The state of our soils

Project Coordinator **Professor Steve Banwart** details the international effort to tackle soil degradation and develop an Integrated Critical Zone Model to guide future research efforts

To begin, could you provide an overview of the project and how it is unique in its objectives?

The project provides scientific evidence to support the development of EU policy for soil protection and land use as outlined in the EU Thematic Strategy for Soil Protection. SoilTrEC focuses on the soil ecosystem services of food and fibre production, carbon storage, water filtration, nutrient and pollutant transformation, habitat for organisms and maintaining biodiversity. Our unique approach is to integrate the central role of soil processes into assessment of Earth's Critical Zone, which extends from the top of the tree canopy to the bottom of aquifers, and supports all human activity.

In addition to coordinating the project, you manage the international integration of SoilTrEC's objectives. What does this involve and what challenges do you foresee in implementing standardised methods and training on an international scale?

Within SoilTrEC we have a data management committee with a research leader who coordinates agreement on standards, procedures and collation of data from all partners. It's a major challenge. We also participate in and organise workshops with the U.S. National Critical Zone Observatory Program funded by the National Science Foundation to identify the barriers and the ways forward regarding common approaches to data management and sharing. There are great opportunities to make data and mathematical models much more accessible internationally via web-based sharing. During the five-year SoilTrEC project, we will be able to identify how best to do this, but implementation is not trivial – it requires additional, substantial IT expertise and its own research and infrastructure investment.

How important is educating the public about the impact they have on the environment and the work you are doing?

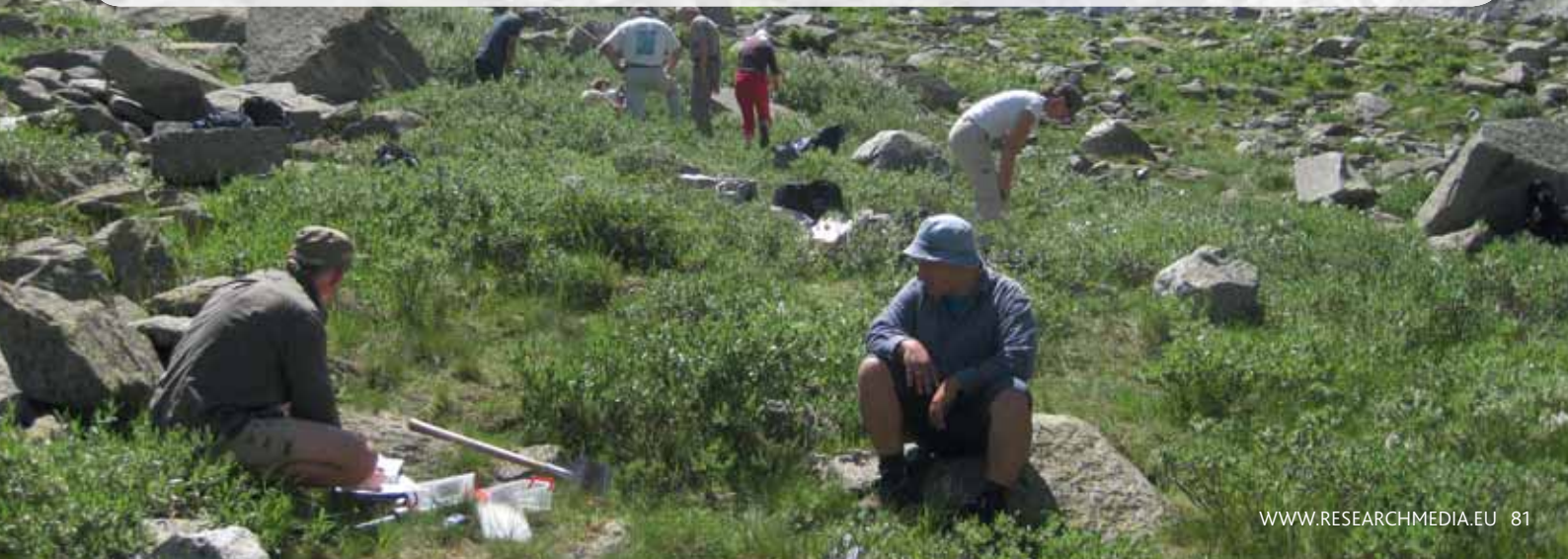
Educating the public is extremely important and it is often challenging for scientists. We are usually better at speaking to each other and to our industry and government partners, rather than to the general public. SoilTrEC has an entire work package for research translation and dissemination that includes the public as an important audience. We have a stakeholder group that so far includes mainly representatives of government agencies but we aim to expand this group as the project moves forward. We need to include educational and public outreach stakeholders in order to gain their advice and help design activities for public dissemination. The website is our main route of public dissemination at the moment.

