Status of Soil Mapping in Finland

Jouko Sippola
Markku Yli-Halla

Resource Management Research, Agricultural Research Centre of Finland, Jokioinen, FINLAND

Introduction

Systematic collection of soil information started in Finland in the late 1800s when the Geological Survey of Finland began mapping the Quaternary deposits. The mapping of soils for agricultural purposes by the Agricultural Research Centre started in the 1920s. In 1972, a collaborative committee representing the Agricultural Research Centre, the national Board of Survey and the Geological Survey (now the Geological Research Centre) was formed by the initiative of the National Board of Survey.

This Committee recommended that a combined geological and agrogeological mapping approach should be used in the mapping of soils, and this should be undertaken along with the updating of the basic topographic maps. Surveyors of the National Board of Survey were trained to collect soil information and the work was controlled by geologists and agronomists. It was estimated that the entire country would be surveyed within 30 years. Initially the joint work progressed rapidly, but in the 1990s, due to financial restrictions, only the Geological Research Centre continues its mapping activities.

Soil Classification

The national soil classification of Finland is based on texture and organic matter (Aaltonen *et al.*, 1949).The soils have been separated into three groups: till soils (on moraine); sorted mineral soils (gravel, sand, fine sand, silt and clay) and organic soils, including mull (organic matter, 20-40%), peat (organic matter > 40%); and gyttja (a mixture of sedimentary organic and mineral material). Little attention has been given to developing a genetic classification, a decision justified on the grounds that the soils are young (formed in Quaternary deposits). In addition, Finland’s cold climate, causing soils to be frozen for half the year, means that soil development processes are slow.

In the last five years a request to supply information about the soils of Finland to the European Union using international classification systems has been met. The Agricultural Research Centre has provided the material relating to Finnish soils for the European Soil Map at 1:1,000,000 scale according to the FAO/UNESCO classification system. The material is based on data prepared for the Soil Map of the World project in the 1970s.

Within the territory of Finland, the following classes of the FAO/UNESCO system (1974) are recognised:

Orthic Podzols	49%
Dystric and Eutric Histosols	28%
Vertic and Dystric Cambisols	7%
Dystric Lithosols, Dystric Regosols	2%
Dystric and Vertic Gleysols	1%
Other Soils	13%

More recent work suggests that Arenosols also exist in Finland, consisting of weakly podzolised soils which were previously included with Podzols. Also, the area of Histosols may be smaller than previously assumed if the thickness requirement for organic layers is strictly followed. Data from typical soil profiles have also been supplied for the European Soil Profile Analytical Database.

Soil Mapping

The Geological Survey has published maps at scales of 1:100,000 and 1:400,000, and a summary map at a scale of 1:1,000,000. The Agricultural Research Centre published its early soil maps at 1:50,000 or 1:100,000 scales. Since the end of the 1940s, the scale of 1:20,000 has been used. In the maps of the Geological Survey, soil type to a depth of 1m is indicated whereas in agrogeological maps the soil type of the plough layer is primarily shown.

Table 1. Means of chemical characteristics of soils (n=1320) in 1987 and their differences from 1974

Parameter	Mean 1987	Difference from 1974	Change (%)1974 to 1987
PH (H_20)	5.75	+0.18***	
	(mg l^{-1})	**(mg l^{-1})**	
Bulk Density	0.90	0.00 NS	0.00
Org. C	9.0	+0.38 NS	+4.4
Ca	1278	+6.7 NS	+0.5
K	1019	+9.6***	+9.7
Mg	178	+2.9 NS	+1.7
P	10.3	+1.43***	+16.1
S	19.0	-	-
Al	508	+19.4 NS	+4.0
B	0.59	+0.3***	+61.5
Cd	0.080[a]	+0.019***	+31.1
Co	0.62	+0.10***	+19.2
Cr	0.33	+0.05***	+16.9
Cu	3.68	+0.90***	+32.2
Fe	717	+64.1	+9.8
Mn	57	-1.1 NS	-1.9
Mo	0.061	+0.013***	+27.1
Ni	0.90	-0.02 NS	-2.0
Pb	1.66	-0.31***	-15.5
Zn	3.70	-1.06***	-22.2
	10^{-4} S cm^{-1}	**10^{-4} S cm^{-1}**	
Elec. Conductivity	0.84	-0.11***	

[a] (n = 142) T-test: * = (P > 0.05); ** = (P >0.01); *** =(P > 0.001); NS not significant

The scale of mapping, following the collaborative agreement in 1972, was 1,20,000 in Southern Finland and 1:50,000 in Northern Finland (Anon, 1977). Separation of the mapping units is made with the help of aerial photographs, taking samples by auger for inspection and visual inspection of profile pits and cuttings. Additionally, soil samples are taken for laboratory analysis. Soil textural types are determined by particle size analysis using sedimentation procedures (Elonen, 1971). Organic matter was determined by wet and more recently by dry combustion methods.

