Soil Survey and Soil Data in Austria

Winfried E.H. Blum
Michael Englisch
Peter Nelhiebl
Wilhelm Schneider
Sigrid Schwarz
Josef Wagner

1 Institut für Bodenforschung, Universität für Bodenkultur, Gregor-Mendelstraße 33, A-1180 Wien, AUSTRIA
2 Institut für Forstökologie, Forstliche Bundesversuchsanstalt, Seckendorff-Gudent-Weg 8, A-1131 Wien, AUSTRIA
3 Institut für Bodenwirtschaft, Bundesamt und Forschungszentrum für Landwirtschaft Spargelfeldstraße 191, A-1226 Wien, AUSTRIA
4 Abteilung Terrestrische Ökologie, Umweltbundesamt GmbH, Spittelauer Lände 5, A-1090 Wien, AUSTRIA
5 Abteilung IV/8 - Bodenschätzung und landwirtschaftliche Einheitsbewertung, Bundesministerium für Finanzen, Himmelpfortgasse 4-8, A-1015 Wien, AUSTRIA

Introduction

There are three principal systems of soil survey in Austria: on forested land the Forest Soil Survey and on agricultural land, the Soil Taxation Survey and the Soil Management Survey. In addition, there is an Environmental Soil Survey, a Soil Monitoring System and a Soil Information System (BORIS). Each of these is described below.

Forest Soil Survey

Forest Site Mapping

Major efforts to map forest sites started in the late 1950s and early 1960s, carried out mainly by the University of Agricultural Sciences in Vienna, the administration of the government-owned forests (Österreichische Bundesforste) and the Federal Forest Research Centre (FFRC).

Today, the chief emphasis is on site classification, with site mapping limited to use in local projects. These local projects are carried out by various organisations of governmental and private forest administration. FFRC acts as service unit for harmonisation, quality control and training.

Methods and Output

Forest site mapping in Austria uses the “combined method” developed in Baden-Württemberg (Kirschner and Schlenker 1955) with some minor variations. The method takes into account climate, soil (geology) and vegetation characteristics in site classification. The goal of mapping is to delineate ecologically-based site units that are locally valid and fit into a hierarchical framework (groups of sites, growth districts, altitudinal zones and growth regions).

Vegetation type, growth data, and soil characteristics, supplemented by chemical analyses (pH-value, C_{org}, N_{tot}, nutrients, CEC, base saturation), are identified on plots selected to be representative of the entire range of the sites in the area to be mapped. The plots, which may be arranged in a grid, a transect covering important gradients or distributed randomly in pre-stratified areas, are used to define the site units of the proposed mapping area. Based on these investigations the site units are classified and from this classification is developed the key for mapping the units. Mapping of soil indicators is carried out using a 1m soil auger (1-4 samples per hectare).
Recently a working group of all involved organisations has completed a guide for forest site mapping in Austria, considering new developments and modern techniques eg. GIS, use of databases, IR-aerial pictures and multivariate statistical analysis (Englisch and Kilian, 1998). Up to now, about 400,000 ha, i.e. approximately 10% of forest land has been mapped, predominantly at scales of 1:10,000 and 1:25,000.

Mapping has been focussed on state-owned forest land (mainly the federal provinces of Salzburg, Upper Austria (southern part) and Styria), the floodplain forests of the Danube, the Vienna Woods and North-Eastern Styria. Additionally, the FFRC has carried out site classifications in most of the 21 forest growth regions in order to provide a basis for local mapping projects.

**Application of results**

Forest site maps have been instrumental in the selection of tree species and are thus part of the forest management. In addition, they serve in understanding ecological changes (e.g. to identify changes of the water regime of sites after construction of power stations), as a basis for local forest melioration and can be used for scientific purposes (e.g. selection of trial plots).

Recently, site classification and mapping has been used for environmental planning, as a basis for the assessment of biodiversity, for nature conservation, and for wildlife management, amongst other uses.

