2015 International Year of Soils

wageningen soil conference

SOIL SCIENCE IN A CHANGING WORLD

WAGENINGEN UNIVERSITY
WAGENINGEN UR

Soil Science in a Changing World

EDITORS
Saskia Keesstra
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Jakob Wallinga
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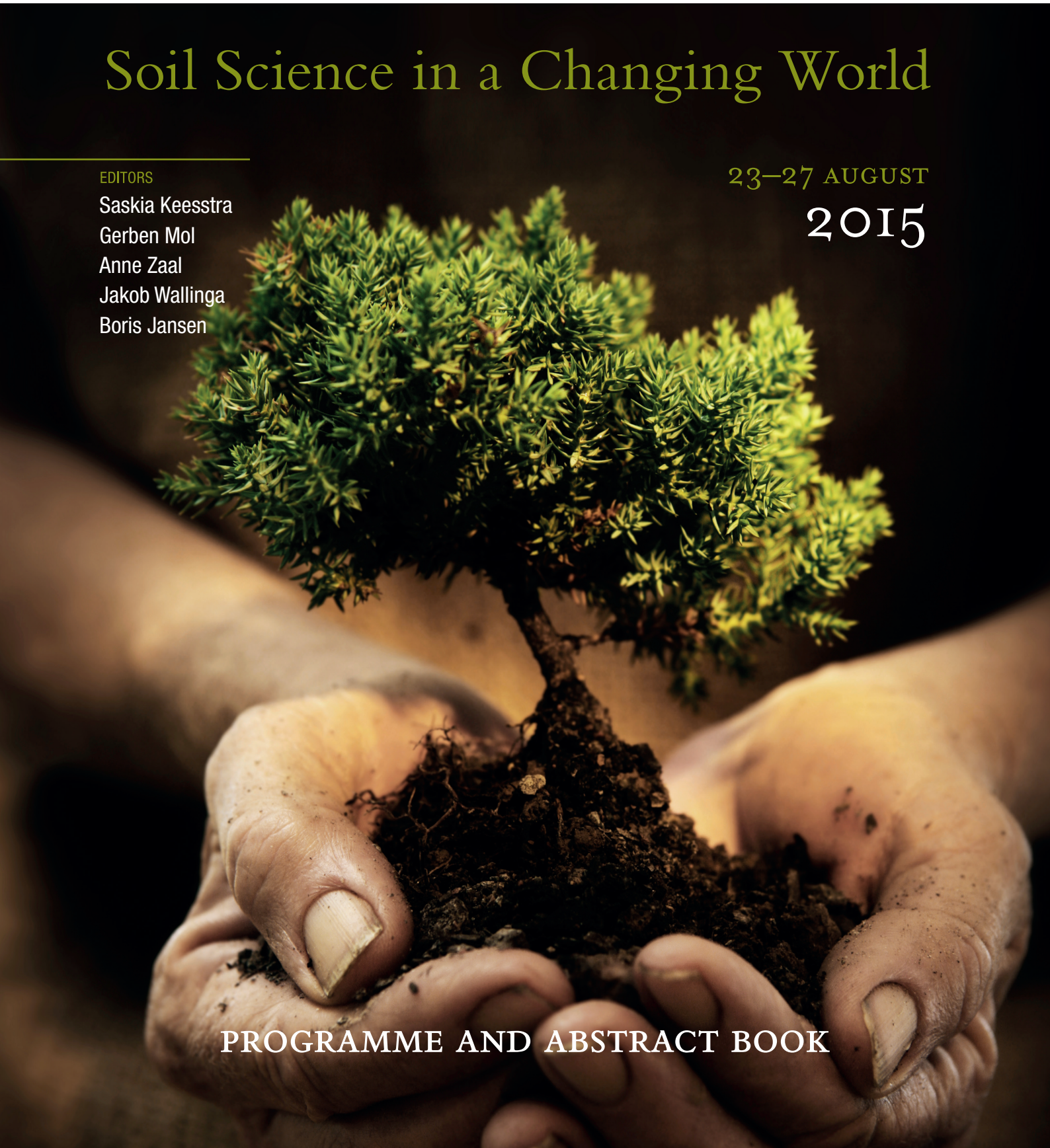
23–27 AUGUST
2015



PROGRAMME AND ABSTRACT BOOK

Book of Abstracts

Wageningen Soil Conference 2015

'Soil Science in a Changing World'

Editors:
B. Jansen
S.D. Keesstra
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23 - 27 August 2015
Wageningen
The Netherlands

Wageningen Soil Conference 2015
'Soil Science in a Changing World'
23 - 27 August 2015
Wageningen
The Netherlands

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Contents

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  Cranfield University, United Kingdom

Welcome

Welcome

We are proud and honoured to welcome you to the second edition of the Wageningen Soil Conference. Recently, I stumbled on a quote by Mehmet Murat Ilday, who stated that *"Sand is for fun; soil is for life!"*. Indeed, soils sustain life on earth, through ecosystem services such as food production, water storage, and climate change mitigation.

The relevance of soils and soil science seems to be increasingly reflected by public and policy attention. 2015 has been declared the International Year of Soils by the United Nations, and next month countries will meet to decide on newly formulated Sustainable Development Goals (SDGs). SDG #15 (... combat desertification, halt and reverse land degradation, ...) specifically addresses soil issues. Many others (e.g. #2: End hunger, achieve food security ...; #13; ...combat climate change and its impacts) can only be reached with thoughtful use of soil ecosystem services.

At the Wageningen Soil Conference we strive to connect soil science to major societal challenges. How does profound understanding of soil processes and dynamics contribute to combating and mitigating the challenges of our time: food security, water resources, climate change, land functions, and ensuring biodiversity? How can we ensure that soil knowledge is utilized to take effective measures, and how do we make sure soil scientists address the questions that are relevant to society?

The four conference days will provide a mix of key-note lectures, parallel sessions, poster sessions, discussions and excursions. With the 200 participants, we hope and expect to foster knowledge exchange and encourage lively discussions on the contributions of soil science to society as well as the societal soil demands.

I hope the Wageningen Soil Conference will provide you inspiration and enjoyment, as soils are not only for life, but also for fun!

Prof dr Jakob Wallinga, chair scientific committee

Organising committee

Boris Jansen

Saskia Keesstra

Gerben Mol

Anne Zaal

Programme

Programme

Sunday, August 23th 2015

18.00 – 19.00 *Icebreaker, drinks & bites and Pre-registration - Café Loburg (Molenstraat 6, 6701 DM Wageningen)*

Monday, August 24th 2015

08.30 Arrival / Registration – *Lobby, Orion Building (Bronland 1, Building 103, 6708 WH Wageningen)*
Poster Placement, Coffee

09.30 – 09.45 **OPENING SESSION** – *Plenary meeting room (Orion 1040)*
Welcome *– Jakob Wallinga, chair Scientific Committee*
Opening address *- Louise Fresco, President Executive Board Wageningen UR*

THEME 1: FOOD SECURITY
Chair: Martin van Ittersum

09.45 – 10.10 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
Bernard Vanlauwe, International Institute of Tropical Agriculture (IITA), Kenya
Pathways towards the sustainable intensification of smallholder farming systems in Sub-Saharan Africa

10.10– 10.35 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
Deborah Bossio, Soils Research Area Director, CIAT International Center for Tropical Agriculture, Kenya
Soil organic matter for climate change mitigation: boon or bane for food security?

10.35 – 11.15 Plenary discussion - *(Orion 1040)*

11.15 – 11.45 One minute poster pitches – *Plenary meeting room (Orion 1040)*

Presented posters:

Azita Behbahaninia: Cadmium and lead transport in the soil and plants under sewage sludge application

Naser Boroomand: Kinetics of zinc desorption from calcareous soils: influenced by concentration and time of poultry manure

Lambert Bräu: Enhancement of phosphate Acquisition and delivery to plants using the cyanobacterium Nostoc Punctiforme

Jelle Dijkema: Beneficial soil microbes reduce plant disease, with implicated improvements in fruit flavour profiles, nutritional value and human health

Leyla Hassani Rezaei: Quantitative assessment of linear sorghum response functions to combined salinity urea

Chantal Hendriks: Soil qualities or soil properties? A novel approach for soil data to address food security

Hala Kandil: Effect of agrosol treatment and phosphorus levels on pea plants (pisum sativum l.)

Lammert Kooistra: Use of RGB aerial photographs for assessment of soil organic carbon distribution in agricultural fields

Richard Kraaijvanger: Evaluating resource use efficiency and stock balances of fertilizer inputs: the effect of soil supply capacity in Tigray (Ethiopia)

Richard Kraaijvanger: Four years of farmer experimentation on soil fertility in Tigray, northern Ethiopia: trends in research strategies

Johan Leenaars: Soil information to feed the African soil, crop and people

Florence Leprince: Impact of a legume living mulch on winter wheat yield and its nitrogen nutrition

Juan Carlos Mendez: Interpolation and validation of soil fertility data in three agricultural cooperatives in Costa Rica

Mikael Motelica-Heino: A new agro-ecologic paradigm for food security in the Sudano-Sahelian zone

Yang Peipei: Yield responses to nutrient management and soil quality in long-term field trials in China

Maria Ruiperez Gonzalez: Digital Mapping of Soil Nutrients for the Republics of Burundi and Rwanda

Maricke van Leeuwen: A quantitative approach on visual soil assessment: validation and reproducibility

Winnie van Vark: Comparable and reliable data from Laboratories within Global Soil Research

Vaclav Voltr: Validation of soil fertility and productivity in the Czech Republic

Jiri Zbiral: Characterization of soil organic matter by near infrared spectroscopy – determination of Glomalin in different soils

11.45 – 12.15 Poster sessions with coffee break with cake – *Restaurant 'The Spot', Orion building*