Printed maps were produced during the early years of soil mapping but nowadays the soil information is stored in digital form, and maps produced for a specific area on demand. About one-third of the country has been mapped at a scale of 1:20,000 or 1:50,000 (Figure 1). About half the cultivated land, located mainly in the southern part of Finland, has been mapped. The proportion of till soils in the cultivated area is 16% and that of organic soils 18%. The area of cultivated clay soils is 20% and the coarse textured mineral soils make up the remainder.

Soil Monitoring

Early monitoring of soil pH and macronutrient levels in cultivated soils was carried out by Soil Testing Service Ltd. which reported the results at five-year intervals (Kähäri *et al.*, 1987). The data were based on samples sent by farmers to obtain recommendations for fertiliser use. On average some 80,000-100,000 samples were analysed annually. Today, with farmers participating in environmental programmes, the number of samples tested annually is much larger.

More comprehensive monitoring was started in 1974, when some 2000 samples were collected from all over Finland (Sippola and Tares, 1978). Samples were analysed for pH, organic carbon, calcium, lead magnesium, nickel phosphorus, aluminium, boron, cadmium, cobalt, chromium, copper, iron, manganese, molybdenum, sodium, strontium and zinc.

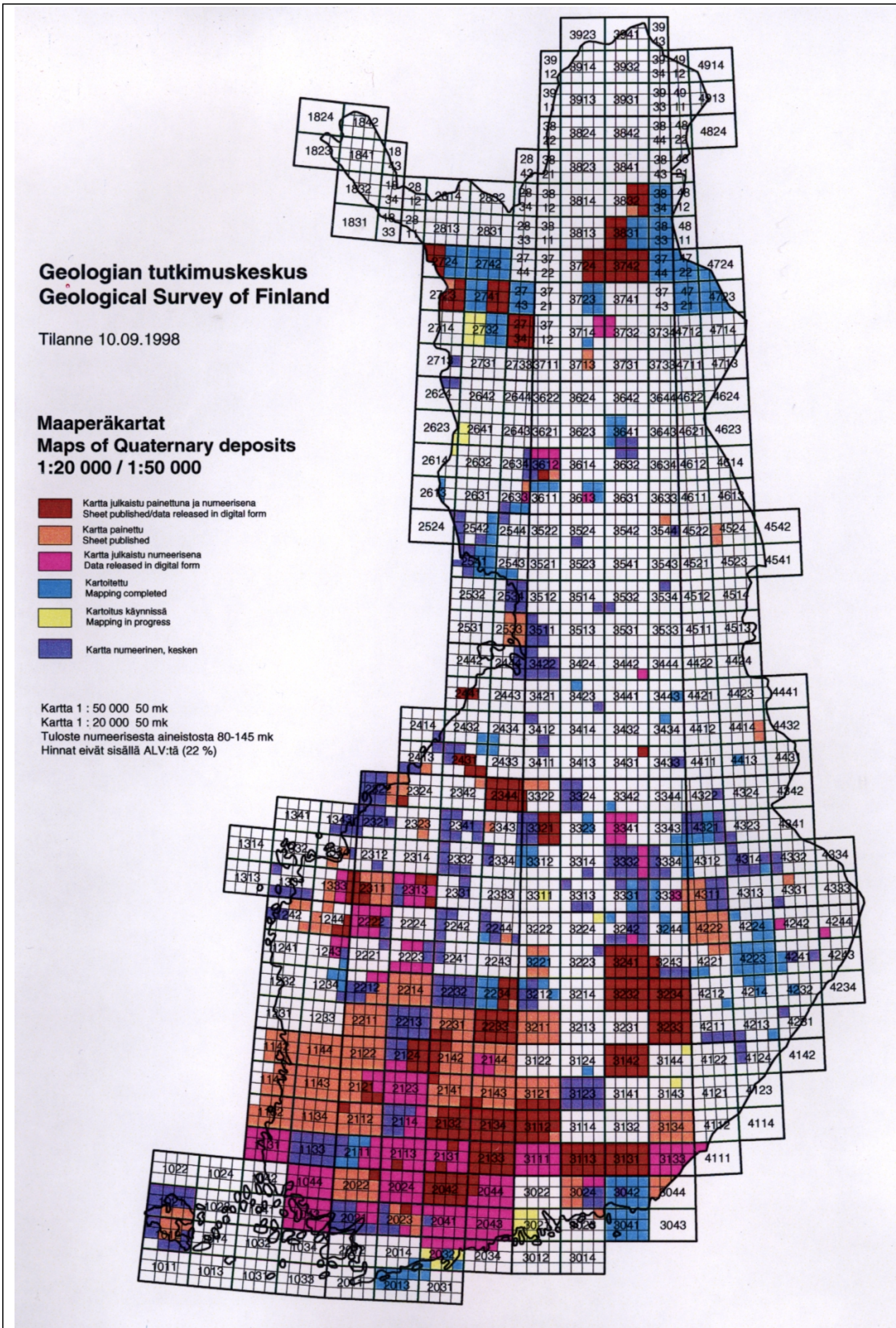

Figure 1: Maps of Quaternary Deposits in Finland

The acid ammonium acatate extraction method at pH 4.65 (Vuorinen and Mäkitie, 1955) was used to analyse for macronutrients and the acid ammonium acetate-EDTA method (Lakanen and Ervio, 1971) for micronutrients and heavy metals. Sampling was repeated in 1987 and this showed significant changes in contents of some elements compared with 1974 (Ervio *et al.*, 1990). Soil pH had increased over the period due to liming (Table 1).