**Forest Soil Monitoring**

In Austria, there are two schemes for forest soil monitoring. In the late 1980s the Forest Soil Monitoring System (FSMS) was started by the FFRC as part of the Forest Damage Monitoring System in order to obtain information on the causes and effects of forest die-back. The FSMS consists of 514 plots arranged in a grid of 8.7km x 8.7km. At each plot, growth measurements and vegetation relevés, site and soil description, chemical analyses of soil and foliar samples are carried out and crown damage assessed.

Soil and site descriptions and soil analyses (pH-value, C$_{org}$, N$_{tot}$, nutrients ("total" contents in aqua regia, cations in BaCl$_2$-solution), carbonate content, CEC, base saturation, heavy metals, texture analysis) were carried out between 1987 and 1990. Soil samples, including soil organic (ectorganic) horizons, were taken at predefined soil depths (0-10 cm, 10-20 cm, 20-30 cm, 30-50 cm). About 140 plots are included in the European-wide level I ECE/ICP forest soil monitoring network. Repetition of soil sampling is not planned before 2003.

Additionally forest soil monitoring networks were established in several Federal Provinces (Länder), including Lower Austria, Salzburg, Tyrol and Vorarlberg. All plots of the FSMS and of the regional networks were included in the combined report on soil conditions in the countries of ARGE Alp and ARGE Alpen-Adria (Huber and Englisch 1997).

The main results of these projects indicate moderate regional forest soil acidification, widespread heavy metal pollution (Pb, Cd), which peaks at the northern fringe of the Alps and varies with increasing altitude, and accumulation of nitrogen.

Another 20 plots are part of the level II/ECE/ICP intensive soil monitoring network, which was established in 1994. Intensive soil sampling (5 samples as a mixed sample of 8 subsamples in the upper soil horizon, 4 samples as a mixed sample from 4 subsamples in the lower soil horizon) is carried out in soil organic (ectorganic) horizons and mineral soil horizons at predefined depth intervals of 0-5 cm, 5-10 cm, 10-20 cm, 20-40 cm, 40-80 cm. The same methods of soil analyses as in level I are used. The aim of the intensive monitoring is to assess soil changes with time.

**Forest Soil Database**

The largest forest soil database (GEA) in Austria is managed by FFRC. It includes descriptions of about 5,000 forest soil profiles and about 26,000 analyses of individual soil horizons (standard suite of analysis: compare FSMS). It is planned to enlarge this database to become a general forest–site information system.

**Applications of Forest Soil Data**

Forest soil data are principally used for site mapping, for the protection of forest soils and forest ecosystems (mainly in relation to heavy metal pollution, acidification, nitrogen input), ground water protection and environmental planning, for forest melioration and fertilisation, and for scientific purposes.

**Outlook**

Recently introduced methods for intensive soil monitoring mainly focus on soil biological parameters. They have been used in soil surveys in Upper Austria and in monitoring programmes (e.g. Salzburg) as indicators of soil fertility. These methods can reveal local soil pollution (Tscherko and Kandeler, 1997).
The most widely applied microbial parameters are microbial biomass (measured as substrate induced respiration: Beck et al., 1996) and nitrogen mineralisation potential (Kandeler, 1996).

Soil fauna can also be used as an indicator of soil quality. Earthworms (lumbricidae), potworms ( enchytraeidae ), and springtails (collembola) have proved to be successful indicators in the intensive monitoring programmes. Because of the constant development of new biological methods and increasing experience in this field, it can be expected that in the future those methods will be used increasingly as an obligatory part of intensive soil monitoring programmes.

Agricultural Soil Survey

Soil Taxation Survey

Since 1947 the taxation of agricultural land has been carried out by the financial administration in co-operation with the Federal Surveying Office. 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 a new legal basis, regulating the continuity and updating of soil taxation data as well as their integration into the Austrian cadastre.

The main task of the soil assessment is to maintain up-to-date data on agricultural properties. Since 1974 the data have been updated through revision and reassessment to take into account changes in important environmental factors.

