ENV.2009.2.1.2.1 Soil Processes and Modelling
Large-Scale Integrating Project

SoilTrEC

Soil Transformations in European Catchments

Grant agreement no. 244118

Deliverable 8.7 – Final Report

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PROJECT FINAL REPORT

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1. Declaration by the scientific representative of the project coordinator

I, as scientific representative of the coordinator of this project and in line with the obligations as stated in Article II.2.3 of the Grant Agreement declare that:

The attached final report represents an accurate description of the work carried out in this project for 5 years;

The project (tick as appropriate) [2]:

X has fully achieved its objectives and technical goals for the entire project.

has failed to achieve critical objectives and/or is not at all on schedule.

- The public website, if applicable

X is up to date.

To my best knowledge, the financial statements which are being submitted as part of this report are in line with the actual work carried out and are consistent with the report on the resources used for the project (section 3.4) and if applicable with the certificate on financial statement.

All beneficiaries, in particular non-profit public bodies, secondary and higher education establishments, research organisations and SMEs, have declared to have verified their legal status. Any changes have been reported under section 3.2.3 (Project Management) in accordance with Article II.3.f of the Grant Agreement.

Name of scientific representative of the Coordinator:

……

Steven A. Banwart

Date: ..29...../ ...01...../ ...2015.....

For most of the projects, the signature of this declaration could be done directly via the IT reporting tool through an adapted IT mechanism and in that case, no signed paper form needs to be sent

2. List of Beneficiaries

Beneficiary Number	Beneficiary name	Beneficiary short name	Country	Date enter project	Date exit project
1	University of Sheffield	USFD	GB	1	60
2	Institute of Soil Science, Agrotechnology and Plant Protection Nikola Poushkarov	ISSAPPNP	BG	1	60
3	Technical University of Crete	TUC	GR	1	60
4	Deltares	Delt	NL	1	60
5	European Community represented by the European Commission – Directorate General Joint Research Centre	EC-JRC	IT	1	60
6	University of Iceland	HI	IS	1	60
7	Wageningen University	WU	NL	1	60
8	University of Natural Resources and Applied Life Sciences	BOKU	AT	1	60
9	NERC – Centre for Ecology and Hydrology	NERC CEH	GB	1	60
10	Swiss Federal Institute of Technology (Zurich)	ETH	CH	1	60
11	Czech Geological Survey	CGS	CZ	1	60
12	Institute of Agricultural Resources and Regional Planning CAAS	IARRPC	CN	1	60
14	The Pennsylvania State University	PSU	US	1	60
15	Swedish University of Agricultural Sciences	SLU	SE	1	60
16	Centre National de la Recherche Scientifique	CNRS	FR	1	60
17	Technical University of Munich	TUM	GE	48	60

3. Publishable Summary

3.1 Executive Summary

The SoilTrEC project delivered advances in the field of Soil Processes and Modelling. The aim is to provide scientific evidence and technical advances to support policy objectives of the EU Thematic Strategy for Soil Protection; namely to develop a scientific framework to quantify soil functions and threats and design methods for improving soil functions.

The research challenge was framed with 2 overarching hypotheses: 1) that soil functions are impacted by increasing intensity and longevity of human use of soils, and 2) that changes in soil structure, particularly the mass fraction of large physically stable soil aggregates, resulting from human activity are a principle metric to define impacts on soil functions.

The research objectives stated in the project description of work are:

1. Describe from 1st principles how soil structure impacts soil processes and functions,
2. Establish 4 EU Critical Zone Observatories to study soil processes at field scale,
3. Develop a Critical Zone Integrated Model (ICZM) of soil processes and functions,
4. Create a GIS-based framework to assess soil threats and mitigation at EU scale,
5. Quantify impacts of changing land use, climate and biodiversity on soil function and value,
6. Form with international partners a global network of CZOs for soils research, and
7. Deliver a programme of public outreach and research transfer on soil sustainability.

The research design defined the soil functions of biomass production, carbon storage, water filtration and storage, nutrient transformations, and maintaining habitat and functional biodiversity. Soil functions were defined by processes that are integrated within the larger environmental system of Earth's Critical Zone (CZ); the thin planetary layer from the top of the vegetation to the bottom of aquifers that supplies most life sustaining resources.

A network of Critical Zone Observatories as research field sites were selected to represent 4 stages of a conceptual life cycle of soil functions; 1) soil formation, productive use of soil in 2) forestry and 3) arable agriculture, and 4) degraded soils under threat of desertification.

The principal deliverable is a computational model to simulate soil functions as flows and transformations of material, energy and biodiversity within the stages of the soil function life cycle.

International leaders in soils and CZ research who composed the SoilTrEC independent advisory board identified 5 headline achievements for the SoilTrEC project.

1. Comprehensive data sets on soil profiles and process model parameters establishes essential baseline data sets for all future EU work on soil threats and soil functions.
2. A validated comprehensive process model of soil functions establishes a formalised state-of-knowledge as a platform for future soil process and function studies worldwide.
3. A quantitative methodology for upscaling soil functions and soil threats from CZO to maps at regional and EU scales demonstrates the application for upscaling to EU scale.
4. Metrics for sustainable use of soil functions: whole-life energy costs, life cycle assessment, and economic valuation expand the decision-support toolkit for land use and soil management
5. An international network of SoilTrEC CZOs demonstrates that Earth's CZ is a powerful interdisciplinary framework for adapting human activities to environmental change.

The legacy of the project is a computational framework to simulate soil functions and assess threats and design restoration and sustainable soil management practices, an upscaling methodology to map soil threats and functions and novel decision support methods for policy applications, and an international network of Critical Zone Observatories to study and test solutions for human adaptation to environmental change.

3.2 Description of Project Context and Objectives (4 pages)

Increasing human population and wealth is creating unprecedented pressure on Earth's land and water resources. By 2050 it is predicted that the human population will approach 10 billion with a quadrupling in the global economy, a doubling in the demand for food and fuel, and a more than 50% increase in demand for clean water [1].

These resource demands must be met while mitigating and adapting to the impacts of climate change and declining biodiversity, and under the constraint of limited available land. The most recent IPCC report [2] predicts that global agricultural production is likely to decline during the coming decades due to insufficient water supply in regions of agricultural production. A 2014 UNEP study Assessing Global Land Use [3] calculates that to meet demand for food by 2050, Earth's productive land area must increase by 320-850 Mha; estimated to be 10-45% greater than Earth's environmental capacity.

As a policy response to these pressing challenges, in 2006 the European Commission published the Thematic Strategy for Soil Protection [4]. The strategy identifies a specific policy need for the EU to address the threats to soil posed by the pressures of increasing resource demands, and the environmental constraints for the essential soil functions to deliver continued benefits for the EU economy and society.

The strategy defines soil as the layer of unconsolidated material that extends from the land surface to the underlying bedrock. This definition strongly parallels the scientific concept of Earth's Critical Zone (Figure 3.1), the thin planetary layer that extends from the top of the tree canopy to the bottom of drinking water aquifers that supplies most life sustaining resources.

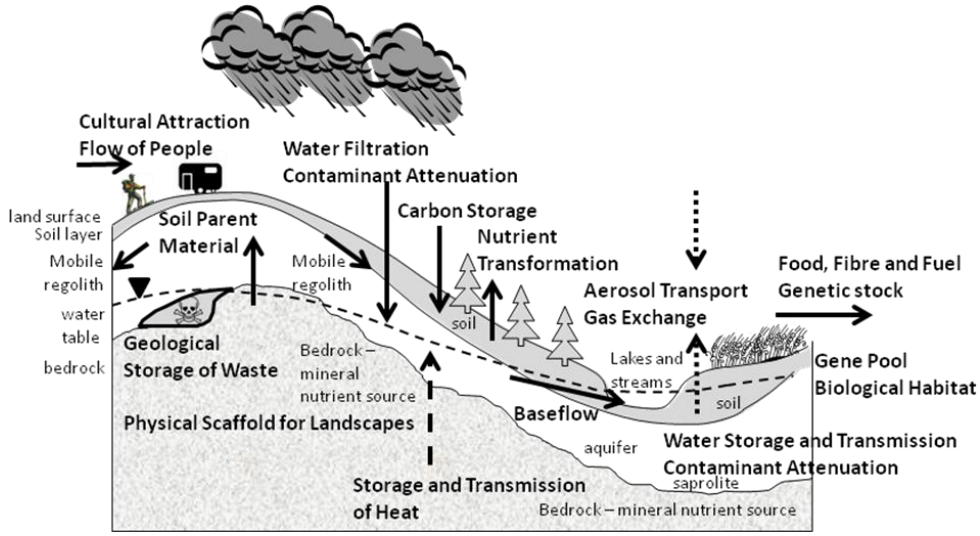

Figure 3.1. Earth's Critical Zone (CZ) provides humans with most of their life-sustaining resources. Soil is at the heart of the CZ. Soil processes produce flows and transformations of material, energy and genetic information. These flows define the soil functions of benefit to humans, including: production of food, fibre and fuel; storage, transmission and filtration of water; storage of carbon; transformation of nutrients; maintaining habitat and supporting biodiversity [5].

The SoilTrEC research hypotheses are that 1) the development of soil functions can be described by a conceptual life cycle of soil functions that is driven by intensification of land use, and that 2) deterioration or improvement in soil functions can be described by quantifying how soil processes change with soil structure along the life cycle [6].

The research objectives of the SoilTrEC project are to:

1. Describe from 1st principles how soil structure impacts soil processes and functions,

2. Establish 4 EU Critical Zone Observatories to study soil processes at field scale,
3. Develop a Critical Zone Integrated Model (ICZM) of soil processes and functions,
4. Create a GIS-based framework to assess soil threats and mitigation at EU scale,
5. Quantify impacts of changing land use, climate and biodiversity on soil function and value,
6. Form with international partners a global network of CZOs for soils research, and
7. Deliver a programme of public outreach and research transfer on soil sustainability.

Each research objective was met through an associated research work package. An eighth work package delivered project management. The overarching experimental design is to quantify soil structure and process at research field sites that are Critical Zone Observatories (CZOs) located along a gradient of land use disturbance that defines a conceptual life cycle of soil functions (Figure 3.2) [7].

1. The Damma Glacier CZO, Switzerland, allows the study of incipient soil formation in the glacial forefield as the glacier retreats, exposing the underlying bedrock. A chronosequence on the order of centuries allows the earliest stages of soil formation to be observed.
2. The Lysina-Slavkov Forest CZO, Czech Republic, allows the study of soil processes during managed forest land use for intensive silvaculture.
3. The Fuchsenbigl-Marchfeld CZO, Austria, allows the study of soil processes during managed arable land use for production agriculture.
4. The Koiliaris River CZO, Crete, allows the study of highly degraded soils that have experienced millennia of intensive agricultural land use, including grazing, and is under additional threat from desertification due to modern climate change.

Headline Achievements

The project advisory board identified 5 headline achievements for the SoilTrEC project.

1. SoilTrEC produced comprehensive data sets on soil profiles and process model parameter sets in 4 CZOs as references sites representing key land uses in the EU, with published meta-data for 170 soil profiles [Table 1] [6]. The results provide an essential database for mathematical model initialisation and upscaling, scaling algorithms, and quantification of soil functions at reference sites, and establish an essential baseline data set for all future work on soil threats and soil functions in the EU.
2. SoilTrEC delivered a validated comprehensive process model of soil functions in Earth's Critical Zone with quantified soil functions as material flows and transformation rates in 9 EU, USA and China reference sites. The conceptual and mathematical model establishes a formalised state-of-knowledge on soil functions as a platform for future soil process studies worldwide. The model application quantified the benefits of soil functions from carbon amendments for soil restoration and agriculture intensification, and established a quantitative modelling tool for "soil sustainability by design"
3. SoilTrEC established a quantitative methodology for upscaling soil functions and soil threats from CZO to regional scale and demonstrated the application for upscaling to European scale. The methodology creates geospatial data (maps) of soil functions and soil threats for policy decisions; i.e. trade-offs to achieve land degradation neutrality
4. SoilTrEC evaluated metrics for sustainable use of soil functions and trade-offs: energy return on investment – whole life energy flow balance, Life Cycle Assessment – global impact on soil functions as an endpoint indicator in product LCA (the burden on soil), novel application of economic valuation of multiple soil functions, and biophysical flows and transformations of material, energy and functional groups of organisms. The project carried out field validation of these metrics as components of a decision-support toolkit for land use and soil management

5. SoilTrEC established an international network of CZOs in collaboration with USA and China and demonstrated Critical Zone science as a powerful interdisciplinary framework for adapting human activities to environmental change [8]. The results substantially raised the CZO science policy agenda to a high international level through interaction with the EC, UNEP, NSF USA, NSF China, Germany, France, Australia and the Belmont Forum.

The integration of the field data and mathematical process models provides quantitative analysis of soil process rates at 12 CZOs representing a wide range of environmental conditions worldwide. Comparison of process rates and parameter values allow the initial hypotheses to be tested (Figure 3.3).

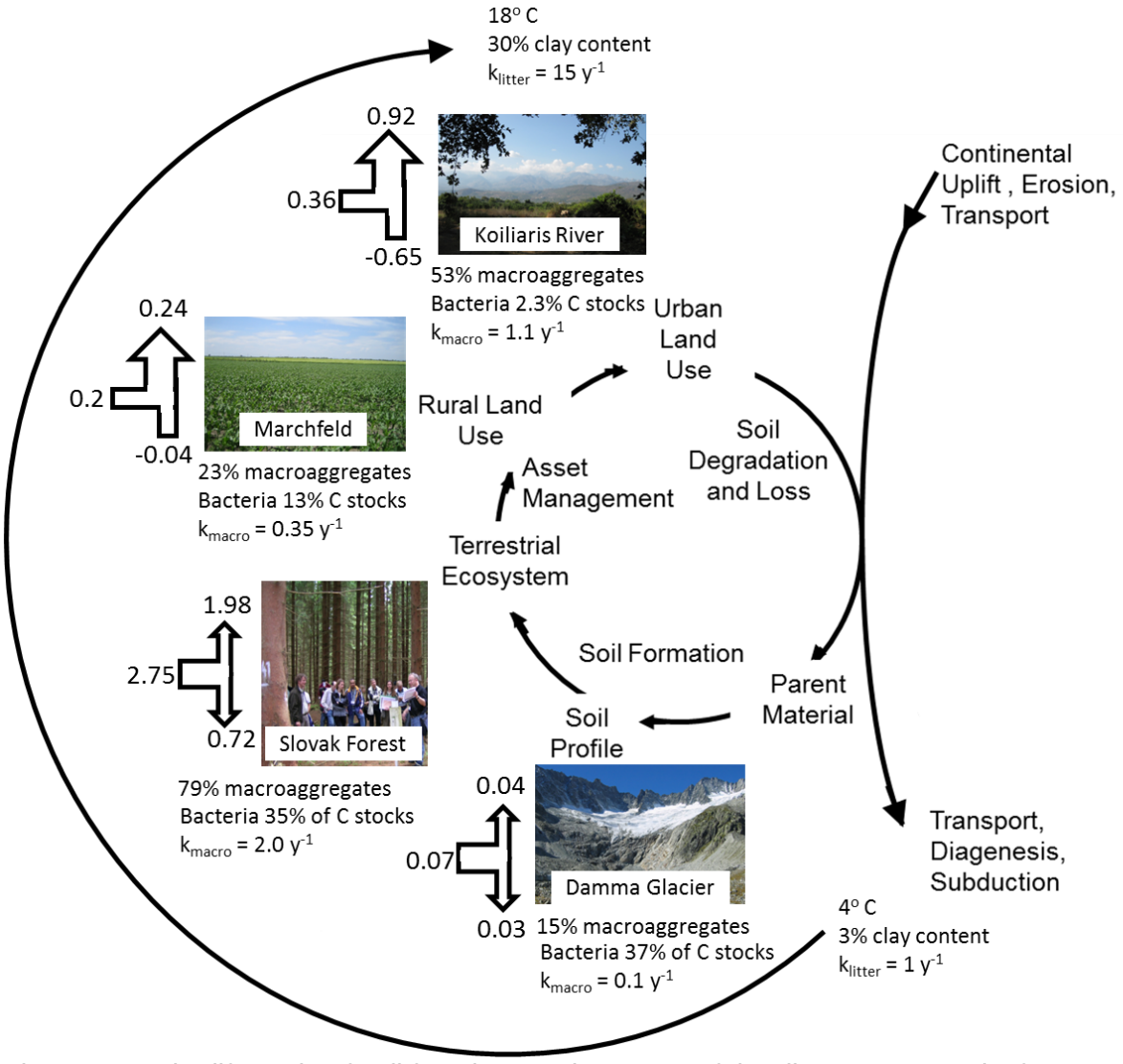

Figure 3.3. The life cycle of soil functions at the centre of the diagram proceeds, from parent material that is exposed or deposited at Earth's surface, through soil profile development, establishment of a terrestrial ecosystem, development of rural land as an asset for forestry and agricultural production, and eventually (not studied in SoilTrEC) urban development. Gradients in soil state across the 4 sites increase mean temperature from 4-18°C, clay content from 3-30%, and litter decomposition rate constants from 1-15 y^{-1}. The large open arrows represent the carbon flux balance in units of t C ha-y^{-1}.

A major advance of SoilTrEC is to define soil state along the conceptual life cycle of soil functions in terms of material and energy flows and transformation rates. Example results of model calculations with the Integrated Critical Zone Model (Figure 3.3) define a flux balance for carbon inputs (photosynthetic fixation, shown at left of open arrows), carbon storage

(shown at bottom of open arrows) and carbon emissions (from organic matter mineralisation, shown at top of open arrows). Initial stages show carbon storage while intensively farmed and degraded soils show loss of stored soil carbon with emissions greater than inputs.

Soil structure development is reflected in rate constants (k_{macro}, Figure 3.3) for macroaggregate (size>250µm) formation from decomposing plant litter within the life cycle where increasing carbon input generally correlates with more rapid macroaggregate production. Although carbon inputs are not particularly high for the degraded soils at the Koiliaris CZO, soil structure development is favoured due to the high clay content. The modelling results led to 2 key metrics of soil function performance. The first is the mass % of soil macroaggregates where a value of 60% is the target threshold. The second accounts for both role of organic matter to favour aggregate formation and accounts for the additional role of clay and silt particles. The 2nd metric is defined by the ratio of soil organic carbon content (SOC) normalised to the content of the clay and silt soil texture size fractions (SOC/(clay+silt)) with a ratio value of 5.5 for the target threshold.

SoilTrEC has established a new methodology for "soil sustainability by design" that utilises computational simulation that is integrated with field site data and hypothesised scenarios for improved soil management practice. The methodology is demonstrated for two scenarios of restoring soil functions that have been degraded by 35 years of vegetable production that utilised 1) light tillage and 2) intensive tillage [9]. The results tracked loss of SOC and soil structure during the 35 years. Improvements following light tillage demonstrate that carbon amendments of 5 t/ha-y for 7 years can achieve soil sustainability indicator thresholds, achieving 70% mass as water-stable macroaggregates and an SOC/(clay+silt) ratio of 5.5. Achieving sustainability thresholds following 35 years of production with intensive tillage required 12 t/ha-y of carbon amendment. An important advance of the ICZM is that multiple soil functions are simulated simultaneously. For carbon amendments, the model also calculated increased fluxes of dissolved organic carbon and nitrate to groundwater. Hence synergies and trade-offs between soil functions (food production, carbon storage and water filtration) during the computational design are scoped out and alternative soil management practices can be compared.

SoilTrEC delivered one of the first monetary valuations of multiple soil functions as decision support for soil sustainability by design. A pilot study for valuation of 3 soil functions under current land use practices at the Koiliaris CZO estimated total values of 1-278 ID$/ha-yr for the filtering of nutrients and contaminants, a total cost of 2,200 – 5,610 ID$/ha-yr for climate regulation through carbon storage and 740 – 7560 ID$/ha-yr for biomass production [10].

SoilTrEC has established a tested platform for soil protection and restoration that integrates 1) comprehensive measurements at field observatories as reference study sites, 2) mechanistic process models of multiple, interacting soil functions, and 3) monetary valuation methods for soil functions that provide both market and non-market metrics for improvement in soil functions. Furthermore, methods for upscaling primary data and derived data from model calculations, produce geospatial information (maps) of soil functions, soil threats, and soil restoration potential, for policy support on management practices from local to regional and EU scales. The following sections highlight the achievements for each work package.

References

[1] Banwart et al. (2014). Ch. 1 in Soil Carbon, SCOPE Vol. 71, CABI, UK. [2] IPCC (2014). Climate Change 2014 synthesis report. [3] UNEP (2014) Assessing global land use: balancing consumption with sustainable supply, UNEP, Nairobi. [4] European Commission (2006). COM(2006)231, EC, Brussels. [5] Banwart et al. (2013). Sustaining Earth's Critical Zone. U. Sheffield, ISBN 978-0-9576890-0-8. [6] Banwart et al. (2011). Vadose Zone J., 10, 974–987. [7] Banwart et al. (2013). Comptes Rendus Geoscience, 344, 758-772. [8] Banwart (2011). Nature,474,151–152. [9] Nikolaidis et al. (2014). Integration Report on Field Applications to CZOs, SoilTrEC deliverable D3.4. [10] D. Maia de Souza (2014). Workshop report for dissemination and consensus building, SoilTrEC deliverable D5.6.

3.3 Main Scientific and Technical Results/Foreground (25 pages),

3.3.1 Work Package 1 - Soil structure and function from first principles

Work package objectives for the project

The aim of WP1 is to develop models that can describe the physical, chemical and biological processes that account for the key soil functions.

Specific objectives are as follows:

- Characterize by measurements the development, composition and the stability of soil aggregates and their size distribution within soil profiles,
- Characterize the soil mineralogy, mineral chemistry, microbiology and microbial community structure,
- Develop mathematical process models that can simulate aggregate formation and stability from first principles of soil physics, physical chemistry, carbon transformation kinetics and ecological theory,
- Apply these process models in order to gain a basic understanding of the processes involved in aggregate formation and stability and the role of aggregate properties in soil functions from molecular- to soil profile- scale
- Contribute process descriptions, parameter values and model results to the other work packages.

Brief description of key results and achievements for the project

Key achievements led by Work Package 1 are the following.

1. Soil physical quality indicators were derived from the Soil Water Retention Curve (SWRC) data of the soil profiles characterising the European SoilTrEC Critical Zone Observatories [1,2,6].
2. A new conceptual model describes the physical-chemical interactions at the different size scales and their relation with aggregates and porosity [4,5].
3. Because of its high functionality, soil biological properties have been studied for their indicative value for soil quality. The micro-arthropod diversity was found to consistently respond to human induced stress.

Soil profile characterization

Soil cores from 18 sites (54 soil profiles, 203 sampling depths) sampled at the four SoilTrEC European CZOs were characterised for physical, (geo)chemical and (micro)biological factors. Soil structure was evaluated through the size, configuration and distribution of soil aggregates and pores. Soil geochemistry and biological characteristics needed for modelling were also evaluated. Soil profile data interpretation enhanced our understanding of the rates of biogeochemical processes and trends in these under different management and environmental conditions across the CZOs.

Soil physical quality indicators

Soil water retention is of primary importance for the majority of soil functions. The estimated parameter values of the equation for the SWRC are directly related to soil structure and the soil water regime and can be used as indicators for soil physical quality. The results showed that most of the studied topsoil horizons have good physical quality according to both the S-parameter and the Plant-Available Water content (PAW) (Fig. 2.1.). It was found that values of $S \geq 0.05$ correspond to PAW > 20 % vol. in the topsoil horizons. The high values of S in subsoil horizons are due to the low PAW and restrict the application of the S categories in these cases. Well defined links are found between the PAW content and the S-parameter when the data from the topsoil horizons are grouped in 2 groups according to the ratio

between air-filled pores (at pF 2.52) and plant available water: <2 and ≥ 2. Generally, the values of S parameters are related to transmission properties of the soil connected with the presence of structural pores.

