

Soils Research in Ireland – the future?

Discussion document outlining possible research structure and approaches in the short, medium and long terms

EurGeol Dr. Robert Meehan, PGeo.

Introduction

Soil is essential to life. It is literally indispensable as a source and sink of nutrients, water and genetic material, as a regulator of life cycles, as the habitat of most organisms and as the bearer of life above the ground. For every society, fertile soil, clean water for drinking and irrigation purposes, minerals and timber are the basis for survival. People will always use the soil, and it is crucial for society that it can continue to fulfil all its uses as well as possible and for as long as possible. Therefore soil is a priceless resource, which must be protected.

Ireland has a long tradition of human intervention to make soil usable – through cultivation, drainage, reclamation, fertilisation, peat cutting, raising and levelling soil levels, irrigation, ploughing and so on. The result is a countryside which is a palimpsest of past and current human activity, with a highly productive modern farming sector, a relatively low percentage of forestry, and expansive mountain and peatland landscapes. Soil management, particularly in the east of the country, was long geared to raising agricultural production and reclaiming and draining land to make it fit for human survival and habitation. In the 1970s and 1980s, attention countrywide turned to environmental matters in agriculture, particularly to diffuse and local water pollution (soils were not examined *per se* within this, but were the indirect pathway), acidification and eutrophication, with resultant programmes and measures in the field of prevention, research and remediation.

Though not explicitly stated as such in an Irish context historically, water and soil form subsystems within a larger whole, and should be managed as such. Land-use planning and management are important in harmonising soil capacity and vulnerability with human use functions. Nature, urban functions and agriculture are the main beneficiaries. This system approach intends a more integrated, area-specific strategy leading to more effective action with fewer unintentional side effects, fewer problems being passed down the line, and low levels of social stagnation as a result of fragmentation or compartmentalisation.

From this, future policy actions by Ireland in the medium to long term in the soils arena must;

- ensure that soil issues are taken on board in other policy fields
- ensure that owners and other title holders shoulder their responsibilities for the soil
- identify and chart problems with the soil across the Irish landmass
- inform the public about them
- ensure that appropriate measures are taken
- monitor the effects, and
- report on them.

The European Commission's initiative: 'Towards a Thematic Strategy for Soil Protection – COM (2002) 179 Final 16.4.2002 (Brussels)' states that

1) there are **two drivers within the soils research area**:

- a) to put soil at the same level of environmental importance and protection as air and water;
- b) to achieve the sustainable use of soil within Member States.

2) Further from this, there are **eight threats** to soil across the EU:

- a) loss of biodiversity;
- b) erosion (water and wind);
- c) decline in soil organic matter;
- d) contamination (local and diffuse);
- e) sealing, *i.e.* 'permanent' loss of soil due building *sensu lato*;
- f) compaction;
- g) salinization;
- h) floods and landslides.

The threats are not listed in any particular order as their relative importance and severity depends on many local and regional factors. Five of these threats will require risk assessment methodologies to identify areas at risk of each threat in member states.

In Ireland, these eight threats are present to differing degrees nationally, regionally and locally, and as a whole the Irish soil system is in a relatively healthy state. The threats are often interlinked, in that, for example, sealing soil can often later result in flooding. Ultimately they can cause soil degradation if not countered, and the soil can lose its capacity to carry out its normal functions. Therefore their minimisation in a practical sense is of the utmost importance.

Taking the threats one-by-one, **loss of soil biodiversity** is thought to be a serious problem in Ireland, especially with the increased use of non-organic fertilisers over the last fifty years. **Soil erosion**, which results in terrain deformation and/or loss of topsoil, is a relatively localised and small problem as our rainfall is evenly distributed and permanently or semi-permanently bare soil is rare across the country. The **decline in organic matter** is concentrated to a large degree in Europe in the arid and semi-arid areas only. **Contamination of soil** is well-publicised and researched with respect to certain topics in Ireland (*e.g.* nitrates), but lesser in respect to others (*e.g.* oil and petrol spills). **Soil sealing** is an exponentially growing problem on the outskirts of towns with the advent of the Celtic Tiger and the building of expansive swathes of housing estates. **Compaction** is a problem that nowadays runs hand in hand with much soil sealing in Ireland, as during the construction process 'green space' within and on the edge of built-up areas is often poorly treated and often becomes compacted by machinery. Compaction has also occurred in many areas of marginal, clayey land historically by keeping stock on the land for extended periods. **Soil salinisation** is not a major problem in Ireland, but does occur today in places where overexploitation of groundwater takes place close to the coast. It is not a regional or national scale soil issue, though, as it is in Mediterranean countries. Finally, **flooding** is a historical

problem on alluvial floodplains, lacustrine basins and turloughs in Ireland, and may be an increasing issue owing both to climate changes and sealing of soils around towns, particularly in gleyed areas. **Landslides** are also a topical issue in some areas owing to the perceived affects of climate changes.

