification system used was based mainly upon the formation, the origin and the parent material of the soils. Accordingly, soils were classified mostly as Red soils, Sedentary, Alluvial or Colluvial soils. Usually, an examination of the master horizons A, B, C, D including soil physical and chemical analysis, was carried out in order to classify the soils of these groups into soil series using local names.

In general, Red soils have been classified into soil series according to the C and D horizons.

Sedentary soils were classified into soil series according to the type of parent material which constituted the D horizons. Soil series have in many cases the same names as the geological formations.

Alluvial or colluvial soils were classified into soil series according to their origin and their physical and chemical properties. Local names have also been used for soil series.

In 1970 the soil legend of the Soil Map of the World elaborated by FAO-UNESCO introduced a new effort to establish a common international language in soil classification. Within this framework of the preparation of the Soil Map of the World, a system of soil horizons was adopted. Soil horizons which are used for identifying soil units are called diagnostic horizons.

The definitions used in this system are drawn from those adopted in the soil taxonomy of the United States Department of Agriculture in 1975. The definitions of these horizons have been summarized and sometimes simplified, in accordance with the requirements of the FAO-UNESCO legend for the Soil Map of the World.

As a result of our observations and soils studies, the following diagnostic horizons from the FAO system have been adopted for use in Cyprus: Mollic, Ochric, Argillic, Natric, Cambic, Calcic and Gypsic.

In order to separate soil units, some diagnostic properties from FAO-UNESCO system are used and a number of soil Orders and Sub-Orders have been recognized, corresponding to the following general definitions:

- Lithosols – Soils which are limited in depth by continuous coherent and hard rock within 10cm of the surface. Lithosols are divided into two sub-orders (in Cyprus): Calcaric and Eutric.
- Fluvisols – Soils from recent alluvial deposits, having no diagnostic horizons other than an ochric A or a histic H horizon.
- Regosols – Soils from unconsolidated material, having no diagnostic horizons other than an ochric A horizon. Regosols and Fluvisols have been divided into calcaric and eutric sub-orders.

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- Rendzinas – Soils having a mollic horizon immediately overlying extremely calcareous material.
- Solonchaks – Soils having high salinity within 125cm of the surface (EC >15 mS cm $^{-1}$). These have been separated into gleyic and orthic Solonchaks.
- Solonetz – Soils having a natric B horizon.
- Vertisols – They have 40 percent or more clay in all horizons, developing wide cracks from the soil surface downwards. Furthermore, they have slickensides and some unfavourable as well as favourable physical properties.
- Cambisols – These soils have a cambic B horizon and no other diagnostic horizon than an ochric or an umbric A horizon, a calcic or a gypsic horizon. Soils classified as Cambisols occupy extensive areas and are sub-divided into the following sub orders: vertic, calcaric, calcic, eutric and chromic Cambisols.
- Luvisols – These soils have an argillic B horizon and they are subdivided into vertic, calcic and chromic Luvisols.

The General Soil Map of Cyprus of 1970 is based on the former classification system.

Since 1974, after the Turkish invasion, soil survey has been carried out in the Government controlled areas of the Republic of Cyprus. The FAO classification system was used and each time revised and improved in the process of soil mapping. Last year, however, an effort was undertaken so that the soil mapping based on previous classifications was adjusted to the new classification system (FAO, 1998) the World Reference Base for Soil Resources, with the aim of preparing a new soil map of Cyprus. For the areas that have not been soil surveyed by any means, other methods have been used such as extrapolation, photo interpretation as well as revision of the general soil map of Cyprus.

Based on the above approach, a new soil map of Cyprus was prepared in electronic form and printed on a scale of 1:250 000 in 1999.

The Scale and Classification System used in the National Soil Map

The General Soil Map of Cyprus published in 1970 was printed at scale 1:200 000 based on the FAO-UNESCO Soil Map of the World 1970 classification system. The following orders and sub-orders were recognized and mapped: Calcaric and eutric Lithosols, gleyic Solonchaks, xeric, rhodic, chromic and pellic Vertisols, calcaric, gypsic, vertic Xerosols, orthic Solonetz, vertic, calcaric, eutric Cambisols, mollic, ochric Rendzinas, calcaric and eutric Rhegosols.

A new soil map of Cyprus was based on the new World Reference Base for Soil Resources soil classification system (FAO, 1998) and was prepared in electronic form and printed at a scale of 1:250 000. The main groups of soils which have been recognized and mapped are shown in Annex A with some general analytical data for them in Annex B.

Problems Envisaged for Adaptation of the National and Regional Maps to a Global Methodology

The problems envisaged for adaptations of the national and regional soil maps to a global methodology of soil taxonomy relate mainly to the following factors:

- Different soils occupying small areas as remnants due to erosion were mapped as associated soil groups. Other soils developed in depressions and on slopes of mountainous areas, were also mapped as associates. This concept has been used as a solution for the mapping of the above cases and it should be clarified whether it is acceptable by the global methodology.
- In a general soil map at a small scale (1:250 000 – 1:1 000 000) where generalization is necessary, small areas with different soil groups are blended. As a result, detailed information about the physical and chemical properties of the soil is lost.
- The formation of several soils related to different geological layers and rocks is very common in our country and since this factor is not fully taken into consideration in this classification system, it is necessary to find an acceptable solution for these cases.

Suggestions for a Regional Mapping Scale and Applications

The regional mapping scale depends usually on the topography, the dissimilarity of soil development as well as on the purpose of the survey. Small scale soil mapping is suggested (1:50 000 – 1:250 000) when it covers areas with natural vegetation and dry cultivation, as well as areas with restricted suitability for agricultural use.

When it comes to agricultural areas with intensive cultivation designated for irrigation, or narrow valleys and terraces of mountainous areas, the scale should range between 1:5 000, 1:10 000 and 1:25 000) so that a more detailed study of the soil is achieved.

Eventual National Copyright Considerations

The legal considerations concerning the eventual national copyright of the soil maps together with the special soil reports are included in the authority of the Government of the Republic of Cyprus.

Conclusions and Recommendations

The revised classification system of the FAO published in 1998 seems to have improved the classification structures used before by the introduction of Soil Groups, Diagnostic Horizons, properties and materials. By the use of the above terminology and coding, the lower category level can be classified in an international code system which abolishes the local names of soil series, if the survey decides to do so.

The recommendations concerning the mapping systems can be summed up as follows:

- General soil maps should be prepared in an electronic form.
- During the preparation of the electronic form, computer programmes will be made to indicate special irrigated agricultural areas on the map for closer study.

Problems arising from the use of different scales should be overcome after the use of an electronic form of mapping. Surveys can be carried out at different detailed scales without any difficulty in the eventual printing of maps at any scale.

Annex A
Legend

Dominant Soil Groups		Associated Soil Groups	
LP.li.eu RG.le.eu	eutric lithic - LEPTOSOLS eutric skeletic REGOSOLS	(CM.le.cr)	chromic leptic CAMBISOLS
CM.eu RG.oh.eu	eutric CAMBISOLS eutric anthropic RECOSOLS	(CM.cr.eu) (RG.sk.eu)	eutric vertic CAMBISOLS eutric skeletic REGOSOLS
LP.li CL.ptp	lithic LEPTOSOLS epipetric CALCISOLS	(RG.ca)	calcaric REGOSOLS
LP.li.ca RG. le.ca	calcaric lithic LEPTOSOLS calcaric leptic REGOSOLS	(CM.ca)	calcaric CAMBISOLS
CL.ptp LV.cr.le	epipetric CALCISOLS leptic chromic LUVISOLS	(CM.le.cr)	chromic leptic CAMBISOLS
LV.cc LV.vr.cr	colcic LUVISOLS chromic vertic LUVISOLS	(CM.le.cr)	chromic leptic CAMBISOLS
RG.co.uk LP.li.ca	skeletic calcaric REGOSOLS calcaric lithic LEPTOSOLS	(RG.le.ca) (LP.rz.ca)	calcaric leptic REGOSOLS calcaric rendzic LEPTOSOLS
LP.rz.ca CM.le.ca	calcaric rendzic LEPTSOLS calcaric leptic CAMBISOLS	(RG.ah.ca) (RG.co.sk)	calcaric anthropic REGOSOLS skeletic calcaric REGOSOLS
RG.le.ca LP.li	calcaric leptic - REGOSOLS lithic LEPTOSOLS	(CM.vr)	vertic CAMBISOLS
CM.vr RG.ca	vertic CAMBISOLS calcaric REGOSOLS	(LP.li.ca)	calcaric lithic LEPTOSOLS
CM.fv.ca CM.vr	calcaric fluvic CAMBISOLS vertic CAMBISOLS	(RG.ca) (FL.ca)	calcaric REGOSOLS calcaric FLUVISOLS
CM.ca RG.ca	calcaric CAMBISOLS calcaric REGOSOLS	(CM.cr.ca) (LP.rz.ca)	calcaric chromic CAMBISOLS calcaric rendzic LEPTOSOLS
CM.vr RG.ca	vertic CAMBISOLS calcaric REGOSOLS	(CM.fv.ca) (VR.ca)	calcaric fluvic CAMBISOLS calcaric VERTISOLS
VR.cr.eu	eutric chromic VERTISOLS	(CM.vr.cr)	chromic vertic CAMBISOLS
LP.li.ca LP.rz.ml	calcaric lithic LEPTOSOLS	(CL.ptp.sk) (LP.rz)	skeletic epipetric CALCISOLS rendzic LEPTOSOLS
SC.gl	gleyic SOLONCHAKS	(SN.gl)	gleyic SOLONETS
RG.le.sk	skeletic leptic REGOSOLS	(CM.vr.cr)	chromic vertic CAMBISOLS
CA.le.vr VR.cr	vertic leptic CAMBISOLS chromic VERTISOLS	(RG.le.sk)	skeletic leptic REGOSOLS
RG.gp GY.le	gypsiric REGOSOLS leptic GYPSISOLS	(RG.ca)	calcaric REGOSOLS
SALT LAKES			

This Soil Map is based mainly on previous surveys and observations, which were adjusted to the terminology and coding of the World Reference Base for Soil Resources. (FAO, ISRIC and ISSS, 1998).

Annex B

			Clay Mineralogy	Mechanical Analysis									Exchangeable cations meq /100g soil	
				Depth in cm	Clay %	Silt %	M. C. Sand %	Fine Sand %	pH	CaCO3	Organic Matter	C.E.C. meq /100 g soil - (0-10 cm)	Ca	K
LEPTOSOLS														
eutric	lithic	LP	Montmorillonite >60	0 - 4	13	32	36	18	7.2	nil	4	25	22	0.3
			Vermiculite	4 - 10	18	29	38	15	7.3	nil	1.5	25	20	0.1
			Chlorite 0 - 20%											
calcaric	lithic	LP	Beidellite >60											
			Montmorillonite 20 - 25%	0 - 10	32	35	14	19	8.4	68	0.7	31	28	0.28
			Kaolinite-Calcite 5 - 20%											
calcaric	rendzic	LP	Montmorillonite	0 - 12	36	38	8	18	8.5	62	2	38	33	1.5
			Chlorite 20 - 60%	12 - 25	40	36	6	19	8.6	68	0.8	37	34	1
			Kaolinite											
			Calcite 5 - 10%											
	rendzic	LP	Montmorillonite	0 - 05	27	33	28	12	8.1	23	4	30	25	0.8
			Chlorite 20 - 60%	5 - 25	46	28	17	9	8.3	17	1	28	23	0.09
			Kaolinite											
	lithic	LP	Calcite 5 - 20%											

			Clay Mineralogy	Mechanical Analysis									Exchangeable cations meq /100g soil	
				Depth in cm	Clay %	Silt %	M. C. Sand %	Fine. Sand %	pH	CaCO3	Organic Matter	C.E.C. meq /100 g soil - (0-10cm)	Ca	K
VERTISOLS														
eutric	chromic	VR	Montmorillonite >60%	0 - 12	32	23	11	34	8.3	14	0.5	38	32	0.6
			Chlorite, illite 05 - 10%	0 - 15	51	22	12	14	8.1	3	1.8	39	32	0.9
				15 - 50	62	21	9	10	8.3	4	0.5	40	35	0.6
				50 - 120	60	23	8	9	8.3	4	0.5	47	36	0.5
	chromic	VR	Montmorillonite >60%	0 - 25	43	31	14	12	8.4	6	0.8	26	18	0.5
			Chlorite 20 - 60%	25 - 75	48	33	9	10	8.8	3	0.3	28	14	0.5
	calcaric	VR	Montmorillonite >60%	0 - 30	42	36	6	14	8.4	25	1	40	32	0.9
				30 - 60	50	30	3	16	8.5	28	0.8	43	38	0.5
				60 - 120	47	29	6	17	8.5	27	0.5	45	37	0.6
FLUVISOLS														
	calcaric	FL		0 - 25	34	32	4	30	8.2	33	1.5	22	10	0.9
				25 - 60	26	37	3	34	8.4	38	0.9	20	11	0.6
				60 - 120	25	36	6	33	8.6	30	0.2	17	8	0.3
SOLONCHAKS														
	gleyic	SC	Beidellite >60%	0 - 20	28	25	10	37	8.5	34	8	55	22	2.5
			Illite-Kaolinite 5 - 20%	20 - 50	33	28	4	36	8.3	36	6	58	26	1.5
				50 - 120	30	32	3	35	8.2	38	6	58	22	0.7
SOLONETZ														
	gleyic	SN		0 - 30	28	39	8	24	8.2	45	10	50	22	1.5
				30 - 60	42	36	8	16	8.5	52	6	58	28	1.8
				60 - 120	42	34	6	17	8.4	53	2	53	18	1.6

			Clay Mineralogy	Mechanical Analysis									Exchangeable cations meq /100g soil	
				Depth in cm	Clay %	Silt %	M. C. Sand %	Fine. Sand %	pH	CaCO3	Organic Matter	C.E.C. meq /100 g soil - (0-10cm)	Ca	K
GYPSISOLS														
	leptic	GY		0 - 30	36	28	4	32	8.4	48	1.5	32	25	0.8
				30 - 75	42	34	8	15	8.6	52	1	48	28	0.5
CALCISOLS														
	epipetric	CL	Illite 20 - 60%	0 - 20	38	16	14	27	8.3	18	1.5	32	26	1.2
			Montmorillonite 5 - 20%	20 - 45	45	25	10	20	8.4	24	0.5	34	28	0.8
LUVISOLS														
lepic	chromic	LV	Illite >60%	0 - 20	37	30	8	25	8.3	14	1.5	43	36	1.5
			Montmorillonite	20 - 45	48	24	8	20	8.4	18	0.8	41	32	0.8
			Kaolinite											
			Calcite <5%											
chromic	vertic	LV		0 - 35	40	26	8	24	8.2	4	1.5	38	32	1.5
				35 - 70	55	20	6	18	8.4	6	0.8	42	37	0.8
				70 - 120	54	22	8	18	8.4	10	0.5	33	28	0.8
	calcic	LV	Beidellite >60%	0 - 25	36	32	12	20	8.4	12	1.5	40	34	1
			Montmorillonite 5%	25 - 60	48	25	8	18	8.3	15	0.7	37	32	0.8
			Illite-Kaolinite 5 - 20%	60 - 70					8.6	65				

			Clay Mineralogy	Mechanical Analysis									Exchangeable cations meq /100g soil	
				Depth in cm	Clay %	Silt %	M. C. Sand %	Fine. Sand %	pH	CaCO3	Organic Matter	C.E.C. meq /100 g soils - (0-10cm)	Ca	K
CAMBISOLS														
chromic	leptic	CM	Beidellite >60%	0 - 10	15	32	38	14	6.2	Nil	16	36	29	0.6
			Illite-Kaolinite 20 - 60%	10 - 30	17	36	30	13	6.5	Nil	4	27	18	0.4
				30 - 70	18	34	36	12	6.8	Nil	1.5	22	17	0.4
	calcaric	CM	Montmorillonite >60%	0 - 25	18	24	8	50	8.2	12	0.8	42	38	0.5
			Chlorite 20 - 60%	25 - 60	22	18	11	48	8.3	16	0.5	44	40	0.3
			Kaolinite 5 - 20%	60 - 120	16	20	12	52	8.6	14	0.5	43	38	0.2
			Calcite <5%											
	eutric	CM	Montmorillonite >60%	0 - 10	17	24	32	27	7.5	Nil	1.8	31	15	1.5
			Vermiculite 20 - 60%	10 - 35	18	19	40	23	7.6	Nil	1	25	9	0.8
			Chlorite 5 - 20%	35 - 75	22	25	41	22	7.6	Nil	0.6	28	14	0.5
				75 - 120	22	26	29	23	7.4	Nil	0.4	20	15	0.5
eutric	vertic	CM	Montmorillonite >60%	0 - 30	48	38	7	8	7.5	Nil	1.5	32	26	0.6
			Vermiculite 20 - 60%	30 - 75	45	45	6	7	8.2	2.2	0.8	29	20	0.7
			Chlorite 5 - 20%	75 - 120	60	30	4	6	7.8	Nil	0.5	33	25	0.5
calcaric	leptic	CM	Beidellite >60%	0 - 30	36	42	8	14	8.5	63	0.1	39	32	0.1
			Montmorillonite 5 - 20%	30 - 75	38	40	8	16	8.7	65	0.5	43	38	0.3
			Kaolinite, Calcite <5%											
chromic	vertic	CM	Montmorillonite >60%	0 - 30	49	29	7	15	8.1	19	1.5	31	22	1.4
			Chlorite-Illite 5 - 20%	30 - 65	56	25	5	14	8.2	20	0.9	29	21	1.3
				65 - 120	65	21	9	5	8.1	12	0.5	37	29	1.2

			Clay Mineralogy	Mechanical Analysis									Exchangeable cations meq /100g soil	
				Depth in cm	Clay %	Silt %	M. C. Sand %	Fine. Sand %	pH	CaCO3	Organic Matter	C.E.C. meq /100 g soil - (0-10cm)	Ca	K
calcaric	fluvic	CM	Beidellite >60%	0 - 25	35	37	2	26	8.1	43	1.2	19	15	1.1
			Illite-chloride <5%	25 - 64	40	36	2	22	8.2	45	0.7	23	17	1
				64 - 120	34	34	2	20	8.2	42	0.4	21	14	0.5
calcaric	chromic	CM	Montmorillonite >60%	0 - 25	25	44	22	9	8.1	70	1	25	23	0.6
			Chlorite 10 - 20%	25 - 60	26	41	29	4	8	69	0.5	26	23	0.6
				60 - 85	35	37	29	3	8.3	68	0.3	28	25	0.4
				85 - 120	37	35	26	2	8.4	64	0.3	28	26	0.3
vertic	leptic	CM	Montmorillonite >60%	0 - 15	32	41	11	15	8.6	4	0.8	39	34	0.3
			Chlorite-Illite 5 - 10%	15 - 35	38	45	6	12	8.4	Nil	0.3	34	29	0.1
REGOSOLS														
eutric	skeletic	RG	Montmorillonite >60%	0 - 25	20	22	16	41	8	0.3	1.5	26	13	0.3
			Chlorite 5 - 20%	25 - 60	18	37	18	27	7.6	Nil	0.6	24	11	0.1
				60 - 100	10	35	28	26	7.7	Nil	0.2	33	15	0.2
	calcaric	RG	Montmorillonite >60%	0 - 30	13	25	33	29	8.3	35	0.9	45	41	0.9
			Chlorite 20 - 60%	30 - 65	17	23	32	28	8.6	37	0.5	46	45	0.5
			Kaolinite, Calcite 5 - 20%	65 - 100	21	26	28	23	8.8	42	0.4	49	46	0.7
	gypsiric	RG		0 - 25	33	30	13	18	7.8	48	0.8	35	30	0.5
				25 - 50	30	42	10	12	7.6	49	0.2	41	33	0.5
calcaric	leptic	RG	Montmorillonite >60%	0 - 30	22	21	30	27	9	31	0.5	52	49	0.4
			Chlorite 20 - 60%	30 - 75	18	22	33	27	8.8	37	0.2	56	52	0.3
			Kaolinite-Calcite 5 - 20%											

			Clay Mineralogy	Mechanical Analysis									Exchangeable cations meq /100g soil	
				Depth in cm	Clay %	Silt %	M. C. Sand %	Fine. Sand %	pH	CaCO3	Organic Matter	C.E.C. meq /100 g soil - (0-10cm)	Ca	K
skelectic	calcaric	RG		0 - 25	28	41	12	15	8.4	69	1.3	38	27	0.7
				25 - 60	27	43	13	17	8.6	73	0.5	32	26	0.6
				60 - 110	30	40	12	18	8.7	75	0.3	31	23	0.4
xertic	leptic	RG	Montmorillonite >60%	0 - 35	40	24	16	20	8.2	5	0.5	29	27	0.6
			Vermiculite	35 - 70	43	27	16	13	8	3	0.2	34	28	0.9
			Chlorite 20 - 60%											

The status of soil mapping in the Czech Republic

Systematic soil survey of agricultural lands at a large scale, using field sheets at 1:10 000 scale, was implemented in the period 1962 – 1972. Soil maps were drawn at scale 1:10 000 for immediate use in farms and at 1:50 000 for district planning. The programme was entrusted to the Soil Survey Institute, Praha-Suchdol, and Soil Research Institute of the Central Institute for Crop Production, Praha-Ruzyne. The reorganizations in 1981 and 1990 led to a merger with the Research Institute for Land Reclamation to form the Research Institute for Soil and Water Conservation, Praha-Zbraslav (RISWC).

A typological survey of forests using field sheets at 1:5 000 scale, which involved also soil survey, was completed at the end of the seventies (Forest Management Institute, Brandys n. L).

In the period 1972 – 1980, additional soil-ecological survey of agricultural lands was carried out in the framework of the soil productivity rating in cooperation with the Institute of Agricultural Economics. Maps at scale 1:5 000 display not only grouped soil units, but also relief features and climatic regions.

Maps of soil associations at scales 1:1 000 000, 1:500 000 and 1:200 000 were compiled by the generalization of the above mentioned large-scale materials. The Soil Map at scale 1:1 million has been used for international cooperation with Dudal, Tavernier, Jamagne. A soil map at 1:200 000 was published (RISWC, Ministry of Environment). Soil associations and soil regions of the soil map 1:500 000 were characterized in "Geography of soils in the Czech Republic" (1983).

On the whole territory of the Czech Republic there exist soil (1:10 000, 1:50 000) and soil-ecological (1:5 000) maps of agriculturally used lands, and forest typological maps (1:5 000) from which soil maps can be derived. Only mapping of urbanized and industrial areas is lacking. Soil maps at medium and small scale (1:200 000, 1:500 000, 1:1 000 000), derived from maps at large scale, cover the whole territory of the Czech Republic.