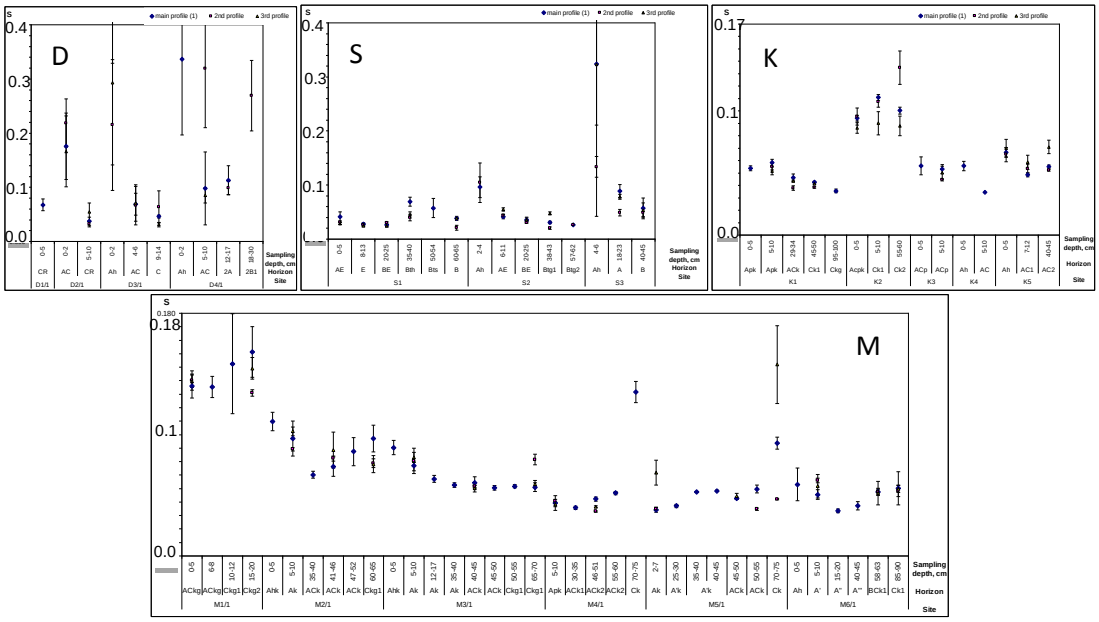

Fig. 2.1. Soil quality index S (slope at the inflection point of soil water retention curves) along all 54 studied soil profiles at Damma glacier (D), Slavkov forest (S), Koiliaris (K) and Marchfeld (M) CZO. .

Soil physical-chemical processes and soil structure

The interactions between soil physical-chemical processes and soil structure at different size scales were assessed (Fig. 2.2.) and a mechanistic conceptual model of aggregate formation was proposed (Fig. 2.3.)

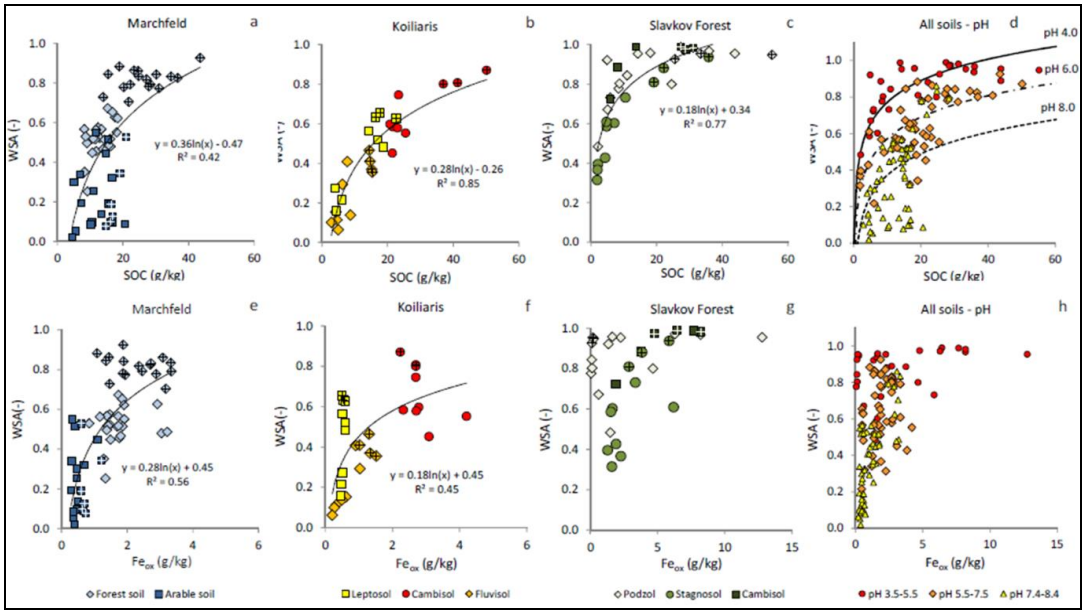

Figure 2.2. The fraction of water-stable macroaggregates (WSA, size>0.25 mm), as a function of the soil organic carbon (SOC) content and the amorphous Fe-(hydr)oxide content (Fe_{ox}) in the Marchfeld, Koiliaris and Slavkov Forest CZO.

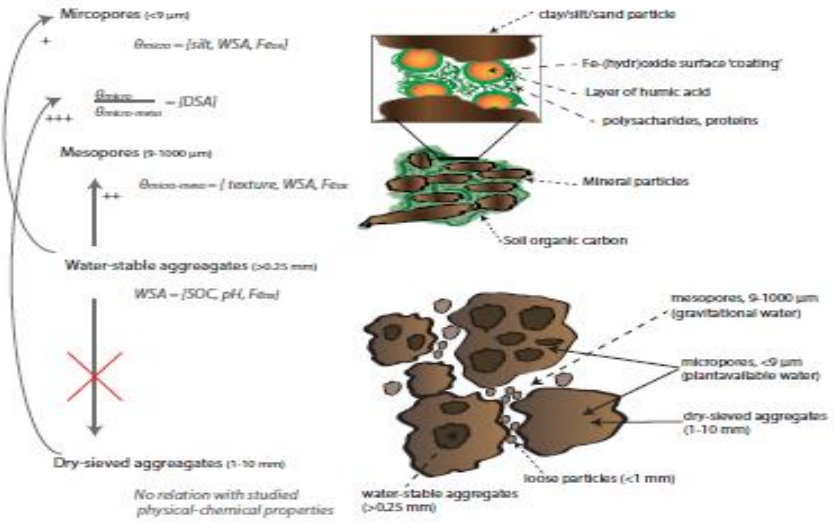

Fig. 2.3. Conceptual picture of aggregate formation and the linkages between the soil aggregates and porosity. *WSA = water-stable aggregates, DSA = dry-sieved aggregates, Fe_{ox}= oxalate-extractable Fe, SOC = soil organic carbon*

Microbial diversity and functional guilds in soil aggregate fractions

Microbial diversity (bacteria, archaea, Fungi) and functional guilds related to N transformations in soil aggregate fractions ranging from <0.250 to 10 mm) were studied using q-PCR. Example results (Figure 2.4) show significant difference between size fractions and land use types. Additional investigations are being carried out using pyrosequencing (awaiting results).

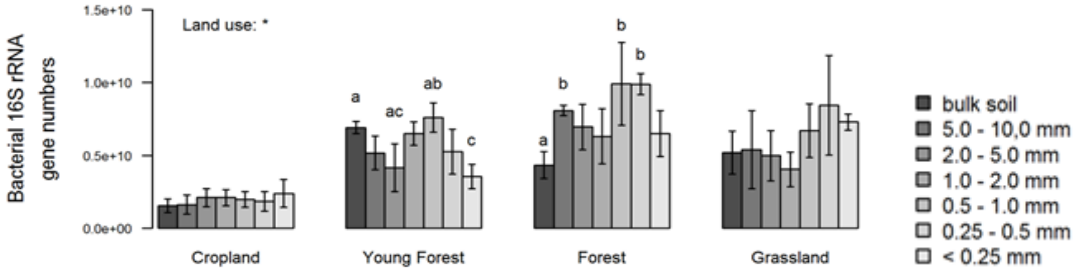

Figure 2.4 Variation in gene abundance of bacteria (16S rRNA gene) between bulk soil [g^{-1}] and 6 different aggregates sizes fractions [g^{-1}] from 4 different land uses in Marchfeld CZO.

Practical relevance of the results and key dissemination materials and activities

Soil characterisation data at profile scale was applied to develop mathematical models from 1st principles linking soil structure to physical, chemical and biological processes. These models contributed to process descriptions, parameter values and model results to the other work packages that produced 1) conceptual and mathematical models for soil processes at the CZOs (WP2) and 2) the ICZM) that was applied across all CZOs (WP3).

References

[1] Kercheva M. et al. (2012) 4th International Congress EUROSOIL, p. 2654.
[2] Kercheva M. et al. (2015) Advances in Agronomy (in preparation)
[3] Menon M. et al. (2015) Functional microbial biodiversity in soil aggregates, in preparation.
[4] Regelink et al. (2013) Mineralogical Magazine, 77(5) 2038
[5] Regelink I. et al. (2015) GEODERMA (in review)
[6] Rousseva S. et al. (2014) Geophysical Research Abstracts, Vol. 16, EGU2014-5970.

3.3.2 Work Package 2 – Soil process studies at Critical Zone Observatories

Work package objectives for the project

By studying soil processes and function within the critical zone at field and catchment scale at selected European field sites, we achieved the following aims:

- SoilTrEC established a harmonised network of European field sites as Critical Zone Observatories (CZOs) for soil processes research.
- This enhanced knowledge of soil processes and dynamics under conditions associated with different stages of the soil life cycle, as represented by the different CZOs.
- Relevant soil process models were identified and their data needs assessed, both in terms of required input data and model parameters/rate constants.
- Targeted field measurements at small plot and catchment scale at each of the four main CZO's provided the essential, harmonised data for the soil process models.
- The soil process models are applied and tested with the data from the CZOs and the results interpreted in relation to soil functions at key stages of the soil lifecycle.
- The project experience provides an important overview of measurements and long-term monitoring requirements within a - global - network of CZOs that are necessary to meet EU policy objectives in relation to the Soil Thematic Strategy. It further identified the required characteristics for a long term data repository for CZO data.

Brief description of key results and achievements for the project

Key achievements led by Work Package 2 are the following.

1. SoilTrEC pooled together existing field research sites into a European Critical Zone Observatory (CZO) network and as part of a global CZO network. The coordinated plot and pilot scale research within WP2 built new understanding of soil processes at the four main sites [1,2]. These sites represent a breadth of conditions associated with different stages of the soil life cycle. This provoked further development of models with respect to functionality and more sophisticated calibration of process models for soil structure dynamics [3] carbon dynamics [4], catchment hydrology [5,6] and food web dynamics [7] and describes soil processes across the 4 main CZOs.
2. In spite of the enormous range in environmental conditions represented by the CZO network, the range of processes encountered at the sites could be consistently represented by a basic set of soil process models. This achievement allowed the development of site conceptual models to design field measurement campaigns and was instrumental in guiding the development of the Integrated CZ Model led by WP3.
3. The experience within SoilTrEC contributes to benchmarking on i) the practice of reviewing existing field research data, ii) building datasets and models around a core of common data, and iii) the use of modelling to drive data harmonisation and standardisation [8].

Plot and catchment scale field studies

Although the field studies were aimed at collecting similar data for all CZOs and the application of a common set of soil process models, CZO-specific research questions and detailed experimental design brought focus to each individual study. Damma CZO allowed the study of a chronosequence of incipient soil formation. Lysina-Slavkov Forest allowed the study of a gradient in parent material lithology. Fuchsenbigl-Marchfeld allowed the study of a chronosequence of soil formation since the last glaciation as well as a gradient of land use intensity across forest, grassland and arable land. The Koiliaris CZO provides studies of climosequences along the elevation gradient, land use gradients from natural to grazed and arable land and across gradients of parent material lithology. These studies allowed the development of a conceptual model for soil processes at each of the CZOs (Figure 3.2.1).

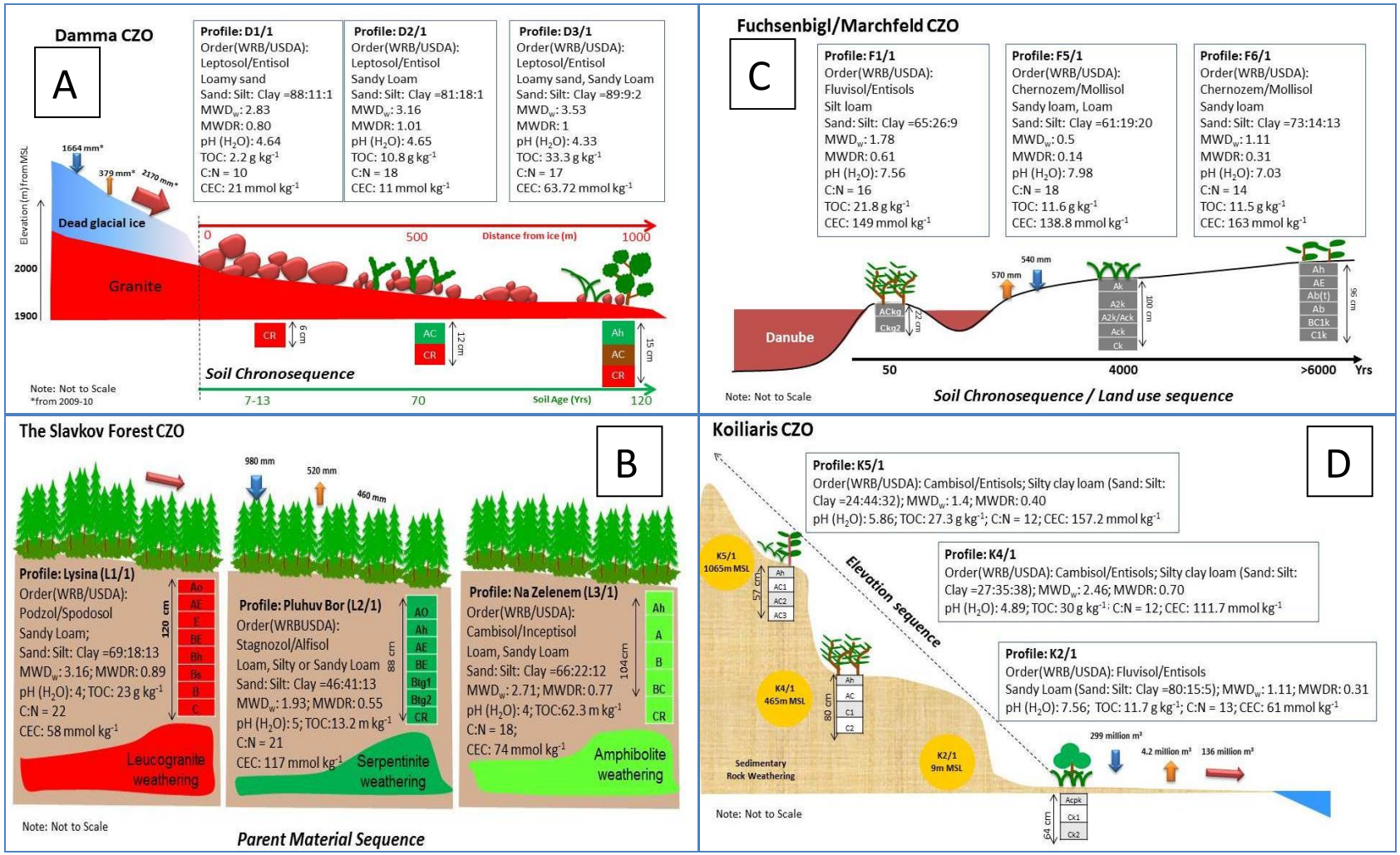

Figure 3.2 (A-D) A. The Damma Glacier located in the central Swiss Alps. The glacier retreat since 1850 has formed a chronosequence of soil formation on the bedrock that is exposed in the glacier forefield. B. The Lysina CZO is located in northwestern Czech Republic, in the Slavkov Forest with Norway spruce (Picea abies) monoculture and with nearby sister catchments of similar land use but differing lithology. C. Productive agricultural soil at the Fuchsenbigl-Marchfeld CZO, located in the Danube River floodplain downstream of Vienna, Austria. D. The Koiliaris CZO, Crete, Greece, extends 25km inland from the coast to elevations over 2000m. Soil degradation occurs from water erosion, due to the landscape relief and clearing of forests and natural vegetation for cropping and livestock grazing.

Soil process modelling

The CZO modelling led to further developments of the Penn State Integrated Hydrologic Model (PIHM), with incorporation of functionality for karstic fracture flow (Koiliaris CZO) and fracture flow anisotropy (Damma CZO). The Soil and Water Assessment Tool (SWAT) modelling showed the CZOs to mainly differ in hydraulic conductivity, how fast rainfall results in runoff, and in soil moisture capacity. Application of the Rothamsted Carbon (*Roth-C*) model and the Carbon, Aggregation, and Structure Turnover (*CAST*) model showed carbon sequestration fluxes to be low or even as a source of carbon emissions for old cultivated soils (Koiliaris) and high for new soils (Damma), where the latter site also had very high turnover rates. The Ligand Charge Distribution (LCD) modelling focussed on the calcareous floodplain soils of Fuchsenbigl/Marchfeld CZO. There it revealed that the competition between phosphate and soil organic matter for adsorption sites on Fe-(hydr)oxides explains differences in C-sequestration capacity between forest soils and agricultural soils. In forest soils the adsorption sites are completely occupied by SOM whereas in arable soils they are saturated with phosphate. The Terrestrial Ecology Model (TEM) modelled C and N mineralisation rates and compared these to measured data. This required site specific calibration of the microbial turnover rates, which are sensitive to environmental conditions. TEM predicted CO_2 emission rates in the same order of magnitude as the CAST model, although the predictions between and within sites by the two models were not similar. Only the relatively low C mineralisation rates at the Damma CZO were confirmed by both models.

Data standardisation and archiving

The first step was an inventory of the existing data and monitoring efforts for all CZOs and satellite sites. This was followed by the generation of a more uniform database through the soil profile sampling and analysis for the four main CZOs that were performed within WP1, and for which sampling and analytical procedures were well documented. The next step was the selection of common soil process models and the collection of the necessary data for each CZO (where not yet available).

Experiences within SoilTrEC showed that the use of common data archives and models steers towards increased standardisation. However, there is a need for greater cyber infrastructure support on the European scale to facilitate CZO data archiving for the future, and better delineation of the roles and responsibilities of the various parties involved.

Practical relevance of the results and key dissemination materials and activities

The extensive set of research results contribute to the strength of the global CZ network and community. The soil process models as tested and further developed can be applied in scenario studies to assess the effects of different land management practices. Focussing research effort on CZOs was particularly useful from the point of view of dissemination. At Damma, a climate audio trail “Gletscherblüte und Zeitreise” was developed (in collaboration with myclimate and Wasserwelten Göschenen (http://www.wasserwelten.ch). It has nine stops and leads around the Göscheneralpsee and Damma glacial forefield. There are separate versions for adults and children. At Koiliaris, the local population was involved in the tomato-plot experiment and at several locations within the catchment, information boards have been placed to explain about the research to the wider public.

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3.3.3 Work Package 3 – Developing a Critical Zone – Integrated Model of Soil Functions

Work package objectives for the project

The objectives of Work Package 3 were the following:

- Constructing an Open Source integrated process model of soil formation and loss and soil functions in the Critical Zone (CZ-Integrated Model)
- Development of up-scaling methods for Critical Zone simulations at catchment and regional scales
- Field validation of the CZ-Integrated Model across a range of scales
- Evaluation of the sustainability and longevity of soil functions by modeling soil function at the stages of the soil life cycle represented by the 4 SoilTrEC CZOs.
- Provision of a validated CZ-Integrated Model for application across a global network of field sites

All objectives have been achieved and the 5 Deliverables have been completed successfully and on-time.

Brief description of key results and achievements for the project

Key achievements led by Work Package 3 are the following.

1. The 1D-ICZ model is the first model available in the scientific literature that can simulate nutrient sequestration dynamics, their turnover time, plant-soil-micro-organism interactions as well as changes soil structure dynamics and dynamic changes in soil hydraulic properties [1-5].
2. The 1D-ICZ model can simulate all major soil functions including biomass production, carbon and nutrient sequestration, maintaining soil biodiversity and water filtration and transformation and thus is capable of quantifying soil ecosystem services. The model can be used as a tool to demonstrate "sustainability by design" land management measures and support sustainable land care practices [6-9].
3. The application of the ICZ model to sites that spread around Europe, Asia and the North America cover all major climatic gradients and attested to the universality of the model to assess soil functions and soil threats around the globe [10-11].

The primary aim of this work package was to develop a tractable and defensible mathematical model, the 1D Integrated Critical Zone Model (ICZM) that links the development and loss of soil structure to water flow and solute transport, plant growth and nutrient dynamics, carbon dynamics and biodiversity. Models of flow and transport (Hydrus 1D); bioturbation; chemical equilibria and weathering kinetics, SAFE; C/N/P dynamics and aggregate formation, CAST; and vegetation dynamics, PROSUM, were integrated to formulate the 1D-ICZ Model. The ICZM was validated using data derived from plot experiments where tomato plants were grown using commercial fertilizers, compost, manure and a 30% manure - 70% compost amendment. Detailed data have been collected over four growing seasons on soil and soil solution chemistry, aggregate formation, and plant production. These data were used to calibrate the 1D-ICZM for the different treatments. The model was able to capture the dynamics of the water-stable macroaggregate formation, and the carbon and nutrient sequestration in the different sized aggregates (see Figure 3.1), and variability of water filtration and solute transformation efficiency in the different treatments.

The model has been able to simulate the carbon fluxes (Above-ground Net Primary Production, Soil Organic Carbon Sequestration, Biomass and Fauna Carbon Increase, CO_2 Production), soil structure indicators (% Water Stable Macroaggregates Increase, % Bulk Density Decrease) and carbon and nutrients (NO_3, PO_4, K) that leach to groundwater. The concept of sustainable use of soil suggests that soil functions can improve due to management practices.

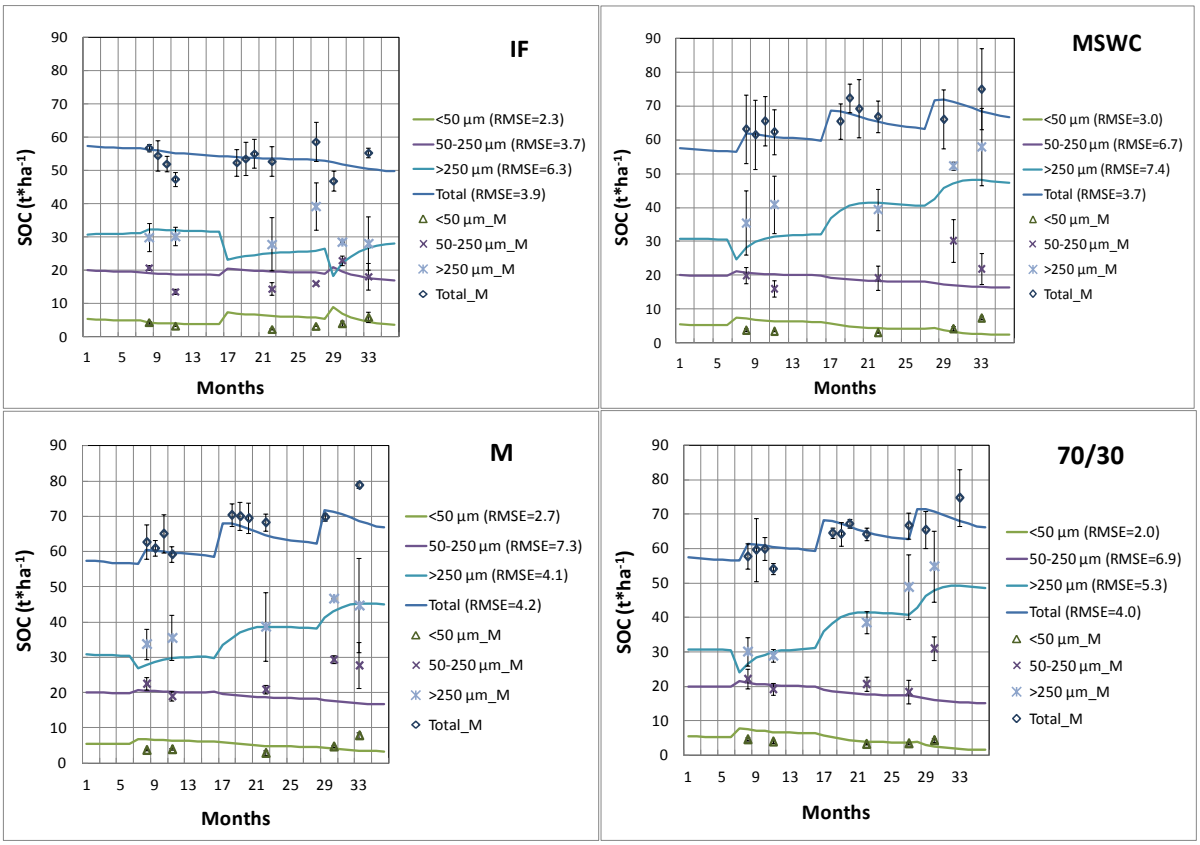

Figure 3.1: Simulated evolution (plotted lines) of soil organic carbon (total SOC, aggregate sizes d<50mm, 50mm<d<250mm and d>250mm plus the coarse particulate organic matter in 4 experiments: the inorganic fertilization (IF), municipal solid waste compost (MSWC), manure (M) and mixture (70/30) treatment. Symbols are plotted values of measurements.