Methods and Output

Field methods are used to estimate the quality and natural productivity of soils for taxation purposes. Soil is described to a depth of 1 metre at intervals of 40 metres across the agricultural land using a soil auger. Parent material, texture, organic matter, horizons and structure are investigated. Units with comparable conditions of soil, relief, water regime and climate are defined and included in the Cadastre Map. Such maps are at a scale of 1: 2,000 or 1:2,880 (scale of the old cadastre).

For comparison purposes, a system of values between 1 and 100 is used to assess soil conditions, relief, climate and water regime. The best possible value is 100, attributed to the soil with the highest yield potential. In typical Austrian regions, 470 standard sites guarantee a harmonised assessment. There is a close relationship between a given soil taxation and these standard sites.

The results of the soil assessment are documented in the Soil Taxation Register, the "Schätzungsbuch", and in soil taxation maps. These data exist for every parcel of agricultural land in Austria. For each parcel the value...
mentioned above is multiplied by the size of the parcel and this new value forms the basis for agricultural taxation.

Soil assessment data exist in analogue form for approximately 2.8 million hectares of agricultural land, corresponding to 33% of the total area of Austria.

**Application of Results**

As the soil taxation data have been investigated with a high degree of continuity and comparability for decades and are characterised by very precise geometric positioning, they can be combined with other data of the Cadastre for every parcel. Therefore, soil assessment data are not only used for taxation of agricultural property. They also include basic ecological information about soils and are used for various purposes, including:

1. soil reform;
2. compensation;
3. land use planning;
4. use of sewage sludge;
5. proceedings of the Water Act;
6. measures within the Austrian Programme for the Promotion of Environmentally Friendly and Extensive Agriculture that Protects Natural Habitats (ÖPUL);
7. basis for site adapted soil management;
8. scientific projects.

**Outlook**

Following the realisation of a pilot programme in co-operation with the Federal Surveying Office, the digital capture of the soil assessment data is planned.

**Soil Management Survey**

The origins of agricultural soil mapping – a cartographic representation of soil conditions at a scale as large as possible – go back to the 19th century. One of the oldest "agro-geological" soil maps was drawn in 1858, in the Austro-Hungarian Empire, at a scale of 1:500,000 (Szabolcs, 1997).

In Austria, soil mapping has been carried out since the 1920s. Experimental soil mapping was carried out after the Second World War. Since 1958, systematic mapping has been conducted by the Federal Institute of Soil Survey and Soil Management. At that time it was decided to survey agriculturally used land only, and involved the collection of field data and production of maps.

By 1969, 20% of the arable land in Austria had been surveyed at a scale of 1:2,880 (Cadastre scale) and maps produced at a scale of 1:5,000. Since 1970 the survey has been made at a scale of 1:10,000 and published at a scale of 1:25,000, to accelerate the procedure. The latter scale is exact enough to meet several needs and related questions.

**Methods and Results**

Soil mapping, which includes an assessment of geological, geomorphological and climatic conditions, is carried out from an agricultural and pedological point of view. The sampling density varies with soil heterogeneity but on average one boring per hectare is made. This approach is used to identify Soil Units which are defined as areas with the same soil type and similar site characteristics.

For each Soil Unit at least one profile is described (to approximately 120 cm depth) and samples of the individual horizons are subjected to laboratory analysis, including texture (percentage of clay, silt and sand), organic matter, carbonate, pH-value, electric conductivity, exchangeable cations, nutrients, heavy metals. Until now, the 1:25,000 soil maps as well as the supporting explanatory texts have been produced by offset printing. A digitised soil databank is currently being established. Maps of some 144 mapping regions (mostly judicial districts), representing an area of approximately 22,000 km² or 63 % of agricultural land have been published (Figure 2).

Manuscript soil maps (1:25,000 scale) exist for another 10 % of agricultural land. In total, about 98 % of the agricultural land has been surveyed and the results are available to interested persons or institutions. The Institute for Soil Management in the Federal Office and Research Centre of Agriculture has succeeded the Federal Institute of Soil Survey and Soil Management and is responsible for problems and questions dealing with soil management.