12.15 – 13.45 **PARALLEL SESSIONS**

2 sessions with 6 oral presentations

	Session Food Security 1 ***(Orion 1040)*** *Chair: Martin van Ittersum*	**Water Resources 1** ***(Orion 2051)*** *Chair: Saskia Keesstra*
12.15 – 12.30	*Takoutsing Bertin* Land health surveillance for identifying land constraints and enhancing soil productivity in smallholders' agriculture in Cameroon	*Hendrik Bruins* The effect of water harvesting, ash and dung on soil development in terraced wadis in the Central Negev Desert (Israel): the longue Duree
12.30 – 12.45	*Lieven Claessens* The Global Yield Gap Atlas for targeting sustainable intensification options for smallholders in Sub-Saharan Africa	*Antonietta La Terza* The BioPrint Pilot Project: ciliated protozoa communities as a tool to assess soil quality in agroecosystems and natural sites of Marche Region (Italy)
12.45 – 13.00	*Renske Hijbeek* Effects of organic matter on attainable yields across Europe	*Miriam Muñoz-Rojas* Understanding the effects of climate and soil characteristics on seedling emergence to improve restoration of semi arid environments
13.00 – 13.15	*Veronika Hansen* Gasification biochar has the potential to improve soil quality and crop production	*Jianhui Zhang* Soil hydrological properties as a response to tillage erosion in a Regosol of hilly landscapes
13.15 – 13.30	*Christy van Beek* Fertile grounds initiative: it's not the soil that needs to change, it's the people who manage the soil	*Wei Shangguan* On aggregation methods for estimated soil hydraulic parameters by pedotransfer functions
13.30 – 13.45	*Rafael Segura-Mena* Soil management as an effective strategy for crop disease management: the case of Panama disease in banana	*Fons Jaspers* Hydrological corridors for landscape and climate restoration: proof of concept and impact assessment

13.45 – 14.45 Lunch and poster sessions – *Restaurant 'The Spot', Orion building*

THEME 2: WATER RESOURCES
Chair: Artemi Cerdà

14.45 – 15.10 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
John Quinton, Lancaster Environment Centre, Lancaster University, United Kingdom
Soil water: the nexus for food production and environmental quality

15.10 – 15.35 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
Günther Blöschl, Institute of Hydraulic Engineering and Water Resources Management, Vienna University of Technology, Austria
Floods across scales in a changing world

15.35 – 16.15 Plenary discussion - *(Orion 1040)*

16.15 – 16.45 One minute poster pitches – *Plenary meeting room (Orion 1040)*

Presented posters:

Dwi Priyo Ariyanto: Short Drought Irrigation by Small-Farm Reservoir at Rainfed Lands

Vasiliki Bota: Determination of hydraulic conductivity in unsaturated soil samples

Artemi Cerdà: Changes in soil infiltration rates after wildfires in the Serra de Grossa and the Massís del Caroig, Eastern Spain

Artemi Cerdà: Rice straw as a cover mulch to reduce overland flow in olive plantations in the Enguera municipality. Eastern Iberia Peninsula

Saeid Hamzeh: Modelling shallow groundwater in sugarcane fields using hyperspectral satellite imagery

Saskia Keesstra: Assessing catchment connectivity using hysteretic loops

Florence Leprince: Evaluation of pesticide's leaching under drainage conditions in a laboratory tracing experiment with controlled conditions

Florence Leprince: Long term impact of no tillage on water and solute flux in drainage

Jestinos Mzezewa: Water infiltration patterns under in-field water harvesting tillage in the semi-arid Limpopo Province of South Africa

Estela Nadalromero: Hydrological connectivity dynamic and temporal stability in an afforestation area in the Central Spanish Pyrenees

Muhammad Sanaullah: Water balance assessment of a river bounded aquifer using visual *MODFLOW® applications, Eastern Punjab, Pakistan*

Ieyasu Tokumoto: Simulation of leaching and rootzone salinity control at tsunami affected rice fields in Miyagi, Japan

Jos van Dam: When do soil hydraulic properties matter for root water extraction?

16.45 – 17.15 Poster sessions with coffee break – Restaurant 'The Spot', Orion building

17.15 – 18.45 **PARALLEL SESSIONS**

2 sessions with 6 oral presentations

	Session Food Security 2 ***(Orion 1040)*** *Chair: Jannes Stolte*	**Session Water Resources 2** ***(Orion 2051)*** *Chair: Artemi Cerdà*
17.15 – 17.30	*Zhiping Cao* Gaia theory: the valve mechanism of phosphorus cycling	*Martine van der Ploeg* The landscape of biophysical interactions
17.30 – 17.45	*Jessica Mackay* Evaluation of organic amendments, soil microbes and plant P uptake	*Mirjam Hack-ten Broeke* Quantification of the impact of hydrology on agricultural production
17.45 – 18.00	*Hanan Siam* Improving Calcareous soli productivity by integrating effect of compost or Sulfur in the presence of different sources of phosphorus	*Paul Murphy* Effects of mitigation measures on phosphorus loss across the transfer continuum from soil to water in a monitored dairy grassland catchment
18.00 – 18.15	*Ahmed Afifi* Identification and quantification of P mineralogical forms in sandy calcareous soils by infrared spectroscopy and chemometric methods: an approach by increasing complexity	*Iael Raij* Optimization of in-situ drainage lysimeters for fertigation efficiency
18.15 – 18.30	*Jordon Wade* Can Soil Respiration Predict N Mineralization?	*Yasser Refaey* Adsorption of copper, nickel, and zinc as related to soil constituents and timing of addition of dissolved organic carbon
18.30 – 18.45	*Supriatin* Selenium Speciation and Extractability in Dutch Agricultural Soils	*Aneta Trajanov* Assessing the risk of tile-drained water pollution with pesticides

18.45– 19.45 Snacks with refreshments sponsored by WEPAL and poster sessions – *Restaurant 'The Spot', Orion building*

Tuesday, August 25th 2015

Excursions, with various options.

At 19.00 hours the Conference dinner starts at Restaurant H41.
We offer an Italian buffet style dinner with drinks, dessert and coffee. You can find Restaurant H41 in Wageningen City Centre, Heerenstraat 41, 6701 DH Wageningen.
Excursions and dinner are not included in the standard Conference fee; participating in these events requires prior registration and payment or payment on site at the conference desk.

The excursions will be guided by scientists and most of the excursions have a scientific character; some are combined with a cultural treat. Most of the excursions will leave around 08.30 at the Hof van Wageningen and return around 17.30 hrs; transport, coffee/tea, packed lunch and refreshments are included.
All our excursions include shorter or longer walking trips in the open air, so we advise you to bring watertight easy walking or hiking shoes and rain clothes with you. The average temperature in August is 19-21 degrees Celsius, with a fair possibility of rainfall.

1. A combined excursion in Wageningen: Wageningen Campus: ISRIC-World Soil Museum, Wepal and NIOO

Excursion leader Thomas Caspari, ISRIC

The excursion starts with a visit to the ISRIC-World Soil Museum. We will then visit the new NIOO premises including laboratories. We will take a short bus tour to WEPAL where we will have lunch and a guided tour.
The first excursion point will be ISRIC-World Soil Information. Since 1966 this institute is serving the international community as custodian of world soil data and information. During a guided tour through the ISRIC World Soil Museum you will be able to explore the largest soil monolith collection in the world, and learn how soils are connected to global challenges. Please visit isric.org for more information.

This trip will leave at the Hof van Wageningen on 08.30 hrs and return at the Hof van Wageningen around 14.30-15.00 hours. In the afternoon you will have some time to explore Wageningen yourself.

2. Excursion to the National Park Hoge Veluwe

(http://www.hogeveluwe.nl/en)
Excursion leader: Roel Dijksma, Wageningen UR, Section Hydrology and Quantative Water Management

National Park Hoge Veluwe is a relic from glaciers that covered the Netherlands during Saalien (2 104 – 1.2 104 years ago). It is a large complex of ice-pushed ridges with an elevation up to 110 m+NAP. Excess rainwater can infiltrate in the sandy soil and feeds the underlying aquifer. This groundwater rises to the surface in springs and brooks in the surrounding area. In this excursion the geology and related water management of the region will be shown. The excursion will start on top of an ice-pushed ridge with an overview to the adjacent river landscape. Then we will visit an old mill-brook, which is fed by Veluwe water, and some of the upper branches of this brook (manmade springs). This field trip is followed by a visit in the afternoon to the National Park Hoge Veluwe and the Kröller Muller Museum which hosts many famous paintings of Dutch masters such as Van Gogh. De Hoge Veluwe National Park is the largest actively managed conservation area in private hands in the Netherlands.
The Park covers 5,400 hectares of woodland, heathland, peat bogs and drift sand. It enjoys a

wide variety of plants and animals and provides habitats to extremely rare Red List species. You have the possibility to have a guided nature walk in the park or enjoy a visit to the Kröller-Müller museum on your own. This trip will leave by bus at the Hof van Wageningen on 08.30 hrs and return around 17.30 hours.

3. An excursion about 200,000 years of landscape formation in the surroundings of Wageningen: consequences for current day use

Excursion leader: Arnoud Temme, Wageningen UR, Section Soil Physics and Land Management

The Saalien ice age has set the scene for today's landscape around Wageningen: the cover ice reached the area and deep depressions and pushed moraines were formed. Since then, the landscape was further shaped by a combination of climate change, geomorphological processes, soil formation, vegetation dynamics, and human influence. This excursion tells the fascinating story of this dynamic landscape and discusses the consequences for current day use.
This trip will leave by bus at 8:30 from the 'Hof van Wageningen' and returns at ca. 17.30 (there will be relatively little 'bus time' but we will be most of the time in the field). Amongst the places we visit are: the Wageningse Berg, Rhenen/Veenendaal (Grift waterway), Doorwerth, Bennekom, the Floodplains of Wageningen.

4. Geological and landscape evolution of the Rhine-Meuse delta

Excursion leader: Kees Kasse, VU university Amsterdam, Section Climate Change and Landscape Dynamics

The excursion will demonstrate the geological and landscape development of the Rhine-Meuse delta in the western and central Netherlands during the Late Pleistocene and Holocene. The impact of climate, sea-level rise and man on delta evolution will be demonstrated in several excursion stops. We will make a west to east transect through the delta starting at the present-day coast where the (sub)recent coastal development and dune formation will be shown. East of the present-day dunes older Holocene coastal barriers systems are present and their relation to Holocene sea-level rise will be explained. The western part of the Netherlands consists of Holocene back-barriers deposits like tidal flat sediments and peats that will be shown by coring. Human reclamation of the peat lands since the late Middle Ages, peat digging and destruction of the landscape followed by lake drainage in historic times will be shown in the field and museum. Further to the east the impact of the river Rhine on the Holocene delta formation is more prominent and a fossil fluvial Rhine course will be visited. Finally, the impact of continental (Scandinavian) glaciation (~150,000 years ago) on the Rhine-Meuse delta and its influence on landscape evolution until the present day will be elucidated in the central Netherlands.
This trip will leave around 08.15 hours at the Hof van Wageningen and return around 17.30 hours.