These data can be used to assess the improvement of soil functions due to carbon amendment compared to inorganic fertilization. There are trade-offs that have to be taken under consideration when managing soil functions. Even though carbon amendments improve significantly most of soil functions, they contribute adversely to groundwater nutrient pollution. In addition, increases up to 50% have been observed in the CO_2 fluxes to the atmosphere compared with the inorganic fertilization. This suggests that the amount of carbon amendment to the soil has to be studied in order to optimize the benefits and the impacts it has to soil functions and elemental fluxes respectively.

Data from 10 sites, the 4 EU CZOs (Koiliaris CZO, Damma Glacier CZO, Lysina CZO and Marchfeld CZO) together with five additional satellite CZOs (Plynlimon-UK, Kindla-Sweden, Strengbach-France, Clear Creek-USA and Black Soils-China) and an additional site in Crete, Greece (MILIA) (the site had unique chronosequence data for a carbon addition cultivated soil) were used for the integration of modelling results. The 0D version (a single layer in a soil profile) and the 1D version of the ICZ model have been applied to these sites and their results were assessed in a comprehensive way in order to deduce their state of soil function and/or degradation. The application of the ICZ model to sites that spread around Europe

and cover all major climatic zones as well as the application to China's black soil and the US Clear Creek CZO attested to the generality of the conceptual and mathematical model to represent the stages of the life cycle for soil functions, and to assess soil functions and soil threats when parameterised for local conditions.

A unique feature of the 1D-ICZ model is its capability to simulate dynamically soil structure and soil hydraulic property changes as a function of time by having incorporated new pedotransfer functions. A simulation was performed using the Olive grove at Koiliaris CZO to evaluate the impact of carbon addition to soil hydraulic properties. Carbon amendment enhanced the biomass production, carbon sequestration and also improved soil structure through macro-aggregates' increase and bulk density reduction. On the other hand, leaching of nitrates was almost doubled as OC leaching tripled. The organic carbon input in the soil increased the saturated water capacity of the soil and reduced the hydraulic conductivity. The impact of tilling on the values of the hydraulic conductivity is very evident and it is fully simulated by the model. This is the first simulation in the scientific literature that shows the impact of carbon addition on the dynamics of soil structure and changes in the hydraulic properties of the soil.

Practical relevance of the results and key dissemination materials and activities for the project

In this work package, the first model available in the scientific literature was developed that can simulate all major soil functions including biomass production, carbon and nutrient sequestration, maintaining soil biodiversity and water filtration and solute transformation and thus is capable of quantifying soil ecosystem services. The 1D-ICZ model can simulate soil structure dynamics as well as changes in soil hydraulic properties together with nutrient dynamics and plant-soil-micro-organism interactions. The application of the ICZM to sites around Europe, Asia and North America cover all major climatic gradients and attest to the universality of the model to assess soil functions and soil threats around the globe. The model can be used as a tool to carry out "sustainability by design" by designing computational experiments that simulate hypothesised improvements in land management practices and that can support sustainable soil functions.

Five training workshop events were organized as part of SoilTrEC project. The aim of the workshops was to train primarily SoilTrEC researchers on how to use the modeling tools that were used and were developed by the modeling team of the project. These workshops were open to other researchers and in this way SoilTrEC project members benefitted from the cross-fertilization interaction with other projects. More than 150 scientists were trained in these workshops. The results of this work package have been published in 15 peer-reviewed scientific journal papers, 8 peer-reviewed conference proceedings and 17 presentations at international conferences.

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3.3.4 Work Package 4 – Upscaling to assess European soil threats

Work package objectives for the project

Throughout the SoilTrEC Project, WP4 developed models and produced numerous maps and data as part of the deliverables (4.1 to 4.7). All the datasets were successfully included in the data flow among the work packages to be part of project activities. The Work Package 4 (WP4) has mainly focused on mapping and upscaling the soil data to assess EU soil functions and soil threats. WP4 developed a hierarchical process meta-model for mapping and upscaling soil data from field scale to regional scale and moreover to European Scale. WP4 also studied the incorporation of smaller scale data into the larger European Soil Information System.

Furthermore, the WP4 established a Proof-of-Concept for methodology to assess soil threats and impacts at European level and for better delineation of soil risk areas. The WP4 has developed models in a Geographical Information Systems (GIS) platform to fulfil the above-mentioned actions. To carry out these studies, digital soil mapping techniques were used to predict key soil properties in the CZOs and to transfer processes from CZOs as small reference areas to larger regions.

EC DG Joint Research Centre researchers team which led WP4 have developed a modelling framework which is fully integrated in the Multi-scale European Soil Information System (MEUSIS) Framework and European Soil Data Centre (ESDAC) (Figure 4.1).

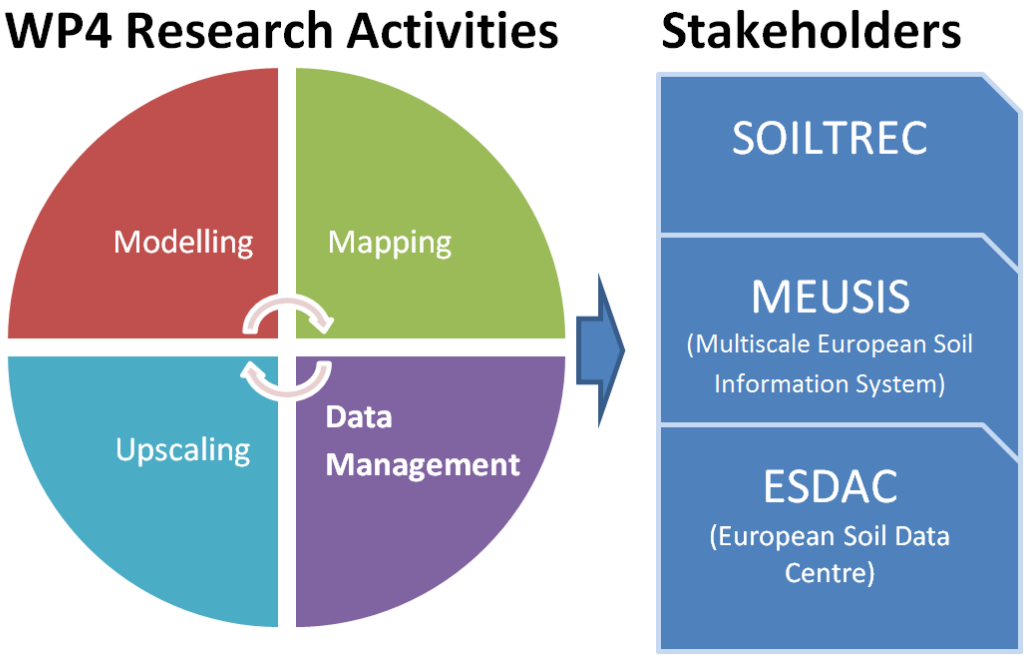

Figure 4.1 WP4 Activities and Beneficiaries.

The European Soil Data Centre (ESDAC) in JRC is collecting, hosting and serving regional, national and continental datasets and acts as the primary data contact point for the European Commission's soil data and information. ESDAC serves raw point data (LUCAS) as well as modelled datasets (soil organic carbon, soil erosion, compaction etc.). In addition to data management, ESDAC also works on numerical models to improve soil data interoperability to address and solve different problems at different scales developing the Multi-Scale Soil Information System (MEUSIS). The WP4 has integrated the soil organic carbon modelling platform (Data management, Mapping, Modelling and Upscaling) into MEUSIS and ESDAC for the needs of SoilTrEC project (Fig. 4.1).

Brief description of key results and achievements for the project

The key achievements of the project that were led by Work Package 4 are

1. Development of GIS-based modelling platform for upscaling point observations at regional and European scale maps of soil threats and functions,
2. High resolution maps of current soil organic carbon content (%) and stocks incorporating future predictions (year 2050) based on land use and climate scenarios, and
3. The soil erosion risk estimation with the G2 model in Crete was 8.1 t/ha annually and the total lateral C (carbon) flux due to soil erosion estimated with CENTURY model was 0.012 Mt for the agricultural soils.

The WP4 has developed a meta-model for mapping and upscaling the soil function and soil threats. The application of the meta-model contributes to new maps and datasets of soil functions and threats (better delineation of risk areas) which are incorporated in the European Soil Data Centre. The studies are mainly focused on soil organic carbon (SOC) modelling because SOC is an important aspect of soil quality and plays a very important role in soil productivity, environmental protection, and food safety. Moreover, SOC is the largest part of the terrestrial carbon cycle. Digital soil mapping techniques produced SOC Maps for the CZOs (Koiliaris, Damma Glacier, Lysina, and Fuchsenbigl). The meta-model upscaled the soil information from the CZOs as reference sites to regional scale (Crete, Bohemia and North East Austria) while a regression kriging model predicted SOC stocks at European Scale and projected SOC changes based on land use and climatic scenarios.

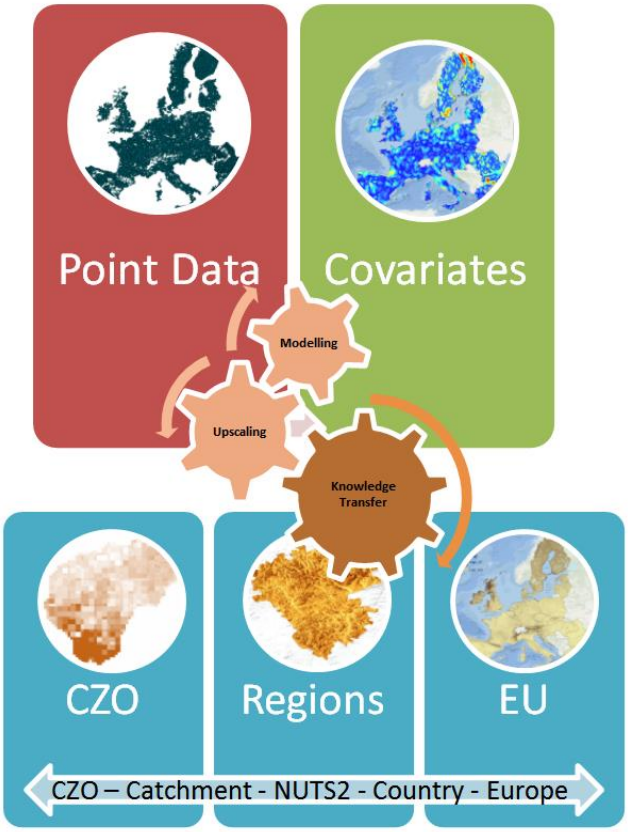

Figure 4.2 Workflow for the WP4 Modelling activity. SoilTrEC pioneered the use of high quality field data from CZOs a small reference sites to inform upscaling meta-models to transfer information on soil functions and soil threat to regional and EU scale.

In addition to SOC modelling studies, WP4 also modelled other soil threats which are related to land degradation (soil erosion, soil sealing) and produced valuable data and maps of the CZOs and broader areas. The CZO experimental design allowed WP4 model testing, fine tuning and validation. Finally, WP4 has coupled the soil erosion outputs with SOC models and estimated the carbon fluxes due to erosive processes. The JRC researchers implemented widely accepted digital soil mapping techniques (Kriging, Regression Kriging) and suggested also new approaches like reference area method to transfer the CZO knowledge to larger areas (Geographic Regions, EU) (Figure 4.2).

The available measured point observations (LUCAS Soil, CZO Measurements, Biosoil) are modelled with covariates (terrain, land cover, climate) using a GIS-based model consisting of two components. The "Upscaling" module interpolates the point data with an objective to develop maps at large scales (country, EU) while the 'Knowledge Transfer' module applies the developed spatial interpolation rules of CZOs at regional level (Fig. 4.2). The combined results of the two modules are maps of soil threats and functions at different scales (CZO, catchment, Regions, Country, European).

Practical relevance of the results and key dissemination materials and activities for the project

WP4's modelling applications are led by researchers within the European Commission DG Joint Research Center. The applications have produced a large amount of data on soil functions and threats in different scales (CZO, Regional and European). The proposed meta-model reduced uncertainty and allows better delineation of the risk areas. The more precise assessment of soil threats and their geospatial variation will allow making cost-benefit estimation of the policy scenarios for mitigation strategies.

The results give a significant input for improved estimation in local (CZO), regional level and further in European Scale. The model application produces new databases and maps which improve the current status of European Soil Information System in the European Soil Data Centre (ESDAC) and makes predictions of future land use and climatic scenarios. ESDAC is the thematic centre for soil related data in Europe hosting soil data and information for soil threats and functions and distributing them to soil researchers and policy makers.

The modelling platform developed by the WP4 Researchers is a GIS-based framework that can be easily repeated in different CZOs, regions and different time scales. Moreover, this modelling framework can be extended to host other soil functions and threats. All this fits to the JRC work programme objectives as a research based policy support organisation; JRC translates scientific outputs into policy to mitigate risk by taking decisions on land use, water management and agricultural practices.

The results of this work package have been published in 6 peer-review scientific journal articles with a further 1 in review and 2 submitted, and 8 peer-reviewed conference proceedings. The results of the WP4 have been also disseminated with the European Soil Data Centre (ESDAC) Newsletter to 3,780 scientists (November 2013). The soil erosion dataset in Crete has been published in ESDAC after a peer review process and have been download by 40 registered users. After the peer review and acceptance of rest of articles, the modelled data will be available in ESDAC:
http://eusoils.jrc.ec.europa.eu/projects/Soiltrec/Indicators.html.

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3.3.5 Work Package 5 – Quantifying soil function impacts in Decision Support Tools

Work package objectives for the project

Work Package 5 has met all the objectives during the SoilTrEC FP7 Project. These include the integration of soil process model results into an environmental decision-making assessment framework as life cycle assessment (LCA). Soil function impacts were quantified and made available in LCA, for the island of Crete, under the impact category “land use”. Furthermore, a framework for monetary valuation of multiple soil services has been proposed and an initial set of quantifiable indicators for soil function impacts was defined, based on expert judgement and involvement of local farmers.

WP5 linked to WP4 capability to better delineate soil risk zones and integrated the results of upscaling into LCA for four different soil functions and threats mapped in the CORINE land cover maps. Broad dissemination and consensus building was reached by means of project deliverables, scientific publications, fact sheets and future integration of results in LCA operational tools.

Brief description of key results and achievements for the project

The main achievements led by WP5 are the following.

1. Deliverable 5.1 [1] successfully introduced the concepts of life cycle assessment (LCA) and the available models for assessing land use change in decision-making. We provided an initial set of quantifiable indicators for soil. Deliverable 5.2 [2] presented the methodology report to the International Reference Life Cycle Data System (ILCD) on making benefits of land use changes quantified in terms of environmental impacts. Deliverable 5.3 [3] successfully presented a review of the existing literature on soil natural capital and soil ecosystem services (ES) and presented the methodology report on economic valuation of these services. The proposed framework aimed at classifying and valuing soil ES in the Earth’s Critical Zone. These three reports not only served as background for the work developed later in WP5, but also as general information for soil quality assessment and economic valuation of soil ES.
2. Deliverable 5.4 [4] briefly explained the current conceptual framework of land use impact assessment in LCA and proposed characterization factors (CFs) calculated for a pilot area, Crete, based on SoilTrEC data delivered by Work Package 3 (WP3) for Koiliaris and up-scaled by Work Package 4 (WP4). Based on the review of current existing soil quality models and the data supplied by SoilTrEC WP3 and WP4, WP5 proposed two types of characterization factors: site-specific (indicate the impact of occupation – taking into account the four parameters - for each 100mx100m grid cells in which Crete is divided) and site-dependent (indicate the impact of “occupation” in different land cover types – independently from where they are located in Crete).
3. Based on the framework proposed in Deliverable 5.3, WP5 suggested, in Deliverable 5.5 [5], a prototype assessment framework structure of sustainability goals measured by core and optional or satellite indicators derived from survey results. Deliverable 5.6 [6] presented the minutes of the WP5 integrating workshop and a summary of results of LCA analysis and monetary valuation and aimed to ensure broad dissemination and build consensus on the proposed CFs and valuation methods for soil functions.

Integration into decision-making tools as Life Cycle Assessment

WP5 aimed at quantifying impacts on soil function in decision support tools. Four soil threats indicators were incorporated in LCA as a support to decision-making of supply chain impacts associated with land use: (i) total nitrogen content [g/kg], (ii) soil sealing [% area], (iii) soil

organic carbon content [SOC, %], and (iv) soil erosion [t/ha]. Figure 5.1 depicts these indicators for site-specific and site-dependent characterization and inventory data required.

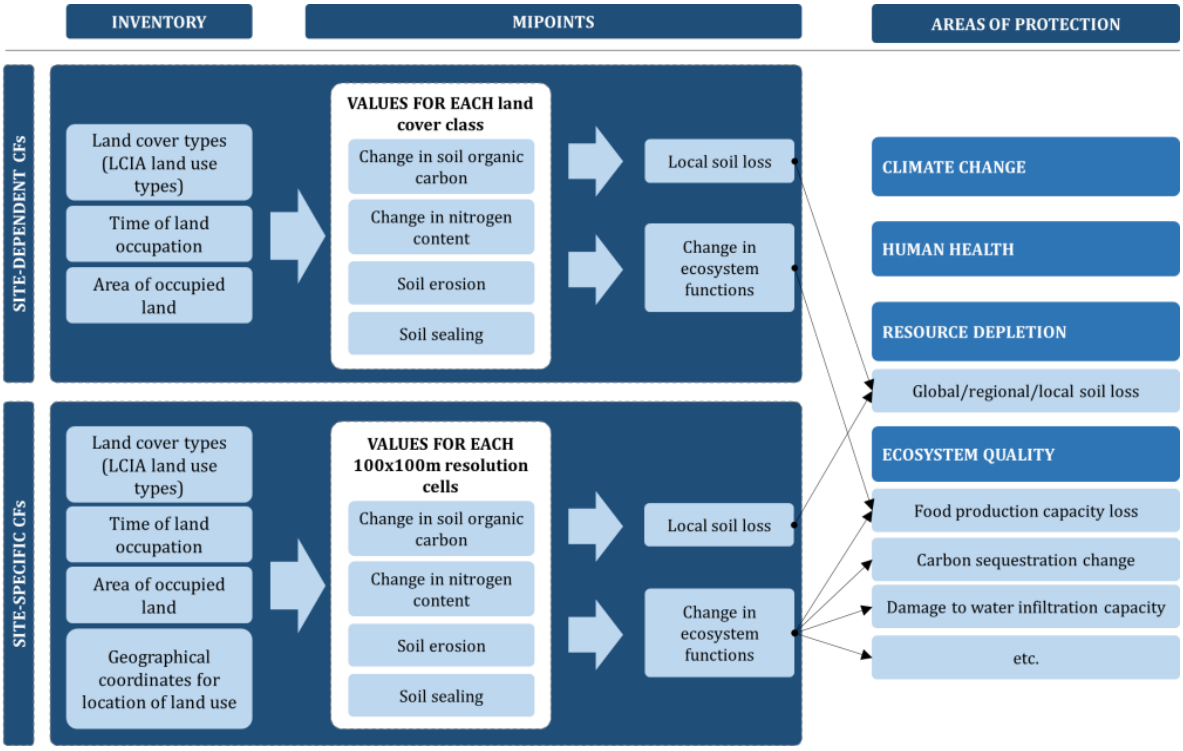

Figure 5.1. Schematic representation of the environmental mechanism from inventory data required up to representation of possible end-points. The scheme presents the environmental mechanism for both site-dependent and site-specific characterization factors for occupation. After endpoints are represented, in terms of change in ecosystem functions related to soil functions affected, an economic valuation may be carried out to evaluate the economic impact of changes in soil/ecosystem functions.

LCA studies require mostly a lot of data (life cycle inventory) and demand a considerable amount of economic resources. Moreover, practitioners may not have exact information on where the production system, or part of it, takes place. Therefore, in general, characterization factors in LCA are proposed based on a *top-down approach*, i.e., making use of more generic data (e.g. national or global scale). However, for indicators such as soil quality, these factors do not fully represent local and/or regional impacts and damages to the environment. The results obtained in the SoilTrEC FP7 project helped solve this gap, as characterization factors were proposed, following a *bottom-up approach*, in which data is provided at a local scale, allowing a much more accurate representation of soil quality in a local and regional context (in this case, Crete Island).

Soil Sustainability Indicators

WP5 also developed a justified set of sustainability indicators for soils. This process led to the development of an extensive review of available indicators for soils, the development of a framework for indicator development that could be used in other contexts and relying on this development process created an indicator set that can be used at different levels of decision-making.

Two major stakeholder consultations contributed to the final justification of a ranked set of indicators. A World Café procedure was carried out in 2011, in Italy, with an initial set of 360 indicators. SoilTrEC partners and stakeholder groups brainstormed and voted on a set of

possible sustainability indicators for soil. 44 indicators, belonging to three different pillars of sustainability (environment, economy and society) were finally chosen.

As a second step, after the World Café, the Delphi survey method was applied. Forty-four indicators were set out to 90 participants made up of scientists and user stakeholders. The overall final results are shown on Table 5.1 [6].

Table 5.1. Overall results of the survey that applied the Delphi method

Indicator nr.	Ranking place high	Indicator name	Low score	Standard deviation
32	1	Public awareness of the value of soil	4.52	0.68
1	2	Net carbon sequestration in soil	4.48	0.68
14	2	Change in soil total organic matter (TSOM)	4.48	0.68
7	3	Soil sealing	4.38	0.74
9	4	Soil contamination	4.38	1.12
39	5	Changes in flora diversity above ground	4.3	0.57
10	6	Changes in pH	4.33	0.73
4	7	Aggregate diversity	4.25	0.64
5	8	Bulky density	4.24	0.77
11	9	Changes in microbial biomass	4.24	0.94
25	1	Labor intensity	3.00	1.03
36	2	Age diversity in rural areas	3.19	1.08
38	3	Soil iron oxides content compared to ref. value	3.24	1.14
26	4	Access to information and justice	3.33	0.86
18	5	Waste generation intensity	3.33	1.02
34	5	Human health	3.33	1.02
21	6	Energy returns on investment	3.43	0.87
30	7	Literacy	3.43	1.4
42	8	Temperature – daytime temperature during the growing season	3.48	0.93
41	9	Public access to nature areas	3.52	0.98

Monetary Valuation of Multiple Soil Functions

A pilot study for valuation of soil functions utilised data from the Koiliaris CZO due to the CZO having the most comprehensive data available and due to the development of LCA characterization factors for that area. The soil services (functions) chosen were two regulating services (climate regulation (GHG buffering cold and heat) and filtering of nutrients and contaminants) and a provisioning service (biomass production). A summary of the services and the ecosystem method used is found in Table 5.2 [1].

Table 5.2. Soil services evaluated with economic methods in Koiliaris CZO

Soil service	Economic valuation method	Metric	Beneficiary
Climate regulation	Mitigation or restore cost	C kg/ha/yr	National/World
Filtering of nutrients	Avoided cost	N/kg/ha/yr	National/World
Biomass production	Producers price	Price per biomass	Local (farmers)/National (consumers)

The results showed a total cost of 1-278 ID$/ha/yr for the filtering of nutrients and contaminants, a cost of 2,200 – 5,610 ID$/ha/yr. for climate regulation and 740 – 7560 ID$/ha/yr for biomass service.