**Application of Results**

Examples of the practical applications of the 1:25,000 scale soil maps include:

1. Fertilisation and cultivation of soil in an environmentally friendly way;
2. Selection of experimental sites;
3. Crop suitability modelling;
4. Regional and Provincial land-use planning;
5. Background to the preservation of ecological sites;
6. Survey of the Potential of Natural Habitats;
7. Use in research projects.
On the basis of the 1:25,000 soil map, a number of special maps have been generated, concerned with:

1. Water regimes;
2. Sensitivity to erosion;
3. Use of sewage sludge;
4. Sensitivity to nitrate leaching.

These special soil maps allow early detection of negative impacts on soil, such as wind erosion, water erosion, decline of soil structure, and contamination and drought, enabling relevant measures to be taken.

**Outlook**

Thirty hectares of agricultural land are lost to non-agricultural purposes every day. This is likely to lead to a greater pressure on soils suitable for agriculture in the future, especially if the planned extensification of crop production takes place. By this time a well organised digital soil information system will be indispensable. Areal and point data for Austrian soils are essential to protect/conserve the soil and to sustain soil fertility.

**Environmental Soil Survey**

The decision to establish an intensive environmental soil survey programme was taken by provincial governments, which have the main responsibility for soil management and soil protection of agricultural land. In 1986, Vorarlberg, the most western province of Austria, began an environmental soil survey although at the time no special guidelines were available.

A recommendation for carrying out an environmental soil survey was prepared by the working group “Environmental Soil Survey” of the ASSS (Austrian Society of Soil Science) (Blum et al., 1989) to create a basis for comparable soil data all over Austria. As a result of these guidelines the investigations of all the other Federal Provinces are to a large extent comparable in soil sampling design and analytical methods.

**Methods and Output**

The sites are situated in a basic grid of about 4km x 4km. In some regions the grid was narrowed to 2.75km x 2.75km. For the FSMS a grid of 8.7km x 8.7km was used. Each sampling site is marked and coded.
Sites and soil profiles are described and composite soil samples are taken at predetermined depths (mixed from several parallel samples) using a soil auger. The number of subsamples in each composite sample varied between the Environmental Soil Surveys in the different Federal Provinces. Soil analyses include pH, carbonate concentration, nutrients, heavy metals, humus content, particle size distribution. Special programmes also included organic pollutants, biological and physical soil parameters.

Figure 3 shows the actual state of environmental soil surveys in Austria. In Table 1 the number of investigated sites according to land use is given.

In Tyrol a replicate sampling was made in 1996, eight years after the first investigation. 107 of the original 658 sites were investigated in the second sampling. In Vienna – the capital of Austria – a special programme covering only heavy metals has been launched.

Most of the sites of the environmental soil surveys are situated on agricultural land.

The Forest Site Monitoring System (FSMS) of the Federal Forest Research Centre (FFRC), under which forest soils are investigated, is included in Table 1, although the FSMS is a Federal nationwide investigation (cf. Forest Soil Monitoring Section above).

An evaluation of all the data (of more than 5,000 sites), investigated with comparable methods, will be possible after the completion of the Environmental Soil Survey in Carinthia and the recording of data in a Soil Information System (see BORIS below).

An overview of the state of agriculturally used land in Tyrol (153 sites), Salzburg (197 sites), Lower Austria (1,449 sites), Upper Austria (453 sites), Burgenland (174 sites) and part of Styria (84 sites) has been made by the Federal Office and Research Centre of Agriculture in 1997 (Danneberg et al., 1997), based on the upper 20 cm of agricultural and grassland soils, with data from approximately 2,500 sites.
### Tab. 1: Number of Environmental Soil Survey (ESS) sites in Austria according to land use (1998).