Disclaimer: The Wageningen Soil Conference-excursions are subject to availability and will be offered to participants of the Conference who have registered and paid the separate fee for an excursion. All best endeavours will be made to present the tour programme as published. However, the Wageningen Soil Conference reserves the right to alter or cancel without prior notice, any of the arrangements, timetables, plans or other items relating directly or indirectly to the tour programme for any reason beyond its reasonable control. Wageningen UR is not liable for any loss or inconvenience caused as a result of such alteration. **Please be aware that participants take part at their own risk. Wageningen UR will not be responsible for personal injury or loss or damage of property.**

Wednesday, August 26st 2015

08.00 Arrival / Registration – *Lobby, Orion Building*
Poster Placement, Coffee

THEME 3: GOVERNANCE AND POLICY
Chair: Luca Montanarella

08.30 – 08.55 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
Ronald Vargas-Rojas, Soils and Land Management Officer, FAO
Soil governance: a precondition for sustainable development

08.55 – 09.20 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
Gerda Verburg,
We need collaboration and concrete results

09.20 – 10.00 Plenary discussion - *(Orion 1040)*

10.00 – 10.10 One minute poster pitches – *Plenary meeting room (Orion 1040)*

Presented posters:

Sandra Boekhold: Get inspired – help share the European Strategic Research Agenda on soil, land use and land management

Mark Kibblewhite: Valuing and managing urban soil resources for food production

Jacynthe Masse: Microbial communities and nitrogen cycle in reclaimed oil-sand soils

10.10 – 10.30 Poster pitches ISCRIC-session – *Plenary meeting room (Orion 1040)*

Presented posters:

Oene Oenema: Relating variations in crop yields to soil quality; a case study

Wei Shangguan: Soil information for Earth system modelling

Jannes Stolte: Soil threats in Europe

Genesis Yengoh: Perennial polycultures replacing annual monocultures? Implications for soil management and sustainable agriculture

10.30 – 11.00 Poster sessions with coffee break – *Restaurant 'The Spot', Orion building*

11.00 – 12.30 **PARALLEL SESSIONS**

3 parallel sessions (90 minutes each)

	Session Governance and Policy 1 ***(Orion 1040)*** *Chair: Mark Kibblewhite*	**Session Biodiversity 1** ***(Orion 2005)*** *Chair: Wim van der Putten*
11.00 – 11.15	*Sandra Boekhold* Soil organic matter for food, water, climate, energy and health	*Gera Hol* Impact of microbial species on rhizosphere microbiome assembly
11.15 – 11.30	*Lucie Greiner* Assessment and mapping of soil services for spatial planning procedures	*Anne Winding* Assessment of soil microbial diversity with functional multi-endpoint methods
11.30 – 11.45	*Rogier Schulte* Making the most of our land: meeting supply and demand of soil functions from farm to European scale	*Mart Ros* Underlying mechanisms driving earthworm-induced increases in phosphorus availability
11.45 – 12.00	*Siva Muthuprakash* Significance of soil parameters in evaluating the farming practices: a systems approach	*Jack Faber* Land use intensity impact on functional diversity in earthworms regarding regulation of soil structure and water infiltration
12.00 – 12.15	*Willie Towers* The Scottish Soil Framework: implementing Soil Protection Policy at regional scale	*Michiel Rutgers* Mapping earthworm communities in Europe
12.15 – 12.30	*Johan Bouma* Business-as-usual will not suffice when contributing to the Sustainable Development Goals	*Rachel Creamer* Eco-Finders: defining biological indicators of three soil functions across Europe

Optimizing Soil Information Services for Solving Global Issues (ISRIC session)
(Orion 2051)
Chair: Rik van den Bosch

11.00 – 11.22 ***KEYNOTE Speaker:***
Pete Smith
Soil data needs for a global framework for soil carbon modelling

11.22 – 11.39 *Niels Batjes*
New gridded data sets for global sustainability studies - WISE30sec and SoilGrids

11.39 – 11.56 *Lenny van Bussel*
Comparative analysis of options for the spatial framework of yield gap analyses: a focus on soil data

11.56 – 12.13 *Thomas Terhoeven*
Archetypal analysis of soil fertility indices (soil testing results) as basis for soil improvement strategies: example for three Kenyan counties

12.13 – 12.30 *Bas van Wesemael*
Estimating topsoil organic carbon stocks in Europe using geo- referenced harmonised topsoil and land cover data

12.30 – 14.00 Lunch and poster sessions – *Restaurant 'The Spot', Orion building*

THEME 4: BIODIVERSITY
Chair: Lijbert Brussaard

14.00 – 14.25 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
George Kowalchuk, Institute of Environmental Biology, Utrecht University, The Netherlands
Exploring and explaining the magnitude of soil-borne microbial diversity

14.25 – 14.50 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
Laurent Philippot, Agroecology Department, INRA Dijon, France
Linking soil microbial diversity, nitrogen cycling and greenhouse gas emissions

14.50 – 15.30 Plenary discussion - *(Orion 1040)*

15.30 – 15.45 One minute poster pitches – *Plenary meeting room (Orion 1040)*

Presented posters:

Adetunji Alex Adekanmbi: Interactions between tillage and crop genotype diversity

George Ametsitsi: The role of soils in the distribution of forest and savannah vegetation in an ecotone

Denisse Archundia: Sulfamethoxazole sorption in soils of the Bolivian Altiplano and impacts on bacterial populations

Célia Patrícia Martins Bento: Glyphosate decay in loess soil: is glyphosate a major risk for soil contamination?

Pella Brinkman: Centre for Soil Ecology (CSE)

Federica D. Conti: Biochar in soils: effects on soil microarthropods

Joana Frazão: Earthworm communities in relation to arable management in a landscape context

Amber Heijboer: Linking microbial diversity to the functioning of soil food webs using stable isotope probing

Gera Hol: Waking up the microbial seedbank: which rare bacteria are opportunists?

Dominika Piwcewicz: Multielemental stoichiometry: what is the impact of funghi and bacteria on decomposing litter

Saeideh Rajaei: DNA Extraction from Pistachio roots with the aim of endophytic studies

Naomi Rintoul: Effects of soil contamination from historical industrial sources on plant biodiversity

Xiaomei Yang: Glyphosate decay and transport related with soil erosion in Loess soil, China

Marleen Zanen: Effect of no-till versus ploughing on soil quality and wheat yield on heavy clay soils

16.00 – 16.30 Poster session with coffee break – *Restaurant 'The Spot', Orion building*

16.30 – 18.00 **PARALLEL SESSIONS**

2 sessions with 6 oral presentations

	Session Biodiversity 2 ***(Orion 1040)*** *Chair: Lijbert Brussaard*	**Session Land Functions 1** ***(Orion 2051)*** *Chair: Johan Bouma*
16.30 – 16.45	*Antonietta La Terza* Soil biodiversity and sustainable vineyards: hints from the analysis of microarthropods and ciliated protozoa communities	*Lizeth Manuela Avellaneda-Torres* Evaluation of changes in soil quality in coffee agroecosystems (ecological and conventional) with different scores of resilience to climate variability in Anolaima, Colombia
16.45 – 17.00	*Elly Morriën* Soil biodiversity and nutrient cycling in an agricultural land abandonment chronosequence	*Ute Hamer* Afforestation or intense pasturing improve the ecological and economic value of abandoned tropical farmlands – the soil perspective
17.00 – 17.15	*Guénola Pérès* Is reduced tillage systems a sustainable arable farming? An integrated assessment of soil properties, soil ecosystem services, and socio-economic aspects	*Jan Peter Lesschen* Areas at risk of crop yield losses in Europe due to low or decreasing soil organic carbon levels

17.15 – 17.30	*Hsiao-Hang Tao* Effects of long-term crop residue application on soil biota, soil aggregation and organic matter allocation in oil palm agroecosystems	*Oleg Makarov* Cost estimate of agricultural land degradation in Russia applying different methodological approaches
17.30 – 17.45	*Ludovic Henneron* Forest management adaptation to climate change: soil biodiversity and ecosystem functioning response to stand density reduction	*Jan van den Akker* How serious is subsoil compaction?
17.45 – 18.00	*Marcel van der Heijden* Soil biodiversity as a driver of ecosystem sustainability	*Wim de Vries* Impacts of revision of fertilizer policies on soil balances of copper, zinc, cadmium and lead in EU-27
18.00 – 19.00	Snacks with refreshments and poster sessions – *Restaurant 'The Spot', Orion building*	

Thursday, August 27nd 2015

08.00 Arrival / Registration – *Lobby, Orion Building*
Poster Placement, Coffee

THEME 5: LAND FUNCTIONS
Chair: Violette Geissen

08.30 – 08.55 **KEYNOTE** – P*lenary meeting room (Orion 1040)*
Gerard Govers, KU Leuven, Belgium
Developing new visions for soil conservation

08.55 - 09.20 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
Jetse Stoorvogel, Wageningen University, The Netherlands
What is the window of opportunity for our soil functions? A global and historical perspective

09.20 – 10.00 Plenary discussion - *(Orion 1040)*

10.00 – 10.30 One minute poster pitches – *Plenary meeting room (Orion 1040)*

Presented posters:

Romain Armand: Using plant functional traits to improve the mitigation of runoff-erosion efficiency of herbaceous hedges

Ayse Basbozkurt: Spatial analysis of soil ‘s some physical and chemical properties in Southern Anatolia

Elena Bondarenko: Assessment of damage caused by land degradation at the farm level in Moscow Region, Russia

Matthijs Bouwknegt: New developments in contaminated land management in Vietnam

Khalil Ur Rahman Butt: Soil characteristics mapping is a pre-requisite to conduct applied agricultural research and transfer of technologies to farmers

Mark Caulfield: Exploring Dominant Land Uses and their Associated Soil-Based Agroecosystems in a Heterogeneous Agricultural Landscape in the Ecuadorian Andes

Mark Caulfield: Exploring the Inter-Relationship between Landscape Heterogeneity and Within Farm Variability in Resource Allocation in the Andes

Vanessa Cristina de Carvalho Oliveira: Soil functionality indicators and multifunction assessment of Cerrado – Brazil

Majid Dowlati: Remote Sensing of Burned Residue in Fields using Landsat -8 Sensor Imagery

Mohammadreza Hosseini: Effect of fire frequency on nutrient losses in burned Pine forest of North-Central Portugal