It was verified that it was possible to up-scale valuation results (national scale or even European scale). However, upscaling depends on the data for biophysical flows that describe the services being valued and what data is applicable for the specific context and objectives of the valuation. Some price data is available for national and EU wide comparison, specifically FAO commodity prices and national mitigation cost numbers.

Practical relevance of the results and key dissemination materials and activities for the project

Currently, soil quality indicators are not yet operational in LCA software. This means that soil functions are not taken into account when considering impacts from supply chains or single products. The first important contribution of SoilTrEC WP5 was the proposal of characterization factors for soil quality parameters, in order to allow the quantification of soil function impacts in a decision support tool as LCA. These factors are the site-specific characterization factors. Moreover, in order to contribute to current practice, on bigger scales, site-dependent characterization factors were also proposed. This is highly relevant, having in mind the incorporation of LCA in many policy instruments, not only in Europe, but all over the world. In practice, the incorporation of soil function impacts on LCA will allow soil quality to be considered, when making decision on different products. This affects not only the producer, but also the aim of more sustainable land management practices, at farm level.

Indicators for soil sustainability have also been proposed. They can be used in many contexts, ranging from decision-making at various levels (e.g. farmers) to policy-making. The process of setting the sustainability indicators took into account the experience and participation of different groups (farmers, other stakeholders, scientists), allowing all those groups to contribute to identifying the set of indicators. In addition, WP5 also provided quantified economic models to assess the monetary value of soil ecosystem services. The study revealed also the need to assess these ES in context with other indicators when making decisions regarding land-use, as economic valuation may favour actions that yield high economic values in the short run, possibly degrading the soil resource in the long run.

Valuation analysis is relevant in the context of illustrating the contribution of different soil services and the cost associated with soil degradation, i.e. loss of services. It provides information that may be useful when making decisions on management practice by bringing additional non-market information into decisions; such as raising awareness of the scale of off-site environmental costs that might not otherwise be considered.

The results of this work package are presented in 7 peer-review journal articles by Maia de Souza et al. and Robinson et al.

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3.3.6 Work Package 6 – International Integration

Work package objectives for the project

- Establish a global network of Critical Zone Observatories
- Experimental design to quantify soil processes along global environmental gradients
- Comparison of field and modelling results for soil processes and rates along gradients
- Standardisation of methods and data sets for the global network
- Delivery of an international training programme with the global network
- Organisation of specialist conference sessions and an international conference

Brief description of key results and achievements for the project

Key achievements led by Work Package 6 are the following

1. SoilTrEC established a global network of Critical Zone Observatories anchored by the 4 main CZOs at its core (Damma, Fuchsenbigl/Marchfeld, Lysina (the Slavkov Forest) and Koiliaris), and including CZOs in Europe (Plynlimon, Kindla and Strengbach) a further CZO in China (Red Soils) and the Shale Hills and Clear Creek CZOs in the USA [1,2].

2. SoilTrEC led an international effort to establish the conceptual experimental design to quantify soil processes along global environmental gradients of climate and land use. Together with the USA National Science Foundation CZO programme, SoilTrEC organised an international workshop for global experimental design at U. Delaware in November 2011 [3,4]. Sixty CZO sites from 25 countries were represented at the meeting. Within the project, SoilTrEC completed a comparison of field and modelling results for soil processes and rates along gradients of environmental conditions using the project network of CZOs. The project team frequently met throughout the project using dedicated workshops to discuss both field and modelling results. The workshops in Vienna (2011), Zurich (2013), Chania (2013, 2014) and Paris (2014) were important integration activities. Initial results were published [2] and a final technical report [5] presents the main results that will form the basis for additional journal papers in preparation.

3. SoilTrEC delivered an international training programme of 10 events with 349 participants in total. The training content will continue to be used as project foreground that will continue to be developed and contribute and to future training of young scientists and stakeholders. Additional participation from outside SoilTrEC was funded from the USA National Science Foundation (NSF) and NSF China. Events in Wuhan, Boulder, Prague and Chania were co-organised with participation from the USA CZO programme funded by USA NSF, and the meeting in Boulder was noted as evidence of international collaboration between the EU and USA in the Nature comment article that was commissioned from the SoilTrEC project in 2011 [3].

SCOPE Rapid Assessment Process project

SoilTrEC contributed substantially to the SCOPE Rapid Assessment Process project on Soil Carbon. The project followed publication in the UNEP Yearbook 2012 of an emerging issues chapter on the benefits of soil carbon management to tackle major global challenges of land degradation and food, fuel and water security. Seventy-five authors from 17 countries on 5 continents produced background chapters of science evidence for policy advances. SoilTrEC and the EC DG Joint Research Centre organised with SCOPE an international workshop in March 2013 that produced cross-cutting chapters. The main output of the project, SCOPE volume 71 Soil Carbon – science, management and policy for multiple benefits [6] was launched on Global Soil Day, 5 December 2014.

Standardisation of methods and data sets for the international network

Through joint discussions with overseas partners at the co-organised training events and in technical development led by Work Package 2 on data management, sharing and curation, SoilTrEC contributes to improved practices and standards for data management in collaborative international soils research. The detailed results are presented in a series of 3 SoilTrEC project reports:

1. Harmonized database of existing field data [7]
2. Initial report on standardized data acquisition and connected experimental methods, as well as for long term data storage, maintenance, and accessibility of the CZO data [8]
3. Technical report on routes to standardisation [9]
4. Final report on standardization of data acquisition and experimental methods [10]

SoilTrEC experience and consultation with international partners identified the need for greater e-infrastructure support on the European scale to facilitate CZO data curation for the future, and better delineation of the roles and responsibilities of the various parties involved. Improved data curation will enable greater transparency in data quality and ensure access to future research users.

Delivery of an international training programme with the international network

SoilTrEC delivered 10 training events with 1-3 events in each year in order to develop field, laboratory and the modelling skills and cross-disciplinary knowledge in the Critical Zone research program as listed in the table below. The training events were highly successful with the participation of international participants from Europe, USA and China. All training materials are accessible through the members' area of the website.

No	Event	Date	Venue	Number of participants
1	Training Event: Critical Zone Biogeochemistry; and International student symposium	1-2 Jun 2011	Boulder	35
2	International Workshop on Design of Global Environmental Gradient Experiments using International CZO Networks	8-9 Nov 2011	Newark	80
3	Social and Economic Frameworks for Natural Resource	16-18 Jan 2012	Ispra	25
4	Workshop on reactive transport modelling	16-19 Jul 2012	Chania	41
5	The 2nd Int. Geobiology Conference: critical zone observatories for sustainable soil development and beyond	5-8 Sept 2012	Wuhan	79
6	Soil aggregation and organic carbon – Sampling, analysis and modelling	10-12 Apr 2013	Vienna	11
7	Land-use practice and sustainable use of soil	30 May-2 Jun 2013	Sólheimar	27
8	Hydrology and Soil Functions	2 – 4 Jul 2013	Zurich	15
9	Terrestrial Ecology	18-20 Sept 2013	Prague	11
10	Europe and international policy to address global soil threats	3 Oct 2014	Ispra	25

Organisation of specialist conference sessions and an international conference

The SoilTrEC team successfully organised critical zone research sessions in the following international conferences:

1. European Geoscience Union conference in 2014 (SSS9.12/BG2.18/GM4.7/HS8.3.23; Coevolution of soils, landforms and vegetation: ecosystem stability thresholds and critical zone observatories) [11]. The conference abstracts were collected as a SoilTrEC report.
2. Eurosoil 2012 - S13.5 International Critical Zone Observatory research focusing on soil
3. Goldschmidt 2011- Session 14a. Critical Zone Processes at Multiple Scales

SoilTrEC co-organised the international conference Geochemistry of the Earth's Surface IX, held in Boulder, Colorado and featured the research outputs and participation of scientists form SoilTrEC and the USA National Science Foundation CZO programme. A joint training event preceded the 5-day conference and an abstract volume was published [12].

Other significant conference where SoilTrEC was well represented:

1. Frontiers in International Critical Zone Science, 21-23 May 2014, Beijing
2. Geochemistry of the Earth's Surface (GES), 18-22 August 2014, Paris

Practical relevance of the results and key dissemination materials and activities

The project web site is the main dissemination mechanism to support training and international collaboration. Key documents and supporting material are available from the home page or the training or members' areas.

Dissemination materials include the following.

- A well maintained project website with training events: http://www.soiltrec.eu/events/events.html
- E-Learning Portal: http://www.soiltrec.eu/main/elearning.html
- Training materials from international training programs (member's area): https://sites.google.com/a/sheffield.ac.uk/soiltrec-members-area/events
- The conceptual design of global experimental design and a 10-year science agenda: Sustaining Earth's Critical Zone: Basic Science and Interdisciplinary Solutions for Global Challenges [4] (http://www.soiltrec.eu/files/Sustain_Earth_CZO.pdf)
- The state of our soils, International Innovation October 2011 (http://www.soiltrec.eu/files/SoilTrEC%20Research%20Media.pdf)
- UNEP Year Book 2012 (Reynaldo, Banwart et al.): http://www.unep.org/yearbook/2012/pdfs/UYB_2012_CH_2.pdf
- Google Scholar Page on SoilTrEC publications: http://scholar.google.co.uk/citations?user=Ism9760AAAAJ

References

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3.3.7 Work Package 7 – Integration through Research Transfer

Work package objectives for the project

Work Package 7 has met during the SoilTrEC FP7 Project the following objectives:

- Study farming and land management practices that promote soil health
- Evaluate what constitutes a sustainable soil system from weathered bedrock through the soil horizons (C,B,A)
- Evaluate the need for energy for different land-use methodologies
- Evaluate "organic" farming and land-use methodologies that work with nature: "organic, permaculture, biodynamic
- Investigate the soil conservation potentials of various tilling methodologies
- Determine the importance of symbiotic fungi for extracting nutrients from underlying bedrock2013.
- Measure the bioavailability of nutrients according to farming methodologies
- Investigate the carbon sequestration potential of various land –use practices
- Introduce the concept of soil sustainability to all Partners at the kick-off meeting
- Promote the concept of soil sustainability to stake holders and the public
- Integrate the concept of sustainable soils into all Partners of SoilTrEC

All above objectives were successfully met (see deliverables 7.1 to 7.9) and achievements under each objective are given below.

Farming and land management practices that promote soil health were studied with organic and conventional farming practices in Iceland (sub-arctic soils) and Austria (Chernozems). The Austrian framing site was within the Fuchsenbigl/Marchfeld SoilTrEC observatory. Evaluation of what constitutes a sustainable soil system from weathered bedrock throughout he soil horizons (C,B,A) was studied by sampling soils in all SoilTrEC study sites from all soil horizons, extending the soil sampling strategy from conventional soils science from zone A into routinely including zone B and C.

The energy needs of different land-use methodologies were evaluated using the Energy Return on Energy Invested (EROI) for organic and conventional farms in Iceland and Austria. The farms were the same as studied under objective 1. Evaluation of farming and land use methodologies that work with nature, organic, permaculture, and biodynamic, was done by comparing the soil properties in conventional and organic farming in Iceland and Austria. One of the organic farms studied in Iceland is also biodynamic. Permaculture was studied (mostly used in gardening) and introduced along with other sustainability principles in the PhD training course in Iceland (2014): Land use practice and sustainable use of soil.

Soil conservation potentials of various tilling methodologies were studied by including tillage in the evaluation of soil sustainability indicators from all three sustainability dimensions: Nature; Economy; and Society and wellbeing. The indicators that were evaluated were: 1. *Nature dimension*: Bulk density, soil depth, potential for N-mineralisation, total soil organic matter; 2. *Economy dimension*: Land management; and 3. *Society and wellbeing dimension:* Bioavailability of essential major and trace elements.

The importance of symbiotic fungi for extracting nutrients from underlying bedrock was the focus of a desk study of whether greater fungal/bacterial (F:B) ratios in soils correlate with favourable conditions for soil functions and development of a conceptual model that considers whether F:B is a potential metric of favourable conditions for soil functions. The bioavailability of nutrients according to farming methodologies was included in the studies of conventional and organic farms in Iceland and Austria as outlined in objective 1. The assessment of carbon sequestration potential of various land –use practices was carried out on soil chronosequence (mostly Chernozems) from 10 to 4500 under agricultural cropping, pastures and forests in the Critical Zone Observatory Marchfeld in the Danube floodplain

east of Vienna (Austria). The results infer that high soil organic carbon accumulation occurs during the first decades

A special session was held at the project kick-off meeting to introduce sustainability thinking and the concept of soil sustainability to all Partners at the kick-off meeting. Promoting the concept of soil sustainability to stake holders and the public was achieved by holding a workshop with stakeholders at the EC DG Joint Research Centre, Ispra (Italy) and by involving stakeholders and policy makers in a Delphi survey for justifying soil sustainability indicators (see WP5). The Work Package leader presented and reinforced the concepts of soil sustainability at all partner meetings.

Brief description of key results and achievements for the project

Key outcomes from the WP have been to

1. Complete for the first time soil sustainability indicators with the participation of stakeholders. This lead to the soils sustainability indicators that were justified with the participation of policy makers, stakeholders and scientists with a series of Delphi surveys that culminated in justified soil sustainability indicators.
2. In addition to championing the concept of soil sustainability, SoilTrEC focussed on the importance soil chronological development, and the effect of land management on the stability of soil aggregates.
3. SoilTrEC demonstrated with a case study in Iceland (Andosols) that organic land management can support the stability of macro aggregates (>250 μm), which are crucial for the support of soil functions and fertility in addition to the protection of organic matter in soil. The case study showed for the farms in Iceland that the Energy Return on Energy Invested (EROI) for farming was significantly higher at the organic farms than the conventional farms.

Additional outcomes include the following results.

The EROI was calculated for in the same farms as the comparative farming studies. For the Icelandic grassland farms results show that one organic farm had an EROI of 1.21, whereas the conventional farms had EROI of 0.79 and 0.82, respectively. The other organic farm had an EROI of 0.89 and the conventional farm 0.54. This indicates that in general, organic farms provide a better EROI than conventional farms and in one case the output contains more energy than the input. This is mainly due to the absence of artificial fertilizers within the organic practice where the farms still maintain relatively high output of produce. For the Austrian arable farms we found that organic sugar beet production provided an overall energy return on investment (EROI) of 11.3 whereas the conventional farming practice showed an EROI of 14.1 and 15, respectively. Our study indicates that organic sugar beet production shows potential to substitute conventional industrial sugar beet production to provide inputs to ethanol production. By using organically produced sugar beets as inputs to the ethanol production, fossil fuels can be avoided to a large extent in the production process, thus, it may be possible to mitigate some of the environmental impacts associated with ethanol production.

For the chronosequence and comparative farming studies a new method for evaluating aggregate stability was developed. It was found that it is very important that researchers carefully select the amount of ultrasonic energy used, and the energy ranges depends on the type of soil studied.

In studying the chronosequence in the Marchfeld Critical Zone Observatory it was found that the persistence of soil organic carbon depends mainly on its physic-chemical composition. Other factors such as ecological and environmental conditions were identified, amongst which, soil physical parameters seem to be of great importance. All biological and chemical processes occur in the pore space defined by the soil structure, indicating that the

accessibility of organic carbon by soil biota could be key for understanding the persistence of organic carbon against biological decomposition. The main conclusions were that carbon sequestration is strongly influenced by human induced land use:
Forest ≥grassland>>cropland

WP7 also found that co-evolution of soil organic matter and clay mineral surfaces is the main mechanism for carbon sequestration and that SOC that is not physico-chemically bound is easily decomposable (excluding peptides and aromatics). The results show a high soil organic carbon accumulation during the first decades of soil development, decreasing intensively in later in time, reaching a very low accumulation rates after some hundred years. This process is strongly influenced by different types of land use (D7.8).

The comparative farming study in Icelandic grasslands (Andosols) showed that macroaggregates (>2 μm) in topsoils were most prominent in unimproved soils (62-77%) and organically managed soils (58-69%), whereas 20-250 μm aggregates were the most prominent in conventionally managed sites. Oxides were shown to be important binding agents of macroaggregates and they correlate positively with fungal biomass. The higher macroaggregate stability in organic farming practice compared to conventional farming is of interest due to the importance of macroaggregates in protection soil organic matter. SOM is a prerequisite for soil functions in grasslands that are envisaged for food production in the future.

The comparative farming study in Austria (Chernozems) showed that there were no significant differences in mean weight diameter (MWD) or amount of macroaggregates between the conventional- versus organically managed arable farms. The smallest fraction of aggregates (<20 μm) at one farming pair and the medium fraction (20-250 μm) at another farming pair contained the most organic carbon and total nitrogen. Further studies are required on cultivated Chernozems to understand on a quantitative basis whether it is beneficial to use biowaste compost and horse manure as organic inputs, in order to increase soil organic matter content and macroaggregation.

Practical relevance of the results and key dissemination materials and activities

Currently the concept of soil sustainability, soil chronological development and effect of land management is not very well researched. WP7 studies are therefore important for furthering soil sustainability thinking, the effect of time on the development of soil function, as well as the importance that organic land management can have on the stability of soil aggregates. Furthermore, we have demonstrated that the EROI for organic farms is higher than that of conventional farms for Andosols in Iceland. The results of this work package have been presented in 3 peer-reviewed scientific journal papers with 5 more currently in review and 3 in preparation, 1 peer-reviewed conference proceedings, 2 PhD theses and 3 presentations at international conferences. The journal Nature commissioned a Comment article entitled Save Our Soils by the project coordinator in 2011. Our work was noted by the Springer Publishing House, resulting in a commissioned book to be edited by the WP7 leader entitled: Soil Sustainability and Policy Needs. The book will come out in 2015. In addition to that the well-respected international journal Advances in Agronomy has invited an issue from the SoilTrEC project highlighting the outcomes of soil research framed by soil observatories in Earth's Critical Zone. The results have also been brought out of the academic world. The project has written a Soil eBook for secondary schools that will come out in January 2015. The WP7 leader has met with a number of stakeholders in Brussels that will continue to disseminate the results of this project throughout Europe and the international community (see Table 1 in section 3.4.1).

3.3.8 Work Package 8 – Project Management

Work package objectives for the project

- Provide leadership and decision-making capacity for successful delivery of the project.
- Ensure effective scientific and administrative communication between partners.
- Monitor progress, assess risks and define clearly the partner responsibilities for delivery.
- Assess measures of success and report these to EC and partners.
- Effective management of research results and advances for pro-active research transfer.
- Stimulate a team ethos and effective working as a research partnership.

The project management section in the Consolidated Review Reports gave very positive comments on the management of SoilTrEC. In period 2 the reviewers stated that "The project management has performed very efficiently and professionally through the duration of the project. The frequency, length and detail of periodic report is exceptional and there was any significant delays for the deliverables."

In period 3 the report stated that "the project management has been performed efficiently and professionally through the duration of the third period of the project. The deliverables were very clear and well performed with no delays and any deviations from the DOW which indicates the high level of management. Collaboration between beneficiaries: the collaboration between beneficiaries is effective and evident in the documents. The interaction between WPs is high and upgraded during the project. Project achievements seem to have benefitted a lot from very good cooperation, considering that there was a strong link between field measurements and model evaluation among all partners."

During year 3 of the project, the management team conducted a short, anonymous survey amongst SoilTrEC partners on the management of the SoilTrEC Consortium. The purpose of the survey was to gain feedback from project partners on the performance of the University of Sheffield in the coordinating role. 63% of respondents rated the overall management of the consortium as "excellent" and 38% as "good". Overall, 64% of respondents rated project communication as "excellent" and 34% as "good" with, 2% as "satisfactory". Of those responding 75% thought email communication was "excellent" and 25% though it was "good". 64% of respondents rated the information circulated by the management team as "excellent", 31 as "good" and 4% as "satisfactory". Partners felt the information they received for meetings was particularly good, with 69% rating meeting information as "excellent" and 31% "good". We also asked partners about responsiveness from the management team. 70% of partners felt this was "excellent", 24% thought it was "good" and 6% felt the responsiveness was "satisfactory".

Brief description of key results and achievements for the project

Throughout the project, the consortium continued with the management format agreed at the beginning of the project. The management team, made up of the Coordinator, Assistant Scientific Coordinator, Project Manager and Work Package Leaders continued to manage the consortium to ensure that the integration of effort and results were monitored and reviewed and that deliverables and milestones were achieved within the deadlines. Management of the consortium was successfully maintained through regular communication and meetings involving different groups.

The Project Manager led the project office at USFD and liaised with partner administrators to maintain and monitor project administration coordination. Administrative roles and responsibilities were clearly defined with each partner in the Partnership Agreements. Project finances were also managed by the University of Sheffield. The Project Manager monitored actual spend within the project by requesting financial reports from all partners every six months. Partners were provided with a draft Form C, in which they recorded their

financial spend. Furthermore, this was considered good preparation for the period end reporting.

SoilTrEC Management Group Meetings

Throughout the project, the management group met on a quarterly basis via Skype. The following management meetings were held during the final period of the project:

	Title	**Date**	**Venue**
1	SoilTrEC Management Group Meeting	05/12/2013, 04/04/2014, 26/06/2014, 04/09/2014, 04/12/2014, 19/01/2015	Skype

SoilTrEC Committees Meetings

During all periods of the project, each committee held at least one meeting by Skype. The meetings ensured effective management and planning within key areas of the project.

The three committees within the project are:

- Training Committee, chaired by Steve Banwart (Coordinator, WP6 and WP8 Leader).
- Data Management Committee, chaired by Pauline van Gaans, (WP 2 leader)
- Dissemination Committee, chaired by Vala Ragnarsdóttir (WP7 Leader).

During the final period of the project the following committee meetings took place by Skype:

	Title	**Date**	**Venue**
1	Training Committee	01/05/2014	Skype
2	Data Management Committee	01/05/2014	Skype
3	Dissemination Committee	05/12/2013,04/04/2014,10/072014,19/12/2014	Skype

Project Board meeting

Due to the number of large number of partners on SoilTrEC, the decisions made by the project board were carried out via email discussions. This proved to be a successful process. Ten project board members attended the final advisory board meeting in 2014.

Advisory Board Meetings

The final advisory board meeting took take place at the EC-JRC office in Ispra, Italy from the 1st – 3rd October 2014. The meeting was attended by 40 participants, including advisory board members, SoilTrEC partners, researchers and students. As part of the meeting we also held final integrating workshops for work package 5 (1st October) and work package 4 (2nd October).

The formal advisory board meeting included presentations from the Work Package leaders to report the results during the final year of the project. This was followed by Q&A with the advisory board. Time was provided for the Advisory Board members to meet separately with the coordinator to review outcomes and headline achievements. These were reported back to the full meeting with discussion on final steps for integration and dissemination.

Forward plans were also discussed with the Advisory Board. An action was agreed that the coordinator would submit to the DG RTD Sino-European Panel and Land and Soil (SEPLS) a proposal for a joint EU-China-USA workshop on urban soils and renaturing cities with a potential timing of mid-2015 proposed.

Internal Management meetings (USFD team)

The internal management team (Coordinator, Project Manager and Assistant Scientific Coordinator) at USFD meet regularly to discuss project progress and to plan for forthcoming events, meetings and deadlines. If needed, necessary relevant partners from the consortium join in discussions via Skype.

	Title	**Date**	**Venue**
1	SoilTrEC Periodic Report Meeting	05/12/2013	Sheffield
2	SoilTrEC Website Meeting	12/12/2013, 11/03/2014	Sheffield
3	SoilTrEC Finance Meeting	07/01/2014, 20/02/2014, 18/06/2014, 14/07/2014, 10/09/2014, 17/09/2014, 23/10/2014, 18/11/2014, 09/12/2014, 08/01/2015	Sheffield
5	SoilTrEC Project Management Meeting	06/02/2014, 06/03/2014, 02/04/2014, 04/04/2014, 01/05/2014, 25/06/2014, 03/07/2014, 07/08/2014, 06/11/2014	Sheffield
16	SoilTrEC Advisory Board Prep Meeting	04/09/2014	Sheffield
18	SoilTrEC Final Report Prep Meeting	12/09/2014, 04/12/2014, 15/01/2015	Sheffield

Progress Evaluation and Risk Management

Progress evaluation and risk management has been reviewed throughout the project. There were no significant issues during the project that needed to be addressed.

Reporting

Scientific reporting within the consortium has been carried out through a variety of methods. Researchers within the project reported on progress within their area of work via presentations and participation at training events and workshops. Work package leaders reported scientific progress to the management group at the quarterly team meetings. Each work package leader provided updates on progress, results, events and planning. Technical reports were also produced as reporting methods and were contracted deliverables within the project, which were submitted within the requested deadlines.