Why is a cross-disciplinary approach vital to improving our understanding of processes in Earth's Critical Zones (CZ)? What are some of the fields contributing to this work?

The global challenge of soil threats and how to sustain and intensify soil ecosystem services can't be tackled or solved by any single discipline – it's too complex. In addition to the science and engineering experts that are contributing to the Integrated CZ Model, we have partners who are experts in ecological economics and in the application of Life Cycle Analysis to natural resources. To assess threats and design sustainable solutions requires land use practices to be evaluated through the relative deterioration or enhancement of the soil ecosystem services, and over the time scale of several human generations. The Life Cycle Assessment methodology allows this 'whole life' approach to consider the long-term impacts and strategies of land management options. Ecological economics embraces the full range of ecosystem services; so their evaluation addresses what would otherwise be 'external' environmental costs. For example, it would be a mistake to focus solely on food production without accounting for the benefits or costs of changing soil carbon levels in cropland – which can be very different depending on agricultural practices – and could help alleviate or accelerate green house gas emissions.

What was the focus of SoilTrEC's workshop held in Vienna in July of this year? Who participated and were any conclusions developed from the workshop's discussions?

The Vienna workshop was held to identify the data requirements for development of the Integrated CZ Model, and to agree the field investigations and measurements that are needed for this. The various disciplines explained how they will contribute data and models and we agreed how to link these together. The major scientific challenge and expected achievement of SoilTrEC is developing the Integrated CZ Model. This requires linking mathematical models of water flow and solute reactive transport, soil food web dynamics, soil carbon and nutrient transformations. Most models so far might incorporate two of these four classes of processes, but to describe soil ecosystem services requires the full suite of processes. The Vienna workshop was an essential step along this process of integration.



Digging for data

The pressures placed on Earth's soil systems by humans are intensifying at alarming rates. The **SoilTrEc** project seeks to build capacity for European researchers to forge the trail to recovery for this valuable resource

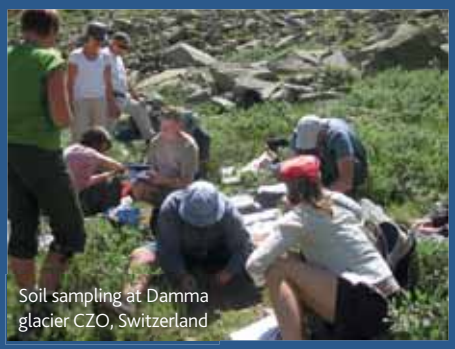
WITHIN EUROPE, SOIL degradation results in a loss of approximately 20 billion euros annually. Water and wind erosion alone affect roughly 15 per cent of land area in the region and costs 14 billion euros each year. The backlash of soil degradation extends beyond financial losses; soil serves as one of Earth's most valuable resources, producing food and fibre, storing and filtering a range of substances including water, nitrogen and carbon, sheltering habitats and serving as a home to numerous species.

Other effects include the loss of carbon within soil, which can release greenhouse gases and contributes to desertification. Our food supplies are threatened by the loss of soil fertility through nutrient depletion as a result of uptake into vegetation and removal of the crops, soil compaction caused by heavy agricultural machinery, an increasing salt concentration brought on by the evaporation of infiltrating irrigation waters and industrial pollution. These effects are exacerbated by the demands of an increasing world population and growing wealth, which put additional pressure on the Earth's soil systems. Even more worrying is the fact that soil is a non-renewable resource, as it takes millenia to produce just a few centimetres of soil.