Sergiy Kolomiets: Dynamic model of soul functioning and development

Adam Lajczak: Anthropogenic changes in relief of raised bogs in the Polish Carpathians

Stanislav Maly: Validation of models describing relationships between microbial soil properties and characteristics of stands in Coniferous and Deciduous forests

Elly Morriën: Natural and induced supressiveness of Globodera Rostochiensis by Pochonia Chlamydosporia on a chronosequence of abandoned agricultural soils

Joao Pedro Nunes: Comparing erosion rates in terraced agriculture fields and fire-disturbed forests in a humid Mediterranean mountain catchment

Taco Regensburg: The role of vegetation patches and soil moisture conditions in runoff and erosion connectivity in a 4 times burnt pine stand

Pim Rijkee: Low-Land Gully Formation in the Amhara Region, Ethiopia

Andrea Román Sánchez: Single-grain OSL and IRSL dating for reconstruction of soil forming processes in a hillslope catena in Sierra Morena, S Spain

Jeroen Schoorl: Soil redistribution and landscape evolution modelling: LAPSUS

Hanan Siam: Evaluation of methods application for urea fertilizer by compost addition and its effect on peanut productivity, mineral content and quality under the newly reclaimed saline soil

Vera Silva: Pesticide distribution in European soils resulting from decades of application and related risk for the environment

Alexey Sorokin: Economics of land degradation and improvement: challenges for regional-scale assessments

Jaime Villacis: Performance of forest species on substrates derived from disturbed soils due to Petroleum activity in the Ecuadorian Amazon

Henk Wösten: Soil map providing basic information for crop and site specific water and fertility recommendations in Ethiopia

Irena Ymeti: Monitoring soil strength dynamics at plot scale using image texture analysis

10.30 – 11.00 Poster session with coffee break – *Restaurant 'The Spot', Orion building*

11.00 – 12.30 **PARALLEL SESSION**

2 sessions with 6 oral presentations

	Session Climate Change 1 ***(Orion 1040)*** *Chair: Boris Jansen*	**Session 5.2: Land Functions 2** ***(Orion 2051)*** *Chair: Violette Geissen*
11.00 – 11.15	*Juliane Filser* Soil fauna: key to soil organic matter dynamics and modelling	*Julian Campo* Soil aggregation and soil organic carbon redistribution in a Mediterranean hill-slope affected by forest fires, erosion and deposition
11.15 – 11.30	*Edward Gregorich* Plant residue decay in diverse Canadian soils	*Clovis Grinand* Mapping temporal change of soil organic carbon: Impacts of deforestation in tropical humid and dry soil-landscape
11.30 – 11.45	*Jan Willem van Groenigen* Does the effect of earthworms on the soil greenhouse gas balance differ between farming systems?	*Adam Lajczak* Factors of abiotic environment influencing distribution and growth of peat bogs in Flysch Mountains, as exemplified by the Polish Carpathians
11.45 – 12.00	*Ingrid Lubbers* Exploring the relationship between soil mesofauna, soil structure and N2O emissions	*Estefania Perez-Fernandez* A near infrared spectroscopy method to monitor changes in C content of soils in response to land use change
12.00 – 12.15	*Kees Jan van Groenigen* Application of a two-pool model to ecosystem carbon dynamics under global change	*Hedwig van Delden* Changes in soil organic carbon stocks at the European scale due to changes in climate, land use and management practices
12.15 – 12.30	*Liz Veerman* Use of lipid biomarkers to trace the source of soil organic carbon in afforested soils across Europe	*Esperanza Huerta* Earthworms are plastic transporters

12.30 – 14.00 Lunch and poster sessions – *Restaurant 'The Spot', Orion building*

THEME 6: CLIMATE CHANGE
Chair: Karsten Kalbitz

14.00 – 14.25 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
Ingrid Kögel-Knabner, Chair of Soil Science, Technische Universität München, Germany
Understanding organic matter sequestration for sustainable management of soils

14.25 – 14.50 **KEYNOTE** – *Plenary meeting room (Orion 1040)*
Pete Smith, Institute of Biological and Environmental Sciences, University of Aberdeen, United Kingdom
Soils and climate Change

14.50 – 15.30 Plenary discussion - *(Orion 1040)*

15.30 – 16.00 One minute poster pitches – *Plenary meeting room (Orion 1040)*

Presented posters:

Adoum Abdraman Abgassi: Carbon stocks in polders soils developed in inter Dunes landscapes under semi-arid climate (Lake Chad)

Amira Aschi: Effects of faba bean position in rotation system on abundance and diversity of soil microorganisms and nitrogen availability

Padraig Flattery: Estimating Soil Carbon: Exploring Methodologies

Boris Jansen: The use of biomarkers to trace carbon transformations and input in soils

Hala Kandil: Role of cobalt in wheat water relationships under two different moisture regimes

Miriam Muñoz-Rojas: Soil respiration in biodiverse semi arid ecosystems: effects of vegetation type and seasonal variation

Estela Nadal-Romero: The effects of land use changes on soil carbon stocks

Nuria Valbuena: The effect of mole drainage on N2O emissions from a clay-loam soil under grassland

16.00 – 16.30 Poster session with coffee break – *Restaurant 'The Spot', Orion building*

16.30 – 18.00 **PARALLEL SESSIONS**

2 sessions with 6 oral presentations

	Session Land Functions 3 ***(Orion 1040)*** *Chair: Erik Cammeraat*	**Session Climate Change 2** ***(Orion 2051)*** *Chair: Karsten Kalbitz*
16.30 – 16.45	*Estela Nadal-Romero* How do soil properties change after land abandonment in Mediterranean areas?	*Ni'matul Khasanah* Carbon neutral? Changes in mineral soil carbon stock under oil palm plantations derived from forest or non-forest in Indonesia
16.45 – 17.00	*Andrea Román Sánchez* Mediterranean landscape dynamics: soil formation processes long term	*Gillian Kopittke* On the Rise and Fall of Carbon Balances in a Managed Heathland
17.00 – 17.15	*Jeroen Schoorl* Resolution effects on feedbacks between soil redistribution and land use change in the Guadalhorce Valley, Alora, Spain	*Albert Tietema* A 15N tracer experiment shows long-term stabilization of N deposition in organo-mineral complexes in the mineral soil of a forest ecosystem: consequences for C sequestration
17.15 – 17.30	*Arnaud Temme* LORICA: a new soil landscape co-evolution framework	*Jerome Ebagnerin Tondoh* Assessing the potential of soils for climate change mitigation and adaptation in West African drylands
17.30 – 17.45	*Marcos Angelini* Digital soil mapping of an Argentinian Pampa Region using structural equation modelling	*Jan van den Akker* Subsidence and CO2 emissions of peat soils in agricultural use
17.45 – 18.00	*Oren Hoffman* Experimental and natural changes in semi-arid vegetation patterns affect runoff production and shrub-herb interactions	*Juniarti Yuni* Soil carbon stock in sub-optimal land due to climate change on development Cymbopogon nardus L. Simawang Village, West Sumatra, Indonesia

18.00 – 19.00 *Restaurant 'The Spot', Orion building*
Conference closure - Jakob Wallinga, chair
Snacks with refreshments and poster sessions

Theme 1
Food Security

Keynote
Bernard Vanlauwe

PATHWAYS TOWARDS THE SUSTAINABLE INTENSIFICATION OF SMALLHOLDER FARMING SYSTEMS IN SUB-SAHARAN AFRICA

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Sub-Saharan Africa needs to produce more food, feed, and fiber to support its growing population and intensification of smallholder agriculture is a crucial component of any strategy towards this goal. Where intensification is desirable, Sustainable Intensification (SI) denotes a commonly accepted goal to achieve this but does not specify a priori how it should be approached. While various definitions of SI circulate, most of these are phrased around three principles: (i) production of more food, feed, fuel and/or fiber per unit of land, labor, and/or capital used, (ii) preservation of important ecosystem services, including those governed by healthy soils, and (iii) resilience to shocks and stresses, including climate change (Pretty et al, 2011).

A very diverse group of smallholders dominate SSA agriculture, with large heterogeneity in socio-technical regimes, famer typologies, production objectives, and biophysical conditions. This potentially generates a multitude of pathways towards SI from the current low productivity based on nutrient mining (Vanlauwe et al., 2014).

In sub-Saharan Africa, enhanced crop productivity is a prerequisite to alleviate rural poverty. Integrated Soil Fertility Management (ISFM) aims at increasing crop productivity and the agronomy efficiency of applied inputs but targeting appropriate combinations of improved varieties, fertilizer, organic resources, and other soil amendments, the latter as required based on site-specific constraints limiting crop productivity (Figure 1). ISFM also targets scarcely available production resources within heterogeneous farming systems, thereby taking into account within-farm soil fertility gradients (Figure 1) which are common feature of smallholder farming systems in densely populated, resource-limited farming landscapes. Examples are given on the performance of ISFM interventions with maize-legume and cassava-legume systems within heterogeneous farming environments. Specific attention is given to the role of soil fertility conditions on the performance of ISFM interventions, including the management of non-responsive soils. Also discussed is the impact of farmer production

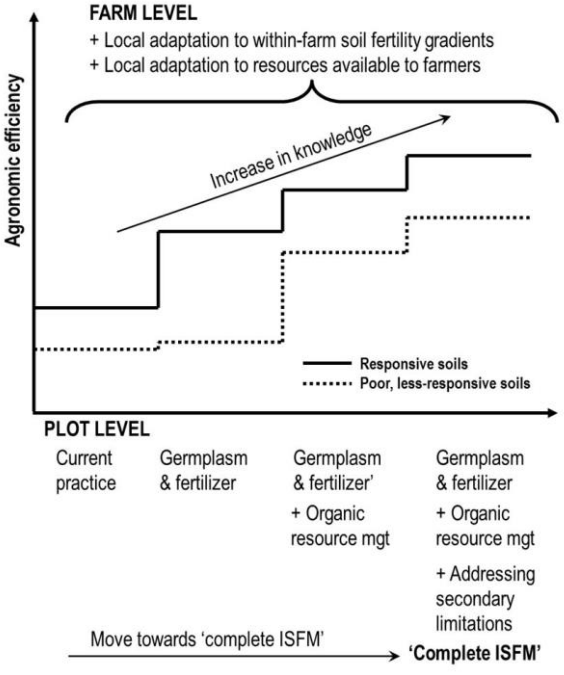

Figure 1: Figure 4: Revised conceptual framework underlying Integrated Soil Fertility Management (ISFM), adapted from the original version (Vanlauwe et al., 2010). The current version distinguished plot from farm-level 'local adaptation' interventions.

objectives and resource endowments, often expressed as farmer typologies, on the potential of ISFM interventions to deliver on their anticipated productivity benefits. The provision of other soil-based ecosystem services at plot scale, including the build-up of soil organic carbon, enhanced nutrient cycling, and improved water use is also discussed.