<table>
<thead>
<tr>
<th>Land use</th>
<th>Tyrol</th>
<th>Tyrol 1</th>
<th>S</th>
<th>UA</th>
<th>LA</th>
<th>St</th>
<th>Vbg</th>
<th>B</th>
<th>Car 2</th>
<th>FSMS</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>forest</td>
<td>263</td>
<td>(15)</td>
<td>177</td>
<td>90</td>
<td>17</td>
<td>150</td>
<td>1,211</td>
<td>1,211</td>
<td>514</td>
<td>1,211</td>
<td></td>
</tr>
<tr>
<td>agricult. land</td>
<td>47</td>
<td>(33)</td>
<td>14</td>
<td>439*</td>
<td>1,151</td>
<td>193</td>
<td>40</td>
<td>164</td>
<td>140</td>
<td>2,188</td>
<td></td>
</tr>
<tr>
<td>grassland ext. used</td>
<td>139</td>
<td>(59)</td>
<td>137</td>
<td>441*</td>
<td>298</td>
<td>256</td>
<td>243</td>
<td>10</td>
<td>250</td>
<td>1,637</td>
<td></td>
</tr>
<tr>
<td>intensively used</td>
<td></td>
<td></td>
<td></td>
<td>134</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>137</td>
<td></td>
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<tr>
<td>alpine pasture</td>
<td>209</td>
<td></td>
<td></td>
<td>61</td>
<td>91</td>
<td>361</td>
<td>361</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>others</td>
<td>21</td>
<td>2</td>
<td>286</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>286</td>
<td>309</td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>658</td>
<td>(107)</td>
<td>462</td>
<td>880</td>
<td>1,539</td>
<td>548</td>
<td>435</td>
<td>174</td>
<td>481</td>
<td>435</td>
<td></td>
</tr>
</tbody>
</table>

1. replicate sampling
2. to be completed in 1998
3. investigations of heavy metals (1992: 286 sites; 1994: replicate sampling at 257 of 286 sites)
* agricultural and horticultural land
** grassland incl. alpine pastures, pastures and others
+ As the ESS in Vorarlberg was completed in 1996 before the ESS-guidelines (Blum et al., 1989) were published, the data cannot be compared to the other ESS, due to different methodology.

### Acidification and pH Value

Acidification is a minor problem on agricultural land compared with land under forest, since acidic inputs are smaller. Moreover, they are neutralised by regular fertilisation and by liming. Problems occur only in extensively used areas.

Alkaline sites, with a pH value of more than 7.2, occupy more than 40% of the areas in the east of the country, in Lower Austria and in Burgenland, whereas the percentage in Tyrol, Salzburg and Upper Austria is less than 4%. Strongly acidic sites with a pH-value below 4.5 are found in Styria (14%), Tyrol (35%) and Salzburg (38%).

Low cation exchange capacity, which indicates sensitivity to acidification, occurs in soils on siliceous parent materials (e.g. granites) in the Wald- and Mühlviertel area, Semmering, Wechsel, Central Alps and the foothills of the Alps.

### Organic Matter Depletion

The content of organic matter is determined by the amount of organic litter produced by plants and by the intensity of turnover processes. This is why the humus content in grassland is higher than in crop land and therefore is higher in the cool and humid west of Austria than in the warm and dry east.

For example, in Salzburg 40% of the soils have more than 8% organic matter in the topsoil whereas in Lower Austria about 40% have less than 2%. In the areas used for agriculture in the east of Austria the organic matter content may have diminished by 0.5%, due probably to an intensification of soil tillage and former straw burning or a dilution of organic matter caused by increasing the plough depth.

### Heavy Metal Contamination

In general, contamination with heavy metals is not very extensive. The standard values ÖNORM L 1075 (Austrian standard L 1075) for most heavy metals are only exceeded in less than 3% of the sites. Arsenic, lead and cadmium pollution occurs in more than 3% of the sites.

Arsenic contents are especially high in some regions of Salzburg, Styria and Lower Austria. This may be due to geogenic or anthropogenic sources. A study is currently being carried out by the Institute of Soil Science of the University of Agricultural Sciences, Vienna to answer this question and to determine the effects on the environment and on humans.