Ireland has already had to take many measures in order to implement the recent Nitrates, NEC, Bathing Water and Water Framework Directives. In particular, water management authorities are currently engaged in implementing the Water Framework Directive. The European Strategy for Soil Protection will relate to the Water Framework Directive, particularly where groundwater, river sediment and sludge are concerned. From this, **soils research must take an integrated and holistic approach.**

Many of these aspects have been discussed extensively, during the last two years, by a large number of Soils Working Groups on behalf on the European Commission and Member States. The Draft Directive on Soil Protection was published in June 2006, with an implementation date scheduled from approximately 2008. It is important to keep in mind that much of the thinking in relation to the 'Thematic Strategy on Soil Protection', its application to the research arena and the any resulting Directive on Soil Protection will take into account the DPSIR (Driver-Pressure-State-Impact-Response) Framework. The European Commission sees the framework as a very useful tool in the broad environmental policy context.

The Future Structure of Soils Research – A 'Soils Research Platform'?

Soil science education in Ireland historically was the domain of the Faculty of Agriculture at University College Dublin, at the undergraduate and graduate levels, while applied soil research was the focus of the National Soils Research Centre at Johnstown Castle, now part of Teagasc. Soil-related research and education is also currently pursued at the University of Limerick and on an *ad hoc* basis in other University Department and public bodies. Often, research in other physical sciences in Ireland takes into account soil conditions and models soils-water-geology interactions, but this is not explicitly thought of as 'soils' research.

With the advent of the Environmental Protection Agency in the early 1990s and EU Environmental Policy at the time, funding was released for large-scale soils research in Ireland for the first time. Several projects were initiated (*e.g.* National Soils Database) and others which had started with a separate applied purpose (*e.g.* the FIPS-IFS Project) were remoulded and acquired different foci in order to maximise their environmental use. In the medium to long term, given the Water Framework Directive and Soils Thematic Strategy, much more funding will be available. The EPA will fund projects over the next few years but at this juncture rather than proceeding in a piecemeal fashion a Soils Research Platform is now required, the process of which should begin with the inception of an advisory forum and (possibly) several steering groups on soils research in Ireland. This should involve major stakeholders and research institutions, as well as a sizeable governmental presence from several departments and regional authorities.

The approach required is therefore a 'top-down' approach, with the EPA at the head (with strong links to Teagasc, academic institutions and other academic and government bodies), rather than the previous 'bottom-up' approach to soils research, which researched on a reactive, institution-by-institution basis, rather than in a planned, coherent, and proactive manner. This will enhance expertise by co-operation and dissemination of ideas and information.

The Research Platform would co-ordinate and plan soils research in Ireland, as well as carrying out and managing much of the research and disseminating information to the public, to soil 'managers', to academic institutions, and to government departments. The Platform would include members of the following (the list is suggestive and not exhaustive) ...

- Agricultural Science Association
- An Bord Pleanála
- An Taisce
- Birdwatch Ireland
- Bord na Mona
- Central Fisheries Board
- Coillte
- Department of Agriculture
- Department of Arts, Heritage and the Gaeltacht
- Department of Communications, Marine and Natural Resources
- Department of Education and Science
- Dúchas
- Environmental Protection Agency
- Geological Survey of Ireland
- Inland Waterways Association of Ireland
- Institute of Archeologists of Ireland
- Institute of Engineers of Ireland
- Institute of Geologists of Ireland
- Irish Creamery and Milk Suppliers Association
- Irish Farmers Association
- Local and Regional Authorities
- Marine Institute
- National Parks and Wildlife Service
- National Roads Authority
- Office of Public Works
- Radiological Protection Institute of Ireland
- River Basin District Management
- Soil Science Society of Ireland
- Teagasc
- The Forest Service
- The Heritage Council

A critical element of the Platform is that all relevant institutions have a representative on it, in order to prevent a situation where a few individuals solely influence the research direction, and that all interested and active in Soils Research in this country have a viable say.