Since ISFM is not addressing the provisioning of soil-based ecosystem services operating beyond an individual plot or farm, to achieve SI, other investments will be required that require interventions beyond individual farms, often based on collective action (Figure 2). It is argued that such interventions, in absence of incentives such as payment for ecosystem services schemes, will be of interest to smallholder farming communities once the productivity question is addressed.

Besides improving productivity while conserving/enhancing the natural resource base, SI also aims at increasing resilience to climate shocks and change. Adaptation to climate change at farm level often includes many of the elements that are key to ISFM, such as adoption of new crop varieties, adoption of mixed crop-livestock farming systems, optimized intercrop systems including trees and shrubs, and soil and water conservation practices. The 'climate-smart' nature of ISFM is briefly discussed.

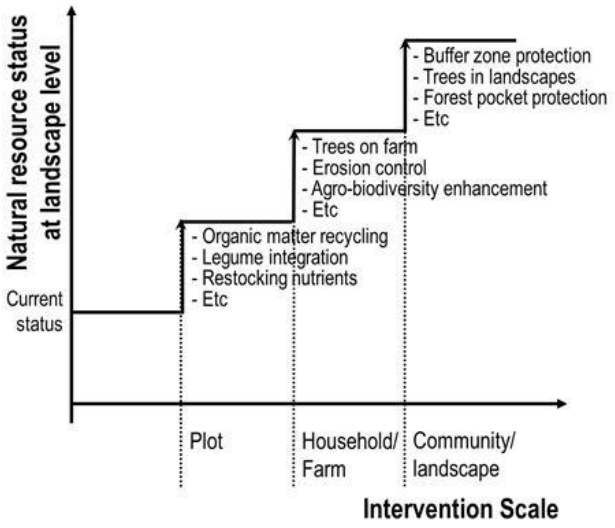

Figure 2: Conceptual relationship between natural resource status at landscape level (at which scale sustainable intensification is defined) and soil health and land management interventions at different scales.

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Keynote
Deborah Bossio

SOIL ORGANIC MATTER FOR CLIMATE CHANGE MITIGATION: BOON OR BANE FOR FOOD SECURITY?

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In March of 2015 a press release[1] from the French authorities announced the 'establishment of an international research program, which aims to develop agronomic research to improve soil organic matter (SOM) stocks at an annual rate of 4‰,' and that 'such an increase would offset emissions of greenhouse gases on the planet.' At a subsequent press conference[2] it was said that this research program would lead to an 'action plan contributing to the agenda of solutions promoted by COP21 helping to reconcile food security objectives and the fight against climate change.'

In a note prepared by scientists of INRA, CIRAD and IRD (Soussana et al, 2015), it was explained that this proposal arose from the recognition that the stock of soil organic carbon (SOC) is at least twice as much carbon as that represented by CO_2 in the atmosphere (Bolin et al. 1986) and therefore an annual increase in this reservoir by only 0.4% per year would store as much carbon as the anthropogenic emission of fossil carbon (Balesdent and Arrouays, 1999).

However, as pointed out by Sommer and Bossio (2014), adoption of SOC-sequestration measures will take time, and SOC will increase only over a limited time, up to the point when a new SOC equilibrium is reached. Sommer and Bossio (2014) predict that if a global program started in 2014 in this area, it would result in a peak of carbon sequestration in the 2030s, which is coherent with the need for early action.

This new focus on soil carbon in the climate change discussions seems to be an excellent opportunity to improve food security. Cultivated soils have lost 50 to 70% of their initial carbon stock before cultivation (e.g. Lal et al, 2004). Storing carbon as SOC restores soil nutrients and increases soil quality. Soils rich in SOM also better retain water, which promotes productivity and the adaptation to climate change. Thus the win-win according to the equation: SOC = Soil Fertility = Productivity = Food Security.

However, there are significant hurdles, both scientific and social, to achieving such an ambitious goal and making the SOC = Food Security equation work.

For example, drivers of soil organic carbon (SOC) dynamics across various land uses in tropical soils and smallholder farming systems are poorly understood. In a study in Tanzania, Winowiecki and others (2015) found an overall decrease in SOC as a result of cultivation, as would be expected, but with high variability between sites.

Strong linkage to climate change mitigation may also raise some difficult questions. A positive correlation exists between SOC and green house gas emissions. In conditions of smallholder farming in Western Kenya, Sommer and colleagues (2015) found that *Tephrosia* cover crop and farmyard manure treatments emitted larger amounts of N_2O than nitrogen fertilizer

[1] Press release 'Contribution de l'agriculture à la lutte contre le changement climatique: Stéphane Le Foll annonce le lancement d'un projet de recherche international: le «4 pour 1000» MAAF, Paris, March 17, 2015.

[2] See http://agriculture.gouv.fr/Cop21-le-4-pour-1000

treatments. In this study the emission factor was found to be twice as high as the IPCC-Tier-1 emission factor (Sommer et al, 2015).

On the plus side there are many known management strategies that can increase productivity, restore degraded soils and store SOC, even in tropical soils, and even at depth where it is more likely to remain sequestered. One example is use of improved tropical forages to restore degraded pastures, which in Colombia was found to increase SOM by 35%, with 75% of that increase below 20cm, while at the same time resulting in a 4 to 5 fold increase in animal production (Fisher et al, 1994). Agroecological approaches, including organic farming, have also long been known for building soil organic matter and increasing yields for smallholder farmers (Pretty et al. 2006).

Perhaps most difficult however, will be to ensure that 'carbon farming' does not result in reduced access to land for smallholder farmers, and compromise their food security. Payment for ecosystem services (PES) schemes are making progress in equitable sharing of benefits amongst ecosystem services providers and beneficiaries; one example is the recently launched Nairobi Water Fund in Kenya[3]. The question is if this focus on SOC for climate change mitigation can have the same direct benefit to smallholder farmers and food security. It is posited that without strong institutional support this may not happen.

A research agenda emerges from this political agenda. A challenge for soil scientists is to integrate studies on agricultural soils, sustainable intensification and food security with studies on the carbon cycle, and on institutional frameworks that can ensure equitable distribution of benefits from global agreements.

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[3] Nairobi Water Fund: http://ciat.cgiar.org/news-2-2/africas-first-water-fund-to-tackle-rising-threats-to-food-security-water-and-energy-supplies

Session Food Security 1

LAND HEALTH SURVEILLANCE FOR IDENTIFYING LAND CONSTRAINTS AND ENHANCING SOIL PRODUCTIVITY IN SMALLHOLDERS' AGRICULTURE IN CAMEROON

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Food production will have to increase substantially to overcome the challenges of the fast growing population. Intensification to increase agricultural productivity is seen as one of the solutions and also entails enhancing the capacity of soil to increase yields per hectare, increasing cropping intensity per unit of land, and changing land use from low value crops to those that receive higher market prices. This can be achieved if quantitative and up-to-date information on land health indicators are available to help understanding land degradation trends and patterns, as well as formulating appropriate and specific interventions. A study was carried out to identify land constraints and/or potentials in smallholder farming systems in Western Highlands of Cameroon using the Land Degradation Surveillance Framework (LDSF). The LDSF is a spatially stratified, random sampling design framework use to characterise sentinel sites consisting of 10 km × 10 km blocks and clusters of 160 plots. The approach makes use of systematic field surveys to collect soil information and other ecological parameters. Our results showed that large parts of the site (88%) are under intensive cultivation inferring that the area has good potential to sustain agricultural production; less than 20% of the sampling points have SOC below the critical level of 2% while high tree and shrub densities (143 tree ha^{-1} and 192 shrub ha^{-1}) were observed in large part of the site. Soil infiltration rates were generally moderate due to good physical (texture) soil composition and suggesting relatively low risk of soil erosion. However, slope (>10%) and high soil acidity (pH = 5 – 6) were found to be the main limitations that require appropriate land management interventions (e.g. liming to reduce acidity and soil conservation measures to reduce erosion) for the successful enhancement of soil productivity and fertility in smallholder's agriculture in Cameroon.

THE GLOBAL YIELD GAP ATLAS FOR TARGETING SUSTAINABLE INTENSIFICATION OPTIONS FOR SMALLHOLDERS IN SUB-SAHARAN AFRICA

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Providing food and water security for a population expected to exceed 9 billion by 2050 while conserving natural resources requires achieving higher yields on every hectare of currently used arable land. This is especially relevant for sub-Saharan Africa (SSA), where food production is not keeping pace with population growth. While recognizing there are other aspects to food security than production alone (e.g. distribution, demand, diets, waste, governance, population), efficiently increasing production on existing farmland forms an essential component of the sustainable intensification paradigm, which is a cornerstone of climate smart agriculture, as increased resource use efficiency contributes to both adaptation and mitigation via effects on farm incomes and reduced emissions per unit product. In SSA 80% of the food is currently produced by smallholder farmers, and rural population is projected to increase while average farm size will decrease in most SSA countries. Therefore, smallholder farms must be part of the solution to local and global food security. However, smallholder production systems across SSA are extremely diverse in terms of agro-ecology (climate, soils) and socio-economic conditions. Characterizing this diversity at a high enough resolution is essential for better targeting of research and policy interventions in the context of global food security. The Global Yield Gap Atlas project (GYGA, www.yieldgap.org) has developed methodologies and protocols and collected data for yield gap assessments with local to global relevance. A new global agro-climatic zonation scheme was developed, with zones homogeneous enough in terms of climate relevant for crop growth, not too small to prevent robust local data collection on climate, soils and cropping systems, and covering the most important current cropping areas so yield gap assessments can be upscaled from local to regional and national level. In addition we make use of improved digital soil information available from the Africa Soil Information Service (AfSIS). The Atlas can be used for national food security assessments as well as to target agronomic research and/or policy interventions.

