Application of Soils Data to Land Use and Environmental Problems in Ireland

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Introduction

The National Soil Survey of Ireland was established within the Agricultural Institute in 1959. This marked the first real attempt to survey, classify and map the soil resources of Ireland in a systematic manner. From the beginning, modern scientific methods were used to classify the soils but emphasis was also placed on the interpretation of the results for agricultural development in particular and for land use planning in general.

The basic programme of land resource appraisal in Ireland has operated at three levels of organisation:

1. Detailed studies of experimental stations and also extension experimental sites (at 1:2,500 scale).
2. Detailed reconnaissance studies of counties (at 1: 126,720 scale) where the soil series is the unit of mapping.
3. A combination of detailed reconnaissance and general reconnaissance to derive a national picture, the General Soil Map of Ireland in 1969, at a scale of 1:575,000. The soil association is the unit of mapping.

The major emphasis in the soil survey programme was directed to detailed reconnaissance on a county basis. Soil mapping was carried out on maps of 1:10.560 scale, which were reduced to 1: 126,720 for publication (Lee, 1991).

Soil Mapping

Progress

Some 44 per cent of the country has been surveyed and mapped to date (Figure 1). Complete reports on nine out of twenty six counties have been published together with reports on a number of regions and districts. Fieldwork has also been completed in three counties, and also some work has been conducted in several other counties. Publications can be grouped into County Surveys, An Foras Taluntais (Agricultural Institute) Farms, Department of Agriculture Farms, other farms and miscellaneous areas.

The first Generalised Soil Map of Ireland was published in 1969 but the information for many areas was not very reliable. A 10-year programme was then started, the aim being to produce an improved version at the end of that period. This was achieved in 1980 with the publication of a second edition of the Generalised Soil Map (at 1:575,000 scale) together with an explanatory bulletin. A Peatland Map of the country together with an explanatory bulletin was published in 1979, at the same scale. In December 1988 a decision was taken to discontinue the field programme (Coulter *et al.*, 1996a).

Soil Database

The research programme at Johnstown Research Centre changed in 1988 from one that was mainly concerned with soils and land use to one mainly relating to environment and land use. A Soil Survey GIS programme was initiated in 1988 with a view to capturing existing soil maps in digital form to facilitate the environmental brief, and so that geocoded data collected in environmental surveys and experiments could be related to soil survey data.

ARC/INFO was chosen as the most appropriate GIS software because of its widespread use within soil research institutes in the European Communities, and because of its native Dbase data management system was most compatible with information technology standards in research centre. The programme involved digitisation of existing soil survey and related maps, creating databases of soil information and linking the digital maps and databases.