The Scale and Classification System used in National Soil Maps

Soil maps and soil classification

Soil maps at large scale (1:10 000) are based on a taxonomic approach. Soil mapping units of agriculturally used lands reflect pure soil units, their combinations and contrasting accessory soils. Soil maps at medium and small scales are based on soil associations (combinations reflecting the dominant, co-dominant, accompanying compounds and accessory soils at scale 1:200 000).

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The soil map at 1:200 000 comprises 1 025 different associations. There are 125 main soil forms in the created map at 1:250 000. The soil map at scale 1:500 000 comprises a soil associations map with 125 soil associations and soil parent materials maps with 46 types of substrate.

The soil classification system for the systematic soil survey was based on the detailed soil diagnostics of soil taxa making use of the concept of diagnostic horizons and types of soil parent materials (linked to quaternary geological map). The hierarchical system of soil classification comprised the following taxonomic levels: soil type, subtype, variety, erosion form, and lithogenic variant. The set of soil maps involved: a map of soil units (genetic taxa, parent materials), a map of soil texture, rock fragments and actual water regime, a map of interpretations, a map (only at 1:50 000) of parent materials (detailed quaternary geologic map). In the survey of forests an adapted classification after Mückenhausen was used (Houba, 1962).

The harmonization of the soil classification was made in two steps: first between 1962 and 1981, and a second phase between 1991 and 1999.

The last proposal (including soil profile and micromorphology slides, analytical data, roentgen difractograms, schemes of water and temperature dynamics) will be presented in a digital form (http://193.84.41.165/mksp). It involves the following taxonomic levels: main soil groups (linkage to international reference systems especially to the FAO /IUSS classification of 1998), soil types, varieties, soil forms.

The main soil groups and soil types (in parentheses) involve:

LEPTOSOLS (lithozem, ranker, rendzina, pararendzina)
REGOSOLS (regozem, arenozem)
FLUVISOLS (fluvizem, coluvizem)
ANDOSOLS (andozem)
CHERNOSOLS (chernozem, chernitza)
LUVISOLS (greyzem, hnedozem, luvizem)
CAMBISOLS (cambizem, pelozem)
PODZOSOLS (cryptopodzol, podzol)
STAGNOSOLS (pseudogleys, stagnogleys)
GLEYSOLS (gley, epigley)
ORGANOSOLS (organozem)
ANTROPOSOL (antropozem, kultizem)

The subtypes (individually used within soil types) represent the following categories: modal, luvic, albic, glossalbic, cambic, lithic, arenic, pelic, eutrophic, acidified, dystric, stagnic, gleyic, histic, fluvic.

Varieties reflect soil features, indicating soils of different land uses (mainly forests, croplands, grasslands) and in different stages of degradation or contamination in the topsoil (depth 0-0.25 m), humus forms (forest soils), eutrophication and structure of ploughing layers, characteristics of contamination or pollution, features of erosion or accumulation and results of micropodzolization. Soil parent materials are subdivided into: deep leistocene and prequatenary deposits (substrata of chernosols, luvisols, stagnosols, vertisols, some podzosols), transported weathering products of consolidated rocks (substrata of cambisols, some podzols), consolidated rocks altered in situ, stony, gravelly or shallow substrata (leptosols), young (holocene) substrata (fluvisols, regosols, antroposols), organic substrata (organosols). All parent materials mentioned are subdivided according to texture, stratification, trophosm and genesis.

Two pragmatic (applied) classifications of soil and soil sites used in agriculture and forestry are the soil-ecological classification of agriculturally used lands which consists of the combination of 10 climatic regions, 76 main soil forms and their complexes, slope inclination and exposure, content of rock fragments and soil depth; all expressed in digits and the forest typological classification which rests upon the delineation of 10 forest vegetation zones, ecological groups (16 trophic, 9 hydric) and plant indicators.

Besides the mentioned maps, a map in SOTER methodology at scale 1 million with 38 units was worked out (CZESOTER).

Although all generalized soils maps are based on soil combinations of the main soil forms, the detailed systematic of soil associations for medium-scale maps is missing.

Soil maps and soil characteristics

Pedon characteristics, which were obtained in the course of soil mapping and parallel research include:

- standardized set of selected soil profiles (about 30 000), with the following analytical data: soil texture, humus, (KC), CEC and base saturation (Mehlich), $CaCO_3$, available P (Égner), K (Schachtschabel).
- extended set of pedon data (about 150 profiles), with the following data: humus quality, exchangeable cations, effective CEC and exchangeable A1, free Fe and A1 (Feo, Fed), mineralogical properties (mainly clay minerals), total contents of pedogenetic, biogenetic and environmentally important macro- and trace elements, physical properties, micromorphological properties.

Soil information system

The soil information system is generated in two complementary ways:

- soil GIS for practical uses, mainly taxation and land tenure appraisal, which is included in the land tenure register, makes use of all detailed cartographic and pedon information. It is entrusted to the RISWC.
- soil GIS (PUGIS) for concept development and international cooperation on different projects is handled in the Department of Soil Science and Geology, Czech Agricultural University (DSSG, CAU).

The soil information system of the RISWC is based on the digitized soil-ecological maps (1:5 000) and a pedon database of all data from the systematic soil survey of agriculturally used soils.

The soil information system of the DSG CAU consists of: 1) polygons of digitized soil maps (at scales 1:1m, 1:500 000, 1:200 000 and in the future 1:250 000); 2) attributes; 3) geomorphology, climate, vegetation, geology; 4) maps of some properties – humus, base saturation; 5) pedon information which is represented by statistically processed data (model profiles) for scales 1:1 million and 1:500 000 and about 2 500 selected profiles with a standardized set of characteristics. PUGIS will also comprise pedotransfer functions and soil groupings for different kinds of interpretations for agriculture, water management and environmental aims.

Soil survey interpretations

Much effort has been put into attempts at soil interpretations concerning the following problems: soil productivity rating, land appraisal, land capability and suitability assessment, gradation of hydromorphic features, erosion status and vulnerability to erosion, trace elements background concentration levels, assessment of soil vulnerability against pollution, predictions of N (P, K) behaviour in soils, soil workability, suitability for waste disposal, soil categories for differentiation of soil protection, vulnerability to acidification, strategies for setting land aside.

Problems envisaged for adaptation of the national and regional maps to the global methodology

The adaptation of national and regional maps to the global methodology has two aims:

- adaptation of the present national soil maps for the creation of a soil map of Europe at a scale of 1:250 000 and a European database;
- adaptation of the global methodology for use in future national survey programmes.

It should be focused on:

- detailed correlation of soil units, although the last "World Reference Base for Soil Resources" (1998) could satisfy most needs of all countries (except details of base saturation and hydromorphy)
- unification of parent materials classification, which is as important as reference soil groups and lower-level units
- unification of soil associations, their systematics is a prerequisite for the delineation of a reasonable and correlated set of soil associations on the territory of Europe
- unification of the set of soil characteristics, which should enable us to make a lot of interpretations from the viewpoint of soil productivity, land use, soil degradation and pollution and other problems of soil and landscape protection
- physiographic approach, which takes into consideration that in areas covered by large or medium scale surveys the soil unit and parent materials (involved in the concept of soil units) should be preferred to general geomorphological boundaries, except of Cambisol areas.

The future soil innovative investigations should pay attention to the following: mapping of all soils, inclusive of urban areas, their classification and pollution, making use of all archived maps and remote sensing, research on landscape trasects, soil heterogeneity and its reflection in soil combinations delineation, getting relevant soil characteristics for a broad set of interpretations, studies of relations between soil geomorphology, with particular regard to the erosion, accumulation, parent materials genesis, subsurface and surface water flows, hydromorphy and distribution of pollutants.

Suggestions for a regional mapping scale and applications

International cooperation should be focused on the creation of soil maps at scale 1:250 000, with a modified SOTER methodology, in accordance with submitted. The geometric database has to be linked to the semantic database of pedon (in some cases topsoil) characteristics, relevant for making interpretations, concerning all problems mentioned.

National Copyright Considerations

Copyright should rest upon the contract among FAO (programme correlator) and two mentioned organizations (RISWG, CAU). It will also enable all co-operating organizations or countries to exchange these materials for non-commercial uses.

Conclusions and Recommendations

The whole territory of the Czech Republic is covered (except urbanized areas) with large-scale soil maps. Pragmatic maps, which are focused on land productivity rating, comprise soil-ecological maps (soil, climate relief, or agricultural lands) and forest-typological maps (vegetation zones, ecological groups of soils) at scale 1:5 000. They exist in a digital form.

Generalized middle and small-scale maps of soil associations in a digital form at scale 1:1 million, 1:500 000, 1:200 000 (in the future 1:250 000) are based on large-scale surveys.

Soil GIS is being developed in two ways: 1) soil GIS, which comprises polygons of soil-ecological maps and pedon characteristics of the systematic soil survey, and a similar approach for the forest typological survey, 2) soil GIS (PUGIS), which consists of polygons of medium and small scale maps and a textual part, comprising selected profiles of the soil survey and research results; it will also involve pedotransfer functions, interpretation and statistical programmes.

The Czech Republic is ready to participate in the project of the 1:250 000 European soil map and all related projects concerning various interpretations.

International cooperation should start with the harmonization of soil taxonomic classification and parent material classification problems, but mainly with soil associations systematics, soil-geomorphology relations, reflection of climate in hydrothermic régimes and some soil characteristics (humus, profile base saturation) and soil regions delineation. It is recommended to adapt the SOTER system for the scale 1:250 000 for territories where large-scale soil surveys have been conducted.

The status of soil mapping in Finland

Systematic collection of soil information was started in Finland at the end of the 1800s, when the Geological Survey of Finland began the mapping of Quaternary deposits. Mapping of soils for agricultural purposes was started in the 1920s by the Agricultural Research Centre, the National Board of Survey and the Geological Survey (now Geological Research Centre) and was formed on the initiative of the National Board of Survey. According to the plan made by the committee on collaboration, the mapping of soils for a combined geological and agrogeological soil map was carried out in connection with the updating of basic topographic maps. Surveyors of the National Board of Survey were trained to collect the soil information and the work was controlled by agronomists and geologists. According to the plan made at that time, the entire country would have been surveyed within 30 years. In the beginning the joint work progressed rapidly but in the 1990s, due to financial reductions, only the Geological Research Centre still continues mapping activities.

The Scale of Mapping and Classification System Used

The Geological Survey has published maps at scale 1:100 000 and 1:400 000 and a summary map at scale 1:1 000 000. Agricultural Research Centre published the early maps at scales 1:50 000 and 1:100 000. Since the end of the 1940s the scale of 1:20 000 has been used.

The scale of collaborative mapping started in the 1970s is 1:20 000 and in northern Finland 1:50 000. About one third of the country has been mapped with most sheets located in southern Finland. Because agricultural soils (27 000 km^2 or 8 percent of the total area of Finland) are mostly in the south, it is estimated that about one half of the cultivated land areas has been covered.

The national system of soil classification in Finland is based on texture and organic matter content. The main soil type groups are till (moraine), sorted mineral soils (gravel, sand, fine sand, silt and clay) and organic soils (mould, gyttja and peat). The share of till of the cultivated area is 16 percent and that of organic soils 18 percent. The area of cultivated clay soils is 20 percent and the coarse textured mineral soils form the rest.

Problems Envisaged for Adaptation of National Information to International Methodologies

Little attention has been paid to genetic soil classification in Finland. This has been thought to be justified policy because soils formed on various types of Quaternary deposits are young and show little soil development. This is due to a cold climate where soils are frozen for half the year, giving little time and intensity for soil forming processes.

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However, the increased international cooperation and publishing of research reports internationally has made it indispensable to describe Finnish soils in international terms. One such need was the request to provide soil information for the FAO-UNESCO soil map of the world in the 1970s. For that purpose, a group of European soil scientists visited Finland and investigated typical Finnish soils to identify their place in the proposed classification system. One of the problems discussed was the extent of Gleysols. Clayey soils have neutral matrix colours, plenty of iron hydroxide mottles and need a drainage system when cultivated. They have a cambic horizon, probably caused by artificial drainage. Another question discussed was soils formed on glacial till. In sandy loam-textured tills, relatively high in fine material buffering weathering processes, podzolization may not be the dominating soil forming process and in addition to Podzols, these soils may contain large areas of Cambisols or Arenosols as inclusions. The changes in definitions of the diagnostic criteria for classification over time, culminating in today's World Reference Base for Soil Resources (WRB), has not diminished the need of learning more of Finnish soils with respect to international systems.

Recently, efforts have been made to classify Finnish soils according to Soil Taxonomy. Experts from United States have visited Finland and several different soils have been investigated. One of the problems met is the classification of dark coarse textured soils. They formally meet the current criteria of Mollisols, even though the high base saturation is caused by liming. These soils also meet the requirements of Phaeozems of the WRB system.

In developing the present 1:1 million database concerning Finland, one major task is the border harmonization with Russia. Because of this and above-mentioned problems, there is a great need for cooperation with international experts, especially when the preparation of a soil information database at scale 1:250 000 is started. Soil information systematically collected in Finland does not contain the information necessary for applying the FAO or WRB classification system or US Soil Taxonomy. The incompatibility of the information makes it necessary to do additional fieldwork in order to be able to successfully apply these systems in Finland.

Applications of Soil Data

The national soil maps at scale 1:20 000 are useful in advisory work because the great diversity of soils in Finland demands different agricultural management practices. The heavy clay soils in southern Finland are rich in potassium but they fix phosphorus. These properties have been taken into account in fertilizer use planning. These soils are difficult to till although freezing helps. Acid sulphate soils are in need of heavy liming and soils maps have been used to identify areas where regional amelioration measures have been planned. Organic soils with their high nitrogen reserves and low pH have been investigated for proper management. Generally in applying research information in practical farming through advisory services soil maps have been widely used where they are available.

Outside agriculture the soil information has many uses. In land use planning of communities the proper use of suitable soils for each purpose has been made clear. Soil maps have been found useful also in planning landscape management and the use of soil as raw materials.

National Copyright Considerations

The Geological Research Centre of Finland has extensive soil mapping information in digitized form for which they have the copyright. Agreement is needed for obtaining the right to use it.

Conclusions

Despite slow progress in collecting soil information at the moment in Finland, there is an ever-increasing need for such information. For proper handling of many environmental problems and their prevention, the soil information is of utmost importance. Computerized data handling and advanced programmes, such as GIS procedures, need more detailed information to make reliable predictions. International cooperation today requires that soil information be given according to international systems to guarantee the relevant use of information. Application of international research results necessitates the same requirement.

Knowledge and monitoring of soil resources in France

This is a progress report on the main programmes for collecting soil information, soil survey and soil monitoring activity in France.

The Service for the Study of Soils and the Pedological Map of France (French acronym: SESCPF) was founded in 1968. Within the INRA (National Institute of Agronomic Research), it ensures the coordination of most soil mapping and monitoring programmes in France. This is made possible by compiling data received from a number of other public or private organizations that have formed a partnership to develop these programmes: research institutes (CNRS : National Center for Scientific Research, Universities), professional development organizations (Chambers of Agriculture, National Forest Bureau), land development companies and design offices, etc. Work is carried out at the request and with the support of the Agriculture and Environment Ministries, as well as local governments (Regional Councils).

The French territory is composed of 56 percent arable lands, 28 percent forested areas, 8 percent of land surfaces that are unused or have been set apart as protected natural reserves and, finally, 8 percent urban surfaces (IFEN, 1999). Current trends indicate a loss of natural and agricultural lands to development close to 40 000 hectares (100 000 acres) per year, equivalent to one French Department every 10 years. This trend constitutes undoubtedly one of the main threats to the "soil" legacy for future generations. It is also an indicator of the large number of other pressures exerted on soils which may also contribute to their irreversible degradation.

Soil mapping programmes are valuable tools for land management. In spite of this, we are currently witnessing a decrease of the resources allocated to these programmes. In parallel, there is an increase in the requests received for more diversified and more specialized information about the agricultural and environmental functions of soils. A systematic inventory of the country is no longer sufficient to respond to these demands. Besides, we are faced with a multiplicity of activities that must be coordinated at the national scale in conjunction with European programmes.

The aim of this paper is to describe several of these activities on the French territory and briefly show their use in long-term natural resource management programmes.

Soil mapping

The "Pedological Map of France" (CPF) programme has been in existence for more than 25 years. It has led to the acquisition of a large quantity of data on the soil resources of our country and of basic understanding of the typology and spatial variability of the main pedological systems (Jamagne *et al.*, 1995). This programme was the reason the SESCPF was created,

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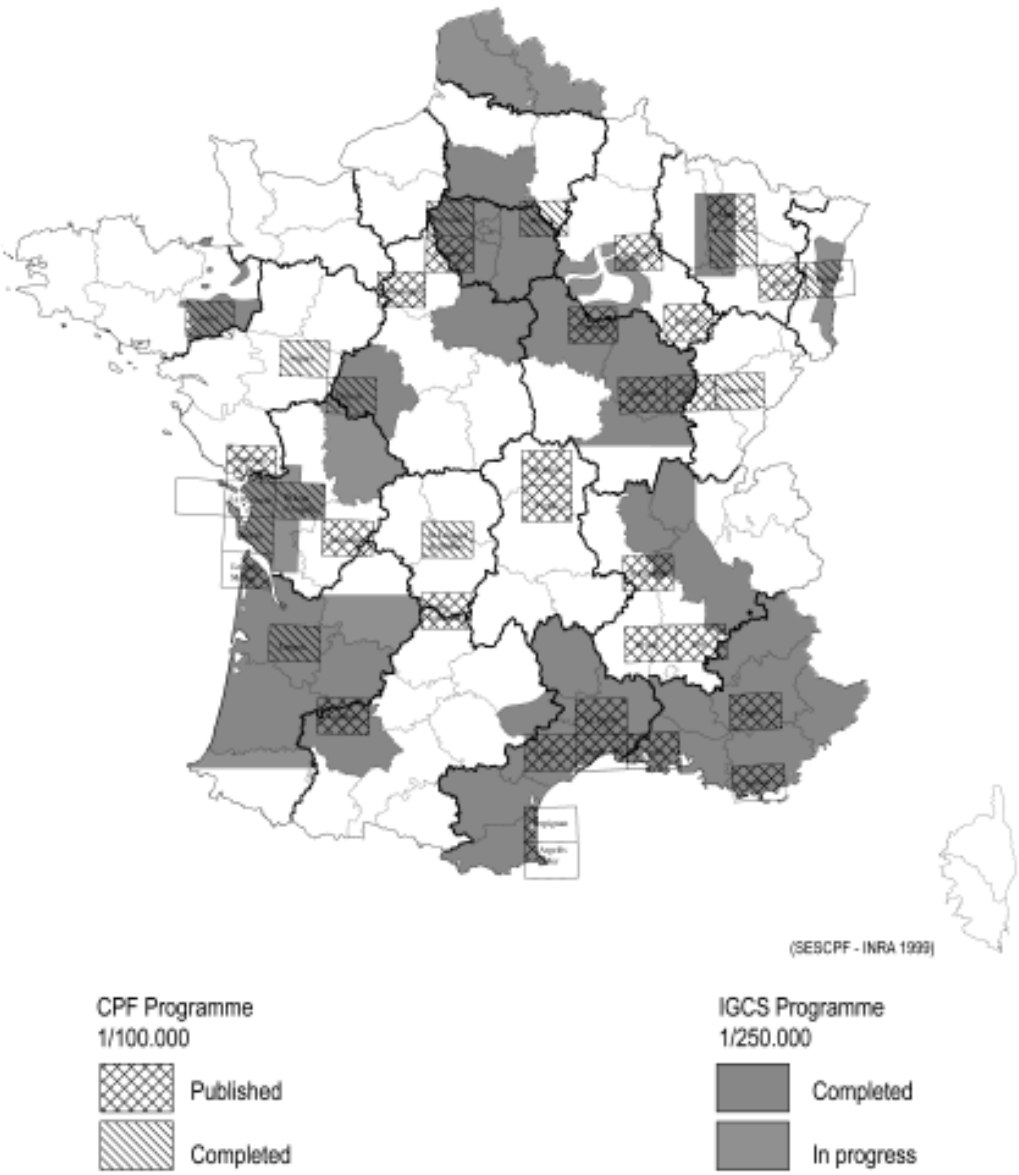
FIGURE 1
State of progress 1999 - CPF and IGCS programmes



leading to the development of a national platform for coordination and cooperation in the field of spatial analysis of soil. By the end of 1998, 27 maps at scale 1:100 000 had been published and 13 additional maps were being prepared, accounting for about 15 percent of the territory (Figure 1).

The resources allocated to this programme are not sufficient to foresee a complete coverage of French territory in the medium term. It was thus decided to change the emphasis of the CPF programme by giving preference to the detailed study of soil distribution laws within areas deemed representative of the main French pedological systems. In concrete terms, this means that older data will be digitalized and new data will be acquired in small selected regions to be surveyed. This programme is intended as a scientific support for inventory at broader scales.

This is the case for the "Soil Inventory, Management and Conservation" (IGCS) programme conducted by the Agricultural Ministry and INRA since 1990. Its initial aim was to prepare a map with an associated database at scale 1:250 000 for each of the French Regions (Bornand *et al.*, 1989, Jamagne *et al.*, 1995). At the present time, three regions have been completed, as well as 12 Departments. All the regions involved account for about 40 percent of the country (Figure 1). A test of data transfer to the European system is under way in the Côte d'Or Department in Burgundy (Finke *et al.*, 1998). The second aim of the programme is to carry out detailed studies, at scale 1:10 000, of small size sample surfaces. Monitoring the agricultural and environmental functioning of these zones provides references that can be generalized and applied to similar soil systems localized at scale 1:250 000 (Favrot, 1987; Favrot and Lagacherie, 1993).

These two programmes do not cover all mapping activities. Several regional or national organizations have started mapping programmes at smaller scales, e.g. 1:50 000 in the Centre Region, 1:25 000 in the Aisne Department, typology of forest stations, regional typologies, etc. In addition, there are many local initiatives for various studies, but it is difficult to make an estimation of that information (Bornand, 1997). Finally, there is the synthesis map at scale 1:1 000,000 that has been revised in the framework of European projects (Jones *et al.,* 1998, Le Bas *et al.,* 1998). Even so, this work is insufficient and the expected coverage at scale 1:250 000 will lead to a thorough revision of this geographic database at scale 1:1 000 000.

