International Innovation

Disseminating science, research and technology

POSEIDON

PERSISTENT EFFECTS OF SUBSOIL COMPACTION ON SOIL ECOLOGICAL SERVICES AND FUNCTIONS

PredICTor

PREPARING FOR THE EU SOIL FRAMEWORK DIRECTIVE BY OPTIMAL USE OF INFORMATION AND COMMUNICATION TECHNOLOGY ACROSS EUROPE

European Soil Bureau Network

| November 2011 |

Compacting **knowledge**

Thomas Keller from the Agroscope Research Station ART Switzerland and the Swedish University of Agricultural Sciences, and **Per Schjønning** from Aarhus University, Denmark tell us about the intersection between the POSEIDON and PredICTor projects, and what it means for the future of soil quality in Europe

What inspired your research on soil compaction, and the creation of this initiative?

PS: The European Commission suggested a Soil Framework Directive (SFD), including regulation of soil management in order to cope with a range of threats to sustained soil quality, including compaction. As scientists we need to compile the necessary knowledge for the implementation of the SFD. Some researchers advocate that compaction is fine as long as functions such as water permeability are sustained. I don't support this view, but instead adhere to a 'precautionary principle' because we are dealing with persistent effects on a very complicated ecosystem. We need better knowledge of more subtle functions of soil, and better understanding of the compaction process and the impact of soil deformation on soil functions to deal with this dilemma.

What is the fundamental purpose of the POSEIDON project?

TK: The POSEIDON project aims to quantify the extent to which subsoil compaction is persistent. Moreover, we study effects of soil compaction on the architecture of the soil pore system, and the impact that compaction has on transport of water and solutes through the soil, as well as on microbial activity, gas transport and emission of greenhouse gases.

THOMAS KELLER

PER SCHJØNNING

What are the core objectives of the PredICTor project?

PS: The PredICTor project collects knowledge with the purpose of facilitating precautionary measures against subsoil compaction. One purpose is to create an online decision support tool allowing any farmer to evaluate the risk of compaction when loading soil at a specific water content with specified machinery. Another planned outcome is to create maps of Europe showing which wheel loads (for tyres and inflation pressures) can be carried by European soils at specified water contents. We see this as an input to the implementation of the SFD.

What is the nature of the collaboration between the POSEIDON and PredICTor projects?

PS: In a modern network society, a combination of basic soil science with other research disciplines and stakeholders is necessary to put knowledge into work. The partners participating in the POSEIDON and PredICTor projects together form the necessary 'research chain' including soil scientists, agricultural engineers, geographers and ICT experts.

TK: In POSEIDON, basic studies of long-term effects of subsoil compaction on soil functions give a solid basis for the tools for use by farmers and stakeholders to help prevent compaction developed in PredICTor.

Have you employed any of the strategies or tools developed by PredICTor? How will these technologies help farmers to avoid and overcome soil compaction?

TK: We have conducted initial work in Switzerland and Denmark. We are about to release a test version of our soil compaction assessment web tool Terranimo® to a limited

It's down to earth

Changing climate patterns could have damaging effects on soil, with repercussions across the agricultural landscape. **POSEIDON** and **PredICTor** are two projects helping to secure the future of agriculture in Europe by examining the threat of soil compaction

number of farmers, contractors and people from the agricultural industry.

PS: Such a tool can help farmers estimate the risk of soil compaction of various field operations, and to select the most appropriate machinery for given soil conditions. The tool can be used for comparisons, for example when investing in new machinery or tyres. Long term, farmers can optimise soil management practices with regard to soil compaction.

What would you define as the biggest success of your research to date?

PS: POSEIDON results show that soil may actually be compacted to 90 cm depth by commonly used agricultural machinery, and these effects on soil functions persist for at least 15 years. Such data is highly valuable as it urges scientists, and society, to further address the compaction problem.

TK: PredICTor has only just started, so the tools are still developing. We have made progress in soil compaction modelling thanks to our collaboration, which includes the POSEIDON project.