Formal financial reporting to the EC is carried out at the same time as the periodic/final report. The project manager has monitored project finances throughout the project by requesting updated financial information from each partner on a six-monthly basis. Throughout the project all partners completed the Form C via the participant portal, which was reviewed and submitted by the USFD Team.

All project deliverables, unless agreed with the EC Project Officer, were submitted by the requested deadline.

3.4 The Potential Impact of the SoilTrEC Project (10 pages)

3.4.1 Dissemination of SoilTrEC outcomes

SoilTrEC **Dissemination Strategy** is to reach academics, practitioners, EU Commission, policy makers, the public and the international community. Many scientific outcomes have been presented to the *academic community, practitioners, policy makers, EU Commission, public and international community.* These activities are outlined below. An overview of dissemination activities undertaken by all SoilTrEC partners is given in section 4.1. It becomes evident in reading the table that tens of stakeholder and policy makers are reached, thousands of academics through scientific literature, and potentially millions of the public (e.g. teachers via the TES network noted below with 3.6 million registered members).

Dissemination to academic community: Results from SoilTrEC have been presented at international and national conferences as reported in the WP6 section above, along with scientific papers and other dissemination activities undertaken by the partners. Special sessions on the Critical Zone have taken place at many international conferences, including the **Eurosoil** conference in Bari, 2012, **The European Union of Geosciences** AGM in Vienna, April 2014, and SoilTrEC helping organise **The Geochemistry of the Earth's Surface** in Boulder, June 2011 and again in Paris, August 2014. A special issue with overreaching outcomes from SoilTrEC is invited in **Advances in Agronomy** with papers being ready for submission early 2015. The soil topics that will be addressed include: New directions for research, importance of soils observatories for global research networks, biodiversity and food webs, life cycle analysis, ecosystem services, sustainability indicators, political economy, and opportunities for soils education in schools.

Dissemination to Practitioners*:* Practitioners and soil managers can find out about outcomes from our dissemination website and from SoilTrEC **Fact Sheets** that are available for download from the project´s website; they are also available from the EC DG Joint Research Centre Sustainable **Agriculture and Soil Conservation** website. Partners are encouraged to translate the fact sheets into their languages. Fact sheets were brought and discussed at various farming organisations in Brussels in October, 2014 (Table 1). All fact sheets and the final report of SoilTrEC will be sent to these organisations in addition to others that are identified in the table.

The policy and stakeholder fact sheets that were produced in in SoilTrEC are:

- Soil Structure,
- Importance of Soil,
- Earth´s Critical Zone,
- Soil Organic Carbon,
- Food Webs and Biodiversity,
- Ecosystem Services of Soil,
- Farming Practice and Soil Stability,
- Addition of Compost to Tomato Farming in Crete,
- Training of Farmers in Bulgaria,
- Soil Indicators for Sustainability, and
- Modelling of a Critical Zone Observatory.

In October 2014 seven soil related stakeholder organisations were visited in Brussels by the WP7 leader. They were informed about SoilTrEC and provided Fact Sheets from the project. All organisations were very interested in the project and confirmed that they will inform their members of the SoilTrEC outcomes and distribute the fact sheets. The

organisations, their address, membership, contact persons and geographical focus of activity are given in Table 1.

Table 1. Stakeholder organisations visited in Brussels.

Organisation	Address	Members	Contact person	Geography/ Focus of activity
La Via Campesina http://www.eurovia.org/?lang=en	18 rue de la Sablonniere 1000 Brussels	Small farmers	Bernard Boudin Benjamin@eruovia.org +32 221 731 12	International / Rights of farmers
European Land Owners Organisation (ELO) http://www.europeanlandowners.org/	27 rue de Treves 1040 Brussels	European land owners	Julianna Nagy Ana Rocha julianna.nagy@elo.org, ana.rocha@elo.org greening@elo.org	Europe/ Large conferences, Proactive action on the environment, Soil management award
European Initiative for Sustainable development in Agriculture (EISA) http://sustainable-agriculture.org/	10 rue J-B. Vandercammen 1160 Brussels	European farming organisations e.g. LEAF(UK), FARRE(FR), OIB(SE), FNL(DE)	Robby Schreiber gani-med@skynet.be +32 2 660 82 14	Europe, British Commonwealth/ Integrated pest management
European Crop Protection Association (ECPA) http://www.ecpa.eu/	Avenue E. van Nieuwenhuyse 1160 Brussels		Gavin Withore +32 2663 1550 ecpa@ecpa.eu	Europe/ Crop protection Pesticides
Fertilizers Europe www.fertilizerseurope.com	Avenue E. van Nieuwenhuyse 1160 Brussels		Christian Palliere +32 2 675 35 50 christian@fertilizerseurope.com	Europe/ Chemical fertilizers
Cope-Cogeca www.copa-cogeca.eu	61 Rue de Treves, 1040 Brussels		Tania Runge Antonia Andugar-Minarro tania.runge@copa-cogeca.eu antonia.andugar@copa-cogeca.eu	Europe/ Umbrella farming organisation

International Federation of Organic Agriculture Movements (IFOAM) http://www.ifoam.org/	1124 rue du Commerce, 1000 Brussels	Organic agricul-ture organi-sations	Lena Wietheger Lena.wietheger@ifoam-eu.org +32 2 735 73 81	International / Organic farming practices
European Council of Young Farmers http://www.ceja.eu/			Kleopatra Sidiropoulou k.sidiropoulou@ceja.eu Tel: +32 322 304210	Europe/ Young farmers in Europe
Other organisations/programs that are targeted for SoilTrEC partners outreach				
Sustainable Agriculture Initiative platform (SAIP) http://www.saiplatform.org/			info@saiplatform.org	Global/Food and drink industry
Analysis and Experimentation on Ecosystems (AnaEE) http://www.anaee.com/			Evan O´Connell communication@anaee.com	Europe/ Setting up agricultural observatories
(European Innovation Partnership in Agriculture) Eip-agri) http://ec.europa.eu/eip/agriculture/			Pacome Elouna Eyenga pacome.elouna@eip-agri.eu	Europe/ Lining agricultural research with end users
Land Use, Land Use Change and Forestry (LULUCF) http://ec.europa.eu/clima/policies/forests/lulucf/index_en.htm			Jos Delbeke Director General DG Climate Action Jos.Delbeke@cec.eu.int	Europe DG Clima/ How best to sequester carbon
DG Agri, Unit H4, Unit H5			Olivier Diana Rob Peeters olivier.diana@cec.eu.int rob.peters@ec.europa.eu	Europe DG Agriculture

Dissemination of the EU Commission: The EU Commission has been reached through our SoilTrEC periodic and final reports along with specific EC offices, outlined in Table 1. Annual meetings of soil-related FP7 and Horizon 2020 projects have been organised by DG RTD joint with relevant DG policy teams. DG Joint Research Centre is a SoilTrEC partner and acts as a policy interface with the relevant DG policy teams.

Dissemination to the Public: The public will be reached through high school level book - *Soil: Soil the Life Supporting Skin of Earth*. The book will be published as an **eBook** by the University of Sheffield in February 2015. The schoolbook is being brought to the international community by connecting with **UNESCO´s *Decade on Education for Sustainable Development***. The book will be made available through an international network of teachers (TES – www.tes.co.uk) that has 3.6 million registered online users in 279 countries

and territories around the world. SoilTrEC also has an open **Facebook** group where soil related issues and the results of the project are frequently discussed there.

Dissemination to Policy Makers: Policy makers have been reached through SoilTrEC dissemination via the UN Environment Programme Yearbooks 2012 with an emerging issues chapter on soil carbon that was co-authored by the project coordinator. This chapter was revisited in the UNEP 2014 yearbook, including a description of Earth's Critical Zone. The emerging issues chapter motivated the SoilTrEC coordinator, supported by project partners, to lead a Scientific Committee on Problems of the Environment (SCOPE) Rapid Assessment Process project on the Benefits of Soil Carbon. The project published in December 2014 a 400-page authoritative volume of scientific evidence and recommendation of innovation in practice and policy. Many SoilTrEC partners contributed to the volume and the international writing workshop to produce 4 cross-cutting chapters for the SCOPE volume was hosted by SoilTrEC partner DG JRC.

The policy interface will continue to be reached. A new book is commissioned from SoilTrEC partners by **Springer.** The book is in the format of SpringerBrief and the aim is to have it out before the international soil week in Berlin in April, 2015. The title will be Soil Sustainability and Policy Needs and will include chapters on: Soil and the Earth´s Critical Zone; Soil functions; Soil threats; Soil biodiversity and food web; Land use and soil stability; Modelling the soil ecosystem; The global soil supply chain; Soil ecosystem services; The lack of political economy of soil; Soil restoration – solutions for a sustainable future; and Policy needs for soil sustainability. A paper on policy needs for soil protection was presented at a **Political Economy** conference in Sheffield in June 2014.

Dissemination to the International community: The international community is being reached through all of our activities in SoilTrEC. All partners have provided overview of their own dissemination aims and targets (see Table 2 – D7.9 – and Table 1 in this section). The SoilTrEC website has a dissemination section that both gives results from the project and links to important soil related material already available on the web at large. As can be shown in Table 2 SoilTrEC partners have led and contributed to an impressive number of conferences and workshops – reaching thousands of people around the world. The advisory board with members for outside the EU including USA and China has championed the outputs of SoilTrEC which has led to substantial dissemination in those countries.

3.4.2 Evidence of Impact of SoilTrEC

In Part B of the SoilTrEC proposal the applicants aspired to have a wide-reaching impact on the international CZO and soil communities (see Table 15 in section 3.1 Expected impacts). Table 2 outlines the achievements.

Table 2. Impact of SoilTrEC activities

Impact aspired to in proposal	**Impact achieved during 5 year of SoilTrEC**
SoilTrEC will link directly with USA CZOs as the core of global network of sites. This, along with collaborations with a Chinese partner, will create the first international observatory network which will be based on the extensive US experience in founding and managing their CZO network.	SoiTrEC has worked with the USA CZOs to widen the network of observatories to Europe and together SoilTrEC and USA CZOs have formulated with colleagues in. In addition Africa, Asia, Australia and New Zealand a collection of 61 observatories (http://criticalzone.org/national/)
Soil processes will be evaluated with a critical Zone integrated model, from catchment to EU scale, and applied across	SoilTrEC Deliverable D3.4 reports modelling results from across the international network of CZOs within SoilTrEC including sites in

the global network of sites. This will formulate the first international soil system model that will underpin policy in the EU, EU member states as well as in US and China.	China and the USA. The early results from SoilTrEC outcomes provided evidence to support a 2nd round of funding from the USA National Science Foundation CZO programme and contributed evidence to NSF China to initiate a national CZO programme linked with EU and USA national funders.
Four EU field sites with successful research track records will form a network of CZOs for soils research. This will be added to the CZOs in the US, a site in China and affiliated satellite sites in the participating countries.	The SoilTrEC international network of CZOs stimulated a workshop to design joint research at global scale across a network of 60 field sites in 25 countries worldwide, reported on www.czen.org.
The four EU CZOs represent key stages in the soil life cycle; from soil formation, through productive use, to severely degraded soil. This modelling is a new aspect of research that the US CZOs are currently not addressing. Our collaborative effort will thus be the first field based model that incorporates all stages of soil formation to degradation.	The SoilTrEC unique focus on soils within CZOs has allowed data collection and modelling of the overall processes in the large CZ system. The modelling has not only addressed the biogeochemical processes but also a wide range of soil functions as the ecosystem services of soils – a first time achievement.
SoilTrEC addresses key threats in the EU Thematic Strategy for Soil, soil losses through erosion, loss of soil carbon, changes in biodiversity and declining soil fertility. The knowledge of four CZOs in the EU and three in the US will be further extended by studying affiliated sites where alternative land management, presumed to be more sustainable, is overtaken in order to establish ´best practice´ for stakeholders.	Comparison of land management was undertaken in the CZOs in the Czech Republic, Austria and Crete – in addition to Iceland. Fact sheets have been produced that outline ´best practice´ for stakeholders. The first ever transparently justified soil sustainability indicators were established through involvement of stakeholders and partners – with further Delphi testing that involved SoilTrEC participants, stakeholders and policy makers.
Up-scaling of the Critical Zone integrated model will be done for an EU transect at basin-scale and will enable the analysis of soil threats at EU scale. This will be the first international model that addresses such rocks, climate and geographical location.	The SWAT code provides the 3-D integrated platform for catchment-scale modelling of soil functions. The SWAT code for hydrological processes was used to successfully upscale soil functions of water storage and transmission from the Koiliaris CZO to all of Crete to demonstrate the upscaling methodology. The soil function of carbon storage was upscaled from the 4 main CZOs to regional and national scale and the meta-model used to produce maps of soil carbon storage at EU scale.
SoilTrEC partners will establish with the USA CZOs, standards and procedures for harmonisation of data collection methods, data quality and data management. This will be built on the already established date access and standardisation model in the US.	4 SoilTrEC reports document methods of data management, reporting, sharing and curation for international collaboration. 1. Harmonized database of existing field data 2. Initial report on standardized data acquisition and long term data storage, 3. Routes to [data] standardisation [9] 4. Final report on standardization of data acquisition and experimental methods

The SoilTrEC promised impacts and achievements are further outlined below with focus on generating new knowledge, new approaches, soil protection, common strategy for data access and implementation aligned with the EU Soil Thematic strategy. Indicators of measure of successful impact are outlined in Table 4.

Table 3. Indicators of successful achievement of SoilTrEC goals

Activity	**Success Indicator**	**SoilTrEC achievement**
New knowledge on soils through cooperation with North America	Joint publication s between EU, North American and Chinese partners	13 peer-review publications and monograph
	More flexible and versatile data bases of soil process measurements that will help to develop, calibrate and validate computational models and their outputs	Meta-data for SoilTrEC soils profiles data base described in peer-review publication[1], published online at www.czen.org
	A comprehensive plan of how the CZOs will operate	SoilTrEC reports on harmonisaton of data and modelling methods address this. A forward plan for operation of a global network of CZOs is published[2]
New approaches to models and unifying conceptual frameworks for soil research	A well-constructed and tested model that is critically welcomed by colleagues within all science disciplines and which is adopted and developed further in the future as a unifying model	The vision of the model is presented in a commissioned article in the journal Nature. 2 SoilTrEC reports describe the model and its application across the SoilTrEC network of CZOs. Several new proposals have been submitted with the ICZM as a core research capability with 1 funded so far, and full journal articles to report the cross-CZO modelling results will be submitted in 2015.
Contribution to soil protection, restoration and management by addressing a broad range of soil management problems	A database of those who would like to have and use the new management tool for future scenario testing. The more people who are on the database, the greater the impact on the practice community	Table 1 outlines a large number of organisations that have an impact across the world
	Links to the SoilTrEC web site on the pages of other organizations. The more links that are created, the greater the impact in creating visibility and promoting the research transfer activities to research users and other stakeholders	Google produces 4340 results when searching for SoilTrEC.
A common strategy for date access, standardisation and management that will facilitate the access to and the	A link to the European Soil Date Centre to the datasets that SoilTrEC have used and created, accompanied by a full suite of metadata documentation	The metadata is published online at www.czen.org and described in publication[1]. Data curation is underway with compiled data sets planned to be deposited with

exploitation of standardised data		ESDC.
	External researchers, stakeholder, SMEs and policy makers becoming involved in SoilTrEC workshop discussion with written outputs about the data formats and best methods for standardisation of soil data across Europe	The joint SoilTrEC – USA NSF workshop in Nov. 2011 at U. Delaware, and a further international CZO workshop organised by the SoilTrEC coordinator with NSF China in May 2014 both have placed international standards and norms for data management and sharing on science policy roadmaps. A current joint LTER-CZO network proposal to the EC ESFRI roadmap place data standards and sharing protocols at the centre of science policy.
The project will adhere to the principles laid down in the EU Soil Thematic Strategy and will contribute to its implementation	A greater number of people will have tools and knowledge at their disposal to reduce soil degradation in practice	See Table 1 for stakeholder organisations that are informed about SoilTrEC outcomes.
	The level of interaction with policy implementers in member states, who will need the type of decision support and science evidence that SoilTrEC will provide in order to adhere to the requirements of existing and new EU legislation on soils	See Table 2 and 3 for organisations that have outcomes of SoilTrEC. 11 Fact Sheets have been produced and are being distributed to stakeholders.

[1]Banwart et al. (2011). Vadose Zone J., 10, 974–987.
[2]Banwart et al. (2013). Sustaining Earth's Critical Zone. ISBN: 978-0-9576890-0-8.

3.4.3 SoilTrEC Consideration of Gender Aspects

SoilTrEC has from the beginning of the project been proactive to support the gender balance of the project. Of the 17 institutions that took part in SoilTrEC, four lead partners are women (24%) and women also form 24% of the established scientists who are named in the original proosal. Of the 8 Work Packages, 5 were led by women (62%). Two institutions had all women established scientist (100% - Partners 2,6). Partners 6 and 13 are both led by women who are internationally known for promoting women in science, and they took on this role in SoilTrEC. Throughout the project 38 early career women and men have been hired into the research activities, and of these women were 47%. The SoilTrEC partnership is very proud of the balanced female participation hired into the project and the visible women leaders in the project and consider that SoilTrEC has been a champion within the EC for increasing the number of women in soil science and research generally in Europe and internationally.

A summary of the some of the main dissemination activities for the duration of the SoilTrEC Project. Many of these are activities led by the Coordinator on behalf of the SoilTrEC partnership. A complete list of dissemination activities is provided in section 4 below.

Partner	Activity	Type/size of audience
USFD	**2010** ● March 2010: Steven Banwart invited speaker to NERC-NSF workshop on Soil and Critical Zone research at the National Science Foundation, Washington D.C. ● May 2010: Steven Banwart invited speaker on Soil Sustainability in Earth's Critical Zone Observatory Session at the European Geosciences Union (EGU) General Assembly, Vienna. ● Sept 2010: Steven Banwart invited to present research of the SoilTrEC project to the USA National Science Foundation's Critical Zone Observatory Programme, annual meeting in Boulder, Colorado. **2011** ● July 2011: Steven Banwart SoilTrEC Presentation at Meeting of Coordinators 'Soil, Desertification and Land Degradation', Natural Resources and Food & Agricultural units of European Commission, Brussels. ● Aug 2011: Steven Banwart, Invited co-author, UNEP 2012 Yearbook: 'Carbon benefits of soils' ● Nov 2011: Steven Banwart, Lead organiser of the Optimising Soil Chemistry for Agriculture and Resource Efficiency (OSCAR) Workshop at Royal Society of Chemistry (RSC) at Burlington House, London. ● Nov 2011: Steven Banwart, Invited Guest Speaker at the CropWorld Global 2011 conference organised by United Business Media (UBM) and the British Crop Protection Council (BCPC). ExCeL, London. **2012** ● Feb 2012: Steven Banwart invited online 'Expert of the Day' on United Nations Environment program (UNEP): Environment for Development website. ● June 2012: Steven Banwart invited talk at Institute of Geology, University of Strasbourg entitled 'Saving Earth's Critical Zone'. ● Sept 2012: Steven Banwart invited talk "Critical Zone Observatories and Soil Sustainability" in Technical Session: Critical Zone Processes, Soil Sustainability, and Elemental Cycling in Soils at "The 2nd International Geobiology Conference: critical zone observatories for sustainable soil development and beyond" Conference held in Wuhan, China. ● Nov 2012: Steven Banwart invited talk in Session 2: Solutions from Research entitled "The role of environmental chemical engineering" at Engineering for Agriculture and Food Security Workshop held in London. ● Nov 2012: Steven Banwart invited attendance at NERC 'think tank' meeting to discuss plans to develop a new research programme on Soil Security, held in London. **2013** ● May 2013: Steven Banwart invited Keynote talk entitled "Harnessing the Multiple Benefits of Soil Carbon - a SCOPE Rapid Assessment Project" at SOM2013: 4th International Symposium on Soil Organic Matter Dynamics in Nanjing, China. ● May 2013: Steven Banwart invited meeting with National Science Foundation of China Vice President of Geosciences. Prof Congqing LIU, to give a 45 minute presentation on my SoilTrEC project and the ambition and potential for an international program of Critical Zone research built around a global network of Critical Zone Observatories (CZOs). ● May 2013: Steven Banwart invited meeting with Prof Ganlin ZHANG, Executive Director, State Key Lab of Soil and Sustainable	

	Agriculture at Chinese Academy of Sciences Institute for Soil Science. I spent a half day with Prof Zhang and his staff and gave a presentation on SoilTrEC. ● June 2013: Steven Banwart invited chair of session 'Research to Stakeholder's needs' at European Commission Workshop: "Fostering innovative dialogue between researchers and stakeholders" in Brussels. ● June 2013: Steven Banwart invited visit to attend Future Earth Town Hall meeting hosted by The Royal Society and the British Academy and led by the International Council for Science (ICSU) in collaboration with the International Social Science Council in London. ● Oct 2013: Steven Banwart invited attendance and presentation of white paper entitled 'Planning an International CZO Programme' at National Science Foundation (NSF) workshop: 'Drilling, Sampling and Imaging the Depths of the Critical Zone' in Denver, Colorado. ● Oct 2013: Steven Banwart invited talk at 2nd Global Soil Week 2013 'Losing Ground?' conference in Dialogue Sessions: 'Focus III - 2.5. Sustaining Earth's Critical Zone: global soils research for adapting to environmental and social change' in Berlin. ● Nov 2013: Steven Banwart, presentation given in the brokerage session "SC5 Managing natural resources + Earth Observation/ GEO" of the Info Day on calls 2014 "HORIZON 2020 SC5: Climate Action, Environment, Resource Efficiency and Raw Materials" in Brussels. **2014** ● April 2014: Joint organiser of "Sustainable Agriculture and Soils Innovation" (SASI) workshop hosted by Royal Society of Chemistry (RSC), London in April 2014. ● April 2014: Steven Banwart - Invited Keynote on the 10-year agenda for international Critical Zone science 'Critical Zone Observatories for Adapting to Environmental Change - a European perspective from the SoilTrEC programme' at the UWA, Perth, Australia (part of Future Farm Programme). ● April 2014: Steven Banwart invited visit to UWA Future Farm; a newly acquired field site for translational research in to adapting farming methods in response to global change pressures. UWA, Perth. ● April 2014: Steven Banwart invited visit and talk at Tongji University, Shanghai by Prof Fenting Li (leads Tongi Environment Institute, affiliated with the United Nations Environment Programme) and hosted by Prof Yalei ZHANG. Visit included a presentation on SoilTrEC project and international CZO activities and plans and a tour of Chongming Island EcoPark as a potential Chinese CZO site and as a possible focus for joint Tongi-Sheffield research collaboration. ● April 2014: Steven Banwart invited talk 'Critical Zone Observatories - research to tackle global soil threats' at Nanjing Agricultural University hosted by Prof Genxing PAN, department of soil science. ● April 2014: Steven Banwart invited keynote speaker 'Designing sustainable soils in Earth's critical zone' at European Geosciences Union General Assembly (EGU) 2014 in Vienna, Austria. ● May 2014: Steven Banwart - Keynote talk 'Critical Zone Science and Global Societal Challenges' with Martin Goldhaber, at Frontiers in International Critical Zone Science workshop hosted by NSF China with NSF USA, NERC (UK), CNRS (France), DFG (Germany) in Beijing, China. ● December 2014: Steven Banwart invited talks 1)'Outcome of workshop "Frontiers in International Critical Zone Science" 2)'Status of Critical Zone Research: Infrastructure, Advances and Opportunities for International Collaboration' (UK & EC) and 3) 'Implementing Recommendations of Beijing Workshop' at the International Critical Zone Observatory Program meeting in San Francisco, USA.	
ISSNP	● Presentations of the concepts, the major outputs of the SoilTrEC project and the contribution of the team of ISSNP re: (i) the open day at ISSNP to celebrate the World Soil Day (*S. Rousseva, M. Kercheva, T. Shishkov* December 5th 2013)	● the audience of the open day

	(ii) the International Exhibition "Agra 2014", held February-March 2014 in Plovdiv, Bulgaria *(S. Rousseva, M. Kercheva, T. Shishkov)*	celebrating the World Soil Day 2013 nos. 180
TUC	● The Reactive Transport Modelling Workshop was held at Technical University of Crete, Chania, Greece on 16-19th July 2012, in collaboration with National Science Foundation, USA.	• 40 researchers and students
DELT	● Activities on European Geosciences Union General Assembly 2014, Vienna, Austria, 27 April - 2 May 2014 ● Soil process modelling in CZO research: gains in data harmonisation and model validation Pauline van Gaans, Maria Andrianaki, Florian Kobierska, Pavel Kram, Anna Lamacova, Georg Lair, Nikos Nikolaidis, Chris Duffy, Inge Regelink, Jeroen van Leeuwen, and Peter de Ruiter	
EC-JRC	● WP4 Modelling Results were presented in the meeting "10th international symposium, Geochemistry of the Earth's surface (GES-10), Between Rocks and Sky: Earth's Critical Zone" on August 18-22, 2014	
HI	● Ragnarsdottir Visited soil related organisations in Brussels, October 2014 ● Ragnarsdottir gave an invited presentation at SPERI (Sheffield Political Economy Research Institute) annual conference, July, 2014	● 7 organisations that lobby for soil and agriculture in the EU (some with international links) millions+ ● Political economists, 150+
WU	● Knowledge transfer to the Dutch soil testing company	
BOKU	● oral presentations at farmers' and policy organisations in Austria, Germany, Belgium (Brussels) and Italy (Rome)	
NERC	● Soil Science Society of America - 2 key note talks at SSSA international meeting Tampa, 2013, Nov. 3-6 David Robinson ● MySoil iphone app, contains acknowledgement to SoilTrEC within the app for and JRC. This has gone from GB to EU and next step is to include Africa. (Contacts, David Robinson CEH, Panos JRC, Russell Lawley BGS) MySoil has now had >5,000,000 hits and now has more than 20,000 users. We continue to discuss and develop. ● David Robinson gave a talk, Brynhildur Davidsdottir organized the session under a SoilTrEC banner	Audience, soil science 100+ people
IARRPC	• Bin Zhang has provided information in Chinese that focus on soil and water management for high crop yield, which are used for training local extension officials and farmers. ● More than 1000 local farmers were trained and visited the agricultural catchment. ● Bin Zhang gave a talk on soil critical zone on the annual meeting of Soil Physics, Soil Science Society of China in 2011, in Harbin.	
SLU	● The SoilTrEC project had been presented at international meetings for the UN ECE Convention on Long-Range Transboundary Air Pollution (CLRTAP), LTER Europe, and EC Life+ project Futmon and Env Europe. Last CLRTAP meeting was in September 2014.	● Representatives of c. 40 countries attended.
CNRS	● Scientific and popularization activities for schools, children and general public (National Science Festival, mineralogical festival…). ● Several excursions and field trip for students, schools, public, colleagues, workshop…	

3.5 Address of the project public website and contact details

Website address: **www.soiltrec.eu**

Contact details: Tracey McNeilly, SoilTrEC Project Manager, Kroto Research Institute, University of Sheffield, North Campus, Broad Lane, Sheffield, United Kingdom, S3 7HQ

4 Use and dissemination of foreground

4.1 List of Scientific (peer reviewed) publications, papers in preparation and list of dissemination activities

Complete list of SoilTrEC Peer Reviewed Journal Publications

Publications with “I” noted after the reference refer to “international” outputs that are jointly authored with partners in China or USA.