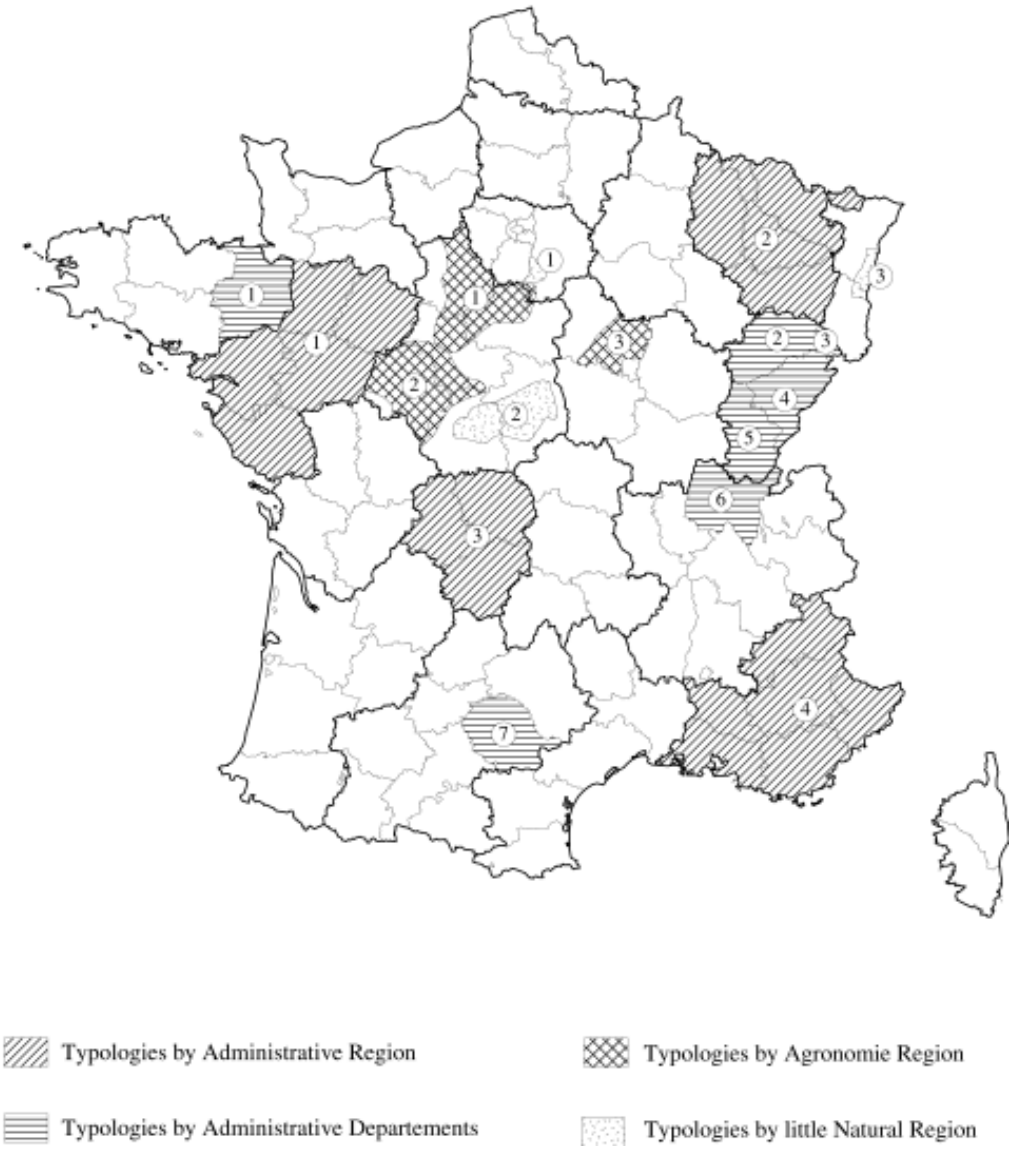
SOIL MONITORING

There are two main French soil monitoring networks. The first deals with long-term changes in cultivated land and natural non-wooded spaces. The second involves forests.

The main purpose of the " Soil Quality Observatory " (OQS) is to assess the present situation of soils and monitor their changes in order to better develop and implement a soil preservation policy (Martin, 1993). Eleven sites around 1 ha each were chosen on the basis of their representative nature concerning soil and land use. There is a minimum set of parameters that are systematically measured at all sites of the network. For some specific degradation problems, additional measurements may be conducted at some sites, e.g. light fraction C and N, mineralizable C and N, microbial biomass, soil enzymes, earthworms. The recommended time interval is five years. In one agricultural site, continuous pig slurry application was shown to significantly increase the organic carbon content and that of some metals (Cu, Zn). In an acid brown soil under a mature spruce stand, we observed a decrease of total elements in the organic layers, and of the exchangeable elements in organo-mineral horizons, which might have severe consequences for future forest nutrition. A decrease of the lead concentration in forest litter may be considered as an encouraging sign in the campaign to render gasoline greener. Other ongoing work involves the definition of biological indicators and sampling strategy for soil microbial biomass and soil fauna determinations.

The RENECOFOR programme is a long-term monitoring system for forest ecosystems (Figure 2). It was created by the National Forest Bureau in 1992 in order to extend the system for monitoring the health status of forests (Ulrich, 1995). It is the French part of a set of permanent parcels installed in 34 European countries. It covers highly varied areas of forests. Two soil profiles are systematically examined and fertility is monitored. Concerning the "Cataenat" sub-system (total acid load of atmospheric origin), atmospheric deposits have been measured in 27 parcels since 1993, and measurements are conducted on soil solutions taken from 20 and 70 cm in depth from 17 parcels.

FIGURE 2
Soil typology maps



Other monitoring systems including soils have been implemented, but they are concerned with other components of the milieu, especially water resources. In addition, means have been devoted to create databases with old soil analyses conducted individually or in the context of local programmes (for example, see next section on the National Base of Land Analyses, French acronym: BNAT). These data are localized in space and in time and provide information on medium- and long-term changes. It has not yet been decided, however, to continue the systematic collection of the data from the laboratories concerned.

Soil databases

In 1990, a unique database structure was adopted for all nationally integrated programmes. The system is called DONESOL and includes three parts (Gaultier *et al.*, 1993):

- point data obtained from observations and measurements conducted on soil profiles,
- descriptive data of soil mapping units, soil typology units of soils and horizons. Additional data take into account the spatial variability within these entities. These data are provided by expert judgment. Digitized contours are included in a GIS coupled with DONESOL,
- metadata that indicate bibliographic references of the studies as well as their localization and precision (Favrot, 1994). Over the past several years, considerable effort has been devoted to cataloguing all detailed scale pedological studies. This work is currently being extended by studies at medium and small scales. Finally, a directory of soil mapping professionals has been published (Favrot, 1997).

Mapping and monitoring programmes can be found on the INRA Orleans Web site (http://www-sescpf.orleans.inra.fr/public/). One objective is to develop this site, in particular including the metadata described above.

Other databases have been prepared in conjunction with or in parallel to the DONESOL database. In contrast to the above-mentioned programmes, these databases were compiled in the context of targeted research projects, including ASPITET, SOLHYDRO and BNAT.

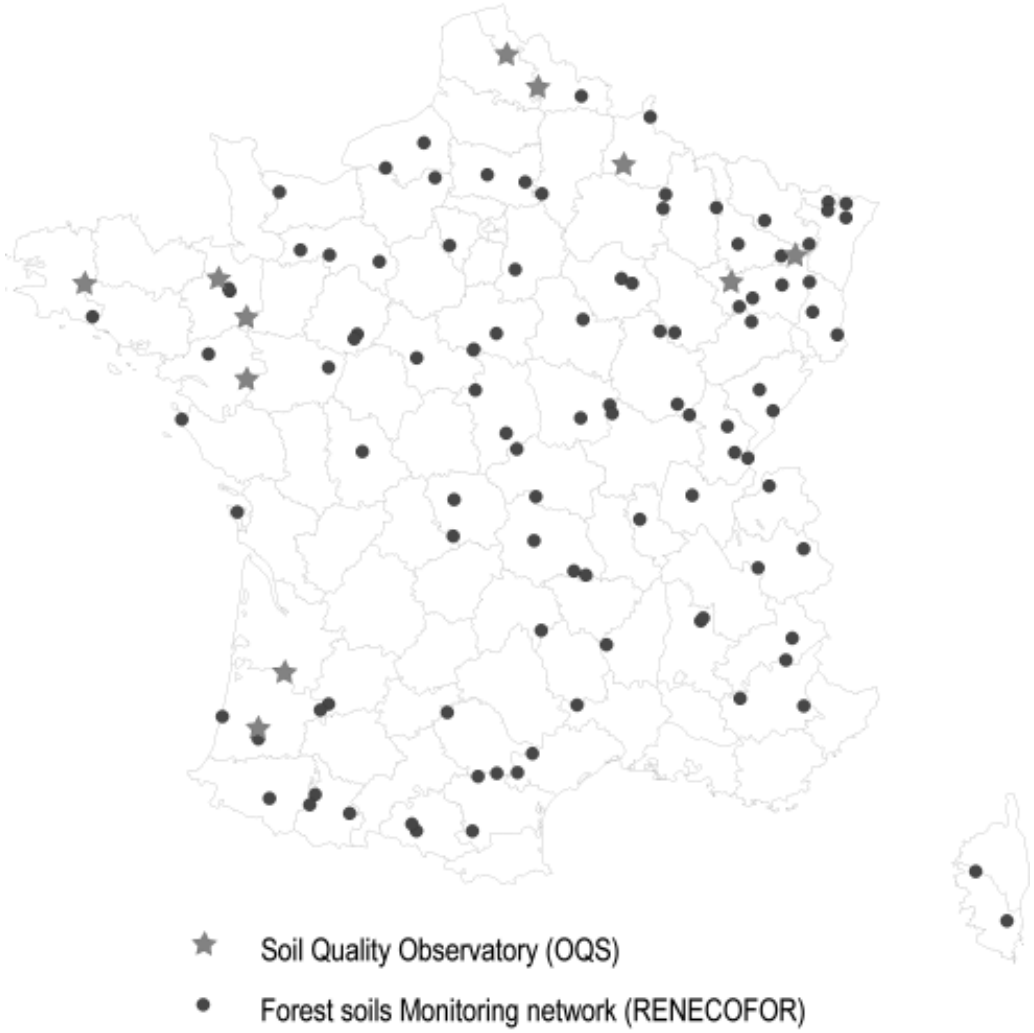
ASPITET: In 1994, the INRA started a research programme entitled "Contributions of a Pedological Stratification for the Interpretation of Trace Elements Contents" (French acronym: ASPITET). The aim of this programme was to acquire reference data on the natural contents of trace elements in soils. The work was carried out by taking into account soil types and geological parent materials. The population studied up to the end of 1998 is composed of 1 310 pedology horizons corresponding to 706 distinct sites. Total trace element concentrations were determined in each sample (systematically Cd, Cr, Cu, Mn, Ni, Pb, Zn, often As, Co, Hg Se, Ti). The results show that the general degree of contamination by human activities is very low in comparison to the stocks of natural trace elements in soils.

SOLHYDRO: A project was started in 1998 to compile an analytical database of the hydraulic properties of French soils. The purposes of this database are to: (i) assemble all data on these properties determined by different research laboratories, as well as any additional analytical or descriptive data, (ii) make these data available to researchers in order to compare measurement methods and prepare pedotransfer functions using the diversity of French soils, (iii) prepare nationally recognized references for users. There are links between this database, DONESOL and the European HYPRES system (Wösten *et al.*, 1998).

BNAT: More than 200 000 soil analyses are carried out by private parties every year. A feasibility study was conducted from 1990 to 1994 in order to recover these data and include them in a database called Base Nationale des Analyses de Terre (National Base of Land Analyses) (Walter *et al.*, 1997, Schvartz *et al.*, 1998). The data were then collated by township and by districts to protect the rights of the analysis owners. Each variable can be expressed in the form of maps or statistical tables and these documents led to the confirmation of spatial structures that are often known but never quantified, especially for variables that are difficult to determine in conventional mapping work (Figure 3). The value of this database involves the analysis of possible changes in soil properties over time. The detection of these changes will require a longer time span.

The collection and structuring of analytical data obtained by private parties is a valuable source for regional or national reviews. In addition to the BNAT, the AGREDE programme conducted by ADEME and INRA recovered close to 12 000 analyses, collected between 1992 and 1997, of heavy metals from studies preceding fertilization by stations for water treatment

FIGURE 3
Localization of monitoring sites in France



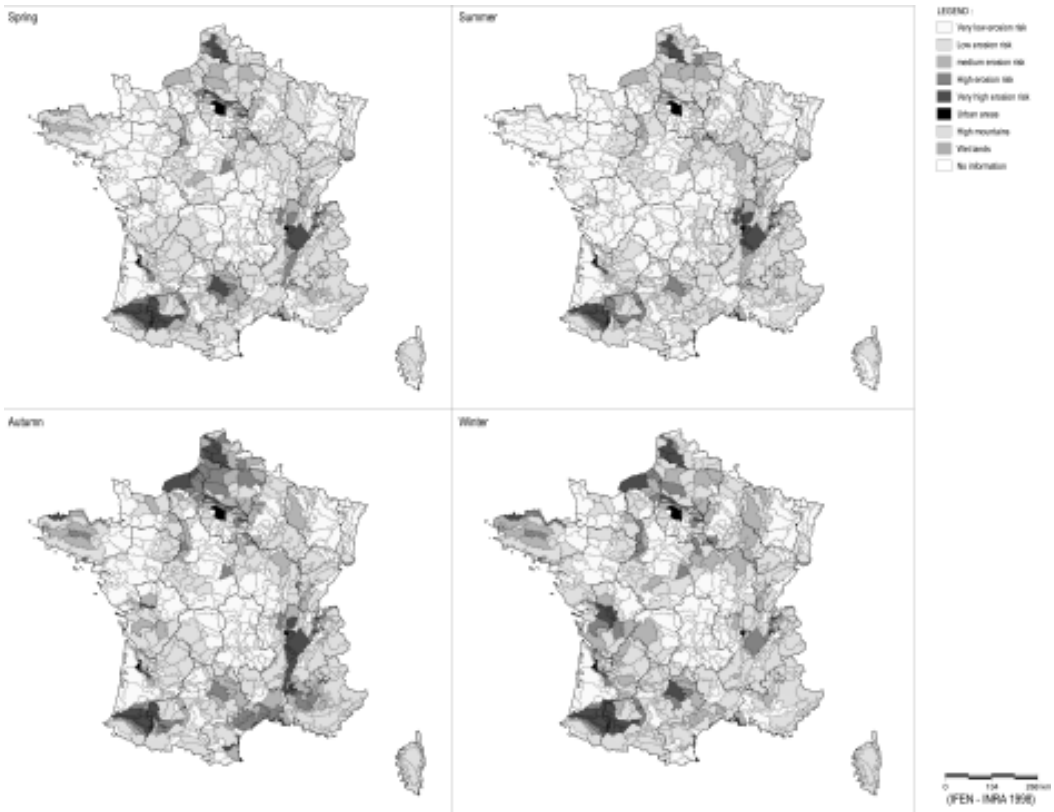
of sewage sludges. Maps currently being edited display the general quality of agricultural soils and reveal zones of anomalies, either natural or provoked by local pollution.

Some uses for soil data

Some examples of the use of soil databases described above can be evoked in relation with topics directly involving the soil (erosion), agricultural production (product quality), or natural resources management (aquifers, rivers). These examples were also selected to demonstrate national or regional applications that illustrate in various ways the value of the different databases.

Among the various threats for the soil, erosion is clearly among the most visible, from agricultural (loss of land) and environmental (water pollution, damage to urban and road infrastructures) points of view. A map of "soil erosion" risks has been realized for the French territory, using GIS to combine the various factors responsible for erosion (Le Bissonnais *et*

FIGURE 4
Seasonal erosion risks in France



al., 1998): crusting and soil erodibility determined from the 1:1 000 000 database, plant cover taken from CORINE land cover, slopes and precipitation (quantity and intensity). The various factors were combined using a simple empirical model and a Digital Elevation Model with a 250 m grid. The results were then computed for small drainage basins or for small agricultural regions and shown for each of the four seasons (Figure 4). These results allowed inter-regional comparisons to help define the nature and intensity of erosion. These documents are then compared with regional studies (King *et al.*, 1998) or presented to regional decision makers to foster an increased awareness through sensitization campaigns and to propose remedial measures.

The database obtained from the IGCS programme is rarely used alone to express a soil characteristic. In most cases it is included in combinations with other databases, in particular those containing climatic, topographic and agricultural data. Combinations are created using dynamic models that reproduce past events by simulation (agrometeorological models, hydrological models, etc.). The maps show risks related to a change in agricultural practices or to climatic changes, in the form of frequency analyses. In this field, the number of studies is high (MAPA, 1998): for example, risk of nitrate leaching in Brittany (Saby *et al.,* 1999), irrigation management in the Beauce (Cousin *et al.*, 1999), vulnerability to fertilizing, fertilizing with urban composts (Legros *et al*., 1991), quality of the agriculture production (Monnet and Gaiffe, 1998), diversification of cultures after removing grapevines (Bornand *et al*., 1994). In most of these studies, the soil has a predominant role in the results, but it is difficult to discern the weight given to it in the final decision. This results from the modeling methods that use other environment variables and from sociological and political factors that are necessarily present in decision-making processes.

This observation has also been verified for the use of monitoring networks. For example, the objectives concerning air pollution are to reduce the emissions of pollutants that affect ecosystems at long distance. The concept of critical loads enables the effects of atmospheric fallout to be quantified in terms of forest decline and streams pH. In France, the ADEME has implemented and led regional and national work in order to respond to the particular needs of the Environment Ministry at the time of revision of international protocols (e.g. Dambrine *et al.*, 1998, Thomas *et al.*, 1998). The network data used in this case are an essential support for international comparisons.

Future work

Future work is are discussed with reference to three questions : soil mapping, soil monitoring and the circulation of information.

In the field of mapping, 1:250 000 work is continuing in order to obtain exhaustive and integrated information for the entire French territory. This scale, however, is insufficient to respond to all kind of social demands that are highly varied and in need of more precise data. There are no national plans to allocate considerable resources to respond to this demand for precise information. On the other hand, it has been proposed to reinforce existing 1:100 000 studies by organizing the results obtained in knowledge bases. In this way, local governments and institutions, rural land managers or design offices can consult the data and apply this knowledge to the areas they are concerned with. In addition, we are noting an increase in the needs for mapping at highly detailed scales, i.e. down to the level of agricultural plots. This has resulted from progress in techniques of spatial positioning and their associated agricultural techniques (precision farming). It is thus planned to reinforce research on these new techniques, in particular in the use of geophysics and digital elevation models. Finally, this multi-scale approach, from the plot to the region, requires continuation of researches about scale transfer methods (e.g. Lagacherie *et al.,* 1997).

Concerning soil monitoring, French systems are judged satisfactory regarding forested areas but insufficient for agricultural zones. Thus, there is a need to plan for a new system that would include the two land use types. The first would be composed of a large number of sites monitored with a time interval of about 5 years. The objective will be to set up a warning system that makes no prior assumptions on pressures that could be exerted on soils during the coming years. The second would be applied to a limited number of sites to monitor fluxes at shorter time intervals (day, month) and thereby be able to analyze and explain recorded long-term changes. In this context, the Environment Ministry has started a research programme (GESSOL) intended to establish the scientific tools and bases to assess, monitor and even restore soil quality.

Finally, it is recognized that all current or future programmes will be of interest only if the data gathered are circulated as widely as possible and in the most instructive manner. This implies the pursuit of research in the field of combining spatial data and in that of evaluating error propagation during these combinations. In addition, there is a need to develop methods for packaging and circulating information, in particular by the use of modern computer technologies (Web, CD-ROM). It is necessary to obtain more information on user needs in order to develop the tools that can be most efficient in responding to these needs.

Conclusions

Inventory and monitoring of soils are in a decisive phase of their development.

Inventory programmes are from now on regrouped within one information system with multiple scales. They should be better able to answer the diverse needs at the different levels of precision requested.

Monitoring programmes are a priority to develop a coherent policy in order to finally dispose of a cartographic coverage and statistical data both at national level and for each region individually.

Research remains one of the main of driving forces for those different programmes, but it cannot alone face the variety and urgency of expressed needs. It is essential to establish a policy for information diffusion and to help create tools for policy makers.

A regroupment of all activities concerning soil inventory and monitoring of rural areas under one umbrella is now being studied by the different Ministries in charge of agriculture, the environment and land management. To be successful in such a project, the participation of direct or indirect users of soil information should be advocated within the proposed structure.

Concerning the relationship between the geographical soil database at 1:1 M developed by the European Union and the countries still not included in the European zone as defined by the FAO, the European Soil Bureau should introduce a proposition to avoid redundancy with that base at 1:1 M resolution and an actual extension to Eastern Europe.

The European area should be integrated in the world database of FAO. This should involve the transfer of parts of the European database in the SOTER format to the FAO database, with a resolution adjusted to the 1:5 M scale used for the other continents.

The policy engaged by INRA with the European partners and the Ministry of Agriculture (IGCS programme) seems to be well adapted to European and national needs. The scales and methods selected for the works by the national coordination are in conformity with the international standards.

The current international trends support the actual project of reorganization of national programmes of soil data acquisition and management that have been submitted to the concerned authorities (MAP, MATE, IFEN).

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Soil information in Germany: the 1999 position

Soil information - general outline

In Germany, the Soil Information System and its application for soil use and soil protection is jointly organized by federal institutes as well as on the individual state level. Since the first German Soil Protection Act came into force on 1 March 1999, soil protection in Germany is defined through a nation-wide framework of regulation. It is stated by this act that the federal level of Germany shall organize a nation-wide soil information system to handle all data relevant for questions of soil use and soil protection.

Recently, a subordinate *Ordinance on Soil Protection*, making specific the German Act on Soil Protection, has passed the German Parliament. It defines soil quality criteria as well as 'precaution levels', 'trigger levels' and 'action levels' and procedures to explain how soil protection measures will be processed.

According to the principles of the German Soil Protection Act, the German soil information system deals with information on the soil itself (e.g. maps, soil analytical databases), other geo-relevant data, data relevant for soil protection such as that from monitoring sites, data on soil background values, data with several impacts, as well as data on contaminated sites.

As a result, data availability and data access have become priorities at national and individual state levels in Germany as well as for the needs of the European Union. To meet this need, German federal institutes, such as the Federal Institute for Geosciences and Natural Resources (BGR, Hannover) and the Federal Environmental Agency (UBA, Berlin), as well as environmental and soil survey institutes at individual state level, have strengthened their activities to improve and extend a joint soil information system for Germany. The exchange of data relevant to soil protection is regulated through the Agreement on Data Exchange between the Federal Government and the Individual States in the Field of Environmental Protection. This agreement includes lists of data that shall be exchanged between the federal government and individual states, e.g. to estimate the state of the environment.

The soil information system will be used for national purposes as well as for cooperation with European institutes. Therefore, the Federal Institute for Geosciences and Natural Resources is a member of the European Soil Bureau (ESB) as well as of the European Topic Centre on SOIL (ETC/S). The Federal Environmental Agency acts as the German National Reference Centre for Soil. Thus European cooperation in the fields of soil mapping and other environmental aspects is well catered for. Cooperation between the national level and the individual states is organized through the working groups on Soil (BLA-BO) and Soil Protection (LABO).