How do you see your studies developing in the future?

TK: Soil is very complex, so there is still more we need to understand about soil deformation and its effects on various processes, such as water flow and transport of solutes and colloids.

PS: We also need a better understanding of the soil mechanical processes, such as stress transmission in structured, heterogeneous soil. We have some ideas for research projects, and hope to get them financed in the near future.

TK: We also want to make progress in the use of ICT to develop improved decision support systems by combining models with sensors in the soil or on machinery and with digital soil maps.

IN TERMS OF maintaining agriculture and the environment it is easy to overlook one of the most important factors: soil – a complex and important element of regulating water and chemical fluctuations between the atmosphere and groundwater. Vital economic, environmental, and human health issues are also linked to the biophysical properties and functionality of soil. Soil quality is under increasing pressure – metaphorically and literally – due to population growth and the subsequent increase in agriculture. Soil compaction, which reduces soil quality (for instance, through reducing its capacity for the infiltration of water) is therefore a major threat not only to agriculture, but also to human populations and the environment. This problem is further exacerbated by the threat of climate change. Soils are more susceptible to compaction when wet, and with rainfall predicted to rise, this could lead to problems for farmers in the future.

The POSEIDON project sees researchers from Aarhus University (Denmark), the Swedish University for Agricultural Sciences (Sweden), Helsinki University and MTT Agrifood Research (Finland), the Norwegian University of Life Sciences (Norway) and Agroscope Research Station ART (Switzerland) coming together to tackle this problem, which is predicted to particularly affect the Nordic region and its agricultural sector. "Soils are most susceptible to compaction when they are wet, and we have a humid climate in the Nordic countries," explains POSEIDON leader, Per Schjønning. As such, the project is receiving funding from Denmark, Sweden, Finland and Norway as mediated by the Nordic Joint Committee for Agricultural Research.

UNDER PRESSURE

The main aim of POSEIDON is to study subsoil compaction effects on soil pore structure, associated with transport processes and denitrification. Subsoil compaction is primarily caused by the use of heavy agricultural machinery. Due to modern farming techniques, machines with wheel loads of up to 10 Mg are used. The consequences of this industrial process are crop yield loss and changes in soil pore functioning, with potential impacts on a range of processes, such as soil erosion, leaching of nutrients and pesticides into water bodies, and emission of greenhouse gases.

Results obtained by POSEIDON already indicate that soil functions in the subsoil are still negatively affected more than a decade after compaction in this way, and it has been estimated that some 30 million hectares of arable land in Europe suffers from similar degradation due to soil compaction.

The influence on the environment is not easily quantified, but it is clear that compaction has impacts concerning phosphorus leaching from agricultural land to water bodies such as the Baltic Sea. The economic damage can be seen in the reduction of crop yields, increased fuel consumption due to increased draught requirement of tillage implements, and soaring fertiliser costs due to reduced nutrient use efficiency.

OUT IN THE FIELD

POSEIDON is conducting experiments in various sites of different soil composition across the Nordic region. POSEIDON aims to study the long-term effects of compaction and has therefore selected some sites that have been compacted between 15 and 30 years prior to the investigation. One site in southern Sweden is on a loam soil and has been subjected to different treatments, including traffic with a six-row sugar beet harvester (total load 35 Mg), and a control plot with no traffic. Another experiment has been conducted in Jokioinen in south-western Finland