1. Anderson, R. S., et al. (2010). "Future Directions for Critical Zone Observatory (CZO) Science."

2. Banwart, S. (2011). "Save our soils." Nature **474**(7350): 151-152.

3. Banwart, S., et al. (2011). "Soil processes and functions in critical zone observatories: hypotheses and experimental design." Vadose Zone Journal **10**(3): 974-987.

4. Banwart, S., et al. (2013). "Sustaining Earth’s Critical Zone Basic Science and Interdisciplinary Solutions for Global Challenges." University of Sheffield, Sheffield: 47.

5. Banwart, S., et al. (2012). "Soil processes and functions across an international network of Critical Zone Observatories: Introduction to experimental methods and initial results." Comptes Rendus Geoscience **344**(11): 758-772.

6. Benčoková, A., et al. (2011). "Modeling anticipated climate change impact on biogeochemical cycles of an acidified headwater catchment." Applied Geochemistry **26**: S6-S8.

7. Bernasconi, S. M. (2014). "Measuring the Critical Zone: Lessons from the Damma Glacier Critical Zone Observatory." Procedia Earth and Planetary Science **10**: 38-45.

8. Bernasconi, S. M., et al. (2011). "Chemical and biological gradients along the Damma glacier soil chronosequence, Switzerland." Vadose Zone Journal **10**(3): 867-883.

9. Bohdalkova, L., et al. (2012). "Atmospheric deposition of beryllium in Central Europe: Comparison of soluble and insoluble fractions in rime and snow across a pollution gradient." Science of the Total Environment **439**: 26-34.

10. Brynhildur, D., et al. (2013). "Indicators for soil sustainability." Final program: 432.

11. Chabaux, F., et al. (2013). "Regolith formation rate from U-series nuclides: Implications from the study of a spheroidal weathering profile in the Rio Icacos watershed (Puerto Rico)." Geochimica et Cosmochimica Acta **100**: 73-95.

12. Clymans, W., Lehtinen, T., Gísladóttir, G., Lair, G.J., Barão, L., Ragnarsdóttir, K.V., Struyf, E., Conley, D.J. 2014. Si precipitation during weathering in different Icelandic Andosols. Procedia Earth and Planetary Science 10, 260-265.

13. de Souza, D. M., et al. (2013). "Land use impacts on biodiversity in LCA: proposal of characterization factors based on functional diversity." The International Journal of Life Cycle Assessment **18**(6): 1231-1242.

14. Duffy, C., et al. (2014). "Designing a Suite of Models to Explore Critical Zone Function." Procedia Earth and Planetary Science **10**: 7-15.

15. Farkaš, J., et al. (2011). "Calcium isotope constraints on the uptake and sources of Ca 2+ in a base-poor forest: A new concept of combining stable (δ 44/42 Ca) and radiogenic (ε/iCa) signals." Geochimica et Cosmochimica Acta **75**(22): 7031-7046.

16. Gangloff, S., et al. (2014). "Characterization and evolution of dissolved organic matter in acidic forest soil and its impact on the mobility of major and trace elements (case of the Strengbach watershed)." Geochimica et Cosmochimica Acta **130**: 21-41.

17. Gangloff S., S. P., Pierret M-C., Weber T., Chabaux F. (2014). "Characterization and evolution of dissolved organic matter in acidic forest soil and its impact on the mobility of major and trace elements (case of the Strengbach watershed)." Geochimica et Cosmochimica Acta: 21-41.

18. Gangloff S., S. P., Schmitt A.D., Chabaux F. (2014). Impact of bacterial activity on Sr and Ca isotopic compositions (87Sr/86Sr and 44/40Ca) in soil solutions (the Strengbach CZO). Procedia Earth and Planetary Science.

19. Giannakis, G., et al. (2014). "Simulating Soil Fertility Restoration Using the CAST Model." Procedia Earth and Planetary Science **10**: 325-329.

20. Giannakis, G. K. N., Paranychianakis, N., Nikolaidis, N.P., and K. N. (2014). "Effects of Municipal Solid Waste Compost on Soil Properties and Vegetable Growth." Compost Science and Utilization **22**(3): 116-131.

21. Hinckley E-L, B. R. T., Anderson S.P., Williams M.W. and B. S.M. (2014). "Ecosystem N retention and transport differ by hillslope aspect at the rain-snow transition of the Colorado Front Range." JGR Biogeosciences **119**: 1281-1296.

22. Hruška, J., et al. (2014). "Changes in Soil Dissolved Organic Carbon Affect Reconstructed History and Projected Future Trends in Surface Water Acidification." Water, Air, & Soil Pollution **225**(7): 1-13.

23. Jónsdóttir, E. M. (2011). "Soil Sustainability Assessment. Proposed Soil Indicators for Sustainability."

24. Jungqvist, G., et al. (2014). "Effect of climate change on soil temperature in Swedish boreal forests." PloS one **9**(4): e93957.

25. Kercheva, M., et al. (2011). "Soil aggregation estimates in CZO-Fuchsenbigl." Applied Geochemistry **26**: S57-S59.

26. Kobierska, F., et al. (2014). "A multi-method field experiment to determine local groundwater flow in a glacier forefield." Hydrological Processes.

27. Kobierska, F., et al. (2014). "Linking baseflow separation and groundwater storage dynamics in an alpine basin (Dammagletscher, Switzerland)." Hydrology and Earth System Sciences Discussions **11**(11): 12187-12221.

28. Kobierska, F., et al. (2011). "Climate change effects on snow melt and discharge of a

partly glacierized watershed in Central Switzerland (SoilTrec Critical Zone Observatory)." Applied Geochemistry **26**: S60-S62.

29. Kobierska, F., et al. (2013). "Future runoff from a partly glacierized watershed in Central Switzerland: a two-model approach." Advances in Water Resources **55**: 204-214.

30. Kram, P. (2010). "Influence of lithology on streamwater chemistry." Geochimica et Cosmochimica Acta **74**(12), Supplement 1): A537-A537.

31. Krám, P. (2011). "Hydrologická bilance dlouhodobě monitorovaného povodí Lysina." Česká geologická služba, Praha: 259-265.

32. Krám, P., et al. (2014). "Bedrock Weathering and Stream Water Chemistry in Felsic and Ultramafic Forest Catchments." Procedia Earth and Planetary Science **10**: 52-55.

33. Krám, P., et al. (2012). "Streamwater chemistry in three contrasting monolithologic Czech catchments." Applied Geochemistry **27**(9): 1854-1863.

34. Krám, P., et al. (2014). "2. Streamwater chemistry at Lysina (CZ 07)." the ICP Waters Programme in Ceský Krumlov, Czech Republic 1st–3rd October, 2013: 7.

35. LAMAČOVÁ, A., et al. (2014). "Runoff Trends Analysis and Future Projections of Hydrological Patterns in Small Forested Catchments." Soil and Water Research **9**(4): 169-181.

36. Lehtinen, T. (2014). "Characterization of soil aggregation and soil organic matter in European agricultural soils."

37. Lehtinen, T., et al. "Response of soil to different farming practices–case studies in Iceland and Austria."

38. Lehtinen, T., Gísladóttir, G., Lair, G.J., van Leeuwen, J., , Blum, W.E.H., Bloem, J., Steffens, M., Ragnarsdóttir, K.V. 2015. Aggregation and organic matter in subarctic Andosols under different grassland management. Acta Agriculturae Scandinavica, Section B – Soil & Plant Science, DOI: 10.1080/09064710.2014.1001778.

39. Lehtinen, T., Lair G.J., Mentler, A., Gísladóttir, G., Ragnarsdóttir, K.V., Blum, W.E.H. 2014. Soil Aggregate Stability in Different Soil Orders Quantified by Low Dispersive Ultrasonic Energy Levels. Soil Science Society of America Journal 78, 713-723.

40. Li, N., et al (2015). "Separation of soil microbial community structure by aggregate size over by land use and tillage after eight-year development from the parent material of a Mollisol." Journal of Soil Ecology (in press)

41. Li, N., et al. (2014). "Contrasting development of soil microbial community structure under no-tilled perennial and tilled cropping during early pedogenesis of a Mollisol." Soil Biology and Biochemistry **77**: 221-232.

42. Lundin, L. and E. WGE (2011). "1 ICP IM activities, monitoring sites and available data." 21st Annual Report 2012 **15**: 14.

43. Magnusson, J., et al. (2014). "Melt water driven stream and groundwater stage fluctuations on a glacier forefield (Dammagletscher, Switzerland)." Hydrological

Processes **28**(3): 823-836.

44. Markart, G. and F. Rosner (2012). "FACCE JPI Mapping Meeting on Core Theme 5–Mitigation of Climate Change." Policy **22**: 23.

45. Menon, M., et al. (2014). "SoilTrEC: a global initiative on critical zone research and integration." Environmental Science and Pollution Research **21**(4): 3191-3195.

46. Milne, E., et al. (2014). "Soil carbon, multiple Benefits." Environmental Development.

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28. Andrianaki, M., Bernasconi, S.M., Nikolaidis, N.P., 2015. Application of the CAST model for the modeling of soil organic carbon and soil structure dynamics at the Damma Glacier CZO. Advances in Agronomy (in prep)
29. Andrianaki, M., Shrestha.J., Kobierska, F., Jonas T., Nikolaidis NP., Bernasconi S.M. 2015. Hydrological modelling and future runoff of the Damma Glacier CZO watershed using SWAT. Validation of the model in the greater area of the Göscheneralpsee, Switzerland. Hydrology and Earth System Sciences (in prep)
30. Atlason R.S., Kjærheim K.M., Davidsdottir B. and Ragnarsdottir K.V. Enerty return on investment of organic and conventional Icelandic farms: a comparative analysis. Icelandic Journal of Agricultural Sciences (under review).
31. Atlason R.S., Lehtinen T., Davidsdottir B., Gisladottir G., Brocza F., Unnthorsson R. and Ragnarsdottir K.V. The sustainability of ethanol production from sugar beet: A comparision between organic and conventional sugar beet production in Austria. Check title of Journal. Biomass & Bioenergy (under review).
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35. Farkas J., Novak M., Holmden C., Kram P., Veselovsky F., Stepanova M., Fottova D., Bohdalkova L. 2015. Magnesium isotope signatures of pools and fluxes in upland catchments affected by pollution-derived spruce decline. Earth & Planetary Science Letters (in prep)
36. Jonsson J.Ö.G. and Davidsdottir B. Classification and valuation of soil ecosystem service. Agricultural Systems (under review).
37. Jonsson J.Ö.G. Davidsdottir B., Nikolaidis N. et al. Framework for assessing and valuing Soil Ecosystem Services - Pilot study Koiliaris watershed, Crete - based on the data

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38. Jonsson J.Ö.G., Davidsdottir B., Jonsdottir E.M. and Ragnarsdottir K.V. Soil Sustainability Indicators - paper based on a Delphi survey, three rounds with stakeholders in Iceland along with SoilTrEC participants. (in prep.).
39. Kercheva M., Rousseva S., Shishkov T., Lair G.J., Nikolaidis N., Moraetis D., Kram P., Bernasconi S., Blum W., Menon M., Banwart S. 2015. Soil water characteristics of the European SoilTrEC Critical Zone Observatories. Advances in Agronomy (in prep)
40. Lehtinen, T., Lair, G.J., van Leeuwen, J.P., Gísladóttir, G., Bloem, J., Ragnarsdóttir, K.V., Steffens, M., Blum, W.E.H. Soil structure and soil organic matter in arable Chernozems under organic and conventional farming practice in Austria. Journal of Plant Nutrition and Soil Science (in prep.).
41. Lugato, E., Borrelli, P., Panagos, P. 2015. Estimating lateral organic carbon fluxes coupling a high resolution biogeochemical and erosion model: the Crete case study. Advances in Agronomy (in prep)
42. Menon, M., Jia X., Lair G.J., Faraj PR., Blaud, A. Analysing the impact of compaction of soil aggregates using X-ray microtomography and water flow simulations. Soil and Tillage Research (in review)
43. Menon, M., Lair G.J., Van Leeuwen, J., Bloem, J., Rousseva S., Kercheva., Blum W.E.H and Banwart S.A. Impact of landuse on development of soil structure (in prep)
44. Montanarella Luca, Panagos Panos. 2014. Policy relevance of Critical Zone Science. Journal of Land Use policy (In Review)
45. Nenov M., Rousseva S., Ilieva R. 2015. Assessments of soil pore shape- and size distributions using image analysis of thin sections. Applied and Environmental Soil Science (n prep)
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50. Robinson D.A and Keith A. Soil Ecosystem Services Surveys and Monitoring (book chapeter in prep)
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58. van Leeuwen, J.P., G. Lair, J. Bloem, L. Hemerik, P.C. de Ruiter. Landuse and soil formation, the role of microbes in the process (in prep)
59. van Leeuwen, J.P., T. Lehtinen, G.J. Lair, J. Bloem, L. Hemerik, K.V. Ragnarsdóttir, G. Gísladóttir, J.S. Newton, P.C. de Ruiter. 2014. An ecosystem approach to assess soil quality in organically and conventionally managed farms in Iceland and Austria. Soil. 1 : 1-19 (in prep)
60. Yigini, Y., Panagos, P. 2015. Projection of Soil organic carbon distribution in 2050 according to land use and climate scenarios. Advances in Agronomy (in prep)

List of Dissemination Activities

Table 2. Summary of Dissemination Materials and Activities	
Exemplars of Dissemination Materials ● Draft web page on a specific result/activity from your team ● Contribute chapter(s) to popular book on soil ● Science and Policy brief summarising key info for stakeholders ● A specific image and caption illustrating a key result or activity ● Powerpoint slide show for public and stakeholders ● Other material (press releases, flyers, videos, thesis, TV clips, posters)	**Exemplars of Dissemination Activity** ● Name your partner's "champion" for dissemination and contact ● Contribute material and participation to stakeholder event ● Present to a specific group (see audience list below for examples) ● Other specific activity on dissemination / stakeholder engagement *Type of audience: Scientific community (higher education, research), Industry, Civil Society, Policy makers, Medias, other

No.	Short Name	Dissemination Material	Dissemination Activity	Type* and size of audience	Stakeholder Contacts
1.	USFD	● 2 chapters for popular book on soils ● Edit popular book with partner's input ● Web page for public highlighting importance of soil ● Web page on EU soil functions and threats ● Fact sheets on key findings from SoilTrEC (available on website) ● Project highlight in Environmental science and Pollution Research Journal ● Lectures on soil and critical zone science for MSc level students as part of newly introduced module on Soils and Global Sustainability in Sheffield. ● posters and oral presentations in international, national and local meetings	● Manoj Menon is USFD champion for dissemination ● Maintain a stakeholder contact list on members' pages ● SoilTrEC Google scholar profile ● Soil and Global Sustainability Module for Master level students at the University of Sheffield. Dissemination activities for Steven Banwart (SoilTrEC Coordinator) **2010** ● March 2010: Steven Banwart invited speaker to NERC-NSF workshop on Soil and Critical Zone research at the National Science Foundation, Washington D.C. ● May 2010: Steven Banwart invited speaker on Soil Sustainability in Earth's Critical Zone Observatory Session at the European Geosciences Union (EGU) General Assembly,	● Book chapters for school students (English speaking audience, worldwide) ● Webpages (worldwide audience) including public and academics ● Factsheets (EU policy makers and general public in EU & worldwide) ● Journal article/google scholar profile for academics (worldwide) ● Masters level	● British soil science society ● UK organic growers alliance ● Environmental Sustainability Knowledge Transfer Network ● Commercial farms (e.g. Leeds university farm, UK) ● Soil Association ● NERC-NSF (March 2010) workshop – 20 scientists and funders. ● EGU (May 2010) – 200 scientists

			Vienna. ● June 2010: Steven Banwart co-organiser of the Theme 'Weathering in Earth's Critical Zone' encompassing 8 sessions at Goldschmidt 2010 Conference held in Tennessee, USA . ● Sept 2010: Steven Banwart invited to present research of the SoilTrEC project to the USA National Science Foundation's Critical Zone Observatory Programme, annual meeting in Boulder, Colorado. **2011** ● June 2011: Steven Banwart interviewed by Mag Johannes Pernsteiner of pressetext Nachrichtenagentur Gmbh following publication of 'Save our Soils' article in Nature. ● June 2011: Steven Banwart keynote talk given at ISMOM (International Symposium on Interactions of Soil Minerals with Organic Components & Micro-organisms), Montpellier, France. ● July 2011: Steven Banwart SoilTrEC Presentation at Meeting of Coordinators 'Soil, Desertification and Land Degradation', Natural Resources and Food & Agricultural units of European Commission, Brussels. ● Aug 2011: Steven Banwart, Invited co-author, UNEP 2012 Yearbook: 'Carbon benefits of soils' ● June 2011: Steven Banwart, Session co-chair, Earth's Critical Zone Processes, Geochemistry of Earth's Surface Conference, Boulder, Colorado. ● Nov 2011: Steven Banwart, Lead organiser of the Optimising Soil Chemistry for Agriculture and Resource Efficiency (OSCAR) Workshop at Royal Society of Chemistry (RSC) at Burlington House, London.	students (8-10 per year) ● Conferences and meetings attended by Steven Banwart have included audiences from business, funding agencies, NGOs, international agencies, regional agencies, advisory boards, policy makers, professional societies and academic organisation, which includes researchers and students. The size of the audience has varied from 5 to 250 people.	• Goldschmidt Conference (2010) – 1000 scientists • CZO Programme annual meeting (Sept 2010) – 50 USA scientists. • ISMOM (June 2011) – 200 scientists. • EC meeting, Brussels (July 2010) – 50 researchers, policy experts and other stakeholders. • UNEP 2012 Yearbook – environmental ministers worldwide, general public and UNEP stakeholders. • Geochemistry of Earth's Surface Conference (June 2011) – 200 scientists. • OSCAR workshop (Nov 2011) – 60 scientists and companies.

			● December 2011: Steven Banwart, Invited Speaker at ECOFINDERS Consortium Meeting, Coimbra, Portugal. ● Nov 2011: Steven Banwart, Invited Guest Speaker at the CropWorld Global 2011 conference organised by United Business Media (UBM) and the British Crop Protection Council (BCPC). ExCeL, London. ● Nov 2011: Steven Banwart, Lead Organiser of International Critical Zone Observatory (CZO) Workshop, University of Delaware, USA. **2012** ● Jan 2012: Steven Banwart invited talk entitled 'SoilTrEC and networking with EU CZO's' at "SUSTAINABLE LANDSCAPES: ADVANCING THE THEORETICAL, OBSERVATIONAL AND MODELING FOUNDATIONS" symposium, Technical University of Crete, Chania. ● Feb 2012: Steven Banwart invited online 'Expert of the Day' on United Nations Environment program (UNEP): Environment for Development website. ● March 2012: Steven Banwart invited Talk at symposium of 'Erosion and Weathering: from fundamental mechanisms to geodynamic consequences' at The French Academy of Sciences, French Institute, Paris and gave talk on 'Sustaining Soil at the Heart of Earth's Critical Zone' ● June 2012: Steven Banwart invited talk at Institute of Geology, University of Strasbourg entitled 'Saving Earth's		• ECOFINDERS meeting (Dec 2011) – 60 scientists. • Int. CZO workshop (Nov 2011) – 90 scientists and funders. • LANDSCAPES: ADVANCING THE THEORETICAL, OBSERVATIONAL AND MODELING FOUNDATIONS" symposium (Jan 2012) – 40 EU and USA scientists. • Online 'Expert of the Day' (Feb 2012) – general public. • 'Erosion and Weathering: from fundamental mechanisms to geodynamic consequences' symposium (March 2012) – 150 scientists. • 'Saving Earth's Critical Zone' talk (June 2012) – 40 scientists. • Int. Conference on

			Critical Zone'. ● July 2012: Steven Banwart invited keynote talk in Session S2: Integrated Studies of the Critical Zone at the 2nd International Conference on Hydropedology in Leipzig, Germany. ● July 2012: Steven Banwart invited talk at EUROSOIL '4th International Congress of the EUROPEAN CONFEDERATION OF SOIL SCIENCE SOCIETIES (ECSSS)' Session 13.04 entitled 'AN INTERNATIONAL INITIATIVE FOR CRITICAL ZONE OBSERVATORIES (CZO) AND RESEARCH ALONG GLOBAL ENVIRONMENTAL GRADIENTS' in Bari, Italy. ● Jul 2012: Steven Banwart invited keynote "Integrating Data and Models using Critical Zone Observatories to Advance Environmental Sustainability of Soil and Water" for EU Marie Curie ITN IMVUL Conference "Groundwater Vulnerability – Emerging Issues and New Approaches" in Session entitled 'Laboratory approaches to furthering understanding of vulnerability issues in aquifers' in Paris, France. ● Sept 2012: Steven Banwart invited talk "Critical Zone Observatories and Soil Sustainability" in Technical Session: Critical Zone Processes, Soil Sustainability, and Elemental Cycling in Soils at "The 2nd International Geobiology Conference: critical zone observatories for sustainable soil development and beyond" Conference held in Wuhan, China.		Hydropedology (July 2012) – 200 scientists. • ECSSS (July 2012) – 200 scientists and stakeholders. • Marie Curie ITN IMVUL conference (July 2012) – 70 scientists. • Int. Geobiology conference (Sept 2012) – 200 scientists from EU, USA and China. • Int. Humic Substances Society (Sept 2012) – 200 scientists.