However, the forecast is not entirely dire; efforts to protect Europe's soil and land area have shifted into high gear in recent years. The EU Thematic Strategy for Soil Protection is one example of these efforts. The Strategy calls for action on the local, national and European scale to ensure the sustainable use of soil. It requires Member States to take specific measures to address soil threats and to increase awareness of these threats to the public and the role they can play ensuring a sustainable future. In addition, the international food security agenda presents the pressing nature of resolving the issue of soil degradation in a timely fashion by directing their policies and efforts towards protecting soil for the critical role it plays in agricultural production.

These policies rely heavily upon accurate and rich scientific data as a basis for their decisions and assessments. Contributing heavily to the advancement of EU policy for soil protection is the research consortium known as SoilTrEC. The project is funded by the European Commission's Seventh Framework Programme (FP7) and collaborates with partners from Europe, Asia and the U.S. Professor Steve Banwart, Project Coordinator for SoilTrEC, expands on the driving force behind the project's research efforts: "The project tackles issues of soil degradation with three major scientific advances. These are to define the life cycle of soil function, to quantify how soil function supports the ecosystem services of Earth's Critical Zone, and to develop a network of Critical Zone Observatories (CZOs) that provide European leadership for international soils research".


Old agricultural terraces at koiliaris CZO, Crete, Greece


Soil sampling at Damma glacier CZO, Switzerland

THE CRITICAL ZONE

Earth's Critical Zone (CZ) refers to the area of the planet which extends from the top of the tree canopy down to the bottom of aquifers. Most human activities take place within the zone, though it is actually only several metres in depth. Soil plays a leading role in maintaining the habitability of the CZ worldwide by acting as a natural chemical reactor which facilitates the processing of geological materials and biomass. Banwart sheds light on the crucial function of soil within the CZ: "This bio-reactor takes rock – the parent material of soil – and causes it to react with water under the influence of plants and microorganisms to create soil and support the essential, life-giving ecosystem services".

SoilTrEC has established Critical Zone Observatories (CZOs) at four locations


Soil cores from Damma glacier CZO, Switzerland

around Europe – Fuchsenbigl, Austria; Lysina, Czech Republic; Koiliaris, Crete; Damma Glacier, Switzerland. These sites offer ideal conditions for studying the processes that take place at all levels of CZ, from above ground vegetation to soil and groundwater. Each location was selected for its ability to represent one of the key stages along the life cycle of soil function. The Damma Glacier in the Swiss Alps, for example, where new soils have been forming for over 150 years as a result of glacial retreats caused by global warming, is a microcosm for the initial stages of soil formation. The Fuchsenbigl and Lysina CZOs, on the other hand, are valued for their conditions which support arable land farming and forestry. The grazing and orchards of Koiliaris are ideal for analysing soil that has been intensively farmed over several millennia. Since it has been highly degraded through agricultural activities, it allows scientists to study land under the threat of desertification from global warming.

Researchers from SoilTrEC will use the data collected at these sites to compare soil characteristics and ecosystem services to generate a clearer understanding of how these vary during the life cycle. This will take the form of a computational model which will be used as a simulation tool for assessing threats to soil. The model will also serve to test methods for mitigating these threats and serve as a reference point for the best ways to manage the dangerously intensive use of soil taking place today around the world without negatively impacting the natural ecosystem processes. Still in the development stages, Banwart expresses the aspirations for this model: "The computational model for soil processes and ecosystem services that we are developing, the 'Integrated CZ Model', describes soil processes at catchment scale. By linking it with GIS geospatial data across many catchments, we will scale-up model assessment of processes and ecosystem services to continental scale". A watershed model has already been developed for the Koiliaris site, with an up-scaled prototype for soil processes at a river basin scale expected to be in use in the near future.

A GUIDING LIGHT

SoilTrEC began in 2009 and has secured funding for a total of five years. Banwart hopes the project's findings and CZ Model will serve as a basis for research beyond the project's lifespan and give way to additional CZOs from the Arctic to the Sub-Sahara. "The range of climates and associated soil processes that span that geographical range provide the input for assessing how soil ecosystem services vary along the transect, and hence into the future with a warming climate," he affirms.