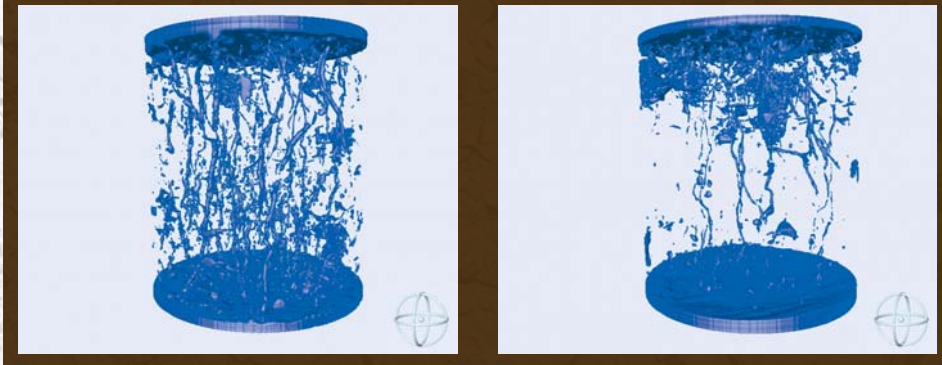


FIGURE 1. Macropores > 0.6 mm in undisturbed soil cores (20 cm height, 20 cm width) collected at 25-45 cm depth in a loamy soil in Skåne, Sweden, with standard management (left) and compacted by a heavy sugar beet harvester 14 years prior to sampling (right). Digitized pictures created from CT-scans by Dr Dorthe Wildenschild (Oregon State University, U.S.).

POSEIDON

PERSISTENT EFFECTS OF SUBSOIL COMPACTION ON SOIL ECOLOGICAL SERVICES AND FUNCTIONS – WWW.POSEIDON-NORDIC.DK

PredICTor

PREPARING FOR THE EU SOIL FRAMEWORK DIRECTIVE BY OPTIMAL USE OF INFORMATION AND COMMUNICATION TECHNOLOGY ACROSS EUROPE – WWW.SOILCOMPACTION.EU

PARTNERS

POSEIDON and PredICTor:

Aarhus University, Denmark • **University of Helsinki**, Finland • **MTT Agrifood Research Finland**, Finland • **Agroscope Reckenholz-Tänikon Research Station ART**, Switzerland

POSEIDON only:

Swedish University of Agricultural Sciences, Sweden • **Norwegian University of Life Sciences**, Norway

PredICTor only:

Institute for Agri Technology and Food Innovation, Denmark • **Copenhagen University**, Denmark • **Swiss College of Agriculture**, Switzerland • **Martin Luther University Halle-Wittenberg**, Germany • **Alterra Wageningen UR**, The Netherlands

FUNDING

POSEIDON and PredICTor:

Danish Ministry of Food, Agriculture and Fisheries, Denmark • Finnish Ministry of Agriculture and Forestry (MMM), Finland

POSEIDON:

The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas), Sweden • The Research Council of Norway, Norway

PredICTor:

Swiss Federal Office for Agriculture (FOAG), Switzerland

CONTACT

Dr Thomas Keller
POSEIDON national coordinator of Sweden; PredICTor national coordinator of Switzerland

T +41 44 377 76 05
F +41 44 377 72 01
E thomas.keller@art.admin.ch

http://www.slu.se/en/faculties/nl/about-the-faculty/departments/department-of-soil-and-environment/research/soil-and-water-management/staff-at-soil-and-water-management/thomas-keller/

Senior Scientist Per Schjønning
Project leader of POSEIDON and PredICTor

T +45 89 99 17 66
F +45 89 99 12 00
E per.schjonning@agrsci.dk

http://pure.au.dk/portal/en/persons/per-schjoenning(35778104-b940-4139-a309-5dcda94363e4).html

THOMAS KELLER (b. 1974) is a scientist in Soil Science at the Agroscope Research Station ART, Department of Natural Resources & Agriculture, Zürich, Switzerland, and at the Swedish University of Agricultural Sciences, Department of Soil and Environment in Uppsala, Sweden. He earned his PhD in Soil Science from the Swedish University of Agricultural Sciences in 2005.

PER SCHJØNNING (PSC, b. 1953) is a senior scientist in Soil Physics at Aarhus University, Department of Agroecology, Denmark. He graduated from the Royal Veterinary and Agricultural University, Copenhagen, as an MSc in agronomy and soil science in 1980. PSC's research focuses soil management effects on soil quality properties, in particular soil compaction and the decline in soil organic matter.