EFFECTS OF ORGANIC MATTER ON ATTAINABLE YIELDS ACROSS EUROPE

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[3] Sustainable Soils and Grassland Systems, Rothamsted Research, UK

Soil organic matter is an important indicator of soil fertility and is assumed to contribute to higher yields worldwide. Benefits of organic matter include release of nutrients, improved soil structure and increase of water holding capacity. In Europe, nutrients are often not a limiting resource to yield. At present, discussion continues on the added value of applying organic fertilisers compared to mineral fertilisers in Europe.

To test the effect of organic additions on yield, over and above the effect of the nutrients they contain, we compared yields at the optimum derived from nitrogen-yield response curves. Yield at optimum can be taken as a proxy for the maximum yield that can be realised (i.e. 'attainable yield'), under the given production constraints other than nitrogen. If a combination of organic and mineral fertiliser gives a higher attainable yield than mineral nitrogen fertiliser alone, we attribute the additional yield to the role of organic matter, provided that non-N nutrient effects can be reasonably ruled out.

In this study, we performed a meta-analysis on crop yields from more than 20 long-term experiments across Europe. Studies were selected where several mineral fertiliser-N application levels were applied with and without an organic amendment. For each experiment, response curves were drawn and attainable yields were calculated. Covariates used to explain the differences in attainable yields included soil texture, type of amendment, climate and crop types.

We found that in the majority of cases organic fertilisers have added value besides mineral fertilisers. First results show increases in attainable yield up to 15%, depending among others on the types of crop and amendment. These results show the value of organic amendments for crop productivity, even in cases where nutrients are not limiting.

GASIFICATION BIOCHAR HAS THE POTENTIAL TO IMPROVE SOIL QUALITY AND CROP PRODUCTION

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[4] Department of Environmental, Social and Spatial Change, Universitetsvej 1, Roskilde University, Roskilde, Denmark

Thermal gasification of biomass is an efficient and flexible way to generate energy and produces a valuable by-product: biochar. Gasification biochar (GB) contains a considerable amount of recalcitrant carbon that can contribute to soil carbon sequestration and soil quality improvement if recycled back to agriculture soils. Porous biochar materials with a high specific surface area have already been described to increase water and nutrient retention. However, the impact of gasification biochars of different origin and composition on the plant available water content in diverse soil types and their ability to improve plant growth still needs to be explored.

A 6-weeks pot experiment with spring barley has been conducted to investigate the effect of straw and wood chips GBs on shoot and root growth under regular and reduced water supply in two different soil types (loamy and course sandy), assessing plant biomass and plant available water in the soil. Reduced water supply had a significant negative impact on plant growth which was also reflected in 13C discrimination and stomata conductance. The addition of straw GB to sandy soil increased the plant available water by 42 % and led to an increase of shoot growth by 165 % and 40 % under regular and reduced water regime, respectively. Wood GB increased the plant available water to a similar extent (30 %), but had a negative effect on shoot and root growth under both water regimes. In the loamy soil, the increase of plant available water after biochar addition was less compared to the sandy soil, which was reflected in a largely unchanged plant growth under both water regimes compared to the control.

Our results suggest that straw GB has a great potential to increase crop productivity on sandy soils by increasing water retention and improving soil structure.

FERTILE GROUNDS INITIATIVE: ITS NOT THE SOIL THAT NEEDS TO CHANGE, ITS THE PEOPLE WHO MANAGE THE SOIL

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In the coming decades global biomass production has to double at least to comply with increasing demands for food, feed, organic fertilizer, and bio-energy. Most of this production gain is targeted in sub-Saharan Africa (sSA) because of the high yield gap, i.e. the high potential of production increase. Paradoxically, at the same time, soil degradation is ongoing at an unpreceded speed, especially in sSA. Soil degradation is often initiated by erosion and depletion of soil organic matter and nutrients. Soil degradation is known for long and many attempts have been made to halt or reverse this trend. These attempts focussed roughly on 3 different strategies: i) increased access to inputs, ii) demonstration of improved practices to farmers and iii) introduction of innovations that increase the efficiency of natural resources. So far, the majority of these strategies have been implemented in isolation and targeting one spatial scale, which is probably one of the key reasons why they have not been able to halt, or better, reverse land degradation. Despite the scientific consensus that soil fertility loss can best be addressed through integrated soil fertility management (ISFM), this is not common practice mainly because the organic sector (composters) and the mineral sector (fertilizer industry) operate in different modalities.

To stop further soil degradation, make ISFM really work and increase biomass production, the sectors and various other stakeholders should build a common fertile ground that allows to collaborate, make joint products and undertake actions tailor made to local soil and crop specific demands. The Fertile Grounds Initiative (FGI) is an coordinated strategy of collaboration between actors in soil health management at various spatial scales, e.g. optimizing nutrient cycling through integration of different sources of organic and mineral nutrients. In this paper, first results from case studies in Ethiopia, Uganda and Burundi are presented.

SOIL MANAGEMENT AS AN EFFECTIVE STRATEGY FOR CROP DISEASE MANAGEMENT: THE CASE OF PANAMA DISEASE IN BANANA

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Crop diseases are an important threat to food security. Crop disease management includes a range of different options, such as breeding for resistance, which is attractive but relatively slow, and chemical control, which may be effective but can have adverse environmental impacts. There is an increased awareness that optimal crop disease management is a combination of different approaches. An option that receives relatively little attention is soil management, which may influence disease incidence. The effects of soil abiotic factors such as pH and N-content on the incidence of diseases in different crops have been reported. In this study we test the hypothesis that optimal soil conditions may help to suppress the predisposition of banana to Panama disease (a soil born fungal disease caused by Fusarium oxysporum f.sp. cubense). Although deficiencies can predispose the plant to present diseases, an excessive level of nutrients can also influence disease incidence or severity. In order to validate the model, we tested the effect of soil pH and nitrogen level on Panama disease in greenhouse trials. Inoculated and non-inoculated banana plants were planted in a soil with two pH and three nitrogen levels. Low pH and nitrogen levels showed a significant higher incidence of Panama disease. Results show that soil abiotic factors do contribute to disease management in crops. Besides, practices as liming to increase the soil pH should be tested as an option to slow down the incidence and reduce the severity of Panama disease in infested areas. Also the application of adequate doses of N contributes to disease management. In field and on-farm trials are planned to substantiate these data demonstrating the role of soil abiotic factors on Panama disease incidence and severity in banana.

Session Food Security 2

GAIA THEORY: THE VALVE MECHANISM OF PHOSPHORUS CYCLING

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James Lovelock formulated Gaia hypothesis in 1972, which proposes that organisms interact with their inorganic surroundings on Earth to form a self-regulating, complex system that contributes to maintaining the conditions for life on the planet. The hypothesis is supported by people engaged in environmental protection, but also continues to attract criticism, because it is only weakly supported by the available evidence. In this paper, a new evidence was presented on the interrelationship between phosphorus—fungi—soil organic carbon, and based on which, a theory on the valve mechanism of phosphorus cycling was formulated. The phosphorus sequestration process is totally open and there is no resistance for it. Meanwhile, the phosphorus cycling started at the weathering of rocks, this very slowly process controls the rate and volume of phosphorus cycling, and result in the lack of phosphorus at the pool of available huge elements for life, and by this controls the rate of carbon and nitrogen cycling. Therefore, phosphorus plays the role of valve during the biogeochemical cycling process on Earth. Disturbance from human activities enhanced greatly the rate of phosphorus cycling. As a possible result based on theoretic deduction, huge available phosphorus will accelerate the greenhouse emission from soil and enhance the climate warm. Meanwhile, both soil organic carbon in terrestrial ecosystem and zooplankton production in aquatic ecosystem will decrease and led to food provision crisis.

EVALUATION OF ORGANIC AMENDMENTS, SOIL MICROBES AND PLANT P UPTAKE

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As phosphorus (P) fertilisers become increasingly scarce and expensive, there is a need to find innovative ways to supply crops with P in order to ensure food security. Organic amendments contain large amounts of P, however, this is present as both organic and inorganic P, and therefore it is difficult to predict how they will contribute to plant P supply. Results of a study in which a range of manures and a compost were added to soil to determine their effect on soil microbes, soil P and plant P uptake will be presented. Manures and compost were carefully analysed for total P and C, P and C species (NMR) and plant available (Colwell) P. While pig manure had higher C:P ratio than chicken manure, a larger percentage of its P was orthophosphate and Colwell P. Manures and compost were applied to soil at the same rate of P in an incubation experiment and a plant growth experiment. The aim of the incubation experiment was to determine when P from amendments would become 'available' to plants. However, there were no differences in plant available P over time (30 days) for any treatment. Microbial biomass carbon (MBC) and P (MBP) also did not show any significant differences between treatments. In the plant growth experiment, plant biomass and P uptake varied among treatments. Plants grown in soils amended with manure had a higher concentration of P in their roots compared with plants grown in soil amended with inorganic P fertiliser. There was some evidence that manures and compost could stimulate arbuscular mycorrhizas. This study provides new insights into plant P uptake where soils are supplied with organic amendments, which could lead to better predictions of plant responses to organic amendments and hence more sustainable food production.

IMPROVING CALCAREOUS SOIL PRODUCTIVITY BY INTEGRATING EFFECT OF COMPOST OR SULFUR IN THE PRESENCE OF DIFFERENT SOURCES OF PHOSPHORUS

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Pot experiment was carried out at the National Research Center, Cairo, Egypt and designed to study, the addition of rate of compost or sulfur in the presence of different types of phosphorus fertilizers namely (superphosphate, Rock phosphate and triple phosphate) on productivity and nutrient content of lettuce plant grown on calcareous soil. The Results indicated that, the addition of organic compost at a rate of 20 or 30 tons/Fed. With the different types of phosphors significantly increases fresh, dry weight either roots or leaves and N, P, K content of the lettuce plant compared with control. In this concern, addition of 30 ton/Fed. Organic compost with super phosphate had significantly increased the fresh and dry weight of leaves and roots of lettuce plants and increased efficiency of nutrient utilization if compared to triple or rock phosphate treatments. Also, Data shows that application 300 kg S with any type of P increased all parts of lettuce plants significantly as compared to the other sources of P. The highest values of yield and mineral content were noticed when lettuce plants received 300 kg S with super phosphate while the lowest values were recorded when rock phosphate fertilizers were used alone. Furthermore, Data representing the growth and nutrients content of lettuce plants as affected by addition of elemental Sulfur or organic compost with types of P should that positive response in comparison with sources of P fertilizer alone.