The Research Platform should be initiated as soon as possible and the research management structure and research plan copper-fastened, and this should be before the next EPA call for research proposals. Duplication of work effort must be minimised in the future and proper planning is essential. Therefore one of the first tasks for such a centre would be an audit of current and past soil research in Ireland and a recommendation of ways to improve co-ordination and communication in soil research throughout the environmental community. Looking at current research on the threats identified above, for instance, three major research projects and initiative are currently up-and-running 'outside' the Irish Soils 'arena'. The Office of Public Works are currently working on a major National Flooding Study and GIS system, as well as an applied project mapping Base Flow Index from Soils countrywide (Catchment Hydrological Models). The third project involves the Landslides Working Group of the Geological Survey of Ireland, which has carried out research

on landslides and landslide susceptibility mapping, as well as drafting a major submission to government for research funding over the medium to long term to eventually incorporate landslide risk into the planning process. In the broader context, an aim of the Soils Research Platform should be to ensure that in the future, other government departments and academic institutions build consideration of soils into their procedures and research, and that research efforts are not duplicated and efficiency is maximised.

The Platform should evaluate the overall success of the EU Soil Thematic Strategy, against its stated aim and objectives, every five years, as well as the Platform's own research and future goals. It should ensure that legislative and other actions of EU Soil Thematic Strategy are appropriate to Irish soils and the pressures on them.

The EPA Soils Research Platform should host all Irish Soils data in a GIS database (including the Digital Soils Map and National Soils Database currently being researched, the recently completed EPA Soils and Subsoils Maps, climate, land use and land cover data, bedrock geology, DEM, geomorphology, habitats *etc.*), and should initiate a programme of education and awareness on soils for the general public, those working with soils, and soil 'managers'. This could be begun by the inception of a website (similar to www.wfd.ie for the Water Framework Directive); this 'Irish soils' website would not only inform on soils policy but illustrate types of soil, have a GIS viewer to generate soils data maps, list current research, have a schools section as well as information for soil scientists, geographers, land use managers, teachers and students, planners, and be up-to-date with 'soils in the news' articles (the current Farmers Journal does this indirectly on a weekly basis, but it should be made explicit to soils!).

As well as this, the Platform could initiate and co-ordinate the acquisition of specialised equipment specifying that this resource is shared by projects across universities and research institutions, and facilitate a better integration of research resources nationally.

The Research Platform should increase an understanding of soils issues through Regional and Local government structure, and eventually devise a proper consideration of soil implications during the planning and development process in the building regulations. In an ideal world soils that should be protected from building should be designated, and the Strategic Environmental Assessment of each planning authority, which is supposed to include soil, should happen definitively and be better informed. This could only be achieved, however, at a detailed level with the eventual completion of a National Soil Survey using field mapping techniques.

In the medium to long terms, the Platform should improve communication throughout the soils community and establish training and education programmes to re-build Ireland's national capacity in Soil Survey and associated research. Furthermore, consideration must be given to examining the incomplete nature of soil datasets within the country. The Platform should review its medium to long term research policies every five years.

Soil monitoring requirements and the Research Platform

Monitoring long and short term changes to soil forms an important component of the process of setting soil policy objectives and targets and tracking progress towards achieving them. Developing our scientific understanding of the way soils function in the environment, and how soils affect, and are affected by, human activities is also an important goal.

Two key areas for examination, research and development by the Soils Research Platform are:

- Improve coordination of soil research by carrying out an audit to assess the current state of research activity as a whole, identify gaps and overlaps and make recommendations for future actions.
- Develop a key set of indicators for monitoring, and a new soil monitoring network ... baseline ! (e.g. nitrate and phosphorus losses from agriculture, phosphorus levels in agricultural topsoils, organic matter content of agricultural topsoils, accumulation of metals in agricultural topsoils, area of agricultural land, change in land use from agriculture to development, area of agricultural land under commitment to environmental conservation).

Soil mapping issues and the Research Platform

Issues for consideration in the medium to long term by the soil research platform are:

- Should Irish Soils be classified as they have been historically, or should we adopt the World Reference Base?
- Should more emphasis be placed within mapping and modelling on soil physical properties, and the use of techniques such as geophysics to gather these data?
- Should the soil survey be reborn?
- Should we begin to pay more attention to our urban soils?

Specific issues with respect to soil in Ireland

The following section details current pressures requiring research in the short to medium term; broader ideas for future, long term soils research are detailed towards the end of the document. Some of the projects listed are basic, short term research projects in terms of time allocation (potential Masters Thesis or PhD studies. Others are more long term, 'five year or more' 'large scale' applied research schemes involving several workers and/or institutions.

Pressures on the extent of soil resource (erosion, sealing, salinisation, floods and landslides).

It is our objective to manage the extent of our soil resource in ways which ensure we can meet our present and future land use needs.