POSEIDON staff from Aarhus University measure mechanical stresses in the soil profile during traffic with a 25 m^3 slurry tanker together with the tractor weighing a total of >50 tonnes.

on heavy clay, where the experimental traffic was applied with a tractor-trailer combination; the trailer with a tandem axle load of 19 tons.

The work also includes measurements in recently compacted soil profiles, which have been created specifically as part of the project. Replicated field plots are loaded with high yet realistic wheel loads. These new compaction experiments are located in Denmark on sandy loam soil and in Sweden on a clay soil. This will serve as a direct study of the relationships between soil stress due to mechanical loading, and soil deformation and associated changes in soil pore functioning.

Some measurements are made directly at the sites, and undisturbed soil cores are collected from the field. Further measurements are then taken in the laboratory, examining factors such as hydraulic conductivity and gas diffusivity. Some samples are subjected to computerised tomography (CT) scanning, in order to visualise the structure of the pore system. The project members also perform infiltration experiments with dyed water in order to visualise and describe the flow pattern in compacted versus non-compacted soil profiles. Emission of greenhouse gases from compacted and non-compacted plots are also measured every 2-3 weeks over a period of one year.

Measuring gas emissions from soil in a compaction experiment in southern Sweden.

PREDICTOR PARTNERSHIP

The POSEIDON project is intrinsically linked to a second project, PredICTor, which aims to help deliver the findings of POSEIDON to those who will benefit most from the project. PredICTor is funded as an ICT task under the European Commission's ERA-NET for ICTs and Robotics in Agriculture and related Environmental Issues, and has two main tasks. The first one is to deliver an online decision support tool for evaluating an intended field traffic situation for any given soil condition and with given machinery, which intends to benefit farmers and agricultural advisers. The second deliverable is concerned with the construction of an online tool for creating pan-European maps of the carrying capacity for wheel loads – defined as the maximum wheel load the soil can carry at given soil moisture conditions and for a given tyre and tyre inflation pressure – which should be useful for agricultural authorities and soil protection offices. The PredICTor project results will be made available to the public, with both online tools accessible for all public authorities and citizens worldwide.

The results of both projects will be presented at international scientific conferences and disseminated in peer-reviewed papers in international journals. There are also plans to produce popular-science communications for helping the end-user in using the tools. A symbiotic relationship between these two projects should ensure the aims are met – with POSEIDON continuing to investigate the causes and persistency of soil compaction on soil functioning, while PredICTor develops the tools that can help farmers, contractors, and others working in the agricultural sector, as well as policy makers, to avoid soil compaction, and thus tackle yet another threat potentially exacerbated by climate change.

International Innovation

Disseminating science, research and technology

ResearchMediaLtd

Subscribe FREE to the leading global dissemination resource

International Innovation is the leading global dissemination resource for the wider scientific, technology and research communities. For a short period only we are offering FREE subscription to this unique publication.

Subscription will give you access to:

- **Exclusive content and presentations from leading research teams and institutes**
- **Bespoke interviews and insightful comment from leading figures across the science, technology and administration industries**
- **Unique opportunity to connect with prospective project partners from the wider scientific community**
- **Up-to-date information on the latest funding schemes**

For your **free** subscription please visit **http://www.research-europe.com/subscribe.php** or for further information, please email us at **subscriptions@researchmedia.eu**

We take privacy very seriously and never share data with third parties.

WWW.RESEARCHMEDIA.EU

European Soil Bureau Network

Soils literally underpin our ecosystems, but historically their importance has been undervalued. Secretary of the ESBN, **Dr Luca Montanarella**, explains the Network's vital work providing policy-shaping research results and their mission to raise public awareness about the importance of maintaining soil quality

Could you give an overview of the European Soil Bureau Network's main aims and objectives?