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The status of soil mapping in Germany

In Germany, sixteen state soil surveys and the Federal Institute for Geosciences and Natural Resources (BGR) are co-operating to collect information about the soils of Germany and to organize a network of soil information systems to recall and interpret the data according to scientific or regional criteria. Additionally and in cooperation with the users of this system, methods and criteria are being developed for the recognition and assessment of soil stresses and soil contamination.

A 1994 documentation of existing soil maps in Germany, showing the availability of 1:25 000 to 1:200 000 soil maps, emphasized the problem of incomplete coverage. Besides these scales, several state soil surveys published soil maps at scales of 1:5 000 and 1:10 000 and soil maps of the entire state at scales of 1:300 000 to 1:500 000. Although some state soil surveys could improve soil information, the availability of soil maps at identical scales and quality is still unsatisfactory with respect to national requirements.

Since 1990, BGR became active at national level to organize a soil information system, including all soil maps relevant to national, European and international needs. This part of the soil information system, called FISBo BGR, is well coordinated with similar activities of the individual state soil surveys through working groups. It consists of three main components:

- The spatial database, containing all small-scale soil maps for nation-wide needs, will be used as an extensive data set from which to create thematic maps.
- The laboratory and soil profile database contains the results of soil analyses, i.e. basic chemical and physical data (soil properties), as well as inorganic and organic contaminants.
- The method database is intended to document and select standardized methods, e.g. for the derivation of the filtering capacity, groundwater recharge or soil productivity from soil maps and from the relevant basic pedological data.

The spatial database established at the FISBo BGR needs to hold soil maps for national and international needs, and representing the digital soil geographical databases; it includes:

- Soil Regions Map of Europe at scale 1:5 000 000, which has been drawn up in close cooperation with the member states of the European Soil Bureau,
- 1:2 000 000 Soil Map of Germany, representing a part of the Hydrological Atlas (under preparation),
- Soil Regions map at a scale of 1:1 000 000 to show landscape relations and to give an overall view of soil information,
- 1:1 000 000 EU Soil Map, representing the German part of the Soil Geographical Database of Europe at a scale of 1:1 000 000,
- 1:1 000 000 Soil Map of Germany, the most important geographical database for national requirements
- 1:200 000 soil map as the joint base map to be compiled jointly with the individual state soil surveys,
- Digital Cartographical Database of Europe (EURODB) to serve as the basic map.

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, including cooperation between the federal state and the international level.

The scales and classification system used for the national soil maps

For national need, maps at scale 1:2 000 000 and 1:1 000 000 are available, maps at 1:200 000 scale are in preparation. They have all been compiled applying the 4th Edition of the German Soil Mapping Guide KA 4. This guide includes all the soil taxonomies that existed before German reunification. It also contains data keys, symbols and all parameters used in soil mapping and site description, replacing older versions relating to GDR and FRG state soil surveys. According to the defined principles of the soil information system, these data keys are assigned to data fields to be used in digital management.

The German Soil Mapping Guide KA 4 deals only with the German Soil Taxonomy. Until now, there were no links to international soil taxonomies such as the FAO Soil Legend. These links will become more important in the future, particularly at the European Union level.

There are also other guides existing in Germany for special soil mapping, e.g. mapping of forest sites. Soil maps compiled using these special mapping guides are integrated into the soil survey's soil mapping activities as far as possible. Naturally this requires transformation of all available data into the standard form as given in the Soil Survey's German Soil Mapping Guide.

The 1:1 000 000 Soil Map

Now that the 1:1 000 000 Soil Map of Germany, describing 72 soil map units, has been established digitally, it is the most important part of the spatial database and is integrated in the FISBo BGR Soil Information System. Soil map units and characteristic soil profiles are described according to the German Soil Mapping Guide KA 4 and the FAO soil classification system as well. Presently, a more detailed version of this map is in preparation, amalgamating the soil map with land cover, geo-morphological and climatic information.

The 1:1 000 000 scale makes the soil map especially suitable for evaluating problems at both national and European Union level. Therefore, thematic maps dealing with nation-wide problems of soil use and soil protection have been derived from it.

The 1:200 000 Soil Map

To solve the problem of incomplete coverage for a nation-wide soil map at larger scale, 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 coordinated by BGR. The first maps have already been published.

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. This hierarchical system classifies landscapes according to geology, morphology, climate, and vegetation. At least *Bodenlandschaften* or Soil Landscapes, *Bodengroßlandschaften* or Soilscapes and *Bodenregionen* or Soil Regions (12 of the latter in Germany) are defined.

BGR is cooperating towards the compilation of a European-wide soil map at scale 1:250 000 initiated by the European Soil Bureau (ESB). As proposed by an ESB working group, the concept of soil regions is to be used in the compilation of the 1:250 000 European Union Soil Map as well.

Problems envisaged for adaptation of the national and regional maps to a global methodology

Adaptation of the national and regional soil maps to a global methodology is now to be handled by BGR. Due to the different soil taxonomies to be applied for EU and German mapping

(respectively FAO standard and German Soil Mapping Guide KA 4), which cannot be adapted adequately everywhere, BGR is presently supporting a project to develop a translation manual for the old and new German Soil Mapping Guide and also for the FAO Soil Classification System. At a later stage, the results of this project will be integrated into the German Soil Mapping Guide KA 4.

The adaptation of national and regional soil maps, e.g. amalgamating soil maps to European and international scales or translations of methodologies, will be done by BGR in close cooperation with the individual state soil surveys and must necessarily be coordinated by a working group of the ESB.

Suggestions for a regional mapping scale and applications

The ESB has proposed a nested system of soil maps and databases, including scales oft 1:250 000, 1:1 000 000 and 1:5 000 000. The 1:250 000 scale seems to be an appropriate scale for regional mapping for Germany, too. It has been successfully applied, for instance in Italian soil surveys, on the basis of the 1998 ESB Manual of Procedures for the Geo-referenced Database for Europe. To realize this approach in total, stable structures are of high importance with regard to well-equipped soil survey institutes at regional level, as well as for all the countries of the EU.

Moreover, it is necessary to define and document standardized methods to evaluate soil databases and soil maps to answer numerous questions, for example:

- potential susceptibility to compaction,
- retention capacity for heavy metals,
- vulnerability to erosion by water,
- groundwater recharge,
- nitrate retention capacity,
- potential agricultural yield,
- vulnerability to erosion by wind,
- vulnerability of forest soils to acidification,
- derivation of precautionary, trigger, and action levels for contaminants in soil (§§ 8 and 17, Federal Soil Protection Act).

With respect to future cooperation with European and international organizations, this approach needs to be adopted at the European level.

Eventual national copyright considerations

In principle, soil and soil relevant data in Germany stay in the ownership of the individual soil mapping or environmental institutes. Recently, the individual state environmental and soil surveys as well as BGR and UBA agreed to cooperate in the field of data exchange through a subordinate agreement, given by § 19 of the new German Soil Protection Act.

At European level, the ESB has set up a Data Access Working Group to define a procedure of data access for the European Soil Database at Scale 1:1 000 000. This procedure has been signed by BGR, too.

Conclusions and recommendations

The German nationwide soil information system covers not only basic soil information but all information related to soil and soil protection. The present status of the information systems at federal and individual state levels is different. But the network will be further harmonized.

To organize soil information and soil protection in a federal state system and connected to the European scale, stable structures of cooperation between soil survey institutes and environment institutes at regional level as well as for the federal state are necessary.

The existence of European partner institutions is undoubtedly necessary for international cooperation.

All institutions should agree to one common structure and common components for soil information systems.

All institutions shall jointly define guidelines for soil mapping, sampling, analyses, map presentation etc., and they shall all use the same soil taxonomy, hopefully linked to the European system.

Regional and national soil surveys shall agree on one scale of common interest (perhaps 1:250 000)

Data exchange between the regional and national levels is necessary for both sides. This necessity should be specified and interactions dealt with in a trustful manner, respecting the aims and tasks of each of the partners (regional or national) on the political level.

Soil databases and their use in Hungary

Rational land use and soil management are important elements of sustainable agriculture development. Soils represent a considerable part of the natural resources of Hungary. Their rational utilization, conservation and the maintenance of their multipurpose functionality have particular significance in the Hungarian national economy and in environment protection.

The scientifically-based planning and implementation of sustainable land use and rational soil management ensuring normal soil functions require adequate information on the soil: exact, reliable, detectable (preferably measurable) and accurate, quantitative territorial data on well-defined soil and land properties with the characterization of their spatial (vertical, horizontal) and temporal variabilities, soil processes and pedotranser functions.

Data Sources for Natural Factors

The most important databases and monitoring systems are as follows (The National Atlas of Hungary, 1989)

- Meteorological data. Systematic and regular measurements from 1850. Basic meteorological parameters are registered at 160 observation points; 18 stations are equipped for detailed atmospheric-chemistry measurements and 4 stations for continuous atmospheric monitoring.
- Hydrological data. Regular records on the quantity and quality of surface waters (rivers, creeks, canals, lakes, ponds, reservoirs) from the first decade of the century; regular measurements on groundwater conditions (depth of water table; chemical composition of the groundwater) for 600 – 1000 groundwater testing wells are available from 1935, including 50 piezometer installations.
- Geological data. As a result of the 160-year-old geological survey, the 1:200 000 geological map of Hungary has been prepared as well as a great number of various thematic geological, hydrogeological, geo-chronological maps at larger scales for different regions of the country.
- Geomorphological data. In addition to the 1:200 000 geomorphological map (geomorphological types, subtypes and varieties) of Hungary a series of regional maps has been prepared, indicating the geomorphology pattern of smaller territories at larger scale using digital relief models in recent years.

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The Status of Soil Mapping in Hungary

A large amount of soil information is available in Hungary as a result of long-term observations, various soil surveys, analyses and mapping activities on national (1:500 000), regional (1:100 000), farm (1:10 000 – 1:25 000) and field level (1:5 000 – 1:10 000) during the last seventy years.

Soil Maps

In Annex 1 the most important thematic soil maps in Hungary are summarized, indicating their content, scale, author and date of preparation. The maps can be divided into three main groups:

Large-scale maps

- In the Kreybig – practical soils maps the soil reaction, carbonate and salinity/alkalinity status is indicated by colours; physical-hydrophysical characteristics and depth of the soil by rasters; the organic matter, total P_2O_5 and K_2O content, depth of the humus horizon and depth of the groundwater table by a code number; and the soil type (according to Sigmond's soil classification) with Roman numbers.
- On the 1:10 000 scale genetic soil maps the most important soil properties (soil type, sub type and local variant according to the Hungarian soil classification system; pH and carbonate status; texture; hydrophysical properties; salinity /alkalinity status; organic matter resource; N, P and K status) are indicated on separate thematic maps (cartograms); and recommendations are summarized in additional thematic maps for rational land use and cropping pattern; soil cultivation; rational use of fertilizers; soil moisture control, including water conservation practices, irrigation and drainage; soil conservation practices for water and wind erosion control, etc.

  The new and revised genetic soil maps – which have been made during 1985 – 1991 for soil evaluation – indicate the soil type, subtypes, variants and parent material by code numbers on soil maps; the same with other soil properties according to soil evaluation on different thematic maps (cartograms). Just before this period (1980 – 1985) a lot of soil surveys were made with the aim of making a new land evaluation system. This database has descriptions of soil profiles and results of laboratory analysis.
- The large-scale maps on the possibilities and limitations for irrigation indicate the soil types, subtypes and local variants and parent material; physical-hydrophysical soil characteristics; salinity/alkalinity status of the soil (salt content, ion composition, ESP, pH); groundwater conditions (depth and fluctuation of the water table; salt concentration, ion composition and SAT of the groundwater) on separate thematic maps. On this basis, two additional map sheets were prepared on the critical depth of the water table and critical groundwater regime, and on recommendations of irrigation practices and groundwater management.
- Large scale (1:5 000, 1:10 000) maps for various soil amelioration projects

Medium-scale maps (Nos. 6-9 in Annex 1)

- In 1978, a national programme was initiated by the Hungarian Academy of Sciences for the Assessment of the agro-ecological potential of Hungary. In this programme a 1:100 000 scale map was prepared by Varallyay and his team in RISSAC on the soil factors determining the agro-ecological potential, utilizing all available soil information. On the map seven soil factors (soil type; parent material; soil reaction and carbonate status; soil texture;

hydrophysical properties; organic matter resources; depth of the soil) were indicated with an 8-digit code number.

- Later, the map was completed with two additional soil characteristics (clay mineral associates and soil productivity index) and the contours of the 9 soil characteristics were printed on the 1:100 000 scale topographical map (indicating relief, surface waters, land use, infrastructure, etc). The agro-topographical map was digitized and organized into a GIS-based soil information system.
- The map of the categories of the hydrophysical properties of soils was also prepared at a scale of 1:100 000. The 9 main and 17 subcategories indicated were defined by the following soil characteristics: texture; saturation percentage (SP); field capacity (FC); wilting percentage (WP); available moisture range (AMR), infiltration rate (IR), saturated hydraulic conductivity (K), unsaturated capillary conductivity (k, k-?, or k-?); and by the layer sequence of the soil profile.
- 1:75 000 scale maps on the status of soil erosion (strongly, moderately and slightly eroded lands; areas of sedimentation; territories under the influence of wind erosion; parent material) were prepared by Stefanovits and his team in the 1950s for the agricultural lands of hilly regions in Hungary.

Small-scale maps (Nos. 10-16 in Annex 1)

- 1:500 000 scale genetic soil map and generalized thematic soil maps (Nos. 10-14 in Annex 1)
- 1:500 000 scale HUNSOTER (HUNgarial Soil and TERrain digital database)
- 1:1 000 000 – 1:5 000 000 scale soil maps, prepared for various international programmes e.g. FAO-UNESCO Soil Map of the World (1:5m); FAO Soil Map for Europe (1:1m); World Map of Salt Affected Soils (1:5m); Global Assessment of Soil Degradation, GLASOD (1:5m); SOVEUR (Soil Vulnerability against various pollutants in Europe, 1:2.5m); CTB (Chemical Time Bomb – time delayed effect of various pollutants); Long Term Environmental Risks for Soils, Sediments and Groundwaters in the Danube Catchment Area; etc.

Soil Susceptibility or Vulnerability Maps

In recent years, special attention has been paid to the characterization of soils from the viewpoint of their sensitivity /susceptibility /vulnerability to various natural and human-induced stresses. Soil susceptibility maps have been prepared for water and wind erosion (1:1m); acidification (1:500 000, 1:100 000); salinization and alkalization (1:500 000); physical degradation, such as structure destruction, compaction and surface sealing (1:500 000). Recently particular attention has been paid to soil and water pollution (hazard) and a series of maps have been prepared on the vulnerability of soils against various pollutants in the RISSAC GIS Laboratory.

Soil Information and Monitoring Systems

Systematic monitoring systems were established registering soil changes.

- The **soil fertility monitoring system** (AIIR) is to provide a soil and agronomy database for rational soil management and plant nutrition. In the system, the most changeable soil characteristics (pH, $CaCO_3$ and organic matter content; saturation percentage (SP); total

salt content; total and mobile N content; available P, K and Ca content; soluble Mg, S, Cu, Zn, Mn content) were measured in the topsoil (0-30cm soil layer or the ploughed horizon; later in the 30-60 cm layer, as well) of about 100 000 agricultural fields covering nearly 5 million hectares (the total agricultural area of the 93 thousand square km of Hungary is about 6.5 million hectares), in 3 year cycles. The programme started in 1978 (I: 1978 – 1981; II: 1982 – 1985; III: 1986 – 1989) and stopped before completing the third cycle. The data were computer stored by agricultural field (their average size was about 50 hectares at that time), without inner boundaries of the maximum 12 hectares sampling sites.

- **Microelement survey**: In this system – in addition to the above mentioned basic soil parameters – the total (interpreted as a potential pool) and soluble (interpreted as mobile and plant available) content of 20 elements were determined in the 0-30, 30-60, 60-90 cm soil layers. On the basis of analytical data 1:2 000 000 scale thematic maps were prepared for Cd, Co, Cr, Cu, Hg, Mo, Ni, Pb. The planned cycle was 3 years, but the programme stopped after the first cycle (1987-1988) because of financial limitations.

In later years, all existing soil data were organized into computerized soil information systems:

- **Soil Information System** (HunSIS = TIR): It contains – in addition to the basic topographic information – point information on the characteristics of soil profiles and their different layers and diagnostic horizons; territorial information (1:25 000 scale thematic maps) on the most important soil and land characteristics; and validated models on pedotransfer functions, soil processes and soil-plant-environment relationships. The system was prepared in RISSAC for Pest County (one of the 19 administrative regions of Hungary, covering about 6500 km^2).
- **Agrotopographical database** (AGROTOPO): Digitized data of the 1:100 000 scale agrotopographical maps (Annex 1, No 7) organized into GIS.
- **National Soil Information and Monitoring System** (TIM) 1992: Based on physiographical /soil-ecological units about 1200 representative observation points were selected (and geo-referenced by GPS): 850 points on agricultural land, 170 points in forests and 180 points in environmentally threatened hot spot regions (representing 12 different types of environmental hazards or particularly sensitive areas, such as: degraded soils; ameliorated soils; drinking water supply areas; watersheds of important lakes and reservoirs; protected areas with particularly sensitive ecosystems; hot spots of industrial, agricultural, urban and transport pollution; military fields; areas affected by (surface) mining; waste (water) disposal affected spots).

In the system some soil parameters are measured every year (the sampling date is Sept 15 – Oct 15), some others every 3 or 6 years, depending on their changeability (annex 2).

According to the basic concept, TIM is an independent but integral mosaic (subsystem) of the Environmental Information and Monitoring System (KIM).

The database management and the hardware-software configuration of the system:

- ♦ guarantee the compatibility of TIM with other subsystems of KIM which are under elaboration (e.g. for the atmosphere; surface and sub-surface water resources; geological deposits and mineral resources; biological resources and biodiversity; landscape; human resources and socio-economic aspects of the environment etc)
- ♦ establish potential conservative connections to similar international systems for the joint regional, continental and global actions of sustainable development

- ♦ give opportunities for the development of various environment-related user-friendly expert systems for scientific applications and for public use.

The database of TIM thematic maps have been prepared for soil physical properties, chemical reactions and humus content. The report is in press.

- SOTER-HUNSOTER. The International Society of Soil Science (ISSS) proposed a worldwide project in 1986 for the establishment of a World Soils and Terrain Digital Database at a scale of 1:1 million. The main function of the SOTER database is to provide the necessary data for improved mapping, modelling and monitoring of changes of world soil and terrain resources and to present a wide range of accurate, timely interpretative analyses for decision and policy makers for their development concepts, decision making, planning and implementation activities.

  In 1993 a project proposal was elaborated (by RISSAC, Budapest) under the title 'Multipurpose applicability of soil and terrain digital database (SOTER) for sustainable land use and soil management (HUNSOTER).' The proposal was submitted to, and accepted by, the United Nations Environmental Programme (UNEP) as 'Establishment of soils and terrain database for sustainable agriculture and environmental protection in Hungary (HUNSOTER)'. The results were presented at the 15th ISSS Congress (Acapulco, Mexico, 1994) and later at several information meetings as an example of successful SOTER application.

  The hierarchic system of the SOTER concept and the HUNSOTER database are compatible with the Global Soil and Terrain Digital Database and with global databases of other environmental factors; amenable to updating and purging of obsolete or irrelevant data; easily applicable for computer storage, digitization and modelling; accessible to a broad array of international, regional and national decision-makers responsible for the development, management and conservation of natural resources; transferable to national databases at larger scale (with greater detail).

Multipurpose Applications of Soil Information

The properly organized hierarchic soil database (global, continental, regional, national, subregional, local, farm and field levels) represents a comprehensive scientific basis for the various Plans of Action for sustainable land use and soil management. It offers wide-ranging opportunities for the spatial quantification and comprehensive analysis-modelling-evaluation of soil properties, pedotransfer functions and for determining soil processes:

- soil fertility and soil productivity for various crops
- the vulnerability of terrain and susceptibility for soils to various natural and anthropogenic impacts and environmental hazards (water and wind erosion; acidification; salinization-alkalization; soil structure destruction; compaction; biological degradation; unfavourable changes in moisture and nutrient regimes; soil toxicity; pollution of surface and subsurface water resources; landscape deterioration);
- degradation and decline of forest and grassland ecosystems; and the forecast of potential future changes due to the impacts of natural factors and human activities, assuming various plausible scenarios.

A well organized soil database can be used properly for:

- assessment of the state of the environment and its long-term global and regional changes; inventory of environmental hot spots (environmentally sensitive, valuable, protected ecosystems and their land-sites; highly polluted areas with susceptible soils; etc); risk assessment of environmental hazards; impact analysis of various human activities;
- protection, conservation, rational use and management of natural resources (surface and subsurface waters, soils, biological resources, etc);
- exact description, quantification, modelling and forecasting of soil processes for their efficient control and the prevention of undesirable changes, such as soil degradation processes, soil pollution, extreme moisture and nutrient regimes;
- objective land (soil and terrain, land site) evaluation, taking into consideration the multifunctionality of soils (media for biomass production; storage, buffering, filtering and detoxification function; habitat of biota);
- optimization, regionalization (zonation) of land use (including non-agricultural land use) and cropping pattern;
- elaboration of regional and national strategies (concepts, main directives, general guidelines) for rural development, sustainable biomass production and rational environment protection, efficient (effective, easily adaptable, widely applicable, transferable) technologies for rational land use, agricultural water management, agrotechnics, amelioration and remediation (including site-specific precision farming and soil-related waste management);
- development and formulation of economically viable, socially acceptable and environmentally sound land use policy and legislation measures.

National Copyright Considerations

The multipurpose applicability of soil information was discussed and summarized during the FAO /EEC International Workshop on the Harmonization of Soil Conservation Monitoring Systems (Budapest, 14 – 17 September 1993).

Hungarian soils science, soil survey and soil testing practices always successfully served agricultural development, the planning and organization of crop production and environment control (rational land use and cropping pattern; control of limiting factors of soil fertility and soil degradation processes, moisture and nutrient regimes, soil and water pollution, biodiversity, landscape deterioration).

The establishment, operation and updating of various soil information sources (databases) were financed – in most cases – fully and directly from the national budget. Consequently, the data are open for public use with some necessary and rational limitations. Because the primary hard data – in most cases – are not directly useable for practical purposes by the public, on the contrary they can be misused and misinterpreted easily, their public use will be regulated officially. According to future plans the databases will be open (useable /utilizable) for the public through the set of local work stations adequately equipped with proper (possibly multimedia) expert systems: hardware – software configurations operated by well-trained technical experts.