The standard value for lead (100 mg/kg) is exceeded in Tyrol at 9.2% of the sites investigated.
and in Salzburg at 3.6% of the sites. This could be due to local emissions, impacts of mining or long range transport of pollutants. The latter is seen as accounting for contamination north of the main alpine ridge. Due to high transit traffic, the valley of the Inn river is the most polluted region in Tyrol. Furthermore, local lead emissions (e.g. metal processing) result in point pollution.

High cadmium contents can partly be explained by long-range pollution and subsequent deposition on exposed slopes. On the other hand, the Northern Calcareous Alps seem to have a naturally elevated content of cadmium.

Application of Results

Some Federal Provinces (e.g. Styria, the Tyrol) have taken measures at those sites where the content of heavy metals exceeded the threshold values. More detailed investigations have been carried out, including analyses of plants. In heavily polluted areas a risk assessment programme has been carried out which is used to derive land use recommendations.

As mentioned above the question of widespread higher contents of arsenic will be answered by detailed studies.

Outlook

One of the Federal Provinces, Styria, is carrying out a replicate Environmental Soil Survey, which forms a transition to an extensive form of Soil Monitoring.

Soil Monitoring

The environmental soil surveys, with approximately 6,000 sites, provide information about the variability of soils all over Austria. A repeat of these surveys was originally planned in order to monitor the changes with time. However, the results of replicate sampling in Tyrol showed that the sampling design at each site was not precise enough to distinguish between changes over time and the variability within the sampling site.

Another reason for changing the plan of carrying out Environmental Soil Surveys at regular time intervals is the great expense. Therefore, for technical and financial reasons and with regard to previous results, fewer but intensively investigated soil monitoring areas are being established. A methodological handbook has been prepared by the Institute of Soil Science at the University of Agricultural Sciences, Vienna, on behalf of the Federal Environment Agency and in co-operation with the Austrian Soil Science Society (Blum et al., 1996).

Appropriate nationwide co-ordination of the sites will result in a reduction of costs for the benefit of the individual provinces. There will be a representative distribution of sites according to characteristic landscape units of Austria (soil landscapes, main agricultural production areas, silvicultural growth areas, etc.), different exposures to pollution (background, close to emission sources, etc.) and types of use (forest, cropland, grassland, etc.).

The Institute of Soil Science has elaborated a proposal for possible sites, which is presented in Figure 4 (Blum et al., 1996). Full points in the Figure refer to already established soil monitoring areas. These are found mainly in Salzburg which was the first province to set up soil monitoring areas (Juritsch, 1994). In the Tyrol, the Loisachtal site has been planned as a soil monitoring area. In Upper Austria, the Federal Environment Agency is running a long-term ecosystem monitoring site (UN-ECE Integrated Monitoring) in the Reichraminger Hintergebirge.

As part of the ECE/ICP-Forest Programme, the Federal Forest Research Centre, Vienna has established 20 forest monitoring areas (see Forest Soil Monitoring Section above). Further sites identified in Figure 4 are non-obligatory proposals. It is expected that between four and ten areas, will be established in each province.

Following establishment of the soil monitoring sites, the data collected will provide information on changes in soil properties as well as on the state of soil pollution. Optimum selection of areas and standardised methods of investigation will allow relevant policy statements to be made on environmental impacts on certain regions and the whole of Austria (UMWELTBUNDESAMT, 1998).

The subject ‘soil monitoring’ is already being considered by the ARGE Alpen-Adria working group in Bavaria and in Switzerland (Blum et al., 1994). The directives of ARGE Alpen-Adria, which are also binding for Austria, provide a framework which has been enlarged to contain additional parameters to those in the above mentioned Austrian methodological handbook and more precise investigation methods.
Soil Information System (BORIS)

A Soil Information System is necessary for effective soil conservation nationwide and for ensuring accessible information on general soil conditions, contamination and the sensitivity of soils to detrimental impacts. Detrimental effects on soils can be assessed more easily by means of a nationally standardised recording of area and point data in a Soil Information System. This will provide the basis for an evaluation and projection system needed for effective soil protection.