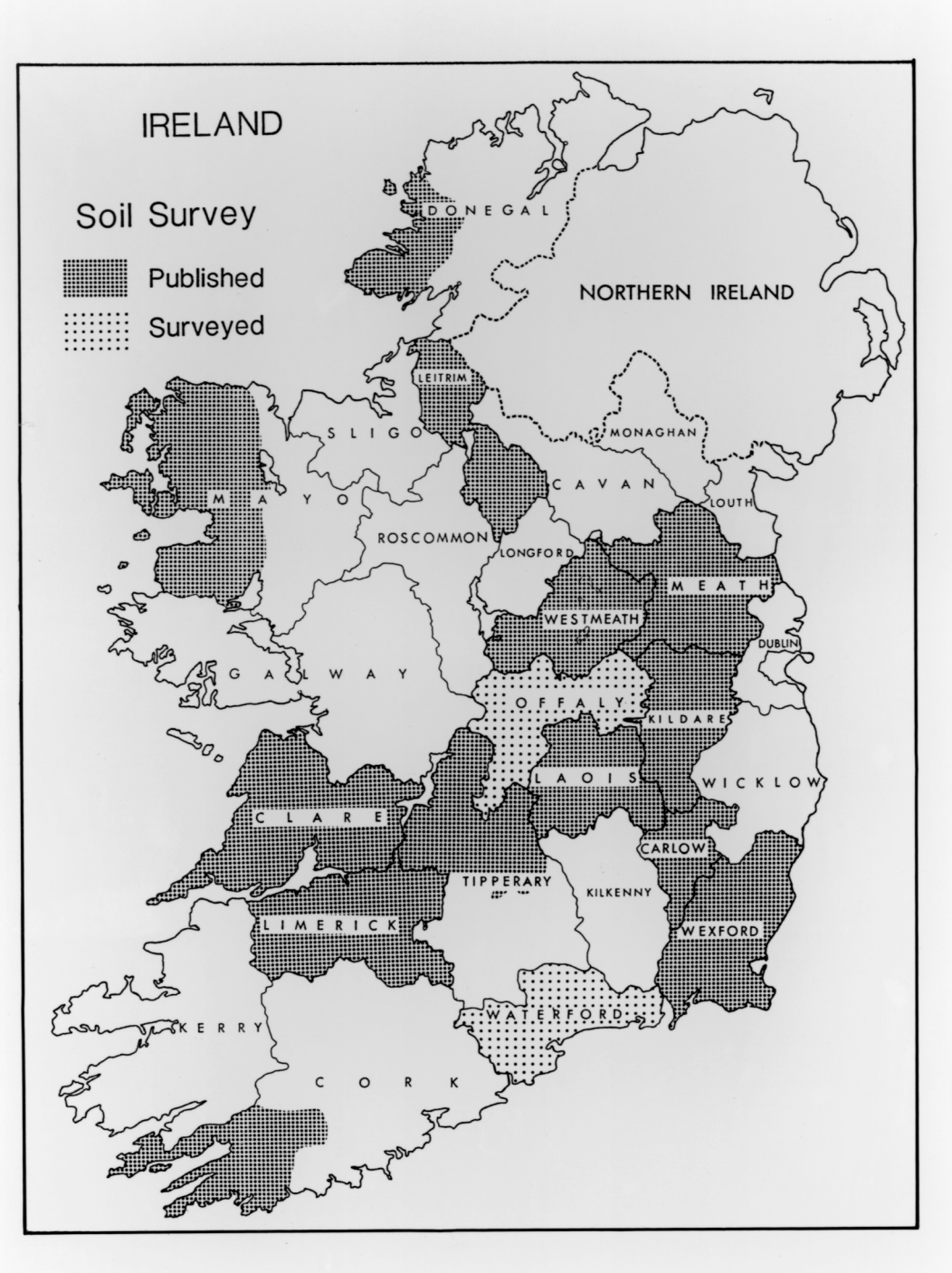

Figure 1: Progress of Soil Survey in Ireland.

The General Soil Map of Ireland published in 1980 at a scale of 1:575,000 (Gardiner and Radford, 1980a, 1980b) has been digitised, and a soil information base constructed. An earlier version of the General Soil Map of 1972 is also available in digital form from the EEA Task Force (CORINE) as part of the Digital Soil Map of Europe (Platou *et al.*, 1989) which was designed for printing at a scale of 1:1,000,000.

Applications of Soil Data

Soil Suitability for Waste Disposal

Quantitative assessments of soil hydrological regimes are required to reduce the risks in the design and management of waste disposal systems. Current research (Diamond, 1997) aims to measure

the soil hydrological regime at selected benchmark sites and to examine the relationship with soil morphological characteristics, e.g gleying, texture, structure.

Differences between soil series are evident, particularly in respect to poorly drained soil series. The results for these series imply a high run-off risk compared to the free draining soils in which the risk is negligible. This has serious implications for environmental risk management. The research has direct application to developing codes of good practice to minimise run-off of phosphorus from farmland, which has a significant capacity for water pollution.

Land Use Management

Ground water vulnerability maps have been derived from the digitised General Soil Map of Ireland and combined with data on diffuse sources of nitrogen (N) to provide a composite ground water nitrate pollution risk map for the country. Using GIS techniques, a methodological procedure has been developed to predict nitrogen from animal manures and chemical fertilisers and release by mineraliosation of organic matter of cultivated soils (Coulter *et al.*, 1996b).

The aim of the research was to develop a computer-based system incorporating land use trends, soil characteristics, topography, fertiliser usuage and major and minor nutrient levels, for use in monitoring and predicting those areas vulnerable to environmental pollution and to provide a basis for land use decision making. The initial phase of the research has concentrated on nitrogen/environment interaction and N inputs from livestock manures, chemical fertilisers and release by mineralisation of organic matter.

Uncultivated soils were considered to be the most significant sources of N with potential risk of losses to groundwater. A six-category system of susceptibility to ground water pollution was elaborated for the country. The most vulnerable areas were shown to be located in the south and east.

Areas of varying sensitivity of groundwater pollution from N have thus been defined. Similarly, there has been ongoing research to determine the susceptibility to phosphorus losses from farmland.. This information in turn has been important in the Nutrient Management Planning at farm level through the involvement of the advisory service. The research has also helped to identify those areas where monitoring of water should be concentrated.

Geochemical Survey

To date 295 soil monitoring points have been identified, in the south-eastern part of the country, representing 22% of the land surface of the country, and soil samples collected and archived. The soils have been analysed for agronomically important soil parameters and for a wide range of environmentally sensitive heavy metals and related elements including arsenic, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium and zinc. In addition the soils have been analysed for persistent organic chemicals including organo-chlorines insecticide and PCB residues. The results have been statistically analysed to determine means and frequency distributions, and maps produced showing spatial distribution of each of the measured components (McGrath, 1996).

It is anticipated that the information generated will be of use in the following areas:

1. *Food:* in the establishment of a credible database to assess and serve as a basis for the promotion of the cleanliness of food.
2. *Health:* to identify locations where there are excesses of heavy metals, in particular, cadmium and mercury, which can have negative effects on food quality and to delineate areas where there may be an excess of elements such as molybdenum and selenium, or a deficiency of copper, selenium and cobalt with deleterious effects on grazing livestock.
3. *Baseline information and waste disposal:* to provide the background information required for the evaluation of baseline surveys or for the disposal of wastes (eg. Sewage sludge) to soil.