Recommendations for Follow-up Activities

In the establishment, operation and multipurpose practical application of soil information (databases), efficient and permanent national, regional and international coordination is required on the following issues

- to collect national information on information systems on soil resources and soil conservation from European countries;
- to compare and evaluate the existing information systems;
- to prepare comprehensive guidelines for the methodology (including the content, structure, up and down scaling; new technologies of GIS, computer application and remote sensing) on the establishment, operation and practical applicability of a hierarchic soil information system supporting the decision making process on various hierarchic levels: global, continental, regional, national, subregional and local (farm, field) level;
- to set national and international priorities and ensure the required financial support for these activities;
- to establish a regular international open ended forum for the discussion of various technical issues (task forces for priority-setting, rationally harmonized structure of information systems, selection of parameters and indicators, sampling and laboratory analysis strategies, database management, GIS and remote-sensing applications) and operational problems (data acquisition, copyright regulations, user-friendly expert systems for various practical applications);
- to give technical and methodological help to those European countries that are interested in the development, establishment and introduction of an internationally harmonized soil information system.

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Annex 1

Thematic Soil Maps and Related Databases in Hungary

No	Map	Scale	Date of Preparation	Prepared for	Content	Author (s)	References
1	Practical soil maps	1:25 000	1935 1955	The whole country per topographical map sheets	m, tm, fd, ld, e	Kerybig and collective	VÆrallyay, 1989
2	Large scale genetic soil maps	1:10 000	1960 1985	50 % of the agricultural land of Hungary, per farming units	m, tm, fd, ld, e	Collective	Szabolcs, 1966
3	Soil evaluation new genetic soil maps Revision of genetic soil maps	1:10 000 1:10 000	1985 1991 1985 1990	15% of the agricultural land per topographical map sheets 22% of the mapped area	m, tm with code numbers, fd, ld	Collective	
4	Soil conditions and the possibilities of irrigation	1:25 000	1960 1970	Present and potential irrigated regions	6 thematic maps fd, ld	Collective	Szabolcs *et al.*, 1969
5	Large scale maps for amelioration projects	1:5 000 1:10 000	1960	Amelioration projects (occasionally)	m, e	Collective	
6	Soil factors determining the agroecological potential	1:100 000	1978 1980	The whole country per topographical map sheets	m (with an 8 digit code), c	Varallyay, G., Szucs, L., Muranyi, A., Rajkai, K., Zilahy, P.	Varallyay *et al.*, 1985
7	Agro-topographical map	1:100 000	1987 1988	The whole country per topographical map sheets	m (with a 10 digit code), c	Varallyay, G., Molnar, S., Sz cs, L.	Varallyay & Molnar 1989
8	Hydrophysical properties of soils	1:100 000	1978 1980	The whole country per topographical map sheets	m, c	Varallyay, G., Szucs, L., Rajkai, K., Zilahy, P.	Varallyay *et al.*, 1985
9	Status of soil erosion	1:75 000	1964	Agricultural lands of hilly regions of Hungary	m	Stefanovits, P.	
10	Limiting factors of soil fertility	1:500 000	1976	The whole country	m	Szabolcs, I., Varallyay, G.	Szabolcs & Varallyay, 1989
11	Main types of moisture regime	1:500 000	1983	The whole country	m, c	Varallyay, G., Zilahy, P., Muranyi, A.	Varallyay, 1985
12	Main types of substance regime	1:500 000	1983	The whole country	m, c	Varallyay, G., Szucs, L., Molnar, E.	Varallyay, 1985
13	Soil erosion	1:500 000	1960 1964	The whole country	m, tm, e	Stefanovits, P., Duck, T.	Stefanovits, I., 1964
14	Salt affected soils	1:500 000	1970 1974	The whole country	m, e	Szabolcs, I., Varallyay, G., Melyvolgyi, J.	Szabolcs, 1974
15	Susceptibility of soils to acidification	1:100 000 1:500 000	1985 1988	The whole country	m, c	Varallyay, G., Redly, M., Muranyi, A.	Varallyay *et al.*, 1993
16	Susceptibility of soils to physical degradation	1:500 000	1985 1988	The whole country	m, c	Varallyay, G., Lesztak, M.	Varallyay & Lesztak, 1990

Remarks: m: soil map; tm: thematic map; fd: field descritpion; ld: laboratory data; e: explanatory booklet; c: computer.

Advances in soil survey, monitoring and applications in Italy

Soil Survey Activity

In Italy, overall soil survey activity has increased considerably in the last few years, but the organization of knowledge on Italian soil is still in its infancy. This increase in activity of survey has been due to various reasons, but principally to a series of national and European legislation, involving soil investigations as part of measures to protect the environment. Examples of these include regulations regarding the application of nitrogen fertilizer and the spreading of slurries and sewage and the need for Environmental Impact Analysis prior to infrastructure expansion programmes.

At different administrative levels, i.e., national, regional, provincial and communal, many strategies and regulations involve the need for soil survey, for example, in support of increased land productivity, such as that of vineyards and forests, or land planning like "watershed plans", "management of water resources plans", "environmental safeguard plans", "province land coordination plans", "communal regulator plans", "forest settlement plans" and creation of natural parks.

Another significant impulse to soil survey has been given by the preparation of soil maps for programming the agricultural policy of some regional Administrations.

Besides the soil survey activities promoted or introduced by public institutions, there are also a number of pedological studies financed by single or associated private bodies. The most common are land suitability for different crops and, in the last decade, agricultural zoning, particularly in relation to viticulture, or location of sites useful for specific agricultural activities, such as growth of truffles and tree nursery plantations.

Finally, a number of soil surveys are included in research activities led by different Universities, centres of the National Research Council and some Experimental Institutes belonging to the Ministry for Agricultural Policies.

Due to the breadth of activity, it is difficult to give a complete picture of current and recent soil survey activity. However, the details laid out in this paper should give an idea of much of the development. Generally, pedological information is relevant, but soil maps and profile descriptions are seldom printed or accessible and have yet to be introduced into databases.

Institutions and databases

The main institutional framework for soil mapping and pedological information is the National Observatory for Pedology and Soil Quality of the Ministry for Agricultural Policies, whose tasks are to address and coordinate the main public projects dealing with soils in Italy. Few

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services or pedological initiatives have so far been created by regional Administrations. A few are in course of establishment, though they have few specialized staff because their role is to manage the surveys and soil data; most field soil surveyors are now free-lance professionals.

A national soil database is completely lacking in Italy. Nowadays, the only soil map of the whole country are those at very small scales: one to five million (FAO-UNESCO, 1978) and one to one million (Mancini, 1966; ESB, 1998). Only four regions, namely Emilia-Romagna (Regione Emilia-Romagna, 1994), Sardinia (Aru *et al.*, 1990), Sicily (Fierotti, 1988) and Trentino (Ronchetti, 1965), have a complete soil map at 1:250 000 scale. The soil maps of Lombardia and Abruzzo are almost complete, but some other regions are still almost completely lacking in soil maps and those available are sometimes not homogeneous due to differences in scale, classification systems and survey methodologies.

The EU has recently funded a soil survey project called: "Pedological mapping in the Operative Territorial Units"(UOT), in pilot areas of particular agronomic interest within eight regions of Italy: Abruzzo, Basilicata, Calabria, Campania, Molise, Puglia, Sardegna, Sicilia (Napoli *et al.*, 1998). The surveys have led to the production of soil maps at 1:50 000 scale and suitability maps for the most important agricultural uses. Due to such variety in soil maps, the Committee for the National Observatory for Pedology and Soil Quantity planned a work programme to produce a Monitoring of Soil Maps of Italian regions. This project, called "MONCAPRI", has been undertaken by the Experimental Institute for Soil Study and Conservation of Florence, which is responsible for collecting and organizing soil map information gathered with the courtesy of regional Administrations. With the collaboration of the Soil Genesis and Ecology Institute of the National Research Council of Florence and of the Geography Department of the University of Bologna, an integration of data on soil maps has been possible (Magaldi *et al.*, 1992, Vianello *et al.*, 1988-90).

Soil maps that have been produced in Italy vary in classification system, mapping methodology, and scale, because origins, aims and purposes of the various surveys were often different. There are some 433 maps in Italy, of which only 126 (29 percent) have been digitized (Table 1).

TABLE 1
Area covered by soil maps (including some survey projects ending in 2000)

	Detailed (Scale <= 25 000)			Semi-detailed (Scale between 30 000 and 100 000)			Reconnaissance (Scale between 150 000 and 250 000)		
	ha	%*	%**	ha	%*	%**	ha	%*	%**
Italy	2 868 527	9.5	40.8	9 686 847	32.1	59.7	9 012 400	29.9	59.1

* = mapped area percentage on total area of Italy
**= digitized map area percentage on total soil mapped area

Point observations, profiles and auger holes, amount to about 200 000 in the whole of Italy and soil profiles to about 17 000 of which 84 percent are georeferenced (Table 2).

TABLE 2
Soil profiles georeferenced and classified according to different systems

Classification System	Profiles
Soil Taxonomy only (USDA)	6 902
FAO only (Revised Legend)	96
Soil Taxonomy and FAO	9 369
Italian Classification	510
Total	16 877

Monitoring

A national soil-monitoring programme is completely lacking in Italy. The only activity aimed at monitoring the state of soils on a national level is that organized under the European programme "Forest Soil Condition Database", and carried out in Italy by the Experimental Institute for Plant

Nutrition and the Ministry for Agricultural Policies. Under this programme, 80 plots have been selected and analysed for a set of chemical properties.

Applications

As mentioned before, soil survey information is widely applied in Italy, so that almost all soil surveys have a practical purpose. This is the reason why thematic maps are so numerous and the range large (Table 3). Among the different typologies, Land Capability evaluations are the most common, followed by maps produced for agricultural, forest and range purposes. The main derived cartography for the whole national territory is a Land Capability map (Mancini and Ronchetti, 1966). Some Regional Administrations have produced thematic maps relating to the different local priorities, e.g. Land Capability in Piemonte (Regione Piemonte – IPLA, 1982), geo-environmental risk in Emilia – Romagna (Regione Emilia-Romagna, 1994), soil suitability for irrigation in Sardegna (Arangino *et al.*, 1986).

In recent years there has been an increase in the range of suitability maps, reflecting the spread of environmental and agricultural interests. The general trend appears to be a shift from generic soil evaluation to more specific interpretations, often integrated with the use of more or less sophisticated models.

TABLE 3

Area covered by soil evaluation maps at scales up to 1:250 000

Theme of maps	ha	% of total mapped area	% of Italian area
Land Capability			
Land Capability	12 800 969	47.6	42.5
	12 800 969		
Land evaluation for agricultural crops			
Suitability for tree crops	99 959	0.4	0.3
Suitability for annual crops	245 295	0.9	0.8
Suitability for horticulture	7 596	<0.1	<0.1
Suitability for vine	133 654	0.5	0.4
	486 504	1.8	1.6
Land evaluation for forestry			
Suitability for forest yield	60 424	0.2	0.2
Suitability for forest mechanization	7 126	<0.1	<0.1
	67 550	0.3	0.2
Land evaluation for pasture			
Suitability for pasture	158 297	0.6	0.5
	158 297	0.6	0.5
General agronomic evaluation			
Soil management agronomic advice	1 724 503	6.4	5.7
Soil fertility and potential soil fertility	475 720	1.8	1.6
Land use limitations	2 799 418	10.4	9.3
Vulnerability to soil tillage	73 219	0.3	0.2
	5 072 860	18.9	16.8
Land evaluation for environmental safeguard			
Suitability for industrial sewage distribution	1 376 572	5.1	4.6
Suitability for slurry spreading	1 736 018	6.5	5.8
Suitability for pollutant degradation	1 592 317	5.9	5.3
	4 704 907	17.5	15.6
Land evaluation for water management			
Soil – water balance	823 208	3.1	2.7
Water erosion risk	611 900	2.3	2.0
Suitability for irrigation	1 638 335	6.1	5.4
	3 073 443	11.4	10.2
Others			
Specific interpretations	531 382	2.0	1.8
Suitability for engineering	15 628	0.1	0.1
	547 010	2.0	1.8
TOTAL	26 911 540		

In the near future, the most important project in soil survey will be the production of a national soil map at a scale of 1:250 000. For this purpose, Italy is planning to invest more than

6 000 000 Euro in two years. The overall activity will be divided into two main projects, one of which is related to soil survey, the other devoted to methodology assessment. The soil survey activity will be steered by regional Administrations and will be an opportunity for setting up regional soil services, where lacking, or to consolidate those in existence.

The project "Pedological Methodologies – Criteria and procedures for the creation and updating of the soil map of Italy" is aimed at developing the methodology to support the realization, management and utilization of a georeferenced soil database of Italy. Another main task of the project is to create a national centre of soil cartography, in collaboration with the regional Administrations, for collection of pedological data and their use for national evaluations.

Standards provided by the project will be defined with the collaboration of researchers and regional officials and will include procedures, manuals, file-cards and software. They will take into account the national and international state of the art, in particular the European Soil Bureau manual, and will be calibrated and validated on pilot areas (Table 4).

TABLE 4
Structure and responsibilities of the "Pedological Methodologies" project.

Sub-project	Sector of activity
1	Definition of the general concepts and glossary; publication of the Italian version of soil manuals; standardization of the soil data bank attributes; separation of the soil regions, pedo-landscapes and intermediate landscape levels. General coordination of the project. Responsible: Experimental Institute for Soil Study and Conservation
2	Publication of the soil survey manual and field file-card; definition of methods of information distribution. Responsible: Emilia-Romagna Region Soil Bureau
3	Standardization of methodologies for the gathering and management of geographic data and its transfer to the GIS; guidelines for the use of aerial photos, satellite and DTM. Responsible: Experimental Institute for Soil Study and Conservation
4	Standardization of the controls for data quality checking; criteria for contracts definition with companies. Responsible: Agricultural Department of the Tuscany Region and Experimental Institute for Soil Study and Conservation
5	Methodology calibration and validation in the pilot area "plains and low hills of northern Italy". Responsible: Soil Service of the ERSAL (Lombardia Region)
6	Methodology calibration and validation in the pilot area "central Italy regions". Responsible: Soil Section of the ARSSA (Abruzzo Region)
7	Methodology calibration and validation in the pilot area "southern and insular Italy". Responsible: Soil Section of the SeSIRCA (Campania Region)
8	Creation of a national centre of soil cartography. Responsible: Experimental Institute for Soil Study and Conservation

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The status of soil mapping in Lithuania

Soil Information

Soils of Lithuania have been regularly studied and mapped (at the scale 1:10 000) since 1950. Soil studies resulted in the excavation, analysis and description of around 500 000 soil profiles and 3 000 000 laboratory analyses. All the lands of the former agricultural companies were covered by soil maps at the scale of 1:10 000. Soil scientists of the Soil Research and Mapping Division of the State Land Survey Institute carried out the studies. The research and mapping of forest soils at the scale of 1:5 000 was executed by specialists of the State Forestry Institute.

The area of Lithuania is 6 530 000 ha. Land designated for agricultural purposes occupies 60% of the area of Lithuania, while land designated for forestry covers 30% of the area.

After generalization of the soil research data at large scale (1:10 000), soil scientists of the State Land Survey Institute compiled soil maps covering the 44 administrative districts of the country (1:50 000) and the overall territory of Lithuania (1:300 000).

The process of soil research also included compilation of other applied maps such as of granulometric soil composition, soil erosion, soil hydromorphy, preparation of textural soil characteristics, and recommendations for soil use, improvement, protection, etc.

All of this abundant and valuable information is kept in the archives of the State Land Survey Institute.

The Agrochemical Research Centre of the Agricultural Institute of Lithuania has been engaged in systematic agrochemical studies of agricultural lands and specialized soil research in Lithuania since 1964. After generalization of research data, cartograms of soil reaction (pH) and nutrients (mobile phosphorus (P_2O_5) and mobile potassium) were compiled.

According to soil research data and with regard to the status and chemical indicators of soils, land valuation maps at the scale of 1:10 000 covering the whole territory of Lithuania were developed by specialists of the Soil Research and Mapping Division of the State Land Survey Institute.

The Scale and Classification System Used for the National Soil Map

The fact that thorough research and detailed mapping of soils of Lithuania have been carried out is acknowledged by cooperating specialists of Western countries. However, a number of problems arise in the sphere of application and use of soil research and mapping data of Lithuania.

One of the main problems is that research and mapping of soils in Lithuania were carried out in line with the soil classification, which was adopted by soil scientists of the Baltic countries in

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1953 and adjusted in 1956. Based on the genetic Russian soil classification, it is inadequate to meet the standards of the countries of the European Union.

Another problem is that a part of the research was carried out several decades ago and the data must be corrected with regard to alterations of some soil properties (e.g. an increased degree of erosion).

The third problem is that the abundant and valuable information is used ineffectively. All the information is contained in a great number of paper files in the archives. Therefore, transferring all the soil research data into a GIS soil database is very complicated.

Therefore, one of the main tasks and objectives of today is the development of the new soil classification of Lithuania in conformity with the international FAO-UNESCO standard requirements used in Western European countries. With partial financing by FAO, data of various accuracy and complexity are accumulated at different levels.

For soil data accumulation on the national level, base maps at scales of 1:300 000 and 1:1 000 000 are used. For data of the district municipalities, at district (regional) level, maps at the scale of 1:50 000 are used. Local level soil data are the most detailed: they are accumulated as maps at the scale of 1:10 000.

Problems Envisaged for Adaptation of the National and Regional Maps to a Global Methodology

Abundant and valuable soil research information is used inefficiently. There are no digital soil data, which could be used easily in the integrated databases of geographical information systems.

Soil classification does not meet the requirements of the European Union. Therefore, one of the main tasks is the development of the new soil classification of Lithuania in conformity with the international FAO-UNESCO standard requirements used in Western European countries. With partial financing by FAO and consultations rendered by experts of European countries and soil scientists from various institutions of Lithuania, this work is coming to completion at the State Land Survey Institute. In principle, the new soil classification of Lithuania has already been developed. This classification is of better quality; it shows the basic genetic, agro-economic and other soil properties.

Along with the introduction of the new soil classification, the grouping of granulometric soil composition used in Western countries was adopted. Previously the grouping of granulometric composition of soils was based on the biominal system (ratio of clay particles to the sum of other particles) rather than on the triominal system (ratios of sand, silt and clay particles).

After introduction of the new soil classification and grouping of granulometric soil composition, methods of transforming the old soil units to the new classification were prepared; equivalents of the old units in the new classification were established.

After execution of minor outdoor studies and laboratory analyses, new soil plans and maps at various scales were compiled and adequate attribute data were developed. It became apparent that updating of the entire soil research information of Lithuania according to the new requirements is possible in a comparatively short period of time. This will be possible only after the second problem is solved, i.e. after all the research data are computerized and digital soil maps for the GIS soil database of Lithuania are compiled.

According to the new European classification, soil maps of the Republic of Lithuania have been compiled at the scale of 1:300 000 and 1:1 000 000. The map at the scale of 1: 1 000 000 will be used for development of the soil map of Europe.

According to the old classification, Lithuania was ascribed to the zone of podzolic soils and it was thought that podzolic processes prevail in the area. On those grounds, podzolic, gleyed podzolic and pine forest podzol soils were identified in the major part of Lithuania. In the Middle Plain sod carbonate and sod carbonate gleyed soils were prevalent.

After analysis of research data and their adaptation to the requirements of the FAO classification, it was established that the soil pattern of Lithuania is more complicated than previously supposed. Leached soils (lessivés, Luvisols) are most extensive, while Albeluvisols and gleyed Albeluvisols cover smaller areas. Calcaric Cambisols prevail in the Middle Plain of Lithuania.

The greater part of the former podzolic and gleyed podzolic soils was ascribed to the Arenosols, though Podsols also occur regularly.

Where granulometric soil composition of the surface layers conspicuously differs from that of the deeper layers, Planosols have now been recognized and mapped.

Grouping of peat soils (marsh) and alluvial soils underwent no major changes in the new classification.

Suggestions for a Regional Mapping Scale and Applications

With the purpose of land use planning, data of the Land Resource Information System, including soil data, are developed on three levels: national, district (regional) and local. At different levels, data of different accuracy and detail are accumulated. As the Land Resource Information System (LRIS) is based on GIS, base maps at the scale of 1:200 000, 1:300 000 and 1:400 000 are used for data accumulation on the national level. LRIS data layers are developed at the scale of 1: 300 000.

Regional level entities in Lithuania are the 44 district municipalities. In this case, the scale of the base GIS map is 1:50 000. Territories of several districts or their parts may form a 'hot' area. However, digital GIS data allow for easy solutions of problems with the use of regional and district data. In individual cases, regional data may be accumulated at the scale of 1:100 000.

Cadastral areas are best suited for local level planning. Boundaries of 1400 cadastral areas in Lithuania were approved by decision of the Government. Cadastral areas are used for unique indexing of cadastral units (farmland, forest, water, protected land, residential areas etc.). However, local level planning may also be carried out in smaller tracts such as villages, farmer's fields, etc. LRIS data for local level planning are accumulated at the scale of 1:10 000, 1:5 000, 1:2 000, 1:1 000, 1:500 and 1:100, depending on size of the area.

LRIS data for local planning are detailed and can be successfully used by farmers and cooperatives in decision-making activities. Various forms of support and subsidies help to enforce district policies and priorities. However, district level data depend on the specific interests of land users.

District policy and priorities must not be in conflict with the national policy and priorities. National land policy and priorities must take into account local and district level needs, problems

and possibilities. Land users, planners and decision-making institutions cooperate closely and are involved in land use territorial planning as provided for in the Law on Territorial Planning of Lithuania.

Soil maps and other soil research data in Lithuania are widely used in land reform activities – for land valuation, calculation of land and land lease taxes, development of land cadaster, agro-ecological zoning, territorial planning of agricultural production, planning of soil improvement and erosion-protection measures as well as for other purposes.

Eventual National Copyright Considerations

Protection of copyrights of author's works in Lithuania is provided for in the Law on Copyright. This is a general law not providing for specific copyrights to soil data and maps.

Conclusions and Recommendations

Development of uniform integrated GIS data standards for European countries with some space left in the database for accumulation of country specific data.

Use of the following map scales for accumulation of soil data:

on the national level	from 1:200 000 to 1:1 000 000;
on regional level	from 1:50 000 to 1:100 000;
on local level	the basic scales could be 1:5 000 and 1:10 000.

Improvement of SOTER programme to make it possible to accumulate data on regional and local levels. It should be possible to use the data accumulated under the SOTER programme in land use zoning programmes without any corrections.

Our request would be that FAO continue with its training on introduction of the new European Soil Information System.

European countries should have uniform laws on soil protection and soil data copyrights.