Compared to many other European countries, Austria possesses comprehensive soil data. Yet, these data are structured heterogeneously, as they have been collected by different institutions with varying objectives. At the Federal Environment Agency, a pilot project (μBORIS) for the implementation of a national Soil Information System was carried out in order to test the possibility of realising a joint soil information system. In the city of Linz and its surroundings, data records from different investigations were linked (point data, area data/maps). Experience with the pilot project has clearly demonstrated that a combined evaluation of the selected data sets is possible (Schwarz et al., 1994).

In future, an integrated Soil Information System consisting of a combination of soil maps, the real estate database, soil data from Environmental Soil Survey sites and from Soil Monitoring sites will be a cornerstone for soil use and management.

Methods and Output

Since 1992 the Federal Environment Agency has been developing the Soil Information System, BORIS. There were three main tasks to fulfil:
1. prepare a handbook, the "key for soil data" ("Datenschlüssel Bodenkunde"), to harmonise the data records of different investigations;
2. develop a complex data model;
3. transform the existing datasets according to the "key for soil data" and the data model.

The "key for soil data" was developed by the Federal Environment Agency. It has been approved by the Austrian Soil Science Society (ASSS) and is to be published.
The Data Model offers special possibilities, e.g.:

1. It is an open system including approximately 600 different parameters (analytical parameters, parameters for site or soil description), which are described with all possible characteristics in the "key for soil data", and new parameters can be added whenever necessary.

2. From every single value there is a link to a variety of information (the owner of the data, the analytical method used, etc.).

3. Information about sampling design, conditions of sample transport, handling and treatment of samples, etc. is available.

4. If replicate sampling or parallel sampling has taken place, this is documented for each sample.

5. The combination of soil description in terms of natural soil horizons and analytical data according to predetermined soil depths is easily possible.

6. A model query is: Select all samples with land-use: forest, soil type: cambisols; lead content more than 100 mg/kg, (analysed with aqua regia) in the depth 5-10 cm.

Currently, the databank holds a soil map of Austria (scale 1: 750,000) and more than 500,000 records from over 5000 sites. These are data from the Environmental Soil Surveys of Styria, Upper Austria, Burgenland, Tyrol, Vienna and data of special investigations e.g. in Brixlegg, Linz, Arnoldstein, Köflach-Voitsberg as well as from the Austrian-wide caesium investigation.

The data of another 600 sites of the Forest Site Monitoring System, FSMS, (500 sites) and of other investigations (100 sites), were added in 1998. Building this extensive data set was made possible through of the constructive co-operation of the above mentioned Federal Provinces and the institutions which carry out the investigations. Much work was involved in transforming the individual data sets. This included considering different aspects of soil science and complying with EDP requirements.

Table 2 and Figure 5 give an overview of the number of sites in BORIS (March 1998).

Austria is one of the countries most strongly affected by the Chernobyl fallout. The average contamination level in Austria amounts to 21 kBq $^{137}$Cs/m$^2$ (= 21,000 Becquerel Caesium-137 per square metre). An amount of 18.7 kBq $^{137}$Cs/m$^2$ originates from the nuclear accident in Chernobyl, the remaining part can be traced back to the fallout caused by the tests of nuclear weapons in the atmosphere in the 1950s and 60s. The maximum level of contamination is above 150 kBq $^{137}$Cs/m$^2$. Higher fallout values can be found only in the Ukraine, Belarus, Russia and in some parts of Scandinavia. An example for an Austrian-wide evaluation of soil contamination with caesium-137 is given Figure 6.

This map was drawn up the Austrian Federal Environment Agency (FEA) and the Austrian Ministry of Health. It presents all the measured data for available caesium-137 ($^{137}$Cs) in soil that are available. More than 2000 results were used in producing the map. Approximately 200 of them were located in neighbouring countries close to the Austrian border (UBA, 1996). The Cs-137 data are available on the Internet.