			• Sept 2012: Steven Banwart invited keynote presentation entitled "Soil carbon flux and biological weathering from nanometric to planetary scale" in Section 3: "HS/NOM and biogeochemical cycling of nutrients" at The 16th Meeting of the International Humic Substances Society held Zijingang campus of Zhejiang University in Hangzhou, China. • Oct 2012: Steven Banwart gave talk entitled Soil Transformations in European Catchments at Meeting of Coordinators of EU funded projects on Land, Soil, Desertification and Urban Issues in SOIL BIODIVERSITY Session in Brussels. • Nov 2012: Steven Banwart invited lecture entitled "Environmental & Ground water research in an International Perspective" at "The Scientific Possibilities in the Oskarshamn Region in Kalmar County", held in Kalmar, Sweden. • Nov 2012: Steven Banwart invited talk entitled "Soil transformations in European catchments" at 50th anniversary of the Orgeval basin, International Conference held in Paris, France. • Nov 2012: Steven Banwart invited talk in Session 2: Solutions from Research entitled "The role of environmental chemical engineering" at Engineering for Agriculture and Food Security Workshop held in London. • Nov 2012: Steven Banwart invited attendance at NERC 'think tank' meeting to discuss plans to develop a new research programme on Soil Security, held in London.		• SOIL BIODIVERSITY session (Oct 2012) – 70 scientists, EU experts and other stakeholders. • 'Environmental and Ground Water Research in an International Perspective' lecture (Nov 2012) – 70 employees, Swedish Nuclear Fuels. • Orgeval Basin, International Conference (Nov 2012) – 150 scientists and funders. • Engineering for Agriculture and Food Security Workshop (Nov 2012) – 80 scientists and agritech companies. • NERC think tank (Nov 2012) – 20 scientists and funders. • Soil Systems and CZ conference (Apr 2013) – 150 scientists. • SOM2013 symposium (May 2013) – 200 scientists. • Lecture, Nanjing University

			2013 ● Apr 2013: Steven Banwart invited talk entitled "Soil Transformation in European Catchments (SoilTrEC)" at Soil Systems and Critical Zone Conference, Monte Verita, Switzerland. ● May 2013: Steven Banwart invited Keynote talk entitled "Harnessing the Multiple Benefits of Soil Carbon - a SCOPE Rapid Assessment Project" at SOM2013: 4th International Symposium on Soil Organic Matter Dynamics in Nanjing, China. ● May 2013: Steven Banwart invited lecture to PGR and PGT students at College of Resources and Environmental Sciences at Nanjing Agricultural University, China. ● May 2013: Steven Banwart invited visit to the field research station of the Chinese Academy of Sciences, Karst Geology Institute in Guilin, China. ● May 2013: Steven Banwart invited meeting with National Science Foundation of China Vice President of Geosciences. Prof Congqing LIU, to give a 45 minute presentation on my SoilTrEC project and the ambition and potential for an international program of Critical Zone research built around a global network of Critical Zone Observatories (CZOs). ● May 2013: Steven Banwart invited meeting with Prof Wen SUN, Deputy Director, Office of International Cooperation and Exchanges at Nanjing University to brief Prof SUN on the international developments on Critical Zone Observatories (CZOs). ● May 2013: Steven Banwart invited meeting with Prof Ganlin ZHANG, Executive Director, State Key Lab of Soil and Sustainable Agriculture at Chinese Academy of Sciences Institute for Soil Science. I spent a half day		(May 2013) – 50 university students. • Field site visit, Karst Geology Inst. (May 2013) – 10 China research leaders. • NSF China (May 2013) – 8 China NSF funders. • Chinese Academy of Sciences visit (May 2013) 0 10 China research leaders. • EC workshop (June 2013) – 70 scientists, EC policy experts and other stakeholders.

			with Prof Zhang and his staff and gave a presentation on SoilTrEC. ● June 2013: Steven Banwart invited chair of session 'Research to Stakeholder's needs' at European Commission Workshop: "Fostering innovative dialogue between researchers and stakeholders" in Brussels. ● June 2013: Steven Banwart invited visit to attend Future Earth Town Hall meeting hosted by The Royal Society and the British Academy and led by the International Council for Science (ICSU) in collaboration with the International Social Science Council in London. ● Sept 2013: Steven Banwart invited attendance to Global Challenge Conference: Adapting to Climate Change 3 for session 3: Climate Smart Development: land-use management (at the catchment scale) organised by at Worldwide Universities Network (WUN). ● Oct 2013: Steven Banwart invited attendance and presentation of white paper entitled 'Planning an International CZO Programme' at National Science Foundation (NSF) workshop: 'Drilling, Sampling and Imaging the Depths of the Critical Zone' in Denver, Colorado. ● Oct 2013: Steven Banwart invited talk at 2nd Global Soil Week 2013 'Losing Ground?' conference in Dialogue Sessions: 'Focus III - 2.5. Sustaining Earth's Critical Zone: global soils research for adapting to environmental and social change' in Berlin. ● Nov 2013: Steven Banwart invited keynote entitled 'Critical Zone Observatories: quantifying the chain of impact between biosphere and geosphere' at Annual Science meeting of National Geosphere Laboratory (NGL) in Oskarshamn, Sweden. ● Nov 2013: Steven Banwart, presentation given		• Global Challenge Conference (Sept 2013) – 70 international science leaders. • NSF workshop (Oct 2013) – 100 USA science leaders and funders. • Global Soil Week (Oct 2013) – 70 international science leaders. • NGL meeting (Nov 2013) – 70 employees Swedish Nuclear Fuels. • "SC5 Managing natural resources + Earth Observation/ GEO" brokerage session (Nov 2013) – 70 scientists, EC policy experts and other stakeholders. • SASI workshop (Apr 2014) – 70 scientists, funders and companies. • WUN CZO workshop (Apr

			in the brokerage session "SC5 Managing natural resources + Earth Observation/ GEO" of the Info Day on calls 2014 "HORIZON 2020 SC5: Climate Action, Environment, Resource Efficiency and Raw Materials" in Brussels. **2014** ● April 2014: Joint organiser of "Sustainable Agriculture and Soils Innovation" (SASI) workshop hosted by Royal Society of Chemistry (RSC), London in April 2014. ● April 2014: Steven Banwart - invited speaker to Seminar 'Critical Zone Observatories: tackling threats to soil in Europe' at WUN Critical Zone Observatory Workshop, U. Western Australia, Perth. ● April 2014: Steven Banwart visited Prof Rachel Burton, Director of the ARC national centre of excellence in plant cell walls, a high-throughput plant imaging facility utilising visible and Infra-Red imaging at University of Adelaide. ● April 2014: Steven Banwart - Invited Keynote on the 10-year agenda for international Critical Zone science 'Critical Zone Observatories for Adapting to Environmental Change - a European perspective from the SoilTrEC programme' at the University of Adelaide. ● April 2014: Steven Banwart invited visit to UWA Future Farm; a newly acquired field site for translational research in to adapting farming methods in response to global change pressures. UWA, Perth. ● April 2014: Steven Banwart invited visit and talk at Tongji University, Shanghai by Prof Fenting Li (leads Tongi Environment Institute, affiliated with the United Nations Environment Programme) and hosted by Prof Yalei ZHANG. Visit included a presentation on		2014) – 70 international scientists. • Talk at Tongji University (Apr 2014) – 10 China science leaders. • Nanjing Agricultural University (Apr 2014) – 70 university students.

			SoilTrEC project and international CZO activities and plans and a tour of Chongming Island EcoPark as a potential Chinese CZO site and as a possible focus for joint Tongi-Sheffield research collaboration. ● April 2014: Steven Banwart invited visit to Nanjing University, China, to meet again with Prof Rong JI to further TUOS joint programme in global soils. ● April 2014: Steven Banwart invited talk 'Critical Zone Observatories - research to tackle global soil threats' at Nanjing Agricultural University hosted by Prof Genxing PAN, department of soil science. ● April 2014: Steven Banwart invited keynote speaker 'Designing sustainable soils in Earth's critical zone' at European Geosciences Union General Assembly (EGU) 2014 in Vienna, Austria. ● May 2014: Steven Banwart invited attendance at European Commission - Directorate General for Research and Innovation - two-day conference in Brussels on "Renaturing Cities: Addressing Environmental Challenges and the Effects of the Economic Crisis through Nature-Based Solutions" under the auspices of the Hellenic Presidency of the Council of the European Union. ● May 2014: Steven Banwart invited talk 'International Frontiers in Critical Zone Science - 10 years to change the world' at Critical Zone in Germany Workshop, MPI for Biogeochemistry, Jena, Germany ● May 2014: Steven Banwart - Keynote talk 'Critical Zone Science and Global Societal Challenges' with Martin Goldhaber, at Frontiers in International Critical Zone Science workshop hosted by NSF China with NSF USA, NERC (UK), CNRS (France), DFG		• EGU (Apr2014) – 200 scientists. • Int. frontiers of CZ Science (May 2014) – 25 German science leaders. • Frontier in International CZ science workshop USA (May 2013) – 60 EU, USA, China science leaders and funders. • WCSS (June 2014) – 100 scientists. • Sheffield Engineering Symposium (June 2014) – 100 scientists and university students.

			(Germany) in Beijing, China. ● June 2014: Steven Banwart invited session organiser 'Biogeochemical Reactivity of Soils and Sediments: Molecular Process Control over Material Flux at Field Scales' at 20th World Congress of Soil Science (WCSS) Jeju Island, Korea. ● June 2014: Steven Banwart invited theme speaker on topic of 'Engineering Global Soils for a Sustainable Planet' at interdisciplinary University of Sheffield Engineering Symposium, U.K. ● June 2014: Steven Banwart invited speaker 'Global Soils and Critical Zone Research – a WUN success story' at Worldwide Universities Network (WUN) Briefing Session at The University of Sheffield, U.K. ● August 2014: Abstract 'Integrated Critical Zone Studies to Quantify Soil Processes and Functions' in Theme 9: Integrated Critical Zone Science at Geochemistry of the Earth's surface (GES-10) - Between Rocks and Sky: Earth's Critical Zone conference in Paris, France. ● September 2014: Steven Banwart invited talk 'International CZO Discussion & Report on meeting in China' at Critical Zone Observatory (CZO) Network All Hands Meeting in, Fish Camp, California, USA. ● September 2014: Steven Banwart invited Keynote 'Global Experimental Design using Critical Zone Observatories – the Update from Beijing' at TERENO International Conference: From observation to prediction in terrestrial systems in Bonn, Germany. ● October 2014: Invited Keynote 'Earth's Critical Zone - interdisciplinary science to protect our planet's life-sustaining resources' at Grantham Centre for Sustainable Futures inaugural		• WUN briefing session (June 2014) – 50 scientists. • GES-10 (Aug 2014) – 200 scientists. • CZO Network All hands Meeting (Sept 2014) – 150 USA and China scientists and funders. • TERENO conference (Sept 2014) – 250 scientists and companies. • Grantham Centre for Sustainable Futures (Oct 2014) – 70 scientists. • ROBUST workshop (Oct 2014) – 40 scientists, funders and companies. • Int. CZO programme meeting USA (Dec 2014) – 15 international science leaders and funders.

			annual symposium, The University of Sheffield, U.K. ● October 2014: Invited talk 'Soil and ecosystem services' at ROBUST workshop 'a nation that destroys its soils, destroys itself' in London, U.K. ● December 2014: Steven Banwart invited talks 1)'Outcome of workshop "Frontiers in International Critical Zone Science" 2)'Status of Critical Zone Research: Infrastructure, Advances and Opportunities for International Collaboration' (UK & EC) and 3) 'Implementing Recommendations of Beijing Workshop' at the International Critical Zone Observatory Program meeting in San Francisco, USA. ● December 2014: Invited talk 'Critical zone observatories for research into soil functions and global soil threats' at Soil Science Seminars at Institute of Biogeochemistry and Pollutant Dynamics, Department of Environmental Sciences, ETH Zurich, Switzerland.		● Department of Environmental Sciences, ETH Zurich, Switzerland (Dec 2014) – 40 scientists.
2.	ISSNP	● Chapter "Soil Threats" for popular book on soils "Earth's Critical Zone and Global Soils" *(S. Rousseva, M. Kercheva, T. Shishkov,* November 2013*)* ● Popular article on soil functions and threats to a popular Bulgarian agro magazine: *Rousseva S.* 2013. Soil protection – a prerequisite for sustainable agriculture, *Agriculture plus*, (2) 8-10, (3) 19-20, 29 (Zemedelie plus / oralo.bg - in Bulgarian) ● Press release for the World Soil Day (in Bulgarian) (*S. Rousseva,* December 5th, 2013) ● Posters and oral presentations in international meetings EUROSOIL 2012 and EGU 2014	● Martin Nenov is ISSNP champion for dissemination ● Presentation entitled "Assessments of soil pore shape- and size distributions using image analysis of thin sections" to present results of ISSNP from WP1 is scheduled for the Seminar "Current methods for soil, plant and water analyses", organized jointly by ISSNP and BSSS (*M. Nenov & S. Rousseva,* May 22th 2014) ● Presentations of the concepts, the major outputs of the SoilTrEC project and the contribution of the team of ISSNP re: (i) the open day at ISSNP to celebrate the World Soil Day (*S. Rousseva, M. Kercheva, T. Shishkov* December 5th 2013) (ii) the International Exhibition "Agra 2014", hld	● book chapter for school children ● the audience of the national agro magazine oralo.bg - printed and also available on-line ● the audience of the Journal of Balkan Ecology ● the audience of the open day celebrating the World Soil Day 2013 nos. 180 ● the audience of	● Bulgarian Soil Science Society (BSSS); contact: radadonkova@gmail.com ● Bulgarian Humic Substances Society (BHSS) http://bhss.itp.bg/nachaloEn.htm contact: efilcheva@abv.bg ● National Agricultural Advisory Service (NAAS): http://www.naas.government.bg/en contact: office@naas.government.bg

		● Papers focussing on the findings of WP1	February-March 2014 in Plovdiv, Bulgaria *(S. Rousseva, M. Kercheva, T. Shishkov)*	national and local meetings (nos: 30-120) ● the audience of international meetings	
3.	TUC	● chapter for popular book on soil ● policy brief of C addition to soil and the results of the tomato experiment ● policy brief on the Integrated Critical Zone Model ● Web page on Koiliaris River activities ● Articles to local newspaper "Chaniotika Nea" on the tomato experiment and the impacts of carbon amendments to soil (August 10, 2010; November 7, 2012; November 16, 2013) ● Article to national newspaper "Elefterotipia" on August 10,2014 ● Annual lectures on soil and critical zone science to undergraduate (freshman class) and graduate students (seminar) in Environmental Engineering ● posters and oral presentations in international, national and local meetings	● Leeda Demetropoulou and Elena Prentaki are TUC champion for dissemination ● Work with the region of Crete to scale up the SWAT model and investigate impacts on water and soil ● Presentation to local farmers regarding the tomato experiment ● Maintain Koiliaris river basin web page ● Questionnaires to local farmers (~20) ● co-organizer of the following training workshops on SoilTrEC Modelling Tools ● The ICZ Model training workshop was held at The Technical University of Crete, Chania, Greece on 20-22 May 2014. ● The SoilTrEC Stakeholder Training Event Training course on the 1D-ICZ model was organised at the Decentralized Administration of Crete, Heraklion, Crete on 12th – 13th November 2013. ● The Critical Zone Integrated Model Development: Training on the 1D-ICZ model was held at Kloster Kappel , Kappel am Albis, Switzerland on 2nd - 3rd July 2013. ● The Reactive Transport Modelling Workshop was held at Technical University of Crete, Chania, Greece on 16-19th July 2012, in collaboration with National Science Foundation, USA . ● The Critical Zone Modelling Workshop was held in Stresa, Italy, on 18-19 of November 2010.	● book chapter for school children ● policy briefs - government and policy makers ● Web page on Koiliaris - worldwide audience ● Articles to local newspaper - 10000 people ● Article to national newspaper - 80000 people ● co-organizer of training workshops ● On 20-22 May 2014 - 15 people ● On 12th – 13th November 2013 - 30 people ● On 2nd - 3rd July 2013- 30 people ● On 16-19th July 2012 - 40 people ● On 18-19 of November 2010 - 40 people	● Regional and local administration stakeholders ● Local farmers at Koiliaris River basin ● Participation in an Australian workshop to build a Critical Zone Observatory Network and presentation of SoilTrEC Project and modelling tools (September 2014)

4.	Delt	● Entree with SOILTREC factsheet on the Deltares website (in Dutch for policy makers and practitioners) ● http://www.deltares.nl/en/project/1169095/soiltrec-soil-transformations-in-european-catchments/2047604 ● posters and presentations	● Linda Maring is the dissemination champion for Deltares ● Valstar, Johan: oral presentation on International Interdisciplinary Conference on Land Use and Water Quality: Reducing Effects of Agriculture, The Hague, the Netherlands, 10-13 June 2013 ● Activities on European Geosciences Union General Assembly 2014, Vienna, Austria, 27 april - 2 mei 2014 <u>Oral presentations</u> o Integrating models to simulate emergent behaviour: effects of organic matter on soil hydraulics in the ICZ-1D soil-vegetation model Johan Valstar, Ed Rowe o Designing sustainable soils in Earth's critical zone. Steven Allan Banwart, Danielle Maia de Souza, Manoj Menon, Nikolaos Nikolaidis, Panos Panagos, Kristin Vala Ragnardsdottir, Svelta Rousseva, and Pauline van Gaans o Soil process modelling in CZO research: gains in data harmonisation and model validation Pauline van Gaans, Maria Andrianaki, Florian Kobierska, Pavel Kram, Anna Lamacova, Georg Lair, Nikos Nikolaidis, Chris Duffy, Inge Regelink, Jeroen van Leeuwen, and Peter de Ruiter <u>Poster presentations</u>: o Soil aggregates as habitats for different microbial functional communities: Impact of different aggregate sizes and land-use. Bas van der Zaan, Aimeric Blaud, Georg Lair, Manoj Menon, Dayi Zhang, Winfried Blum, Wei Huang, Pauline van Gaans, and Steve Banwart o The potential of on-line continuous leach ICP-MS analysis for linking trace elements to mineralogy. Gerlinde Roskam, Marc Verheul,	150+ People from the science, management and policy on hydrology and land management 12,437 scientists & students on geosciences	● Dutch soil platform (twitter) https://twitter.com/DSPsoil @DSPsoil ● platform bodembeheer (platform soil management) http://www.platformbodembeheer.nl/ Platformbodembeheer@deltares.nl ● linked-in group Dutch soil professionals http://www.linkedin.com/groups/Nederlandse-Bodem-Professionals-1356877?trk=my_groups-b-grp-v ● initiatief bewust bodemgebruik (initiative conscious use of the soil) http://www.bewustbodemgebruik.nl/ http://www.linkedin.com/groups?gid=1776331&trk=my_groups-b-grp-v

			Daniel Moraetis, George Giannakis, and Pauline van Gaans o REE profiles in continuous leach ICP-MS (CL-ICP-MS) experiments in soil linked to REE profiles in surface water in the Koiliaris River Critical Zone Observatory (CZO), Crete, Greece. Gerlinde Roskam, Marc Verheul, Daniel Moraetis, George Giannakis, and Nikolaos Nikolaidis ● Meulen, Suzanne van der, Otto Levelt, Linda Maring. Mapping ecosystem services in urban areas on different scales, the changes under different scenarios for the city of Amsterdam. Poster presentation at 7th Annual ESP Conference September 8-12 2014 Costa Rica	350+ People from the professional public and science ecosystem on services	
5.	EC-JRC	● Part of European Soil Portal Projects:http://eusoils.jrc.ec.europa.eu/projects/Soiltrec/ ● Newsletter of the European Soil Portalhttp://eusoils.jrc.ec.europa.eu/utilities/newsletter/201311.pdf ● Input on further development of LCIA (Life Cycle Impact Assessment) Methods ● European Platform on LCA (http://lct.jrc.ec.europa.eu/) ● Data Indicators for Soil Threats are available for public dissemination on the page (http://eusoils.jrc.ec.europa.eu/projects/Soiltrec/Indicators.html) ● Presentation in a meeting on SOC modelling (August, 2014) ● Modelling Workshop was held at JRC on October 1st. (Meeting minutes and slides)	● Panos Panagos is EC-JRC responsible for dissemination ● European Soil Data Centre (ESDAC) will disseminate the Project results (Maps and Data on soil threats) with data authentication mechanism. DG RTD Open data Access initiative ● JRC organised the Workshop for dissemination and consensus building in October/2014. ● JRC organised the Stakeholders workshop in 2014. ● WP4 Modelling Results were presented in the meeting "10th international symposium, Geochemistry of the Earth's surface (GES-10), Between Rocks and Sky: Earth's Critical Zone" on August 18-22, 2014 ● Workshop on Meta Model Application ● Scientific datasets for soil erosion & other type	● Scientific Community ● Modellers ● 1,180 downloads (Readers) in 2014 ● Eurosoil 2012, Bari(IT), British Soil Science Society (2013)	● European Soil Bureau Network:http://eusoils.jrc.ec.europa.eu/esbn/esbn_members.html ● Members of the Mailing list of the European Soil Portal newsletter (disseminated to more than 4,000 scientists). ● European Platform on LCA (http://lct.jrc.ec.europa.eu/) and LCT Forum ● About 80 Critical Zone Scientists ● 25 SoilTrEC Scientists

		● Data/indicators on soil erosion in Crete: http://eusoils.jrc.ec.europa.eu/projects/Soiltrec/Indicators.html ● Scientific article on Soil erosion in Crete published in ELSEVIER ● Scientific articles on land use modelling in LCA published in the journals: Global Change Biology (Souza DM *et al.,* 2015), Journal of Cleaner Production (Souza DM *et al.*, 2015) and International Journal of Life Cycle Assessment (Allacker *et al*., 2014). ● Factsheet on soil quality in LCA ● Posters in International Meetings	of modelling ● Description of the model ● Poster Presentation		● 37 Scientists have registered and downloaded the datasets
6.	HI	● Ragnarsdottir edited with S.A. Banwart an eBook for secondary schools on soils entitled: Soil: The Life Supporting Sking of Earth ● Ragnarsdottir wrote a chapter on Soil and Earth´s Critical Zone with N. Nikolaides (TUC) for school book ● Ragnarsdottir wrote a chapter on Value of Soil Ecosystem Services with B. Davidsdottir and J. Jonsson for school book ● Commissioned and edited 11 Soil Fact Sheets ● Wrote a Fact Sheet on The Importance of Soil ● Papers in scientific literature (see publications list) ● Presentations at International conferences ● Ragnarsdottir will edit a commissioned book by Springer in 2015, on Soil Sustainability and Policy ● Ragnarsdottir Co-organiser of the International Soil Carbon Sequestration	● K.V. Ragnarsdottir Champion for SoilTrEC dissemination ● Built stakeholder groups contact list ● Advised coordinator on stakeholders contact list ● Provided SoilCritZone participant contact list ● Two Presentations to Icelandic Association of Organic Producers (Samtök lífrænna neytenda) ● Two presentation to Icelandic Association of Organic Farmers (VOR) ● Co-taught a course on Permaculture open to the public in Iceland, June 2014	Academic & stake-holder organisations, 50+ Organic consumers 80+ Organic farmers, 40+ General public, 20	● Icelandic Farmers Union ● Icelandic Association of Organic Producers ● Icelandic Association of Organic Farmers ● Tun, organic farming certification ● Agricultural University of Iceland ● UNESCO Education for Sustainable Development ● Google scholar ● ResearchGate ● International network of teachers - tesconect (www.tes.co.uk) 3.6 million registered users, 279 countries and territories, 11 million visits a month

		conference for climate, food security and ecosystem services, May 2013	● Organized a SoilTrEC training course in Iceland on Land Use Practice and Sustainable Use of Soil, June 2012 ● Regnarsdottir Visited soil related organisations in Brussels, October 2014 ● Ragnarsdottir gave an invited presentation at SPERI (Sheffield Political Economy Research Institute) annual conference, July, 2014 ● Presentation at International Society of Ecological Economics, August, 2014 ● Ecosystem Services Partnership Conference, Portland, Oregon, July/August, 2012 ● Presentations at International soil related conferences (see list of abstracts) - Critical Zone Young Scientists Workshop, Pennsylvania State University, June 2010 - Soil Ecology Training course, Wageningen, June 2010 - Young Scientists Forum, BOKU, June 2011	PhD students from USA, Mexico and EU, 25 7 organisations that lobby for soil and agriculture in the EU (some with international links) millions+ Political economists, 150+ Ecological Economists, 1500+ Ecological Economists, 500+ (47 countries Soil science related audiences, 13,000+ Young Critical Zone scientists, 30+ Young ecologists, 30+ Environmental scienists, 40+	