The volume of soil in Ireland is being lost in three ways:

- Loss of soil through development for housing, industry and infrastructure. This sealing is almost irreversible in terms of blocking geochemical and water cycles within that patch of soil.
- Loss of soil through erosion
 - Agricultural erosion in arable areas. This is unquantified but the exposure of soil for part of the year means losses through runoff during heavy rainfall.
 - Upland erosion on peatlands, mainly in the west of Ireland.
 - Coastal erosion.
- Loss of soil through extraction
 - Minerals, including quarrying and sand/gravel extraction
 - Peat and,
 - Topsoil.

Much work has been completed recently by Teagasc, Athenry on the upland peat erosion in the west, and the Geological Survey of Ireland (GSI) are involved in the EUROSION Coastal Zone Management Project. The Landslides Working Group mentioned earlier is co-ordinating future landslide research in Ireland.

Key areas for research on soil loss include:

- A project on best practice guidance on mineral working, reclamation and restoration in relation to topsoils (in conjunction with GSI?) (POTENTIAL Masters PROJECT 1);
 - A study on compaction, and its impacts, through drainage of land by mole ploughs (POTENTIAL Masters PROJECT 2);
-
- A literature review to identify the knowledge gap with respect to erosion, and subsequent quantification of arable soil loss to erosion, and resulting best practice guidelines for agriculture, forestry and horticulture (and possibly a general code of good agricultural practice w.r.t. soils) (POTENTIAL PhD PROJECT 1/1a);
 - A quantification of areas of soils 'sealed' by construction, between say 1990 and 1995, 1995 and 2000, 2000 and 2005, using remote sensed aerial photograph imagery, as well as a quantification of the various categories of soil types 'sealed' within this (POTENTIAL PhD PROJECT 2/2a);

- A project on soil scalping. The extent of scalping is currently not known, and it is a very important threat not explicitly stated as part of the Framework Directive (POTENTIAL PhD PROJECT 3);

-
- Predictive modelling of hydrology of soil types, as well as land use and climate change interactions and their modelled impacts on these soils (greenhouse gas emissions, catchment hydrology *etc.*). This research must be approached by linking climate models, soils, predicted land use change, and socio-economic scenarios (POTENTIAL LARGE SCALE PROJECT A).

A practical goal in the longer term might be to limit unnecessary development of greenfield areas and work towards target of an average of 60% of additional housing in Ireland provided on previously-developed land or through conversions and ‘building up’ rather than ‘building out’.

Further from this, a zonation of areas suitable for extraction should be completed for the entire country. The GSI has completed Minerals Potential Mapping for Donegal and Meath, and the respective local authorities have incorporated these into the County Development Plans and, in Meath, their Strategic Environmental Assessment. Local authorities should also compliment construction and topsoil removal with storage and re-use of topsoil, and manage soil resources before, during and after extraction.

In the medium to long term, research on generating new soils from organic waste and by-products of quarrying might be required.

Pressures on soil diversity (loss of biodiversity, decline in soil organic matter, contamination, sealing, compaction, salinisation, floods and landslides)

The diversity of soils should be managed, concentrating particularly on our most valued soils, so that the right balance of soil types is available to meet current and future needs for soil to support our ecosystems, landscape, agriculture and cultural functions.

Ireland has a diverse range of soils, supporting a wide variety of ecological, landscape, agricultural and cultural functions. We have a variety of different measures to ensure that we maintain this high level of diversity.

The key measures already in place are:

- Legislation for designating and protecting valuable ecosystems, sites and landscapes; and
- Planning controls to protect archaeological sites.

Key areas for research with respect to soil diversity are:

- Research and publish a document on the role of soil management and protection in SACs, NHAs and SPAs (POTENTIAL Masters PROJECT 3);
-

- Within the implementation of Irelands National Biodiversity Plan, identify an initial list of biological and biochemical indicators of soil functional diversity (POTENTIAL PhD PROJECT 4);
 - Draw up a national series of benchmark sites for soil biodiversity, cross referenced with the SACs, NHAs, SPAs, and sites of geological and geomorphological interest (POTENTIAL PhD PROJECT 5);
 - Examine soil quality indicators for each of these sites (POTENTIAL PhD PROJECT 6);
 - Develop robust indicators and soil management guidelines to monitor and maintain functional biodiversity in soils (POTENTIAL PhD PROJECT 7).
 - A study of the role of roots in soils, and their characteristics and variations (POTENTIAL PhD PROJECT 8);
-

- Following the research work on soil keystone species, relate the keystone species list to patterns in the occurrence and diversity of the soil organisms within the countryside reflecting differences in habitat, soil type or soil pH, pollutants, carbon content, texture *etc.* This should include work on the basic microbial diversity and functioning of soils, possibly examining molecular biological techniques (metabolomics) or stable isotope techniques. (POTENTIAL LARGE SCALE PROJECT B).
- Within this large scale project, research to quantify roles of soil biodiversity and soil function and the impacts of various types of human activity on these roles (POTENTIAL PhD PROJECT B1);
- Derive a soils functions map of Ireland? (POTENTIAL PhD PROJECT B2).