Indeed, soil degradation is a worldwide concern and changes in soil conditions vary greatly from region to region. SoilTrEC takes this international aspect into account through many collaborations that have helped the project to expand its knowledge base, particularly by capitalising on the resources from its partners in America and China. These partnerships allow the project to gather data on a wider range of soil types and land use and will also give European researchers the opportunity to take on a leadership role on the world-scene in the field of soil and CZ research. "The ambition is that European approaches to soil policy through the Thematic Strategy for Soil Protection and European leadership of soils research, will create a leading position for Europe's knowledge base in universities and companies to contribute worldwide to solutions to major global challenges such as soil protection and food security," Banwart concludes.

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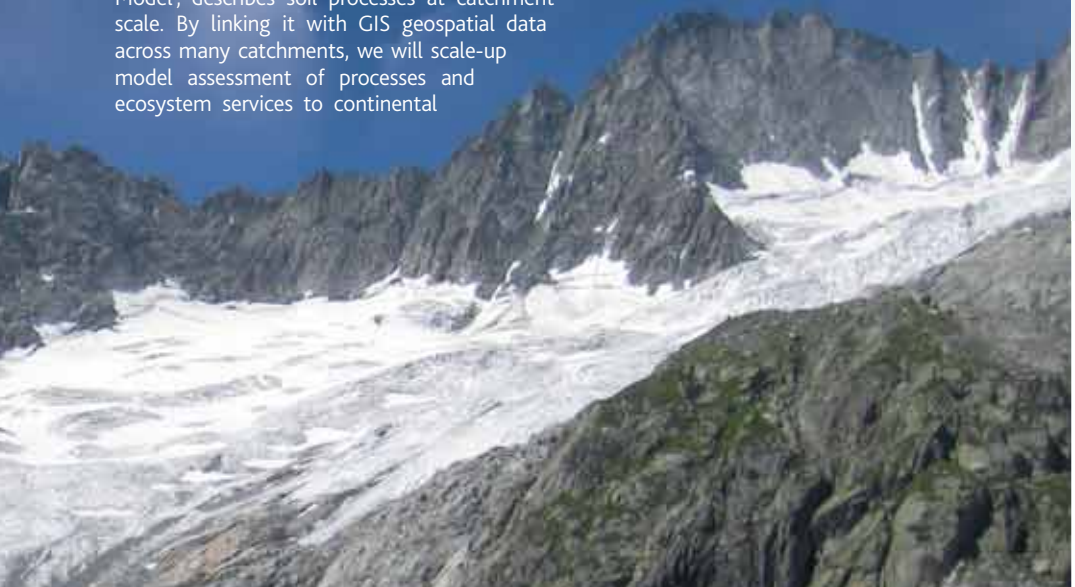

INTELLIGENCE

SOILTREC

SOIL TRANSFORMATIONS IN EUROPEAN CATCHMENTS

OBJECTIVES

To address the priority research areas identified in the European Union Thematic Strategy for Soil Protection and to provide leadership for a global network of Critical Zone Observatories (CZO) committed to soil research.

PARTNERS

University of Sheffield, UK • **N Poushkarov Institute for Soil Sciences**, Bulgaria • **Technical University of Crete**, Greece • **Deltares**, The Netherlands • **European Commission – DG Joint Research Centre**, Italy • **Univeristy of Iceland**, Iceland • **Wageningen University**, The Netherlands • **University of Natural Resources and Applied Life Sciences**, Austria • **NERC – CEH**, UK • **Swiss Federal Institute of Technology**, Switzland • **Czech Geological Survey**, Czech Republic • **Institute of Agricultural Resources and Regional Planning CAAS**, China • **Penn State University**, U.S. • **Swedish University of Agricultural Sciences**, Sweden • **Centre National de la Recherche Scientfique**, Italy

FUNDING

EU Seventh Framework Programme (FP7) – contract no. 244118

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SOILTREC

SEVENTH FRAMEWORK PROGRAMME

The University Of Sheffield.