			- Geochemistry of the Earth´s Surface, 3 presentations, Boulder, Colorado, June 2011 - 4th International Congress of the European Soil Science Society, Bari, Italy, July 2012 - Soil Carbon Sequestration for climate, food security and ecosystem services, Reykjavik Iceland, 2 presentations, May 2013 - European Geosciences Union, Vienna April/May, 2014. - Geochemistry of the Earths Surface, Paris August, 2014	Geoscientists, 200+ Soil Scientists, 600+ Soil scientists, 400+ Geoscientists, 12,000+ (106 countries) Geoscientists, 200+	
7.	WU	● Contribute to the web page on soil aggregates ● Organisation of Soil Science in a Changing World - First Wageningen Conference on Applied Soil Science on September 18-22 2011, with key-note contribution by SoilTrEC participants. ● Poster presentations at various scientific symposia and workshops. ● Expressing the SoilTrEC ideas as member of Dutch governmental advisory committees, like the Dutch Technical Soil Committee and the Dutch Soil Ambassadors. ● Contribute to the workshop Future of Soil Science, organised during the Global Soil Week (berlin 2012). ● Contribute to the Wageningen Conference on Applied Soil Science, 23-26 August	● Liping Weng and Peter de Ruiter are the WU champions for dissemination ● Knowledge transfer to the Dutch soil testing company ● Joint research proposal to implement research outcomes in practice	● Soil scientists ● Policymakers ● Students	● Alterra (research centre) gerwin.koopmans@wur.nl http://www.wageningenur.nl/nl/Expertises-Dienstverlening/Onderzoeksinstituten/Alterra/Expertisegebieden.htm ● Blgg-agroXpertus,(Dutch soil testing company) wim.bussink@nmi-agro.nl http://blgg.agroxpertus.nl/ ● Blgg-research, (consultancy company) peter.vanerp@blgg-research.nl http://www.nmi-agro.nl/

		2015			
8.	BOKU	● articles in dissemination brochures for farmers' associations ● publishing of scientific work in international journals ● Presentations at national and international conferences ● Installation and establishment of a soil science course for Master students at the University of Innsbruck ● together with the RISE foundation in Brussels introduction into the “sustainable intensification of agriculture” as a major challenge in Europe in the future	● Advise on HI stakeholder contact list ● Winfried E.H. BLUM is BOKU champion for dissemination ● oral presentations at farmers' and policy organisations in Austria, Germany, Belgium (Brussels) and Italy (Rome) ● oral presentations: 10.2.2011 Univ. of Evora (70 persons) 12.5.2011 Thessaloniki (300 p) ESSC conf. 5.9.2011 Torun/Poland (220 p) PSSS 16.9. 2011 Tomar/Portugal (150 p) EcoHCC 27.3. 2012 FFA/Brussels (110 p) 17.5. 2012 Izmir/Turkey (300 p) Turkish SSS 27.6.2012 Innsbruck/Austria (80 p) Austr. SSS 5-6.7.2012 Bari/Italy (400 p) Eurosoil 29.11.2012 La Laguna Univeristy, Teneriffa (60 p) 8.2. 2013 Austrian Soilforum, Kaindorf, Austria (60 p) 14.3. 2013 Dübendorf, Biofarmers Saxony/Germany (90 p) 28.5.2013 Humus conference Iceland (120 p) 6.6.2013 Lublin Poland (140 p) Soil conf. 2.7.2013 Zagreb/Croatia, CASSEE Confere. 17.10.2013 Tchn. Uni. Valenzia/Spain, (seminar 90 p) 28.1.2014 Brussels, RISE (60 p) 31.3.2014 Brussels FFA-ELO (150 p) 10-12.6.2014 Jeju, Korea, WCSS (250 p) 19.6.2014 Brussels, EC, “Land as a resource “ conf. 300 p 10-12.9.2014 Tomar/Portugal (180 p) 1.12.2014 Hesselberg/Germany (90 p) bioforum meeting		● Austrian Soil Science Society : http://oebg.boku.ac.at or sigbert.huber@umweltbundesamt.at ● European Confederation of Soil Science Societies : senesi@agr.uniba.it ● Bio-Austria, farmers association in Austria : office@bio-austria.at ● Bio-Farmers association Saxonia/Germany (SIGOEL) ● Forum for Agriculture(FFA), Brussels : info@forumforagriculture.com ● European Land Owners' Organisation (ELO),Brussels : elo@elo.org ● Rural Investment Support Europe (RISE) Foundation, Brussels :www.risefoundation.eu ● Sino-European Panel on Land and Soil (SEPLS) : gergely.toth@jrc.ec.europe.eu ● Global Soil Partnership (GSP) FAO,Rome : luca.montanarella@jrc.ec.europe.eu ● ricardo@uevora.pt (Univ Evora) ● josef_choinicki@sggw.pl (Polish Soil Sci. Soc.) ● c.andrade@ipt.pt (EcoHCC) Tomar

					● forest@elo.org ● antororo@ull.es, Uni. Lal Laguna ● office bio Austria ● Convention Centre Brussels ● raphael.hartmann@demeter-bayern.de
9.	NERC CEH	● mySoil iphone app, shows basic soil properties across soils of Europe and collects crowd sourced data.	● Ed Rowe is NERC CEH champion for dissemination ● Natural Resources Wales - discussions held With Dylan Williams, NRW soils advisor Sept 2013 ● Soil Science Society of America - 2 key note talks at SSSA international meeting Tampa, 2013, nov 3-6 David Robinson ● Wales Axis II monitoring team - SoilTrEC strategy outlines to project leader of the Glastir Monitoring and Evaluation Program Sept 2013. Bridget Emmett ● mySoil iphone app, contains acknowledgement to SoilTrEC within the app for and JRC. This has gone from GB to EU and next step is to include Africa. (Contacts, David Robinson CEH, Panos JRC, Russell Lawley BGS) mysoil has now had >5,000,000 hits and now has more than 20,000 users. We continue to discuss and develop. ● 10th biennal conference of the European Society for Ecological Economics. 18-21 June 2013 David Robinson attended and presented a talk. 20+ people ● David Robinson gave a talk, Brynhildur Davidsdottir organized the session under a SoilTrEC banner ● December 2013. David Robinson went to New Zealand, met with Estelle Dominati and co-authored a book chapter. Also discussed SoilTrEC with Bob Costanza at Kirkham conference who suggested we organize a	Audience, soil science 100+ people 20+ people ranging from land managers, to economists	● Natural Resources Wales. ● Soil Science Society of America. ● Wales Axis II Monitoring Team. ● Zoological Society of London

			session at ESP. Ecosystem Services Partnership meeting, Bali 6th Annual International ESP Conference 2013. 26-30 August 2013. Aidan Keith gave presentation for SoilTrEC CEH, David Robinson was a session co-convenor with Estelle Dominati. ● March 2014, David Robinson gave a talk at the Zoological Society of London, ● David Robinson presented a poster with work on soil value at the ISEE conference in Iceland. ● November 2014, David Robinson gave an invited talk at the Soil Science Soc America meetings in Long Beach CA	150+ People from the general public and science 50+ soil scientists and agronomists	
10.	ETH	● S. Bernasconi and Maria Andrianaki: Coordinates guide book. The work is in progress, planned completion and web publication February 2015 ● Audio guide: implemented and online since August 2013. Contact person Gerhard Furrer, ETH Zürich, gerhard.furrer@env.ethz.ch ● Instruction of Local Guides Wasserwelten: August 17th. 2013, Stefano Bernasconi, Gerhard Furrer. The guides offered guided tours starting June 2014, the tours take place on request. ● Maintain stakeholders contacts, ongoing according to necessity. S. Bernasconi	● Stefano Bernasconi is ETH champion for dissemination ● Coordinates guide book and audio guide publication ● Instruction of local guides of Wasserwelten ● Maintain stakeholder contacts	● approx. 1500 downloads of the audioguide from the general public 45 people took a guided tour in 2014	● Wasserwelten Göschenen www.wasserwelten.ch Mr. Stefan Gamma Unterdorf 46 6487 Göschenen info@wasserwelten.ch ● Kraftwerke Göschenen http://www.kw-goeschenen.ch Mr. Peter Tresch peter.tresch@ckw.ch ● MyClimate http://www.myclimate.org Ms. Julia Hofstetter julia.hofstetter@myclimate.org ● Korporation Uri Gotthardstrasse 3 6460 Altdorf mail@korporation.ch
11.	CGS	● Web page on SoilTrEC results for the general public (in Czech) http://www.geology.cz/soiltrec	● Martin Novak is CGS champion for dissemination ● Briefing of policy makers at the Ministry of Environment and the Ministry of Agriculture ● Institutional events for students and public: The Geochemical Seminar series at the Czech		● Czech Geological Society Dr. Zdenek Taborsky zdenek.taborsky@geology.cz ● Environmental state authorities in 10 counties of the Czech Republic (full contact list can be provided as

			Geological Survey: A long list of noted international lecturers Names of courses and modules relevant to soils and the critical zone at Czech universities, in which SoilTrEC results have been presented: Institution: Charles University, Faculty of Science, Prague Lecturer: Martin Novak Name of course: Isotopes in Biogeochemistry Years: 2010, 2011, 2012, 2013, 2014 Institution: Czech Agricultural University, Prague Lecturer: Juraj Farkas Name of course: Priciples of geosciences and environmental research Years: 2012, 2013, 2014		a pdf document). We routinely send them info about highlight results of our research.
12.	IARRPC	● Produced materials on soil and water management for distribution	● Bin Zhang is the dissemination champion for IARRPC ● IARRPC have organised a field excursion for American students and EU and American delegations. ● Bin Zhang has provided information in Chinese that focus on soil and water management for high crop yield, which are used for training local extension officials and farmers. ● Bin Zhang has organized several field trips to the CZ of Red soil for water management and improving crop productivity in later several years. The visitors included, vice Minister of Agriculture of China, Dr. Taolin Zhang, vice Governor of Jiangxi Province, Madam Dr. Ru Xie, Ministers and vice		● Local gamers and officials talking about critical concept for watershed agricultural management.

			Ministers of Science and Technology of Jiang Xi Province, Mr. Hai Wang and Xiaohong Wang, Ministers and vice Ministers of Agriculture of Jiangxi Province, vice presidents of CAS, Prof. Zhong-Li Ding and Jiayang Li, Yingtang City Vice Major, Mr. Ke Shi. ● Local officials from the S&T bureau and Agricultural Bureau have been provided with frequent updates from the project. ● More than 1000 local farmers were trained and visited the agricultural catchment. ● Hosted a group of American students (20 persons) led by Prof. Hailin Zhang, Oklahoma State University and gave a presentation of News perspectives for integrative research on SoilCritzone for sustainable agriculture in China. ● Presented the catchment to American and European delegations (more than 25 people) from the 7-9th September 2012. ● Bin Zhang gave a talk on soil critical zone on the annual meeting of Soil Physics, Soil Science Society of China in 2011, in Harrbin. ● Bin Zhang is a committee member of CAS and NSFC on Strategy Study for the Development of Soil Science and Soil Biology. ● Invited to present information on CZ science and soil biophysics during several meetings (Wu Yi Shan, June 2012; Nanjing, November 2012; Changsha November). ● Involved in preparation of the speech for Academician of CAS, Prof. Qiguo Zhao on Soil Critical Zone in the annual meeting of Soil Science Society of China		

			in 2012, Chengdu. ● Bin Zhang has contacted deputy director of CAS, Prof. Renguo Feng and Academician of CAS, Prof. Bojie Fu, informing them the ambitions of international of CZO networking.		
13.	PSU	● Public education material on Earth's Critical Zone and Critical Zone Observatories ● Maintain web presence for Shale Hills CZO ● Summary of foreground on Shale Hills CZO investigations, results and their significance ● Short popular film on weathering and soil formation	● Tim White is PSU champion for dissemination ● Host international CZO web portal "Critical Zone Exploration Network" (www.czen.org) ● Maintain education and outreach web pages for Shale Hills CZO (www.czo.psu.edu) ● Annual CZ seminar co-hosted by the Earth and Environmental Systems Institute and the Department of Crop and Soils Science		● USA CZO network and programme contacts ● International hub for CZO contacts worldwide
14.	SLU	● Annual reports for the CZO Kindla site - during SoilTrEC project we have producing reports on the site in years 2009, 2010 and 2011. The 2012 report will be published June 2014. Last report for 2011 was published June 2013; Löfgren, S. (ed.) 2013. Integrated monitoring of the environmental status in Swedish forest ecosystems – IM. Annual report for 2011. Swedish University of Agricultural Sciences, Department of Aquatic Sciences and Assessment. Report 2013:10. Uppsala. 23 pp and 23 appendices. (In Swedish with English summary) ● Results from the CZO Kindla site is also included in the International IM annual report; Kleemola, S. and Forsius, M. (eds.) 2013. 22nd Annual Report for the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems. Reports of the Finnish Environment Institute 25/2013. Finnish	● Lars Lundin is SLU champion for dissemination ● A Reference Group to the national programme. The Reference group has 15 people from authorities, external institutes and NGOs and nine programme experts. Meetings were held on the 26/01/2010 and 25/26/08/2010, which included site field visits with five external reference persons and five experts from the monitoring team. ● New meetings were held 16/01/2011, 11/08/2012, 31/10/2013 and in 2014 on June 10-11 at the field site Aneboda. ● The SoilTrEC project had been presented at international meetings for the UN ECE Convention on Long-Range Transboundary Air Pollution (CLRTAP), LTER Europe, and EC Life+ project Futmon and Env Europe.Last CLRTAP meeting was in September 2014. Representatives of c. 40 countries attended. ● Stakeholder excursion, 29/12/2012, 14 participants mainly from the Swedish Environmental Agency.	● Several national meetings and international at UN ECE in Geneva. ● web page presentation	● Swedish Environmental Protection Agency; Anna.Forsgren@naturvardsverket.se web: http://www.swedishepa.se/ ● Regional County Board; johan.wretenberg@lansstyrelsen.se web: http://www.lansstyrelsen.se/orebro/En/Pages/default.aspx ● CLRTAP Working Group on Effects; Krzysztof.Olendrzynski@unece.org Web: http://www.unece.org/env/lrtap/ ● LTER Europe; SE LTER; ulf.grandin@slu.se web: http://www.lter-europe.net/ ● EU Life+ EnvEurope;

		Environment Institute. Helsinki. ISBN 978-952-11-4206-2. www.syke.fi/publications Kleemola, S. and Forsius, M. (eds.) 2014. 23rd Annual Report for the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems. Reports of the Finnish Environment Institute 23/2014. Finnish Environment Institute. Helsinki. ISBN 978-952-11-4354-0. www.syke.fi/publications A special evaluation with a model approach, to a large extent based on the Swedish IM sites where CZO Kindla is one, has been carried out to clarify the relative importance of biological acidification in relation to atmospheric antropogenic acidifying acidification: Löfgren, S. ,Gustafsson, J.P. and Skyllberg, U. 2014. How does forest biomass production acidify soil and surface waters in comparison with mineral acids? SLU, Uppsala. A special report for the Swedish Environment Protection Agency. ● SLU have developed an Upscaled Field Information Board, Web page; http://www.slu.se/sv/fakulteter/nl-fakulteten/om-fakulteten/institutioner/institutionen-for-vatten-och-miljo/forskning/soil-transformations-in-european-catchments-soiltrec/	● Lars Lundin, SLU contributes in the dissemination of information.		alessandra.pugnetti@ismar.cnr.it web: http://www.enveurope.eu/ ● IM Reference group; Johanna.Fintling@skogsagarna.lrf.se Mora.Aronsson@slu.se Lars.Hogbom@skogforsk.se Ola.Inghe@naturvardsverket.se Anna.Forsgren@naturvardsverket.se Per.Hallerstig@lansstyrelsen.se Ola.Langvall@slu.se Sture.Wijk@skogsstyrelsen.se Borje.Pettersson@bergvikskog.se Eva.Ring@skogforsk.se Linda.Berglund@wwf.se Erik.Eriksson@energimyndigheten.se Anna.Lundborg@energimyndigheten.se Karin.Perhans@formas.se Richard.Johnson@slu.se
15.	CNRS	● OHGE web site with information on specific results on soils ● REALISE (Network of Alsatian laboratories) web site is also used to	● Dissemination champions for CNRS: Strengbach Marie Claire Pierret, ipierret@unistra.fr For REALISE Mme Marie Ange Moser,		

		disseminate information linked to SoilTrEC research of our group. ● RBV web site (French watershed network) : http://rnbv.ipgp.fr ● Writing a guide for field trip on the Strengbach Watershed.	mamoser@unistra.fr ● Maintain a stakeholder contact list on members' pages ● Presentation of relevant results to forest managers ● Presentation of research to territorial authorities and communities. ● Scientific and popularization activities for schools, children and general public (National Science Festival, mineralogical festival…). ● Several articles in the local newspapers. ● Several excursions and field trip for students, schools, public, colleagues, workshop… ● Welcoming and reception of colleagues from SoilTrEC network.		

4.2 Patents/trademarks and exploitable foreground

The Integrated Critical Zone Model is in available upon request to SoilTrEC partner Technical University of Crete. All primary and derived data (such as model and data analysis results) is available upon request to project partners who produced the data set.

4.3 Report on societal implications

A General Information *(completed automatically when **Grant Agreement number** is entered.*

Grant Agreement Number:	244118
Title of Project:	Soil Transformation in European Catchments
Name and Title of Coordinator:	Steven Banwart, Professor of Environmental Engineering

B Ethics

1. Did your project undergo an Ethics Review (and/or Screening)? • If Yes: have you described the progress of compliance with the relevant Ethics	***Yes***
2. Please indicate whether your project involved any of the following issues (tick box) :	***YES***
RESEARCH ON HUMANS	
• Did the project involve children?	
• Did the project involve patients?	
• Did the project involve persons not able to give consent?	
• Did the project involve adult healthy volunteers?	
• Did the project involve Human genetic material?	
• Did the project involve Human biological samples?	
• Did the project involve Human data collection?	
RESEARCH ON HUMAN EMBRYO/FOETUS	
• Did the project involve Human Embryos?	
• Did the project involve Human Foetal Tissue / Cells?	
• Did the project involve Human Embryonic Stem Cells (hESCs)?	
• Did the project on human Embryonic Stem Cells involve cells in culture?	
• Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?	
PRIVACY	
• Did the project involve processing of genetic information or personal data (e.g. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	
• Did the project involve tracking the location or observation of people?	
RESEARCH ON ANIMALS	
• Did the project involve research on animals?	
• Were those animals transgenic small laboratory animals?	
• Were those animals transgenic farm animals?	
• Were those animals cloned farm animals?	
• Were those animals non-human primates?	
RESEARCH INVOLVING DEVELOPING COUNTRIES	
• Did the project involve the use of local resources (genetic, animal, plant etc)?	**Soil**
• Was the project of benefit to local community (capacity building, access to healthcare, education etc)?	**Yes**
DUAL USE	
• Research having direct military use	**No**
• Research having the potential for terrorist abuse	No

C Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Type of Position	Number of Women	Number of Men
Scientific Coordinator		1
Work package leaders	5	3
Experienced researchers (i.e. PhD holders)	20	27
PhD Students	8	11
Other		

4. How many additional researchers (in companies and universities) were recruited specifically for this project?	**38**
Of which, indicate the number of men:	**20**

D Gender Aspects

5. Did you carry out specific Gender Equality Actions under the project?

Yes

6. Which of the following actions did you carry out and how effective were they?

		Not at all effective				Very effective
❑	Design and implement an equal opportunity policy	○	○	○	○	○
❑	Set targets to achieve a gender balance in the workforce	○	○	○	●	○
❑	Organise conferences and workshops on gender	○	○	○	○	○
❑	Actions to improve work-life balance	○	○	○	●	○
●	Other: Actively sought to appoint women leaders					

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?

○ Yes- please specify

● No

E Synergies with Science Education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?

● Yes- please specify: School children reviewed the Popular Book on Soil

○ No

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?

● Yes- please specify: Popular book on Soil, fact sheets on soil and soil education links on the public website

○ No

F Interdisciplinarity

10. Which disciplines (see list below) are involved in your project?

○ Main discipline[3]: Natural Sciences

○ Associated discipline[3]: Engineering and Technology

○ Associated discipline[3]: Social Sciences

○ Associated discipline[3]: Agricultural Sciences

G Engaging with Civil society and policy makers

11a Did your project engage with societal actors beyond the research community? *(if 'No', go to Question 14)*

Yes ●

[3] Insert number from list below (Frascati Manual).

11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?

- ○ No
- ● Yes- in determining what research should be performed
- ● Yes - in implementing the research
- ● Yes, in communicating /disseminating / using the results of the project

11c In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?	○	Yes
	●	No

12. Did you engage with government / public bodies or policy makers (including international organisations)

- ○ No
- ○ Yes- in framing the research agenda
- ● Yes - in implementing the research agenda
- ● Yes, in communicating /disseminating / using the results of the project

13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?

- ● Yes – as a **primary** objective (please indicate areas below- multiple answers possible)
- ○ Yes – as a **secondary** objective (please indicate areas below - multiple answer possible)
- ○ No

13b If Yes, in which fields?

Agriculture		Energy		Human rights	
Audiovisual and Media		Enlargement		Information Society	
Budget		Enterprise		Institutional affairs	
Competition		**Environment**		Internal Market	
Consumers		External Relations		Justice, freedom and security	
Culture		External Trade		Public Health	
Customs		Fisheries and Maritime Affairs		**Regional Policy**	
Development		Food Safety		**Research and Innovation**	
Economic and Monetary Affairs		Foreign and Security Policy		Space	
Education, Training, Youth		Fraud		Taxation	
Employment and Social Affairs		Humanitarian aid		Transport	

13c If Yes, at which level?

- Local / regional levels
- National level
- European level
- International level

H Use and dissemination

14. How many Articles were published/accepted for publication in peer-reviewed journals?	**86**
To how many of these is open access[4] provided?	**4**
How many of these are published in open access journals?	**4**
How many of these are published in open repositories?	
To how many of these is open access not provided?	**82**
Please check all applicable reasons for not providing open access:	
❑ publisher's licensing agreement would not permit publishing in a repository ❑ no suitable repository available ■ no suitable open access journal available ■ no funds available to publish in an open access journal ❑ lack of time and resources ❑ lack of information on open access ❑ other[5]: ……	

15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*		**0**
16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	Trademark	**0**
	Registered design	**0**
	Other	**0**
17. How many spin-off companies were created / are planned as a direct result of the project?		
Indicate the approximate number of additional jobs in these companies:		

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

❑	Increase in employment, or	■	In small & medium-sized enterprises
■	Safeguard employment, or	❑	In large companies
❑	Decrease in employment,	❑	None of the above / not relevant to the project
❑	Difficult to estimate / not possible to quantify		

[4] Open Access is defined as free of charge access for anyone via Internet.
[5] For instance: classification for security project.

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year*) jobs:	*Indicate figure:*
Difficult to estimate / not possible to quantify	■

I Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?

○ Yes ● No

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?

○ Yes ● No

22 Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

■	Press Release	■	Coverage in specialist press
❑	Media briefing	❑	Coverage in general (non-specialist) press
❑	TV coverage / report	❑	Coverage in national press
❑	Radio coverage / report	❑	Coverage in international press
■	Brochures /posters / flyers	■	Website for the general public / internet
❑	DVD /Film /Multimedia	■	Event targeting general public (festival, conference, exhibition, science café)

23 In which languages are the information products for the general public produced?

❑	Language of the coordinator	■	English
❑	Other language(s)		

5 Final report on the distribution of the European Union financial contribution

This report shall be submitted to the Commission within 30 days after receipt of the final payment of the European Union financial contribution.