The ESBN was created in 1996 as a network of national soil science institutions. It is the main scientific network supporting the European Commission in the collection of soil data and information, supporting the implementation of the European Soil Data Centre (ESDAC) operated by the JRC. The ESBN has been supporting the Commission for more than twenty years and, at present, it provides the data currently available within the European Soil Information System (EUSIS).

One of the most relevant datasets produced by the ESBN is the European Soil Geographical Database at scale 1:1,000,000, covering the complete European continent and extending into Eurasia by including also the Russian Federation. Currently all European countries are represented in the ESBN by their main soil survey and data-holding institutions.

What multifunctional properties does soil have and how is the Network maximising awareness of them?

The Network was originally conceived for the collection of the relevant data for the implementation of the Common Agricultural Policy (CAP). 20 years ago there was still a vision of soils as a mono-functional resource, mainly relevant to agricultural and forest production. With the advent of environmental policy and a rapid shift towards sustainability and environmental protection priorities, we have also experienced a change in the focus of the ESBN, from solely agriculture to a multi-functional focus dealing with all major soil functions, as identified in the Soil Thematic Strategy: biodiversity pool, water filtration; source of raw materials; archive of cultural heritage; surface for housing and infrastructure; mitigation of climate change, etc.

What strategies do you use to harmonise, organise and distribute soil information for Europe?

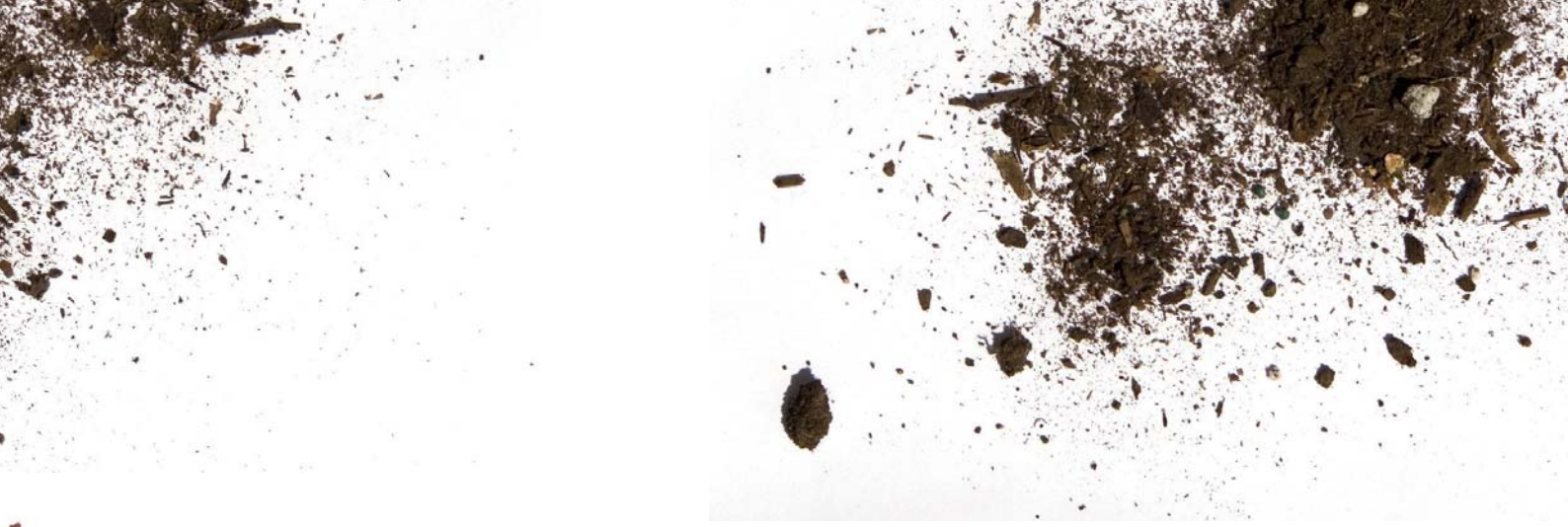
The main success of the ESBN has been the participatory approach of all stakeholders and soil data producers in order to reach a common nomenclature and vision for soil survey and mapping. This has been achieved through hundreds of meetings and cross-border harmonisation exercises. The ESBN has been used as one of the working examples of pan-European data harmonisation and distribution; indeed it is a forerunner of the INSPIRE directive and its principles.