Phosphorus and potassium had increased as a result of intensive use of fertilisers. Concentration of water extractable boron had increased due to general use of boron-containing NPK fertilisers. The extractable soil copper concentration increased by 32 %. This is most likely due to increased copper fertilisation which is needed especially on organic soils. No change in extractable manganese was observed despite the fact that manganese fertilisation is practised in some cases.

The concentration of extractable molybdenum increased by 27% which is assumed to be caused by the increase of soil pH due to liming. Soil zinc decreased by 16% over the period (1974-1987), due to plant uptake. Of the harmful elements, the concentration of cadmium increased due the use of cadmium-containing raw phosphate to prepare fertilisers in some of the years in the period. The concentration of lead decreased over the period, attributable at least in part to the more extensive use of unleaded petrol.

Soil Database

A database of the soil texture and organic matter analyses determined over the past years by the Agricultural Research Centre is currently being created. The dataset consists of texture determinations of some 28,000 samples. There is also the intention to store the chemical analyses of the same samples in the database. Data of larger research projects such as the Soil Monitoring Programme are already stored in the computerised database.

Applications of Soil Data

Soil maps are used in the inventories of natural resources like peat, sand, gravel and clay, in preparing thematic maps of soil vulnerability, and in land use planning. Most of the current uses in Finland serve soil and water protection with soil data being combined with other environmental data such as land use, topographic and ground water information. These uses have almost surpassed the traditional agricultural uses of soil maps.

Land use planning by different authorities is currently the basic use of soil data. Maps of soil vulnerability have been derived by combining soil maps and information on the hydraulic conductivity of the particular soil types. This information is needed when allocating land for different industries in land use planning in general and when approving or rejecting certain activities to be established in given areas. In these environmental assessments, soil information is used in combination with information on ground water reserves. The authorities are often faced with the fact that sufficiently detailed soil information (particularly in digital form) is non-existent in the area of interest.

Inventories of peat resources. The area of peatlands (peat layer >30 cm) in Finland is 7.2 million hectares (15% of land area). Combustion for energy is the major use of peat, and there are large power plants utilising peat in Finland. In horticulture, peat is used as a growing medium in greenhouses. Mires have been identified from maps, and further investigated for the volume of peat. Thematic maps of the peat reserves have been prepared (Lappalainen and Hänninen, 1993).

National inventories of sand and gravel resources have been made by Geological Survey of Finland on the basis of maps of Quaternary deposits.

Erosion risk and nitrogen leaching on a catchment scale have been modelled partly on the basis of 1:100,000 and 1:20,000 soil maps (Laine and Rekolainen, 1996) in Southern Finland and erosion and leaching risk maps have been prepared. In this approach, information from soil maps is combined with topographic and land use maps.

In this way, the impact of different measures (e.g. establishment of riparian buffer zones, use of reduced tillage) on water quality and nutrient loading from agriculture have been assessed. This information is needed in the development and implementation of the Agri-Environmental Support Programme under which farmers receive subsidies for carrying out measures to reduce agricultural loading of waters. There is a strong and increasing need for soil data for modelling of this kind of environmental impact assessment.

Acid sulphate soils cause acidification of coastal rivers particularly on the western coast of Finland, a problem that has been aggravated by intensified drainage. Acid sulphate soils have been identified in order to be able to assess the size of the problem and to direct the remedial measures in a cost-effective way. The potential areas of acid sulphate soils have been identified from soil maps, and the areas sampled and studied in more detail. Examples of such inventories, utilising soil maps, include those of the Kyrönjoki catchment (Erviö, 1975) and the Sirppujoki catchment (Palko *et al.*, 1985). Recently a national estimate of the area of acid sulphate soils was published (Yli-Halla *et al.*, 1999).

Agricultural uses of soil maps have been important particularly in the 1940's and 1950's when new land was intensively reclaimed for agriculture. Soil surveys by the Agricultural Research Centre of Finland were started in order to identify potential agricultural land areas, thus facilitating an increase in agricultural production as the need arises. Soil information has also been used in crop suitability modelling, providing a guide to the most suitable crops for a given area.

Existing soil information has been valuable in the selection of suitable representative sites for field experiments and knowledge of the properties and distribution of the soils has facilitated the uptake and application of research by the Extension Service. A range of agricultural management practices are required on the diverse soils of Finland.

The heavy clay soils in southern Finland are rich in potassium but fix phosphorus, properties which need to be taken into account in fertiliser practice. Organic soils, with their high nitrogen reserves and low pH, also require careful management. Soil maps play a fundamental part in the sustainable, productive use of land for agriculture.

Outlook

Despite the slow progress in collecting soil information in Finland, at present there is an ever-increasing need for such information. Soil information is of the utmost importance in the proper management of the environment and for supporting agricultural production into the foreseeable future. Computerised data handling and advanced techniques are now available but need to be supported with more detailed information so that reliable outputs can be made to provide a firm foundation for future land use in Finland.

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