This area is of international importance with respect to soils research.

Given the importance of biodiversity and heritage in the general media, the publication of this work through articles in popular media and on the website, as well as other general publicity in this area, would be of utmost importance. The biodiversity/heritage areas is a topic that most Irish people have some knowledge of, but its elevation to a priority action with respect to our **soils** natural heritage, and the wide-reaching publicity of such, is of critical importance.

Pressures on soil quality (loss of biodiversity, decline in soil organic matter, contamination, sealing, compaction, salinization)

It should be an objective of the EPA “to maintain and improve the quality of our soils in ways which ensure we can meet our current and future social, environmental and economic needs”.

The main measures already in place for tackling these problems are

- Legislative controls to prevent soil pollution, for example the Integrated Pollution Prevention and Control system.
- Encouraging good soil management practices. Research into these areas have been ongoing in Ireland, particularly through the work of Teagasc’s Johnstown Castle Research Centre, for the last twenty years.

Key areas for research include:

- Research into the drawing up for local authorities of an inspection strategy setting out how they will go about investigating their areas for contaminated land, and a code of good practice in dealing with contaminated land (POTENTIAL Masters PROJECT 4);
-
- A project examining biosensors in soils (*e.g.* phosphate which is chemically complex, and not available to plants) (POTENTIAL PhD PROJECT 9);
 - A project examining the presence and effects of xenobiotics in various Irish soils (POTENTIAL PhD PROJECT 10);
 - A project looking at the % nitrogen available for uptake in soil/plants within composts derived from waste materials (POTENTIAL PhD PROJECT 11);
 - Research into contaminated land under leaking domestic oil tanks, and the associated reduction in soil biodiversity and biochemical function (POTENTIAL PhD PROJECT 12);
 - A study to improve information about for human health risks from contaminated land by researching and publishing new generic guideline values for certain contaminants (POTENTIAL PhD PROJECT 13);
 - A National Inventory of Contaminated Sites and, where this has happened, remediation measures taken (POTENTIAL PhD PROJECT 14);
 - With respect to the sewage sludge directive ... should research be conducted to make sure that application does not impair the long term functioning of soils ... and is similar research necessary for Landfill Leachate, and Septic Tanks (POTENTIAL PhD PROJECTS 15, 16 AND 17)?

- Research should ensure that the return of organic matter to soil in BioWaste Directive should respect natural diversity of soil (POTENTIAL PhD PROJECT 18).
 - Research into the presence of heavy metals and veterinary residues in soils, and their effects (POTENTIAL PhD PROJECTS 19 and 20).
-

- Continue research into nutrient flows and attenuation capacities of the various Irish soils, the relationships between farm soil management practices and physical characteristics, emission scenarios and functions of soils, and especially the physical, chemical and biological aspects of these in an integrated research project (POTENTIAL LARGE SCALE PROJECT C).
-

Summary

Overall, there seems to be a need for several strands of immediate research interest; into the extent, diversity and quality of the soil.

Three large scale, multi-institutional and multi-annual research projects (A – hydrology/climate change/land use modelling; B – microbial diversity and functioning of soils; and C – nutrient flows and biological/chemical/physical attenuation modelling) are suggested. These should be carried out on sites controlled by stakeholder agencies, such as *e.g.* Teagasc, Coillte, Bord na Mona, and should be focussed on long term monitoring and modelling of changes to soils following the initial characterisation and collection of detailed data on the soils, and their functioning, on these sites.

These would have many spin-off detailed, focussed research topics, to be examined as PhD's; two are suggested for the large scale microbial project. As well as these, twenty PhD projects and four Masters Projects focussing on specific themes are suggested.

The soil strategy should be re-evaluated every five years; and further work on indicators for monitoring and reviewing and developing a new soil monitoring network should be carried out. Initially, an audit to assess the current state of research activity into soils as a whole should be conducted.

It is also recommended strongly that all of these developments be channelled through a Soils Research Platform, to be formed by the EPA and stakeholders. This would combine the strengths of several organisations under the EPA's umbrella, with a remit is to focus on soils research and education, and environmental modelling with other natural science agencies.