The status of soil mapping in the Maltese Islands

The soil resources of the Maltese Islands are an important and limited natural resource of great agricultural and environmental value. In general, they are largely artificial, being man made or altered and highly calcareous. In this Mediterranean climate, therefore, the evolution of morphology is slow, the dynamic not clearly defined and partly relic (some soils of the Terra Group) dating back to periods of wetter climate and now not in their original form. As a result of intensive land use and mismanagement of natural resources, the Maltese Islands are facing threats of environmental deterioration, including a soil degradation phenomena. In common with other countries in the Mediterranean region, soil erosion processes are one such problem which is increasing and in need of immediate attention. Changes in agricultural practices as well as a drastic increase in urban development have intensified the environmental problems and accentuated the pressure on agricultural land and fragile ecosystems.

The status of soil mapping in the country

The scales and classification systems used for the national soil map have developed over the past fifty years. The first soil map of Malta, published in 1960 on a scale of 1:31 680 (2 inches to 1 mile) is the result of a detailed study of the Maltese soils by D.M. Lang in 1956 –57. A close relationship can be traced between this map and the geological map as a result of the fact that Maltese soils are mostly derived from local rocks that are highly calcareous and closely related chemically. Using Kubiena's system (1953), Lang classified Maltese soils as Carbonate Soils, Xerorendzinas, Terra soils and soil complexes. With the exception of the soil complexes, the subtypes are further subdivided into "series" of soils named after the localities where Lang had originally encountered them.

The soil survey carried out by Lang was intended to provide basic descriptions of the soils of the Maltese Islands and a map of their distribution as an aid to agricultural planning. The strong correlation between geology and the natural and cultural landscapes enabled some of the mapping to be done from aerial photographs using landscape boundaries as the boundaries of some series and complexes. Soil horizon differentiation is not so clear in calcareous soils under the present climatic conditions of Malta. Where the soils are cultivated the upper few inches, which under more permanent vegetation had well marked characteristics, are overturned and mixed with the subsoil. In many profiles, this produced an almost homogeneous "soil", the characteristics of which show little or no vertical differentiation, because of the slowness of the pedological processes.

As a result of the intensive use of land in the Maltese Islands, the soils change very rapidly over short distances, especially in strongly terraced areas. The soil series identified by Lang

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were designed to fit the landscape and lithology and hence were mappable. However, wide ranges within the series due to the natural processes of mixing of parent materials by erosion and deposition as in soil creep or due to regional or local differences in chemical composition or physical constitution within a given rock strata, were not mappable at a scale of 1:31 680 and hence were included in the range of characteristics of the series. Such differences are confounded by man-made soils on terraces and by the addition of soil and rock materials brought in from outside.

In the early 1970s, an FAO consultant mission prepared a report on the soils of Malta within the scope of WHO Special Fund Project on Wastes Disposal and Water Supply to study the nature of the soils in prospective irrigation areas and to assess their suitability for irrigation with sewage effluent. On the basis of this study, areas of soils were demarcated on a topographic base map according to defined irrigation suitability classes. The same study provides a tentative classification of Maltese soils into families in the USDA Revised System and according to the FAO system (key to soil units for the soil map of the world).

In order to assess soil erosion in the Maltese Islands, a national team is currently undertaking preparatory works for a Soil Erosion and Desertification Assessment and Mapping activity scheduled to start in January 2000. This project is part of the CMP Malta with particular emphasis on the Northwest area of the Island and the responsible institutions are PAP/RAC, FAO/AGL, ERS/RAC and the Environment Protection Department of Malta. One of the objectives of this study is to introduce and apply to FAO/PAP consolidated mapping methodology and apply relevant prevision and rehabilitation techniques. The implementation of the project is based on the principle of sustainable development presented in Agenda 21; principles of the Guidelines on Integrated Coastal Area Management (ICAM) developed by PAP/UNEP and of Guidelines for Erosion Mapping and Measurement (PAP/RAC in cooperation with FAO). The expected project outputs will include basic digitized maps of erosion status and dynamics, trained users of GIS and mapping equipment, photo catalogues and improved land use plans.

Problems envisaged for adaptation of the national and regional maps to a global methodology

The soil descriptive and analytical data are older than 40 years and do not correspond to reality in the field. This is especially true in areas having strong human-influence (carting, manuring, reclamation etc). Locally, man is considered as the most influential factor affecting the soil environment. The Soil Preservation Act prohibiting the covering of soil by building construction and imposing on the builder the obligation to completely remove the soil on his ground and to dump it elsewhere was a very wise step in the conservation of Maltese soils, but has undoubtedly greatly contributed to the confused nature of local soils.

The major problem in adapting the national soil map to a global methodology is a general lack of information. The existing soil map has never been digitized and is regarded as outdated and consequently of little use for land management and planning purposes. At a national level, the soil database layer is non-existent, and soil information is fragmented as a result of specific feasibility or management surveys carried out for project location or for pilot area studies, or for the purpose of soil salinity or fertility thematic mapping. The limitations of the soil data are also maintained by the lack of facilities for soil characterization, such as field survey equipment, laboratory facilities (physical, chemical, hydromorphic and hydrogeological properties) and the lack of necessary expertise in soil science and soil geographic information systems.

Suggestions for a regional mapping scale and applications

In view of the very small size of the Maltese Islands (combined area of the three islands is 316 km^2), a national soil survey should be carried out at a detailed (2nd order) scale 1:12 000 – 1:32 000, to produce a general soil map of the entire country. Detailed map sheets for site planning purposes would require intensive 1st order soil surveys typically at a scale of 1:1 000 – 1:5 000, since management decisions are often taken at the level of the individual field.

Conclusions and Recommendations

The particular position of the Maltese Islands represents an important and strategic point of linkage between the European and the African reality from a geographic and climatic point of view. The development of a Soil Geographic Database for the Maltese Islands would constitute an important step towards the extension of the European Soil Information System to the Mediterranean Basin. The creation of a soil digital database for Malta and Gozo, compatible with the European Soil Bureau database, could be used to assess the sustainability of current soil use and management and to develop models for predicting potential uses and risks. At the national level, there is an ever-increasing demand for harmonized and compatible soil data information by policy and decision-makers, planning regulators, environmental managers, agriculturists and civil engineers. Harmonized soil information would serve as a reference base to facilitate the transfer of knowledge and research results among those involved in planning, decision-making and implementation and would represent a valuable aid for decision support processes in land management, environmental protection and agro-environmental monitoring in Malta.

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Classification of Maltese soils according to Kubiena (1953)

Division	Class	Type	Sub-type (qualified)	Variety	Locality /Series
A. Sub-aqueous	-	-	-	-	-
B. Semi-terrestrial	BA. Semi-terrestrial raw soils	VI Rambla	12 Chalk Rambla		Ghadira Alcol
	BD. Salt soils	-	-	-	-
C. Terrestrial	CA. Terrestrial raw soils	XXIII Syrosem	50 Carbonate raw soils		Fiddien, San Lawrenz, Nadur, Ramla, part SB
	CC. Rendzina-like soils	XXV Rendzina	60 Humid Rendzina	(36) Protorendzina Mull rendzina	Malta E Malta P
			61 Xerorendzina	Xerorendzina	San Biagio, Alcol, Tal-Barrani
	CE. Terrae Calxis	XXXIII Terra	74 Terra fusca	(47) Earthy terra fusca	Xaghra, Tas-Sigra
			75 Terra rossa	(48) Siallitic terra rossa	

Classification of Maltese soils according to USDA revised system

Ramla	sandy, carbonatic, calcareous, Typic Ustorthent
Nadur	coarse loamy, carbonatic, calcareous, Typic Ustorthent
Fiddien	fine clayey, mixed calcareous, Typic Ustorthent
San Lawrenz	fine loamy, carbonatic, calcareous, Typic Ustorthent
San Biagio	fine loamy, carbonatic, calcareous, Lithic Ustorthentic Ustochrept
Alcol	fine loamy, carbonatic, calcareous, Rendollic Ustochrept
Tal-Barrani	fine loamy, carbonatic, calcareous, Rendollic Ustochrept
Xaghra	fine clayey, mixed calcareous, Typic Ustochrept
Tas-Sigra	fine clayey, mixed calcareous, Typic Ustochrept

Classification of Maltese soils according to FAO system

Ramla	Calcaric Regosol
Nadur	Calcaric Regosol
Fiddien	Calcaric Regosol (in some places Chromic Vertisol sodic)
San Lawrenz	Calcaric Regosol
San Biagio	Calcic Cambisol lithic
Alcol	Calcic Cambisol
Tal-Barrani	Calcic Cambisol
Xaghra	Calcic Cambisol
Tas-Sigra	Calcic Cambisol

Information on soil mapping in Poland

The status of soil mapping

There were two major soil survey programmes conducted in Poland after World War II, generating soil maps, databases and inventories of different content and scale. The first detailed soil survey programme was conducted in Poland from 1956 to 1968. The legal basis for conducting this work was an order by the Council of Ministers, dated 4th July 1956. This was published in the Polish federal register under (Dz. U. Nr. 19, poz 97) and included the soil classification criteria defining soil quality /productivity classes (Comments on Soil Classification Table, 1963).

The objective of this survey programme was to classify agricultural soils into classes reflecting soil quality and productivity. In the survey, the arable land was divided into nine different classes with the following symbols: I, II, IIIa, IIIb, IVa, IVb, V, VI, VIRz. Classes IIIa and IIIb as well as IVa and IVb are considered subclasses of III and IV. By convention, the highest class of soil quality and productivity is represented as class I, with class VIRz being the poorest. Similar survey and classification work was conducted for grasslands (meadows and pastures) which were used continuously as grazing or for hay production for at least six years. The classification was based on detailed descriptions of thousands of soil profiles dug to represent spatial distribution of soils with accuracy up to 1 000 square meters.

The technical criteria used for classification of agricultural land included the following parameters: soil texture, depth of topsoil (A horizon), content of organic matter, water retention, drainage, pH, calcium carbonate content, relief (elevation, slope etc), soil type and subtype according to genetic criteria as described in Genetic Classification of Polish Soils (Musierowicz 1956). The physical location of soil in relation to landforms such as river valleys, moraines and depressions was used in the classification as a factor influencing moisture conditions, vulnerability to erosion and effect on productivity. The criteria for grassland classification was based on soil profile characteristics, as described above and type and density of vegetative cover.

Other factors, such as hay yield and number of harvests per year, were considered as well as occurrence of weeds.

Polygons demonstrating spatial variability of soil classes were mapped on a scale of 1: 5 000, or at a more detailed scale for former state run farms, such as grasslands and arable land. Soil class polygons were delineated on the cadastral map identifying the boundaries and property status of each plot. Information on soil class characterizing each polygon on a soil classification map include: soil class, soil type and subtype, and a reference to the soil and profile description provided in the Comments on Classification Table (1963). Unfortunately, most text files containing soil analytical data and a full description of soil profiles made during this survey

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work are not available today. The files were not archived and have been lost. The soil survey covered the entire country and was legally binding. The classification system described above is the basis for calculating taxes paid by farmers. The tax amount is dependent on the area and quality of agricultural land belonging to each farm. Unfortunately soil classification maps, as opposed to cadastral maps, are often not upgraded to reflect spatial changes in soil quality. The upgrading process may speed up as digital systems replace analogue maps and numerical databases are implemented.

In 1965 another extensive soil survey programme was initiated by the Ministry of Agriculture resulting in full coverage of soil-agricultural maps at a scale of 1:5 000. These maps contain information on soil suitability units (complexes) as associates of soils suitable for growing different crops or groups of crops. Soil suitability units (complexes) include areas of soils which may represent different origin but exhibit similar agricultural properties. In a way, soil suitability units (complexes) constitute types of environment of the agricultural land. The background information used to emphasize that the elaboration of soil-agricultural maps also involved detailed field investigations including descriptions of soil profiles and laboratory analysis of soil samples collected from each horizon. The soil suitability units (complexes) are defined based on the following criteria: (i) character and properties of soil (soil type, parent rock material, texture and other basic physical and chemical properties), (ii) climate condition in the area, (iii) land and terrain forms, and (iv) hydrology. In the soil survey programme, the 5700 soil profiles most representative for particular areas were dug and analysed for the following properties: texture, pH, organic matter, exchangeable acidity, aluminium, CEC, exchangeable Ca, Mg, K, Na, $CaCO^3$ and plant available P, K, Mg. The database is maintained by IUNG. Each profile is characterized by its location, local geomorphology, morphology of horizons, category of water availability, texture, stoniness and chemical properties listed above. Polygons of soil suitability delineated on the soil agricultural map are described by the following attributes: soil suitability symbol, dominating soil type according to the Genetic Classification of Polish Soils (Musierowicz 1956), thickness, and texture of soil horizons up to 1.5m depth. Large scale maps (1:5 000), with a full coverage for Poland, were compiled and generalized to produce 1:25 000, 1:100 000 and 1: 500 000 maps of which the latter has already been digitized (Koter and Oczos, 1973). In addition to soil suitability units (complexes), land use information such as forests, water and hypsometry are also vectorized. Both the map and the soil profile database are available at IUNG, based on a license agreement. Soil-agricultural maps at 1:100 000 scale and being digitized now with 20 percent of the full coverage vectorized.

There are other important resources available which are relevant for soil mapping work and environmental assessment and modelling: a 1:50 000 geological map in a digital form with the comprehensive database. Maps demonstrating soil pollution with metals and sulphur, soil acidification and water erosion were developed in a digital form using a 1: 500 000 scale (Terelak *et al.*, 1994, 1995; Jadczyszyn *et al.* 1999). A map and database according to SOTER methodology was developed at scale 1:2.5 million (Batjes and Bridges, 1997). Land use digital maps of 1:100 000 scale were developed using satellite images collected for the Corine project in 1992 (Ciolkosz and Baranowski, 1996).

Scale and soil classification system used in Poland

As mentioned before, there are 3 aspects of soil classification and the associated soil maps in Poland: (i) soil quality /productivity classes (soil quality classes maps), (ii) soil suitability classes (soil agricultural maps) and (iii) soil taxonomy classes (based on soil genesis). Soil

quality classes maps at scale 1:5 000 cover the whole agricultural area. Soil agricultural maps (soil suitability classes) are available for Poland's agricultural area at scales 1:5 000, 1:25 000 and 1:100 000. Soil maps at a scale of 1:25 000 demonstrating spatial variability of soil types (genetic map) cover 60 percent of the entire Polish agricultural land.

Problems with adaptation of the national and regional maps to a global methodology

Problems arise converting one classification system to another. Correlation tables were proposed to allow conversion between different soil classification systems by Marcinek (1997). A map at a scale of 1:1.5 million characterizing soil types according to FAO /UNESCO legend was generated using the comparison table correlating the Polish classification system and that of FAO (Bialousz, 1994). This map is available in a digital form. The major problem with converting the national system into the FAO system, arises from the fact that the methodology of the survey work conducted in the past was not designed to consider any particular aspect of the FAO system. Therefore, using the existing profile analytical data does not allow for a precise characterization of diagnostic horizons. In particular, the scope of analytical work did not include measurements of a number of key properties which are obligatory in the FAO taxonomy. This includes different forms of iron, aluminium, manganese and phosphorus.

The critical gaps in the soil profile database are the lack of bulk density, colour according to Munsell chart and the inconsistency between criteria for texture and structure used in Poland and FAO systems. Limitations described above may be ignored for the purpose of developing small-scale maps. In order to develop medium and large-scale maps (1:500 000 and larger), an analysis of existing profiles stored in soil laboratories throughout Poland is suggested as a solution to the conversion problem. IUNG itself has over 1 000 geo-referenced soil profiles stored. These represent different physiographic units, lithology, geomorphology and landforms. A project proposal will be developed to conduct this work. The objective will be to analyze soil samples according to FAO requirements. It can be assumed that the spatial distribution of available profiles gives a good representation of the soil cover in Poland. It is desirable to co-ordinate such efforts on an international level, possibly as a follow up of the SOTER /SOVEUR project conducted by 13 Central and Eastern European Countries (Batjes and Bridges 1997).

Suggestions for regional mapping scale

Regional mapping scale will depend on the size of country and type of information needed for a particular application such as planning, assessment, modelling and research. It seems practical to integrate soil-mapping work at the European level using 1:500 000 or 1:1 million scale. These scales would be adequate for a country such as Poland. However, it may be too detailed for larger countries such as Russia. A scale of 1:2.5 million is relatively easy to work with, but the amount of detailed information is limited and the accuracy of analyses generated using this scale may be questionable.

National copyright considerations

Copyrights in Poland are regulated by law, however the access to soil maps used for non-commercial purposes is not limited. But, at times, it is difficult to distinguish between research, education and commercial applications which may be a cause of potential conflicts. Any copying and processing of analogue materials needs approval by the copyright owner. IUNG holds the

copyrights for soil-agricultural maps (soil suitability complexes at scales 1:25 000 and 1:100 000). There are similar concerns about copyrights of soil profile databases; however, at the moment, there is more interest in accessing maps than analytical data characterizing soil profiles. We expect that soil profile data will be used more extensively as different modelling and pedotranfer functions are used for environmental assessment.

Conclusions

The volume of available data characterizing soil and other elements of the environment is extensive. However, the inconsistency of method and criteria used for data collection is a true challenge in any attempt undertaken to work on the European level. Adjusting the data to required common formats is possible. However, a substantial amount of analytical work is necessary to allow a valid conversion of indicators and criteria used in a national system.

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The status of soil mapping in Romania

L'état de la cartographie des sols en Roumanie

La Roumanie a une longue tradition en matière d'utilisation de l'information pédologique et de la cartographie des sols qui couvre presque entièrement le XX-ème siecle.

L'activité de la cartographie des sols a commencée d'une manière organisée après les années 1964 et depuis 1970 on a mis les bases de l'élaboration pour un système de cartes pédologiques et thématiques selon les demandes de la pratique. C'est au bout d'un travail de plus de 50 années que la Roumanie a acquise une information pédologique complexe et diverse. Elle est collectée, ordonée systématiquement et gestionnée par deux types de structures d'organisation :

- au niveau national : Institut de Recherche en Pédologie et l'Agrochimie (IRPA), une sous-division de l'Académie de Sciences Agricoles et Forestières, qui a son tour dépends du Ministère de l'Agriculture et de l'Alimentation ;
- au niveau local: trente-sept Centres d'Etudes Pédologiques et Agrochimiques sont coordonnés méthodologiquement et scientifiquement par l'IRPA.

Depuis 1987, on a assurré un cadre organisé pour collectionner et interpréter d'une manière uniforme les informations sur les sols et terrains en rédigeant une méthodologie de l'élaboration des études pédologiques. Elle impose à la fois des normes uniques sur le contenu des études pédologiques selon l'échelle et le type et le but des ceux-ci.

Suite à ce cadre crée, les études pédologique contiennent des cartes et des données pédologiques descriptives et analytiques.

Le système national de cartes concernant de sol contient :

- cartes pédologiques au niveau national (200 000 – 1 000 000 – ème) et au niveau des départements et communes (local) à l'échelle de 5 000 – 50 000 – ème et les cartes corrélatives, dérivées des premières ;
- cartes pédologiques thématiques suivant des processus caractéristiques comme l'érosion des sols, l'excès d'humidité (500 000 0 ème) et la salinisation des sols (1 000 000 – ème) au niveau du pays, et les mêmes cartes à 10 000 – ème et 50 000 – ème au niveau local ;
- cartes écopédologiques : la carte des microzones pédoclimatiques et des écorégions a 500 000 – ème et la carte de la vocation des sols à 50 000 – ème seulement pour l'espace agricole ; au niveau local, il y a des cartes de la vocation des sols a 10 000 – ème pour la moitié de la superficie arable du pays (cca 4.5 mil ha) ;
- cartes pédogéochimiques avec la teneur en métals lourds (Cu, Zn, Pb) dans l'horizon A des sols (1 :3 000 000) au niveau national ; au niveau régional on a des données sur la teneur en métals lourds dans le profil des sols.

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Tous ce système de cartes est soutenue par une base de données pédologiques obtenues par des activités diverses:

- études pédologiques et de favorabilitité des sols (évaluation) au niveau des fermes ou communes à 5 000 – 10 000 – ème pour la superficie arable et al zone forestière. Malheureusement, une bonne partie de ceux-ci sont assez anciennes (20 – 30 ans) et elles devraient être actualisées tous les 10 – 15 ans.
- base de données descriptives et analytiques (PROFISOL) pour un nombre d'environs 7 000 profils.
- l'activité de surveillance (monitoring) et la protection de l'environnement qui apporte des données géographiques sur la dynamique de la qualité des sols (matière organique, réaction, teneur en éléments nutritifs, pollution) et des données du réseau de monitoring sur la qualité de l'environnement (947 points).

A ce fond de données analytiques, on y ajoute l'information contenue par les cartes (5 000 – 10 000 – ème) et données au niveau des fermes sur les caractéristiques agrochimiques de la couche arable : réaction, bases échangeables, teneur, en matière organique, macro et micronutrients. Aussi, cette information nécessite d'être renouvelée à tous les 4-5 années.

L'information pédologique de l'échelle 1 :1 000 000 est organisée dans le Système d'Information Géographique (GIS) en utilisant le système ARC /INFO. Aussi on est en train de finir la digitation et l'enrichissement de la carte pédologique a 200 000 – ème (50 planches) sur la base de la méthodologie SOTER.

La qualité de l'information sur les sols en Roumanie est d'un bon niveau aux standards internationaux.

Pour les cartes nationales ou régionales (locales) des sols, on utilise le Système Roumain de Classification des Sols (SRCS) depuis 1980. Il joint des critères et éléments diagnostiques intrinsèques du sol pour le définir et classifier qui sont utilisés dans la classification de la FAO, ou bien la Soil Taxonomie (Etats Unis). La classification roumaine des sols est structurée, au niveau supérieur, sur trois rangs taxinomiques : classe (10), type (39) et sous type (ca 470) pouvant aller au niveau inférieur jusqu'à la variante de sol donnée par le mode d'utilization, la pollution, etc. Un travail est en cour pour actualiser cette classification et de la rapprocher le plus que possible de la Base Mondiale de Reference pour les Resources de Sols.

A part des préoccupations de rendre meilleure le système de classification des sols au niveau national, les chercheurs roumains ont montré d'intérêt pour une corrélation des unités taxonomiques de la classification roumaine avec celles des classifications utilisées dans le monde. Ainsi, Dr I Munteanu a mis au point une corrélation entre les unités de la classification roumaine et celles de la classifications FAO et la Soil Taxonomie de l'USDA. D'ailleurs, c'est sous cette forme qu'on a remis à la Communauté Européenne la dernière édition de la Carte des sols de la Roumaine (1 000 000 – éme) pour la Carte des sols de l'Europe. En ce qui concerne l'adaptation des cartes nationales et régionales a une methodologie mondiale, il faut dire qu'ils restent encore plusieurs aspects qui doivent être rendus claires et d'une manière unitaire comme la définition de certaines catégories de sols (aux différents niveaux), les critères de séparation utilisés qu'on les rencontre dans les classifications de certains pays. Aussi est il le cas avec le contenu des associations des sols : la nomenclature, combien des membres peut-elle avoir une association et quelle doit-elle être la proportion (en %) entre eaux, la grandeur (la surface) maximum qui peut être représentée sur la carte des sols, e.a.