**Application of the Results**

Following the integration in BORIS of all of the Environmental Soil Surveys of Austria and some other special investigations, the system will contain information about approximately 8000 sites and approximately 1 million records to be combined with soil maps (on different scales) and data sets of related subjects such as land cover, geology, water, cadastre, etc. These data form the basis of:

1. broad set of reference data over all Austria with which to compare and classify data with similar characteristics (of site or soil description, methods, sampling design, etc.);
2. all-Austria evaluations (pollutants, heavy metals, erosion);
3. development and adaptation of standard values;
4. combined evaluation with CORINE land cover data, Austrian Surface and Groundwater Monitoring System;
5. decision-making with regard to land use planning;
7. decisions on the spreading of sewage sludge and other organic waste;
8. service to Provincial authorities (e.g. templates for data output, which will be completed automatically by BORIS, in case a Provincial authority decides to pass on information about selected sites);
9. aggregated data for international reports and projects;
10. further international agreements and protocols for the reduction of trans-boundary pollutants and other inputs;
11. translation of Austrian soil types into international classification schemes (FAO-System, WRB);
Figure 6:
Soil Survey and Soil Data in Austria. Blum et al.

The efforts towards the enlargement and intensification of the nationwide soil information system will be continued as well as the co-ordination with European soil information networks.

General Outlook

Soil survey and the collection of soil data in Austria is now well developed to the extent that the use of soil data for specific purposes or their link with other environmental data through GIS or other geo-statistical tools can be facilitated.

Unfortunately, many governmental and private institutions have not yet recognised the value of soil information, especially for the management of natural resources on a local, regional or country level. Therefore, the BORIS project is certainly a way to raise public interest in soils and to promote the use of these data for the future development of sustainable land use.

This goal will be reached more easily when all the monitoring stations are installed and continuous changes in soils and sites can be measured.

All the above mentioned soil information can also be used in the co-operation with other European countries. Co-operation has already begun and will develop further to harmonise the use and availability of soil information in Europe.

Table 2. Number of sites in the Soil Information System, BORIS (March 1998).

<table>
<thead>
<tr>
<th>Provinces</th>
<th>Bgl</th>
<th>Car</th>
<th>LA</th>
<th>UA</th>
<th>S</th>
<th>St</th>
<th>Tyrol</th>
<th>Vbg</th>
<th>Vie</th>
<th>Abroad: near Austrian border</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESS *</td>
<td>174</td>
<td>-</td>
<td>-</td>
<td>880</td>
<td>-</td>
<td>519</td>
<td>658</td>
<td>-</td>
<td>289</td>
<td>-</td>
<td>2520</td>
</tr>
<tr>
<td>Caesium Data</td>
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<td>165</td>
<td>333</td>
<td>323</td>
<td>285</td>
<td>245</td>
<td>322</td>
<td>119</td>
<td>39</td>
<td>229</td>
<td>2113</td>
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<tr>
<td>Other investigat.</td>
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<td>151</td>
<td>62</td>
<td>92</td>
<td>21</td>
<td>353</td>
<td>47</td>
<td>-</td>
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<td>726</td>
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<tr>
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<td>316</td>
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<td>1295</td>
<td>306</td>
<td>1117</td>
<td>1027</td>
<td>119</td>
<td>328</td>
<td>229</td>
<td>5359</td>
</tr>
</tbody>
</table>

* ESS (Environmental Soil Surveys). The datasets listed in this line were provided by the Federal Provinces of Burgenland, Upper Austria, Styria, Tyrol and Vienna (Municipal Department 22)

Outlook

Two forms of access to the data included in BORIS via Internet are planned in the near future: BORIS INFO and BORIS EXPERT (Schwarz et al., 1998).

BORIS-INFO will be open to the public and will contain meta data for each site such as: data owner, literature, investigating institute, parameters investigated, methods used, date of investigation, land use, etc. Internet users will have an overview of existing data and information about ownership and possible access.

BORIS EXPERT will include the complete database and is accessible to those institutions concerned with soil and included in the list of licensed institutions granted access. These are mainly the institutions that provided data for BORIS.

The soil information system BORIS offers harmonised data sets and technical data processing tools. This facilitates linkages and, therefore, combined study of soil data beyond Provincial borders, making it easier to deal with various aspects of soil protection.
References