Major and Trace Elements in Soils

Coulter *et al.* (1997) produced a National Report on the concentrations of major and trace elements in Irish soils which contains a series of distribution maps of such elements. The following are included: lime requirement (LR), potassium (K), copper (Cu), molybdenum (Mo), cobalt/total manganese (Co/Mn), zinc (Zn) and iodine(I). The Report includes both national and county maps showing element status averaged within 10 km^2 squares according to the national grid (Figure 2). The maps included were constructed from data collected between 1989 and 1995. The Report and maps have important practical applications for Extension Farm Advisers.

Other Applications

These have been described by Lee (1991) and are summarised below:

1. *Agricultural Land Classification:* A national map of livestock grazing capacity at a scale of 1: 575,000 has been produced together with a number of county maps at a scale of 1:126,720 of grass and cultivation suitability and grazing capacity. These have provided an invaluable base for planning land use production targets.
2. *Soil fertility research:* The Soil Survey has provided a framework for soil fertility research through the rational selection of benchmark study sites and the extrapolation of findings on nutrient responses to analogous areas. It also provides an important basis for delineating areas of trace element deficiency and toxicity with respect to plant and ruminant production.
3. *Regional planning and development:* Soil maps have been used to establish agricultural production capacity targets for planning purposes and for general land use strategy development. Examples include Strategy Development Studies for the South-West, North-East and Midland Regions and also the Leitrim, West Cork and West Donegal Resource Surveys.
4. *Afforestation:* A national generalised map of forest potential at a scale of 1: 575,000 has been produced as also have more detailed assessments at 1: 126,720 scale. These maps have been invaluable for land planning for forestry in Ireland.
5. *Drainage and reclamation:* The work of the Soil Survey has provided important information relevant to drainage design, such as depth and spacing of field drains and on the suitability of different drainage and reclamation techniques.
6. Disadvantaged Areas: The soil maps have been used to delineate difficult land areas qualifying for inclusion under the EC Disadvantaged Areas Directive.

The Future

Looking to the future, one of the main aims in Ireland is to continue the existing research programmes to establish a land information system based on soil, climatic, land use and agronomic data. This will provide better organisation and evaluation of available data for planning. It will aid decision making in the context of resource use and improve management at regional and farm levels, leading to improved technical efficiences.

The land information system will allow the development of a framework for modelling land use, waste management and fertiliser use systems based on a number of information technology modules. Generally the system will facilitate the effective transfer of information from research to a wide range of users.

The Need to Revive Soil Survey

Traditionally, soil survey in the Republic of Ireland has emphasised the genetic development of soils. The modern demand is for applied soil survey information gathered in a cost effective way to establish and manage targets. The chemistry of the soils in relation to phosphorus fixation and mobility and the use of models to predict soil moisture, leaching and seepage are obvious applications. These require a knowledge of fundamental soil properties such as mineralogy, soil moisture characteristics, permeability, etc. The traditional texture classification for fine grained soils must be supplemented by plasticity data.

Because in the course of soil survey some fundamental and dynamic properties of soil have been measured, the expected behaviour of soils under a range of management practices could be modelled. To complete this work would underpin public confidence in soil technology and in Teagasc as a provider of high quality reliable scientific data with a multi-purpose use.

Forest Soils Classification and Productivity

A major new project (Bulfin, 1998) has commenced with the following objectives:

1. To develop on a national basis a digital forestry soil classification and productivity ranking.
2. To provide the necessary soils information to the Indicative Forest Strategy, used by the Forestry Service in guiding the location and character of new afforestation at county, regional and national level.

GIS and remotely sensed data from digital air photography, Land Parcel Identification System, Digital Elevation Modelling and Drift Geology will be used to create Landscape Units with unique suites of soil. Existing soils information will be used to ‘train’ the satellite imagery procedures. The process will allow transfer from full soil mapping into areas with little soils information.

Environmental Risk Assessment for Agriculture

Due to production inefficiencies that all industries experience, agricultural practices can also adversely affect environmental quality. The probability, or relative risk, that these adverse impacts will occur is determined by a complex interaction among many factors, over some of which the farmer has little or no control.

Up to now there has been no rational procedure in Ireland to assess these interactions in a way that could provide advice to farmers, local authorities, and others for preventing or minimising the adverse effects of farming at specific locations.

New research at Johnstown Castle is directed towards changing this situation by developing a ranking procedure based on relatively easy to determine physical landscape features, farming practices, soils, land cover, weather and water resource network. The procedure incorporates topographical, hydrological, and soil type factors in addition to controllable factors such as levels of nutrient usuage, timing and method of nutrient application. An adequate soil database will be an essential prerequisite to the development of the system.

The Hill Environment

Due mainly to climatic and topographic factors, 85% of the hill and mountain soils of the west of Ireland are susceptible to erosion if overstocked. Low-level blanket peat is also susceptible to erosion. Approximately 23% of the total Irish sheep population of 8.5 million are in the hill sheep system. Research is required to ensure the economic sustainability of livestock production without detriment to the soil resource.

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