C'est pourquoi il apparaît bien nécessaire la mise au point des application cartographiques régionales par lesquelles se réunissent les conceptions, les critères nationaux pour qu'ils puissent être inclus, par après, dans une méthodologie mondiale pour l'élaboration d'une carte des sols.

Pour les applications cartographiques régionales, l'échelles de travail, aussi que celle des cartes des sols, sont en function du but suivie. Pour les problèmes de la conservation des sols et protection du milieux, l'expérience roumaine montre que l'échelle à 200 000 éme parait d'être la meilleure.

En ce qui concerne le droit d'auteur pour l'information inclue dans la base européenne commune des données pédologiques, la partie roumaine croit que pour l'access au données nationales propres il n'est pas nécessaire d'obtenir l'avis de l'organisme européen de gestion.

Comme recommandation, la partie romaine pense qu'il est nécessaire de constituer un group de travail pour rédiger les critères d'adaptation des cartes nationales et régionales a une méthodologie mondiale.

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The status of soil mapping in Slovakia

Basic soil mapping was implemented through the Complete Survey of Agricultural Land in the period 1961 – 1970. This detailed mapping represents 174 700 soil profile descriptions obtained from dug pits and about 400 000 soil samples for analysis. The survey density was 1 hole per 14.6 ha. A detailed description was made in all sites of the surveyed pits with a record of the most important land attributes. Subsequently after soil sampling, the following analyses were made: soil texture, C_{ox} content, $CaCO_3$ content, pH_{H20}, pH_{KCL}, exchangeable cations, S, T, V values, nutrient contents. From the information obtained during the survey, the Geographical Information System (GIS) of the soils of Slovakia was formed and many generalized map products were created, for example:

- soil maps of Slovakia at scale 1: 10 000 (total 3 000 maps for the whole country)
- mapping records of soil texture, stoniness, water-logging on farmland, scale 1:10 000 (total 9 000 maps complete for the whole country)
- mapping records of the measures for soil fertility improvement at scale 1:10 000 (total 3 000 maps for the whole country)
- soil maps for the counties, scale 1:50 000 (36 maps for the whole country)
- mapping records of texture, stoniness and waterlogging of farmland for the counties (36 maps for the whole country)
- soil forming substrata maps for the counties, scale 1:50 000 (36 maps for the whole country)

Subsequently, surveys and identification of agricultural soil productivity potentials were implemented and the following maps and documents were elaborated:

- agricultural soil productivity potential maps, scale 1:5 000 (in the form of GIS)
- agricultural land productivity potential maps, scale 1:50 000

Later on, these maps were used for elaboration of smaller scale maps, of which the most significant are:

- Soil Map of Slovakia, scale 1:1 000 000 (for the FAO project – Soil Map of Europe, 1971)
- Soil Map of Czechoslovakia, scale 1:500 000 (first map in collaboration with forest pedologists, 1973)
- Agricultural Soils of Slovakia, scale 1:200 000
- Set of basic and thematic maps in the Atlas of Slovakia 1980
- Soil map at scale 1:1 000 000 in the Ethnographic Atlas of Slovakia 1989

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Based on innovative surveys and computing techniques, the following were created:

- Soil Map of the Zitny Ostroc, scale 1:50 000, 1989
- Synthetic Soil Map of Slovakia, scale 1:200 000 (Western Slovakia), 1990
- Soil Map of Slovakia, scale 1:400 000 (with double legend – soil units with translation into the FAO legend), 1994
- Geochemical mapping of Slovakia (Geochemical Atlas, Soil section), working scale 1:50 000, within published Geochemical Atlas of Slovakia individually assessed contents of 36 elements in soils of Slovakia, scale 1:1 000 000, 1999
- Soil maps of pilot regions, scale 1:10 000 (1990 – 1995) – 6 pilot territories
- Map of SLOVSOTER units, scale 1:2 500 000 (SOVEUR project, ISRIC, The Netherlands) 1999 (in the form of a GIS, with interpretation of soil vulnerability etc.)

During survey activities, soil samples have been obtained (since 1960) as a reference base for Slovakian soils. In total, we have archived 15 800 soil samples. Also archived are 43 000 maps and 5 500 remote sensing items, mostly air photos.

The Geographical Information System of soils of Slovakia has been created on the base of maps at 1:5 000 using ARC-INFO software.

The scale and classification system used in the national soil map

The previous agronomic-genetic soil classification used during the Complete Soil Survey, was later (1987) replaced by the Morphogenetic Classification Soil System (valid also for woodland). Since 1991 an upgraded second version is used. Today a third version of the Morphogenetic Classification Soil System is being prepared. Its basal reference taxonomy, reference classification system, and soil forming substrates classification, valid for all soils of Slovakia will be published by the end of 1999. The system is comparable with world classification systems, mainly with the newest FAO legend of The Soil Map of the World 1994, and the WRB system (World Reference Base, 1998).

In the national Soil Map various scales can be used. The most frequent scale is 1: 50 000 at which it is possible to express content of the maps as well as to derive special regions of Slovakia at an acceptable size. For larger territories, the scales used are 1:400 000, 1:500 000, 1:1 000 000 to 1:2 500 000.

The problem of comparing Slovakian soil units to other classification systems is not very important, because there exist newly elaborated comparisons to world systems, through which it is possible to communicate. For thematic maps, it is essential to unite or compare the analytical methods, used to obtain the results. Pedological analyses commonly used in EU countries, ISO standards, or standard coding formulas are preferred. Problems will arise for the lack of some detailed soil units that are specific to the national classification systems; in these cases, compatibility fails. Similarly, absence of soil surveys and pedological analyses can be an obstacle to harmonizing the regions.

Another problem is non-mapped areas, so called ‘white places’, that should be filled in. The most frequent problem is mapping of the frontier areas. The problem usually is solved by mutual international consultation and cooperation (we have had good experience up to this time).

Suggestions for a regional mapping scale and applications

The ideal mapping scale for the regions of Slovakia is 1:50 000, i.e. medium scale which is easily usable also for larger regions. For international projects, the scales 1:400 000 and 1:500 000 and 1:1 000 000 are useful (for more detailed studies a scale of 1:200 000 is adequate).

At present, it is not a problem to create valuable maps at smaller scales using GIS by a progressive procedure of integration of the rich information from databases with digitized and activated areas in a coordinate system. A good example is the map SLOVSOTER at scale 1:2 500 000 a valuable derivative from scale 1:400 000 maps.

Eventual national copyright considerations

Authors rights of international projects should be respected within ordinary scientific ethics. That means that co-author relationships and copyright should be respected for all participating institutions or countries. Simple possibilities for partial use of information on maps in common databases should be solved for all the participants of the work.

Conclusions and recommendations

For commonly mapped territories at regional and international levels, we prefer the scale 1: 200 000 for more detailed mapping, both for basic soil units and for assessment of land degradation and real and potential risks for soil and environment.

From maps and GIS of basic soil parameters it is essential to gradually form and present derived international maps (GIS), for example maps of non-productive functions of soil cover, maps of soil resistance to degradation, maps of soil suitability for various forms of use, etc.

(Remarks: All kinds of maps were presented during the FAO/ECE Technical Consultation.)

Digital data on soils and environment in Slovenia for establishing a soil information system

Soil Types and Soil Forming Factors in Slovenia

The soil forming factors are parent material, climate, topography, the influence of living organisms including humans and time. In mountainous regions of Slovenia the soils are shallow and skeletal, with organic matter which is weakly decomposed (moder humus). These soils in the national classification system are classified as lithosols and moder rendzinas on limestones and dolomites.

At a lower altitude, but still in mountainous Alpine and Dinaric areas, the national soil classification system recognizes rendzinas, rankers, brown soils and leached soils as well as podzols on the more acid and permeable substrata.

In the centre of Slovenia the common soil types are moderately deep, well-structured and sometimes leached brown soils (national classification) depending on geological substratum. On the limestone-dolomite complex brown rendzinas and brown soils on limestone and dolomite are dominant.

In the flatland of eastern Slovenia the dominant soils in the national classification are dystric brown soils on non-calcareous gravel, and pseudogley and gley on fine-textured deposits.

In the southwestern part of Slovenia, on calcareous flysh, eutric brown soils are dominant, with regosols and calcareous rendzinas on steeper slopes and pseudogley on very gentle slopes. On limestones brown soils and rendzinas occur, but also areas of terra rossa are very important.

Soil Information System (SIS/TIS) in Slovenia

The Soil Information System in the Republic of Slovenia (SIS /TIS) is briefly presented here. SIS presents computer data of soil as a natural resource. It unites the data on soil mapping and monitoring of soil pollution into a logical whole. SIS basic goals are to establish a good base for further investigation in soil and environmental sciences using GIS tools and methods and connecting geographically defined soil data into an easy-to-survey and, through computer communications, accessible entity.

Data on soil as a natural resource was organized as a collection of databases: three different soil information layers with objects, types, a cartographic symbol and attribute data. Soil analytical procedures and measurement units that make data compatible and analytical results

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comparable, were particularly specified. Attribute data were determined according to contents, size, position and relationships. Techniques of data input, basic processing and map production have been developed. All the territory of the Republic of Slovenia has been digitized at scale 1:25 000 and soil maps are accessible. Soil data have been defined, entered and related within the system.

SIS unites the soil databases, data on soil mapping at scale 1:25 000 and data on monitoring of soil pollution (five selected regions in Slovenia: Jesenice, Koper, Ljubljana, Maribor, Krsko and separately Celje as a model) into a logical whole. It contains the following layers:

Digital soil map on the scale of 1:25 000 (SM/PK) with soil cartographic units (SCU) as the smallest polygonal elements. SCU are determined with up to three different soil-systematic units (SSU) and their proportions. The soil-systematic unit (soil type) is a soil unit from a certain classification system with typical characteristics, fundamentally different from the characteristics of other SSU. SSU are defined with various attribute data. Soil-systematic units within SCU cannot be shown separately due to the small scale of the map. The properties of SCU are described with percentage of SSU and their attribute data.

Soil profile data (SP/PP). A soil profile is a transverse section of the soil through horizons to the basic foundation. It is a representative, georeferenced (with co-ordinates defined) point containing physical and chemical data of the standard soil analysis, thus describing the type and properties of the soil. By mid 1999, the data on 1 700 soil profiles had been compiled in the Slovenia Information System.

Data on points of soil pollution monitoring in Slovenia (MSPS /MOTS)

A soil pollution sampling point, referenced by defined co-ordinates, contains chemical data on pollution of three soil layers: 0-5cm, 5-20cm and 20-30cm. The MSPS layer contains data of the points of indicative sampling. It is a collection of representative data on soil pollution (soil samples consist of six subsamples sampled within a radius of 100 m, at three different depths) and for the plant pollution indicator (Plantago lanceolata – narrow leaf plantain) 80 leaves are sampled in the area of indicative sampling. These data are the foundation for soil evaluation with the use of mathematical geo-statistical methods.

Government institutions and research organizations need an organized source of soil data for projects of land evaluation, environmental assessment and rural and agricultural applications. It will then be much easier to control rural and environmental policy, agricultural improvement programmes and safety precautions.

SIS data will become the integral part of geo-oriented databases gathered at the Geoinformation Centre of Slovenia – still in the process of being established and furnished.

Land Use

In Slovenia, 42.6 percent of land is agricultural, but only 14.6 percent is arable land. There is only 1246m^2 of arable land per inhabitant, which is not enough for self-reliance, especially in the present state of technology. The message is clear: we must preserve every piece of arable land, because lost fertile soil cannot be replaced through amelioration of soils with less favourable properties. Changing nature requires great risks and large investments: intensification should

be redirected towards biotechnological findings, which would enable the production of enough healthy food to meet basic needs. The socio-economic strategy of the preservation and improvement of agriculture and the countryside is important. Science should help determine land use, and develop new technologies for food production. We all share the responsibility to make sure that their processes are environmentally friendly.

Conclusions

The desired characteristics of SIS are data you can trust, robustness, use of the 'best' available data, different resolutions, representations of the 'real world', easy to use, responsive to user needs, few restrictions on use, easy to contribute to, reliable, stable but able to respond to changing needs, and low cost access.

How do we achieve the vision of efficient production, easy access and shared use of vast stores of data in a distributed environment? Communicate, ensure means to share and use data, develop and use standards, educate and train and encourage partnerships.

Rapport national de la Suisse

L'état de la cartographie des sols dans les pays

Généralités

La cartographie des sols en Suisse se fait á deux échelons : d'une part, des cartes détaillées du sol tracées à l'échelle 1 :1 000 à 1 :10 000 sont utilisées pour des expertises spécifiques ; d'autre part, l'inventaire pédologique de la Suisse, dressé à l'échelle 1 :25 000, met en évidence les propriétés pédologiques de la région agricole et des forêts du pays.

Au cours des ans, on a établi et publié les cartes nationales topographiques à l'échelle 1 :200 000 à 1 :500 000 résultant de l'évaluation des cartes régionales.

Cartographie détaillée des sols à des fins d'expertise

Jusqu'en 1996, plus de 300 relevés cartographiques ont été effectués sur des surfaces agricoles essentiellement, la plupart portant sur de petites surfaces et sur des projets spécifiques sans lien les uns avec les autres. Ils ont surtout servi au pointage des sols, à l'établissement des possibilités d'exploitation, aux améliorations foncières et à l'appréciation du danger de lixiviation et de ruissellement des substances nutritives destinées aux plantes.

Il en est résulté des données ponctuelles (profil et horizons d'endroits déterminés, données chimiques, physiques et biologiques examinées selon des méthodes de référence suisses) ainsi que des données de surface (données pédologiques mesurées par polygonales, géoréférencées et pouvant être associées à des données topographiques ou climatiques).

Les cartes du sol sont disponibles aux échelles 1 :1 000 et 1 :10 000 et les données étant archivées selon un système analogique ou dans des banque de données (env. 50% de la surface cartographiée).

Ces recherches ont été effectuées soit par les pouvoirs publics soit par des particuliers.

Inventaire pédologique de la Suisse au 1 :25 000

Ce projet de recherches à long terme a été lancé en 1977 par les pouvoirs publics (stations de recherches agronomiques [SR], Office fédéral de l'agriculture) avec, pour objectif, le développement méthodique et le monitoring du relevé des propriétés du sol en milieu agricole et forestier ainsi que la représentation cartographique des sols sur des feuilles de carte nationale topographique au 1 :25 000. L'utilisation de cet inventaire à des fins pratiques en agriculture, en économie forestière, dans le cadre de l'aménagement du territoire, de la protection des sols et de l'environnement ainsi que de la recherche et de l'enseignement constitue un autre but important.

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Jusqu'en 1996, 16 cartes pédologiques ont été dressées sur des feuilles au 1 :25 000.

Autres données pédologiques

Les sources sont, et l'occurrence, des plus diverses. On y trouve des informations sur des lieux très circonscrits (places de tir, par exemple), sur des régions déterminées ou, au contraire, sur l'ensemble de la Suisse. Ces données peuvent être utilisées séparément ou en complément des relevés cartographiques du sol. Nous mentionnons ci-après quelques unes de ces sources :

Réseau national d'observation du sol (NABO) : il s'agit d'un réseau de mesures national permettant d'observer la charge du sol en substances nocives. Les données sont saisies à l'échelle nationale dans une centaine de points d'observation (dont 80% sont situés en milieu agricole et forestier). Le NABO permet de suivre l'évaluer la pollution actuelle des sols en dehors du périmètre d'influence immédiat de sources d'émissions spécifiques – les grands axes routiers, par exemple. Le NABO, conçu comme réseau de mesures de référence à long terme, équivaut à une étude écologique transversale des immissions.

Réseaux cantonaux d'observation du sol (KABO) : la plupart des cantons gèrent en outre leurs propres réseaux d'observation, lesquels, contrairement au NABO, fournissent des renseignements sur des problèmes locaux et régionaux.

Geostat : les statistiques relatives à l'utilisation du sol en Suisse sont saisies dans un système d'informations géographiques. A partir des coordonnées, les données pédologiques peuvent ainsi être corrélées avec d'autres indications (altitude, déclivité, exposition, etc.).

Données provenant des anlyses du sol

Si elles veulent bénéficier de paiements directs, les exploitations doivent prouver qu'elles fournissent les prestations écologiques requises. L'analyse du sol est l'une de leurs tâches. Des échantillons pédologiques seront ainsi prélevés tous les 10 ans sur chacune des parcelles de l'exploitation.

Pédothèque sur les sols forestiers

Une SR rassemble des échantillons provenant des différents sols forestiers. Ces données servent notamment de documentation pour l'évaluation EU du sol (niveaux 1 et 2).

Compétence

Jusqu'en 1996, la cartographie des sols était l'œuvre des SR. Suite à la nouvelle orientation de la recherche agronomique, elles ne sont toutefois plus à même de replier cette tâche. Ce sont donc les cantons ou des particuliers qui doivent s'en charger. S'agissant toutefois de prélèvement de données prenant la forme d'analyses chimiques et éco-toxicologiques ponctuelles, il est toujours réalisé de manière systématique dans le cadre du réseau national d'observation pédologique (NABO), et sur le plan contonal, dans le cadre des réseaux cantonaux (KABO).

Des analyses du sol concernant de grandes surfaces ont lieu sporadiquement sous la forme de mandates (p. ex. services fédéraux et cantons).

Dépenses

Les dépenses des pouvoirs publics prévues pour la récolte des données et l'observation des sites ainsi que le travail administratif se montent à quelque 70 millions de francs.

En règle générale, les utilisateurs de cartes (autres que les mandants) ne paient que les coûts des copies.

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Méthode d'analyse

La méthode d'analyse et d'interprétation des données pédologiques a été clairement définie et décrite par les SR. Objectif : recueillir des données sur la base des critères et de directives uniformes. Cette méthode est utilisée dans la plupart des cas. Mais on tend aujourd'hui à adapter la méthode au projet en question. La comparaison des différentes données devient donc de plus en plus difficile.

Echelle et système de classification utilisés pour la carte nationale des sols

Une carte synoptique de la Suisse existe en tant que carte d'aptitude des sols à l'échelle 1 :200 000. Elle renseigne non seulement sur l'aptitude des sols, mais donne aussi un aperçu des conditions pédologiques conformément à la légende de la carte mondiale des sols FAO-Unesco, et sert à l'examen de questions dépassant la cadre de la région. Les documents des SR (Schriftenreihe FAL 24, Cartographie et estimation des sols agricoles, n'existe qu'en allemand) servent de fondement à la cartographie (mi-) détaillée des sols d'après la classification suisse (cf. aussi méthode d'analyse). La plupart des cartes sont établies au 1 :5 000 et au 1 :25 000.

Problèmes liés à l'adaptation des cartes nationales et régionales à une méthode d'analyse mondiale

Il s'agit en premier lieu de bien définir le problème qui se pose en indiquant la politique à laquelle le produit doit servir de base (p. ex. politique environnementale ou agricole). Quant au degré de précision nécessaire, il sera déterminé par le problème en question.

On peut dès lors se poser la question de savoir si une méthode harmonisée permettrait de représenter dans leur spécificité les problèmes pédologiques touchant la Suisse. Pour confectionner une carte où figurent les particularités régionales d'un petit territoire, on devra probablement adapter la méthode d'analyse harmonisée qui a cours au niveau mondial.

L'objectif principal d'une harmonisation est sans aucun doute la comparaison, à l'échelle planétaire, de l'état des sols. Pour les données soient effectivement comparables, leur fiabilité est primordiale. Les personnes impliquées dans ce genre de travail doivent satisfaire 'a des exigences croissantes dans le domaine de al formation et du perfectionnement (saisie, gestion et évaluation des données, etc.). On déterminera donc les exigences minimales. En outre, on précédera, par l'intermédiaire d'un service unique, à une coordination rigoureuse des méthodes de saisie et de mise en œuvre. C'est le seul moyen d'obtenir, à long terme, des séries de données qui soient comparables.

On déterminera le mode de gestion des données (décentralisé ou centralisé). Il faudra rendre possible la réunion des anciennes et nouvelles données sous la forme de modules. L'accès à la banque de donnés devra être facilité (Internet). Il faut en outre éviter l'accumulation de données périmées. C'est pourquoi, on fera tout pour que les données soient constamment à jour et qu'elles puissent être adaptées à de nouveaux problèmes s'il y a lieu.

Outre la saisie et la gestion des données, l'harmonisation des méthodes d'évaluation est importante, car une interprétation uniforme doit être garantie.

Les cantons ont bien souvent des difficultés à consacrer l argent nécessaire à la cartographie des sols. Il est donc important de formuler les problèmes de manière à ce que la plupart des données existantes puissent être utilisées, ce qui diminuera les besoins financiers en la matière. L'introduction d'une méthode d'analyse globale exigerait, selon le genre de la méthode, que la cartographie de certains sols soit refaite ou complétée et, éventuellement, que des données analogues soient digitalines. Cela pourrait entraîner des dépenses importantes.

Propositions pour une échelle et des applications cartographiques régionales

D'après nos expériences, l'échelle 1 :25 000 est nécessaire pour permettre des affirmations valables sur la structure du sol et ses propriétés en matière d'agriculture et de sylviculture sur le plan régional. Par contre, pour l'évaluation des parcelles d'une exploitation, cette échelle est inappropriée ; elle ne se prête pas non plus à la cartographie de régions où les conditions du sol de surfaces peu étendues changent trop souvent. En revanche, les cartes au 1 :25 000 constituent une base utile pour toute question touchant l'aménagement du territoire et l'écologie.

Eventuelles considérations nationales sur les droits d'auteur

Il faudra régler de manière précise l'accès aux informations pédologiques (organisations, particuliers) et l'autorisation à fournir des données en cas de besoins. Il faudra aussi voir si les ayants droit peuvent consulter les mêmes données (description des caractéristiques du sol, charges, etc.) et à quoi celles-ci doivent servir (recherche, politique, statistique).

La protection des données a là un rôle important à jouer (protection du propriétaire des parcelles).

Les données non anonymes (permettant de tirer des conclusions concernant des personnes, des parcelles, etc.). ne pourront être mises à la disposition des ayants droit qu'avec des restrictions sévères. La Suisse n'autorise l'accès à ces données que s'il existe une base légale à cet effet.

Conclusions et recommandations

Dans un premier temps, il convient de définir les objectifs d'une cartographie des sols et d'un système d'information sur le sol harmonisés sur le plan mondial. Ensuite, il faudra choisir la méthode d'analyse la mieux appropriée en conséquence, de sorte que le plus grand nombre possible de données existantes puisse être utilisé. Dans ce sens, nous préférons la légende proposée par FAO-Unesco pour l'établissement des cartes comprenant plus d'une région.