What activities are you currently working on?

Our work programme for 2011 mainly focuses on large European and global soil data collection exercises: BIOSOIL for forest soils; LUCAS Soil for agricultural soils; GlobalSoilMap.net for global soil resources. These large-scale data collection activities will yield next generation digital soil maps that will be the basis for the future European and global assessments of soil resources.

Why is the ESBN experiencing a surge in the demand for soil information in Europe?

Soil is a limited, non renewable, natural resource. Policy makers, as well as the general public, are starting to realise soils are limited and that if we do not manage them in a sustainable way we will not have enough soils left for future generations. As a result, there is a surge of interest to gather updated data and information on soils for local, regional, national, European and global assessments.



eusoils.jrc.ec.europa.eu/esbn

What policy drivers are relevant to this project and why?

The main policy driver is the EU Soil thematic Strategy which covers all soil related policies of the EU. More specifically, the CAP is certainly still a major driver, as well as the energy policy due to the relevance of soil resources for the expansion of biofuel production. Other relevant areas are the waste policy (particularly biowaste), the nature protection policies for soil biodiversity, the water policy for groundwater resources, and the natural hazards policies for the issue of landslides. But also climate change and desertification policies developed in the framework of the Climate Change Convention (UNFCCC) and the Desertification Convention (UNCCD) are gaining a growing importance, not only in Europe but also at global scale.

What does the Network hope to deliver in terms of soil erosion, desertification, and soil suitability for the major crops?

We are responsible for the regular reporting on the Organisation for Economic Cooperation and Development's two indicators for soil: soil erosion and soil quality. Regular reporting on the basis of data provided by Member States is compiled by the ESDAC. Concerning desertification, reporting is coordinated by a related action of the JRC on DESERT.

By what means is the scientific quality of the work guaranteed?

The scientific quality of the work is guaranteed by a Steering Committee formed of outstanding European soil scientists. The constant link with policy makers is ensured by the Advisory Committee along with delegates from the Member States and the relevant customer DGs. Actual operational activities are performed through ad hoc working groups coordinated by the scientific committee. The results of these converge into the EUSIS, designed to be the main source of geo-referenced information on European soils. Ultimately, peer review within the soil science community remains the main instrument for assuring scientific excellence. All outputs of the ESBN are peer reviewed before final release.

How are you related to the European Soil Information System (EUSIS), designed to be the main source of geo-referenced information on European soils, and what has this partnership yielded?

I'm in charge of EUSIS as well as of ESDAC. The ESBN is simply supporting us in these activities. It should be clear that the ESBN is a network of national institutions supported by the JRC. The Network itself is directed by a steering committee currently chaired by Rachel Creamer from Ireland.

What are the major challenges facing soil today and how is the Network helping to address them?

The main challenges that are emerging are linked to the introduction of modern digital soil mapping techniques that will need a complete change of traditional soil data collection.

In the face of climate change, how do you see the role of the Network developing to adjust to Europe's growing needs?

Climate change is a priority for us and we will therefore adapt the Network to better respond to Europe's needs.

Would you like to draw our attention to any other area of the ESBN's work?

The Network is extremely effective in implementing one of the major pillars of our soil thematic strategy: awareness-raising. In order to raise awareness of the general public, policy makers and other scientists of the global importance of soil biodiversity, in the context of the UN's International Year for Biodiversity (2010), we have collaborated with soil scientists from all over Europe to produce the first ever European Atlas of Soil Biodiversity. In such ways, the ESBN is effectively promoting soil protection at all levels in Europe.

Published by **Research Media Ltd**
For more information, visit **www.researchmedia.eu**