IDENTIFICATION AND QUANTIFICATION OF P MINERALOGICAL FORMS IN SANDY CALCAREOUS SOILS BY INFRARED SPECTROSCOPY AND CHEMOMETRIC METHODS : AN APPROACH BY INCREASING COMPLEXITY

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For several reasons (agronomy and agrophysiology, geochemistry modeling), there is a need to better knowing the mineralogical forms of P in the soil. However, informations (identification, quantification) about these P mineralogical forms are generally costly to obtain with classical analytical methods.

On the other side, in recent years, chemometrics methods based on infrared spectroscopy are developed. Thereafter, in this study, our aim was to provide some elements to answer to this global question : is infrared spectroscopy able to identify and quantify phosphorus mineralogical forms in calcareous soils? To answer this question a common approach would consist in studying directly the spectra of a set of soil samples with known amount of several known mineralogical forms.

Consequently, the study was carried out by choosing an approach, consisting in several steps with increasing complexity from pure mineralogical forms to real soil. studying some synthetic mixtures with well known forms and their amount, in order to obtain reference basis, and to be able to reach gradually real soils with better theoretical informations. All forms of Phosphorous (Mono, Di, Tri, calcium phosphate and hydroxiaptatite) in addition to the pure sand and Calcium carbonate were use as a single, binary and ternary mixtures.

Each step of this study was carried out in order to answer to a specific question, and to prepare the following step.

Data analysis was carried out using partial least square regression (pls) after determination of the optimal number of components by cross validation (R pls option "LOO" leave one out).

The study concluded that infrared spectroscopy (NIR and MIRS) and chemometric methods could help for the Identification and quantification of P mineralogical forms in sandy calcareous soils, and may be also others soils.

The next step would be the application of these findings in different types soils, with optimised methods of calibration and validation.

CAN SOIL RESPIRATION PREDICT N MINERALIZATION?

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Soil respiration has been widely touted as a quick, inexpensive measure of soil health and fertility. Although a precise definition of soil health has not been agreed upon, one common thread is the inherent ability of a soil to provide plant-available nutrients, such as N. Short term microbial respiration from rewetted soils has been shown to correlate with long term net soil N mineralization. To further explore and elucidate the nature of this relationship, approximately 50 agricultural fields across California's intensively managed, low carbon soils were sampled, representing a variety of management strategies, as well as edaphic soil properties. Respiration accounted for only 10.7% of the total variation in N mineralization across all management strategies, but accounted for 20.8% of the variation in managements with higher quality C inputs (cover crops, compost, etc.). A best-fit model accounted for 53.7% of the variation in N mineralization with the addition of dissolved organic carbon (DOC) and total soil N (TSN). DOC content had an inverse relationship with increasing aridity, suggesting regional effects, including climate. There was also a slight effect of growing region on N mineralization, although it is unclear if this is due to higher microbial activity from higher temperatures or regulation via labile C. Overall weak relationships between respiration and N mineralization suggest that respiration cannot serve as a standalone estimate, although regional calibrations and the integration of additional parameters have the potential to improve its efficacy.

SELENIUM SPECIATION AND EXTRACTABILITY IN DUTCH AGRICULTURAL SOILS

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The study aimed to understand selenium (Se) speciation and extractability in Dutch agricultural soils. Top soil samples were taken from 42 grassland fields and 41 arable land fields in the Netherlands. Total Se contents measured in aqua regia were between 0.12 to 1.97 mg kg^{-1} (on average 0.58 mg kg^{-1}). Organic Se after NaOCl oxidation accounted for on average 82% of total Se, whereas inorganic selenite (selenate was not measurable) measured in ammonium oxalate extraction using HPLC-ICP-MS accounted for on average 5% of total Se. The predominance of organic Se in the soils is supported by the positive correlations between total Se (aqua regia) and total soil organic matter content, and Se and organic C content in all the other extractions performed in this study. The amount of Se extracted followed the order of aqua regia > 1 M NaOCl (pH 8) > 0.1 M NaOH > ammonium oxalate (pH 3) > hot water > 0.43 M HNO_3 > 0.01 M $CaCl_2$. None of these extractions selectively extracts only inorganic Se, and relative to other extractions 0.43 M HNO_3 extraction contains the lowest fraction of organic Se, followed by ammonium oxalate extraction. In the 0.1 M NaOH extraction, the hydrophobic neutral (HON) fraction of soil organic matter is richer in Se than in the hydrophilic (Hy) and humic acid (HA) fractions. The organic matter extracted in 0.01 M $CaCl_2$ and hot water is in general richer in Se compared to the organic matter extracted in 0.1 M NaOH, and other extractions (HNO_3, ammonium oxalate, NaOCl, and aqua regia). Although the extractability of Se follows to a large extent the extractability of soil organic carbon, there is several times variations in the Se:C ratios, reflecting the changes in composition of organic matter extracted. These results provided new insights in specific Se-rich fractions of soil organic matter.

Theme 2
Water Resources

Keynote
John Quinton

SOIL WATER: THE NEXUS FOR FOOD PRODUCTION AND ENVIRONMENTAL QUALITY

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Soil water is the nexus for food production and water quality. There is certainly little doubt that soil and water are inextricably linked. It is estimated that the earth's soils store 195 500 km3 of water: that's a lot of water, especially when you realise that this volume is an order of magnitude greater than is found in all the rivers on the planet. Not only is soil a major store of freshwater, but it is also a vital filter, buffering surface and groundwaters from pollution, preventing colossal damage to our ecosystems and reducing the cost of water treatment by millions of euros. In this paper I argue that the interaction of water with soil is central to the delivery of both food production and good water quality for the globes surface and freshwaters.

Soil water storage is key for crop production. The ability of soil to store water for later use by plants has been known to farmers for 1000s of years. The Nabateans, working soils 9000 years ago, used the properties of soils to enable them to practice agriculture in the Negev desert. Soils on steep slopes, with little potential for water storage, were utilised as water sources, with early farmers enhancing runoff and erosion by removing the stone cover. Overland flow and sediment from these soils was directed into basin areas. Here soils grew deeper and were able to store the water for use by crops during dry periods of the year. Rainwater harvesting systems, such as those used by the Nabateans, are still in use today, and examples of enhance crop growth due to improved water supply are found throughout semi-arid and arid parts of the earth.

However, rainwater harvesting is not the only way to grow crops in dry regions. Irrigated land occupied 311 million hectares in 2009 (FAOSTAT). In many countries of the world water extraction is almost all for agricultural use, with the global average sitting at 70%. The ability of soils to store and release this valuable water to plants is fundamental to crop production. Yet many soils under irrigation suffer from poor soil structure, making water losses via overland flow more likely. High salt contents associated with poor quality irrigation water can also reduce the ability of plant to extract water from the soil. However, there have been interesting developments in our understanding of how plants react to water stress. These include the use of deficit irrigation and partial root zone drying, which have been adopted in parts of China and Australia, and have shown that there are ways of getting 'more crop per drop.'.

Soils are clearly linked with flooding. In some instances this is to be expected: large amounts of rain exceed the soils capacity for storage and runoff is generated. However, this is not always the case. Recent work in the UK has demonstrated the prevalence of structural damage to the surface of the soil, brought about by machinery and animals crossing the soil in poor conditions – usually when the soil is too wet. The damage reduces infiltration rates and increases surface runoff. Our work in arable areas has demonstrated that much of this runoff is associated with compacted wheel tracks and that by alleviating this compaction the runoff rates return to those of the uncompacted areas. Compaction in livestock areas is a more difficult problem. Dairy farmers in the UK rely on silage to feed livestock overwinter, but the trafficking of the soil during the grass harvest is uncontrolled and the damage to the soil

surface results in high runoff coefficients. New approaches to managing compaction in grasslands are urgently needed.

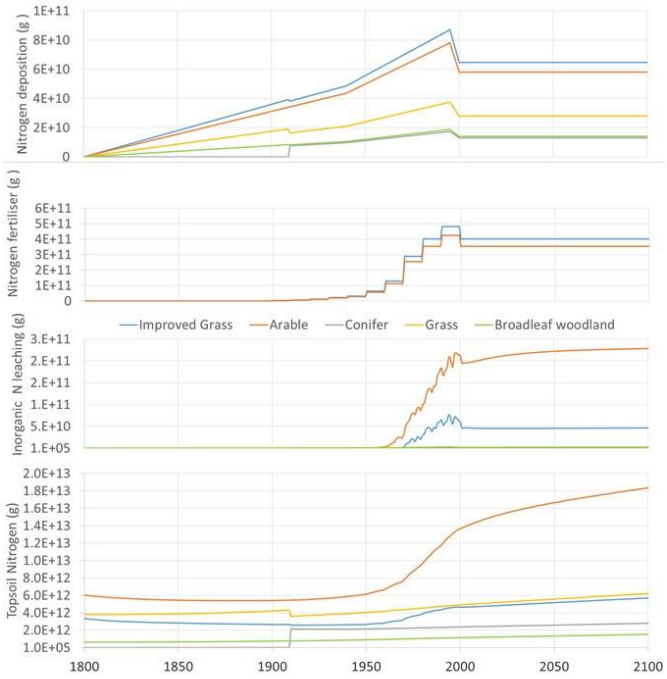

Figure 1. Nitrogen balance 1800-2100 for the UK derived from LTLS model framework (www.ltls.org.uk). Note the increases in the soil N pool and N leaching following the increased use of inorganic N fertilisers post 1950. The increases in topsoil N in semi natural environments is due to atmospheric N deposition.

The soil's role as a water filter is invaluable. According to the FAO statistics, globally 115 Tg of nitrogen, 37 Tg of phosphorous (as P2O5) and 21 Tg of potassium (as K2O) are added to the soil in the form of fertilisers every year, add to this an addition of 25 Tg per year of reactive nitrogen (Galloway et al 2004, Biogeochemistry 70:153-226) from the atmosphere and you an unsustainable situation. This would be even more serious if soils were not able to store N and P in both their organic and mineral matter preventing it from being leached. Globally the size of the soil nitrogen store is estimate to be between 133 and 140 Pg. For the UK we can see the modelled response of the nitrogen soil store to nitrogen inputs under different land uses (figure 1) and the dramatic rise in nitrate leaching since the introduction of inorganic nitrogen fertilizers in the 1950s.

It is clear that soil is central to the supply of water for crops and the maintenance of clean waters for the earth's ecosystems and our water supplies. To ensure that soils are able to continue to fulfil these vital roles we need to maintain and enhance their functioning with respect to water. This requires action at all levels: research to underpin our understanding of soil-water interactions; practical management measures to enhance soil water functioning; and the development of predictive tools that can provide science driven assessments of soil condition and its potential to deliver soil functions..