En outre, il est important de relever les données de manière à ce qu'elles puissent être intégrées dans une observation globale de l'environnement (émissions, charges, atteintes). En même temps, on utilisera les synergies avec d'autres branches.

Par un contrôle permanent, on garantira que les données et les cartes correspondent toujours, lorsque des changements interviennent, aux problèmes posés ainsi qu'aux objectifs.

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The soil information system of Turkey

Soil classification and mapping is rather new to our country as for many other countries in the world. In 1950, modern soil science was established in Turkey by K.Ö. Çaglar. In the same year, he began distributing soil science publications and he prepared the 'Soil Classification of Turkey' schematic map. He took soil colour as the main factor, mapping Turkey's soils into eleven different classes.

In Turkey, the real understanding of soil survey and mapping began in 1952 with the help of FAO and a team under the leadership of American soil consultant Harvey Oakes and a Turkish group of consultants. The group completed a reconnaissance survey. A map of Turkey at scale 1:800 000 called 'Turkey: General Soil Map' and report were completed in the years 1952-1954. Geological and topographical maps were used to develop a reconnaissance level study of all the regions. Results were obtained by taking soil samples, analyzing them and designating the different soil types. The field study was finished in 9 months. In this study map units related to the 1938 American Classification System of soil great groups and characteristics such as slope, stoniness, drainage and saltiness were added. Turkey's Zonal, Intrazonal and Azonal soil orders were defined. This report was considered rather important because it was the first work showing the soil resources of Turkey.

Current status of soil information

After this, maps classifying Turkey's soils were made by the General Directorate of Soil and Water, today known as the General Directorate of Rural Services (GDRS), by coordinating studies at the national level. When a decision was made by European countries to prepare a small-scale map of European soils, the General Directorate of Soil and Water decided to participate in this map study in 1966-1971. It prepared maps called the Turkey Development Soil Map (TDSM) survey study, based on a 1:25 000 scale topographical map used at reconnaissance level. Map units related to the 1938 American Classification System of great groups, with land determiners such as the important phases of depth, slope, stoniness, degree of erosion and similar characteristics, were recorded on the map. After evaluating the data, two sets of maps were published. The first was for all the provinces at a scale of 1:100 000 and called The Soil Resource Inventory Map. The second map shows 17 of Turkey's 26 Great Watersheds at a scale of 1:200 000 and is called Watershed Soil Map and Report. Due to the reconnaissance level of the survey, the detail was not sufficient at a scale of 1:25 000. In Turkey, this was the first original land study that mapped nation-wide knowledge and at the same time brought out important problems of soils and their distribution. Today this study is the main resource which can be applied to problems and uses of Turkey's soils.

Another important study was developed called Soil Taxonomy and first applied in mapping the soils of the Konya plain and Küçük Menderes (Little Meander) valley. These surveys were

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done in conjunction between Wageningen University (Netherlands) Soil and Geology Department researchers and GDRS Soil and Fertilizer Research Institute.

The 'Turkey Soils Potential Survey and Non-Agricultural Land Use Planning Project' was replaced by the 'Turkey Development Soil Map Surveys' by the General Directorate of Soil and Water between 1982 and 1984. In these reports differences in soil depth, soil stoniness, soil erosion levels and distribution, can be seen in all the provincial Great Soil Groups from data obtained from actual field trips. In addition, occurrences of differences in drainage, salinity and alkalinity problems, land use and land feasibility classes were brought up to date for the whole country by obtaining records from field studies at the scale of 1:25 000.

Afterwards, in 1987, maps were prepared from the results of the Turkey Development Soil Maps Surveys with a scale of 1:100 000. After consultation between the GDRS and the surveys, maps were prepared at the scale of 1:2 000 000 called 'Turkey Soil Zones Map'. These were published under the name of Turkey General Soil Management Plan. However, it is emphasized that in the future there will be a need for study of genetic classes, an adaptation of new classification methods, an increase in detail, and the updating of all the maps of the country.

ADAPTATION OF NATIONAL INFORMATION TO GLOBAL METHODS

Turkey does not have its own soil classification system. In order to develop a system, our country would need more information about our soils. On the other hand, a lot of countries are thinking of using an agreed international classification system instead of devising their own systems. Clear examples of such systems are the FAO-UNESCO World Soil Map Legend (1974 and later editions), the Soil Taxonomy (US Soil Survey Staff, 1975 and later) and the World Reference Base for Soils (FAO,1998).

Moreover, the 1938 American Soil Classification System used by Harvey Oakes and the General Directorate of Soil and Water is a pedogenetic system. Because the categories do not cover some newly defined soils in the world, many countries do not use a pedogenetic system. Instead, they prefer morphometric systems such as FAO-UNESCO (1974, 1990) and Soil Taxonomy (1975, 1996, 1998-1999) and the World Reference Base (FAO, 1998).

GDRS and Wageningen University Soil and Geology Department used this new classification system for the first time for the Konya and Ege Watershed. In addition, this new system was completely adopted for the Gap Firat watershed for detailed soil maps and reports with a scale of 1:25 000. Because of the productivity of the land, a map was prepared with great detail at a scale of 1:5 000. The studies were made by the country's University researchers, master and doctoral students, using the new soil classification system, which created detailed soil surveys and maps.

A country's economic development is dependent on its wealth of natural resources and the appropriate use of these resources. Our country's rapid future development is tied to the formation of a database containing correctly surveyed maps and natural resources data and dependent on their transformation and interpretation for the needs of users and planners. Until now, a database meeting the needs of our country has not been created but there is a great need for it. We have to make full use of already developed technology. The ideal methods for our country to use are the Geographic Information System (GIS) and Remote Sensing (RS). GIS and RS are tools that can provide detailed information about different geographical structures, and provide a basis for decision making or management relationship techniques and analysis and use of human resources.

GIS and RS have the facility to provide users with input, storage, analysis and use of data. For this reason, this year the Soil and Water Resources National Information Center was formed. It has two main programmes:

1. Turkey's Soil and Water Resources Database Formation Project
   - To implement a national soil and water resources database
   - An immediate goal is to analyse and plan for development of natural resources because of the urgency and sensitivity of the situation. By using the GIS and RS techniques, the transformation of other map bases will greatly facilitate researchers, users and decision-makers in their work.
   - National soil and water resource service maps must be produced for the preparation of the Five Year Development Plan of our country and as a base for the Rural Area Development Plan.
   - Using the national database, preparations can be made for solving problems related to the use and management of natural resources. New data can be added, changes can be monitored, and the whole information system brought up to date.

2. The GDRS Turkey General Soil Maps and Report Updating Project; using FAO methods and the New Soil Taxonomy

Instead of using its own system, the wisest choice is to adopt the current international system. In Turkey, detailed soil survey and mapping according to the FAO and Soil Taxonomy Systems, has been on-going for a long time and still involves much expense. Moreover, we do not have enough soil surveyors for this job. It is more appropriate from an economic standpoint, and to produce new data on time, to evaluate the current data on the GIS. With this project we can make use of the maps at 1:100 000 and 1:200 000 based on the 1938 American Classification System. New soil maps can be prepared according to the new soil classification system and evaluated, thus updating Turkey's soils information. Soil maps on the scale of 1:200 000 will be digitized and with the new methods the old great groups of 1938 American Classification System can be matched with the FAO and Soil Taxonomy Map Units. To turn this into a reality, the Çukurova University Agriculture Faculty Soil Science Department has been developing this new method for the last 10 years. The digitized soil maps using Soil Taxonomy will in the near future be turning out useful information. Finally, our country's updated 1:1 000 000 General Soil Maps, along with a soil interpretation report, will be prepared by the GDRS National Information Center in conjunction with the Soil Survey and Project Department, Çukurova University Agriculture Faculty, Soil Science Department, Dr Hari Eswaran (USDA Natural Resource Conservation Service, United States) and Prof. P. Bullock (Cranfield University, Silsoe College, Bedford, UK). This should be ready in an estimated time of two years.

International cooperation

It is evident that countries must work together in soil classification. It is for this reason that the amount of soil research and knowledge has increased dramatically in the last few years. Also, possibilities are being created which allow findings from different kinds of soil research to be reliably transferred to other countries with the same soil. As a matter of fact, some of the agricultural research which was done in our country and presented at international meetings, could not demonstrate a scientific relationship because it was based on the old American Classification System. Therefore, although costly research was done it is openly criticized.

Turkey sees itself as an integral part of Europe and in the process of becoming a member of the European Union. Just like other sectors in our country, Turkey will overcome its common soil problems and can be integrated into the European Soil Information System. It is possible to promote continuous and active cooperation in these matters and to speed up the technical and scientific help that we can obtain.

I have tried to summarize the current situation regarding our country's responsibility for establishing soil mapping work through the GDRS. We are ready for full cooperation on every kind of technical and scientific research together with accepting responsibility for the integrity of developments in the world.

The status of soil mapping in the United Kingdom

The European Soil Information System and the United Kingdom

The purpose of this brief report is to summarize the current status of soil mapping and information within the UK, assess the suitability of such information for developing thematic interpretations to support strategic planning and policy development at the regional level and to assess how the existing UK soil information could be adapted for use at the European and global scales.

Current status of soil information in the UK

Soils in the UK have been mapped since the turn of the century, but systematic mapping and characterization only began in 1948. In England and Wales today, approximately 25 percent of the land is covered by maps at the 1:25 000, 1:50 000 or 1:63 360 scale, whereas in Scotland nearly half the country, including most of the arable land, is covered at the 1:63 360 scale. Northern Ireland has complete coverage of soil maps at the 1:50 000 scale. On all these maps, the basic unit of soil classification and mapping is the soil series (Clayden and Hollis 1984). Each large-scale map (at scale 1:25 000 to 1:63 360) comprises polygons that delineate areas in which the soil characteristics conform to one or more soil series. Although the specific criteria used to identify soil series are somewhat different in England and Wales, Scotland and N. Ireland and have also evolved over the years (Hollis and Avery, 1997), the basic concept of the soil series has remained similar in all four countries.

Thus, throughout the UK, a soil series can be considered as a group of soil profiles with a similar sequence of soil horizons and developed on similar soil parent material that produces a limited range of inherent physico-chemical characteristics. Associated with the published soil maps for each area within each county, are published books that contain descriptions of the map units and constituent soil series, together with varying amounts of analytical data for individual soil profiles that were sampled to characterize a specific soil series in the area.

In addition to the more detailed 1:25 000, 1:50 000 and 1:63 360 scale soil maps, 'National' 1:250 000 scale soil mapping programmes have been completed in all four countries. The resulting maps and accompanying descriptive reports represent the only complete systematic soil cover information for the UK. In Scotland and N. Ireland, the 1:250 000 scale soil map units are based on soil parent material 'provinces' that comprise residual or drift material derived from one specific rock or a specific combination of geological source rocks. Within parent material provinces, map units are distinguished according to either the predominant 'soil class' (N. Ireland) or a range of soil classes associated with a specific land form (Scotland).

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In both countries the 'soil classes' are identified according to the presence of specific combinations of pedogenic horizons and named using the local soil classification system (Soil Survey of Scotland, 1984; Cruickshank, 1997). In England and Wales, map units delineated on the 1:250 000 scale maps are composed of a number of soil series (Clayden and Hollis, 1984) that are associated together within the landscape, usually in a predictable pattern related to land form and soil parent material.

Systematic soil mapping has now ceased within the UK, although a limited number of *ad hoc* mapping projects are commissioned for specific purposes by government bodies, their agencies or, more rarely, private companies such as utilities. National digital databases containing much of the data collected during soil mapping have also been developed. The databases comprise spatial information defining the boundary lines of polygons from soil maps, together with tabular information on the soil classes or soil series within each polygon, as well as geo-referenced analytical and descriptive data (Gauld and Paterson, 1996; Cruickshank, 1997, Proctor *et al*, 1998). These databases have been used to create a prototype digital soil data set for Great Britain and, subject to agreement of the copyright holders, it is proposed to incorporate data from N. Ireland to create a complete UK soil resource database.

Adaptation of existing national information to a global methodology

The existing 1:250 000 scale soil maps of the UK should be relatively easy to adapt to a global scheme. At present, two 'supranational' approaches have been proposed, the SOTER methodology (ISRIC, 1993) and version 1.0 of the Manual of Procedures for creating a 1:250 000 Georeferenced Soil Database for Europe (ESB, 1998). Both approaches rely on the identification of map polygons based on 'landscapes' which have a distinctive, and often predictable, relationship between landforms (terrain, geomorphological features), parent materials and soil types (identified by the presence of a specific sequence of pedogenic horizons). The soil data available for the UK are thus more than adequate for use in either approach.

SOTER emphasizes polygon delineation by terrain and soil parent material and restricts the identified associated soils to a maximum of three. The range of geology, climate and landscape evolution within the UK has produced a very variable soil landscape. Some areas have a uniform, simple soil pattern closely related to broad-scale landscape features. The SOTER approach would seem to be very suitable for characterizing such areas. In other parts of the country however, a long and complex Pleistocene history has produced small-scale soil patterns unrelated to the present-day, broad-scale landscape features. Elsewhere, particularly in parts of Scotland and N. Ireland, there are complex, small-scale soil landform patterns. It is not easy to see how such diversity can be adequately expressed at the 1:250 000 scale using the SOTER approach. The situation is similar in other parts of northwestern Europe where landforms are not always closely related to soil types.

The approach proposed for the 1:250 000 Georeferenced Soil Database for Europe is more flexible than for SOTER. The basic unit for identifying map polygons is the 'Soilscape', defined as 'a portion of the soil cover which groups soil bodies having former or present functional relationships, and that can be represented at the 1:250 000 scale.' It is delineated according to physiography, geomorphology, parent material or drainage sub-basin. Each Soilscape comprises a number of 'soil bodies' defined according to the FAO classification (FAO, 1990), at least until the World Reference Base (FAO, 1998) system becomes widely accepted, operational and fully documented. No limit is placed on the number of soil bodies within a Soilscape, but the number identified must occupy more than 90 percent of it.

This approach seems more suitable for characterizing the UK soil pattern at 1:250 000 scale as it permits the identification of complex soil patterns and landforms, as well as simple ones. The delineation of 'Soil Regions' at a smaller scale in order to 'establish discussions on the basis of "natural" regional units' is less successful. Soil regions are delineated principally on the basis of climate and parent material association, although combinations of dominant soils (according to FAO nomenclature) are also used to differentiate areas. A 1:5 000 000 scale map of Europe showing the distribution of 172 different soil regions is included in the published Manual of Procedures. The exact purpose of delineating these small-scale Soil Regions is not clear. Their main purpose appears to be to avoid problems of Soilscape incompatibility across national borders by identifying extensive areas where the geological, morphological and climatic factors of soil formation should produce a similar range of Soilscapes.

However, by including dominant soils, identified from existing maps, as a differentiating criterion for the Soil Regions, this purpose is largely negated. If the Soil Region concept is to be continued, it would be far better to base the delineation of the mapping units solely on climate (temperature and soil moisture balance), geology and geomorphology.

Regional mapping scales required for thematic applications in the UK and in Europe

The 1:250 000 scale national mapping projects for the UK have been published as a set of Regional soil maps, five for England, seven for Scotland and one each for Wales and N. Ireland. Since their completion, a wide range of thematic applications of the maps have been developed and tested. These include:

- Suitability of land for a range of traditional and alternative agricultural crops.
- Status of organic matter in soils: estimation of soil carbon and nitrogen pools.
- Assessment of soil buffering capacity in relation to acid deposition.
- Soil leaching potential as a component of groundwater vulnerability to pollution.
- Assessment of ground stability for the protection of building structures and the fracture potential for buried pipe networks.
- Potential for the immobilization of radionuclides.
- Disposal of agricultural and industrial wastes e.g. sewage sludge and animal slurry
- Soil degradation: Risk of soil erosion from the action of water and wind; structural deterioration of soil under declining organic matter levels and inappropriate land use practices.
  Suitability of land for precision farming techniques.

From UK experience, the 1:250 000 scale appears to be very suitable for traditional cartographic representation of general soil patterns at a regional scale. It has also proved suitable for supporting the development of national policy and planning strategies based on general quantification of land or soil suitability or susceptibility. However, information at this scale is less suitable for the implementation of policy and land management strategies, because decisions are often strongly affected by the identification of local variations or 'hot spots'. Whereas the 1:250 000 scale was ideal for developing the principles of a groundwater protection policy, it has proved too coarse for regional implementation of that policy, which has been undertaken at the 1:100 000 scale. Similarly, although the 1:250 000 soil maps and associated data have proved very useful for estimating the overall amount of land that is least able to immobilize radionuclides or is most likely to benefit from the introduction of precision farming techniques, the precise identification of such areas, for implementing remedial or support strategies, needs to be undertaken at the 1:50 000 scale.

National Copyright Considerations

The UK soil data have been generated by three different organizations, namely the Soil Survey of England and Wales (now the Cranfield University Soil Survey and Land Research Centre, SSLRC), the Macaulay Land Use Research Institute (MLURI) in Scotland and the Department of Agriculture for Northern Ireland (DANI). Government funding has been provided in all cases so copyright ownership is complex. In essence, the data for England and Wales are owned jointly by Cranfield University and the Ministry of Agriculture, Fisheries and Food, but Cranfield is licensed exclusively to distribute the data. In Scotland the data copyright is owned by MLURI, whereas in Northern Ireland, the digital soil maps are the copyright of the Ordnance Survey of Northern Ireland and the associated soil property data are owned by DANI.

Provision of data from these sources for the European Soil Database was handled by granting the EC the right to use the data itself and to issue licenses of an appropriate format, on behalf of the contributing organizations, to third parties at agreed charges. Free and unfettered distribution of the data is not permitted.

Conclusions and recommendations for initiating a national and regional soil information system for use at the European and global levels

Based on experience in the UK, the following recommendations are made:

- The most appropriate scale for developing a European-wide soil information system is 1:250 000.
- The methods for identifying and characterizing soil spatial variation should be based on those proposed in the Manual of Procedures for Creating a 1:250 000 Georeferenced Soil Database for Europe (ESB, 1998), although the Soil Regions concept should be revised to focus solely on climate and parent material criteria.
- The classification system used to identify Soil Bodies within a Soilscape should be based on the recently published World Reference Base for Soil Resources (FAO, 1998) which represents the latest consensus of scientists from IUSS, ISRIC and FAO.
- Base data for delineating polygons should be derived as far as possible at scales between 1:50 000 and 1:100 000. Base data at this scale will provide a practical base for implementing regional policy and land management techniques, whereas less detailed source data will reduce the value of a 1:250 000 map significantly.

A critical component of any European Soil Information System is characterization of the properties of each soil horizon within each identified soil body. The data should be as comprehensive as possible and reflect the variation of individual properties within each Soil Body.

Due to this and the co-variation of many important soil properties, the data should not be derived simply from a single soil profile data set, or from basic statistical analysis of a data set representing each property. Each Soil Body should be characterized from a defined specific set of 'basic properties', derived from measured data, together with pedo-transfer functions that can be applied to the basic data to compute dependent properties such as hydraulic characteristics.

It is also important that associated soil property data reflecting the characteristics of each Soil Body under relevant different land uses should be available. The minimum requirement is for a set of properties under the identified dominant and secondary land use of each Soil Body.

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Annex 1
Opening address

Welcome Address by Mr. M Lindau

On behalf of the Director General and in my own name I wish to welcome you all to FAO and to this technical consultation, which has been organized jointly with the Commission of the European Union, more specifically the European Soil Bureau of the Space Applications Institute. I would like at the outset to thank them for their contribution to the organization and preparation of the Consultation.

As you know, this Consultation has been convened at the recommendation of the 21st Regional Conference for Europe which endorsed a proposal by the presidency of the European Union to that effect.

In fact, in discussing the subject on "the uses and benefits of soil information", the Conference recognized the importance of adequate soil information systems in the prevention of soil degradation and in assisting in the process of crop forecasting. It also realized that not all countries in the European region benefited from homogeneous and compatible soil classification systems.

You do not expect to learn from me the importance of harmonized land resource information, but it may nevertheless be useful to recall its significance in the rational transfer of agricultural technologies, varietal selection and in facilitating communication between researchers and planners. Nor should we forget the possibilities it offers for setting environmental norms and standards for the whole Region.

Allow me also to recall the particular importance land resource information has acquired nowadays in agricultural planning. It is increasingly recognized that agriculture has a multifunctional character making planning a more complex exercise with transboundary consequences. In fact this issue and its various facets are at the heart of the discussions that will take place during the conference organized by FAO and the Government of the Netherlands later this month.

Historical reasons have made it possible for groups of countries in the Region to develop homogeneous methodologies, procedures and map scaling, while in other cases it has impeded that such methodologies gain more general application in the Region.

But today, it is not only conditions that have changed and allow for integrated approaches to be applied throughout the continent, but there are practical compelling reasons that impose the need for harmonization. I have already mentioned some, I would like to add the problems related to climatic change and the various models and scenarios for which coherent soil data appear to be necessary.

In the global village we live in today, Europe is a relatively small geographic area to afford different models to be used by the different countries. The integration process has been in process for many years and in which an increasing number of countries of the Region participate;

it is time, I think, that it is extended to this precious resource which is the basis for all other resources.

I am confident that this technical consultation will come up, as is customary to scientific gatherings of this nature bringing together people with common language and understanding of the problems, with practical and implementable solutions for the benefit of all people living in the European Region.

Thank you.

Annex 2
Programme

Thursday, 2 September

10.00 hours	Organizational Matters Adoption of Agenda and Timetable Welcome statements by: - M. Lindau, FAO Regional Representative for Europe - A. Meyer-Roux, Deputy Director, SAI, JRC, European Commission - R. Florin, Service Chief, FAO Land and Water Development Division
11.00 hours	Soil Information Systems: Global and European Approaches CHAIRPERSON: A. Meyer-Roux, Deputy Director, Space Applications Institute (SAI), Joint Research Centre (JRC), European Commission
14.00 hours	Soil Mapping : The Issue of Scale CHAIRPERSON : Professor Emeritus R. Dudal, Former Director, FAO Land and Water Development Division

Friday, 3 September

9.30 hours	The European Soil Information System: Issues related to copyright Current National and Regional Soil Information System Activities CHAIRPERSON: Dr Wim Sombroek, former Director, FAO Land and Water Development Division and former Director of ISRIC
14.00 hours	General Discussion CHAIRPERSON: Professor W. Blum, Secretary IUSS
16.00 hours	Adoption of Conclusions and Recommendations
17.00 hours	Closure of Technical Consultation

Annex 3
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F – French
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This document contains the proceedings of a technical consultation on the soil resources information systems developed in the various countries in the European region and their incorporation in the European Soil Information System (EUSIS). A summary report of technical discussions, conclusions and recommendations and individual country reports are included.