Keynote
Günther Blöschl

FLOODS ACROSS SCALES IN A CHANGING WORLD

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A surprisingly large number of extreme river floods has occurred in recent years around the world, which suggests that floods may have increased and may increase in the future. However, the realism of such changes is still hotly debated in the literature. Equally important, the main drivers of any changes are the subject of intense discussion.

The main drivers of changes in river floods caused by rainfall and snowmelt can be grouped into three classes: The first is the atmosphere where any changes in the atmospheric circulation and the rainfall regime will affect flood generation. The second are the catchment areas (i.e. the land surface, the soil and the aquifers), that control whether rain water (and any snowmelt) runs off the surface or penetrates into the ground. The third are the river systems that collect the flood flows and convey them downstream. Any changes in these processes will also affect changes in the flood regime.

This presentation will specifically focus on the role of the soil in changed flood regimes. Over the centuries, humans have heavily modified the landscapes by expanding settlements and agricultural activities. Large areas were cleared or drained and steep hillslopes were terraced for agricultural production. Industrialization and population growth in the late 19th century have paved the way for intensified agricultural practices through the introduction of modern, heavy machinery. The recent political priorities in land management, such as increased protection of ecosystems and water retention, induced additional changes. All these developments have changed the soil and land surface properties and can thus also change flood generation at different scales.

The short term dynamics also play an important role. Soil compaction tends to be more severe if the soils are wet. Soil moisture also has a very direct effect on the generation of flood runoff as it determines the amount of rainfall that can not infiltrate and therefore runs from the land surface and contributes to flooding. Soil moisture is controlled by evaporation. Increases in evaporation will decrease the soil moisture. On the other hand, the soil moisture is also controlled by the infiltration characteristics of the soil. The more permeable is a soil, the less water in the vicinity of the surface will accumulate. Because of this, change in land use is an important driver of flood changes. Changes in land use from agricultural land to forest (afforestation) may increase the infiltration because roots tend to create preferential flow paths of rapid water flow into the subsoil, thereby recharging aquifers. Reforestation may also increase evaporation and reduce soil moisture. Therefore, there is a complex interplay in the soil-plant-atmosphere continuum controlling flood generation.

Important issues are how these processes change with catchment scale, specifically, whether soils still play a dominant role at large catchments scales. Similarly, an important research issue is how the role of soils changes with the flood event magnitudes. These questions have important implication for potential flood mitigation measures.

The presentation will address these questions. It is argued that accounting for the feedbacks between processes in the landscape across scales is key to understanding the drivers of flood

regime changes, including the role of soils. It may be useful to go beyond the quasi-stationarity of the usual scenario approach and represent the feedbacks from the perspective of long-term dynamics. Such a perspective will underpin an integrated flood risk management approach for dealing with future flood risks.

Session Water Resources 1

THE EFFECT OF WATER HARVESTING, ASH AND DUNG ON SOIL DEVELOPMENT IN TERRACED WADIS IN THE CENTRAL NEGEV DESERT (ISRAEL): THE LONGUE DURÉE

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The central Negev desert, receiving just 90 mm average annual precipitation, is not suited for dry farming. The aridity index P/PET (Precipitation/Potential Evapotranspiration) is about 0.07. Food crops like wheat and barley require ca 300 mm for a reasonable yield. The lack of rainfall was compensated by water harvesting in valleys. Stone terrace walls were built in wadis to capture runoff and floodwater, generated in the hilly landscape, characterized by rock outcrops and loessial soils. Nevertheless, only 2% of the landscape could be transformed in this way for agricultural production. Extensive livestock rearing remained throughout history the dominant pillar of the rural agro-pastoral economy. Detailed fieldwork and micromorphological research of ancient terraced fields in the Negev, coupled with radiocarbon dating, revealed astonishing soil development in the desert through time. Features such as ferric nodules (iron mobility) and tiny carbonate nodules (calcium mobility) are usually absent in a desert climate. These features can only be explained by the effect of water harvesting, which changed the "soil climate" to considerably wetter conditions. Each rainfall-runoff event also added a small layer of sediment to the soil surface in the terraced fields. Hence the wadi fields grew upward (soil accumulation) with time, providing a precious soil/sediment stratigraphy to unravel the past. Tiny charcoal particles, bone fragments and ceramic or worked flint pieces occur in certain soil layers, indicating past fertility management based on kitchen ash (refuse). Moreover, micromorphology also revealed the presence in certain layers of animal dung fragments, coupled with large amounts of carbonate spherulites, indicating a second source of soil fertility management. Radiocarbon dating surprisingly showed that human influence in these ancient water harvesting fields goes back to the Late Neolithic, about 7000 years ago. Interestingly, soil manuring is absent in modern cereal farming by Bedouin in these ancient terraces.

THE *BIOPRINT PILOT PROJECT*: CILIATED PROTOZOA COMMUNITIES AS A TOOL TO ASSESS SOIL QUALITY IN AGROECOSYSTEMS AND NATURAL SITES OF MARCHE REGION (ITALY)

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In the recent years the potential of ciliated protozoa, as indicators of soil quality has been highlighted by several studies. Thus, in the framework of the *BioPrint Pilot Project* and for the first time in Italy, we have investigated the biodiversity and the community structure of soil ciliates from agroecosystems and natural sites of Marche Region. The aims of our study were: i) to evaluate the capacity of ciliates to discriminate between different types of land uses; and ii) farming management practices; iii) to assess relationships among ciliate community and abiotic parameters. Soil samples were collected twice from 10 sites (5 natural sites: FORest; and 5 arable field: 3 ORGanic and 2 CONventional). Ciliate communities were studied by means of qualitative (*non-flooded Petri dish*) and quantitative methods. Soil chemical-physical (texture, CEC NPK, OM, C/N, soil moisture and temperature) parameters were measured. Qualitative ciliate analysis allowed us to identify a total of 59 species representing 29 genera and 12 orders (plus 10 new species for the science). ORG sites were the richest in species followed by CON and FOR. The mean values for *H'* (2.6), *d* (3.4) and *J* (0.8) were significantly higher in ORG than in CON (*H'*=2.1; *d*=2.7; *J*=0.7) and FOR (*H'*=1.7; *d*=1.95; *J*=0.6) supporting the *intermediate disturbance hypothesis*. Multivariate analysis showed statistically significant differences between natural sites (FORest) and agricultural sites, as well as between the ORGanic and CONventional management farming systems. CCA analysis showed correlations between the distribution of species with environmental parameters indicating the importance of these parameters in shaping the ciliate communities in the different type sites. Altogether, these results showed the bioindicative potential of ciliate communities in discriminating between natural sites (FORests) and agroecosystems, as well as their capacity to discriminate, at least preliminary, between different management systems (ORG *vs* CON).

UNDERSTANDING THE EFFECTS OF CLIMATE AND SOIL CHARACTERISTICS ON SEEDLING EMERGENCE TO IMPROVE RESTORATION OF SEMI ARID ENVIRONMENTS

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Restoration of arid and semiarid ecosystems faces the challenges of limited rainfall, high temperatures and soils with low nutrient levels and water holding capacity. In post mining environments these threats are compounded by the absence of soil forming materials which are critical to support vegetation establishment. In this study, we analyse the effects of climate scenarios and the use of alternative growth media on seedling emergence of a range of native plant species from the mining intensive Pilbara region (Western Australia). Experiments were conducted in controlled environment facilities where climate conditions simulated those found in the Pilbara. Air temperature, relative humidity and soil moisture were modified and monitored routinely. Soil from topsoil stockpiles and waste materials from an active mine site were mixed at different proportions (0:100, 50:50 and 25:75 ratios) and used as growth media. Samples from these soils were analysed to determine physical and chemical properties and hydraulical parameters.

Our results showed that seedling emergence in 100% topsoil growth media is highly dependent on soil temperature and soil moisture, and emergence rates vary significantly ($P < 0.001$) across plant species. Under drought scenarios seedling emergence severely decreased (with emergence rates below 40%) for all species and growth media types. In particular, plant species from the Malvaceae and the Proteaceae family did not perform as well in soils consisting of less than 50% topsoil. These soil blends were found to exhibit reduced water availability. These findings suggest that predicted changes in climate (e.g. rainfall patterns) will have an important effect on the restoration of semi arid environments. Therefore, a thorough knowledge of soil properties such as soil infiltration or water holding capacity from available soil materials is critical to design suitable growth media blends to support plant growth, and ultimately to achieve biodiverse restoration in semi arid areas.

SOIL HYDROLOGICAL PROPERTIES AS A RESPONSE TO TILLAGE EROSION IN A REGOSOL OF HILLY LANDSCAPES

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Two or more processes of soil erosion simultaneously exist in a hillslope landscape, yet, how one process impacts another one remains unresolved. Five slopes were selected from hilly areas of the Sichuan Basin, China to explore the mechanism of tillage erosion impacts on water erosion. On those slopes, soil hydrological properties with reference to water erosion were examined in different landscape positions with discrepant intensities of tillage erosion. The ^{137}Cs data showed that the most severe erosion occurred in upper slope positions, and there was a decreasing pattern of soil erosion from upper, middle, to lower slope positions. Tillage erosion ranging from 80 to 125 t ha^{-1} yr^{-1} mostly contributed to total soil loss in upper slope positions. The drastic differences in total soil depth were observed among different landscape positions, averagely being 17, 28, and 39 cm deep for upper, middle, and lower slope positions, largely due to tillage erosion. Soil water storage capacity (SWSC) at saturation exhibited remarkable differences among different landscape positions as a result of substantial variations in total soil depth. The lowest steady-state infiltration rates were found in tillage-eroded areas (upper slope) with a mean of 0.82 mm min^{-1}, followed by deposited areas (lower slope) with a mean of 1.67 mm min^{-1}, while the largest steady-state infiltration rates were observed in the balanced areas between soil loss and gain (middle slope) with a mean of 2.00 mm min^{-1}. The thickness of soil profiles and local slope gradients that were associated closely with tillage erosion rates were found to be two important determinants of soil infiltrability. It is suggested that soil degradation by tillage erosion alters soil hydrological properties, thereby resulting in poor soil infiltrability which may enhance overland water flow in relation to water erosion.

ON AGGREGATION METHODS FOR ESTIMATED SOIL HYDRAULIC PARAMETERS BY PEDOTRANSFER FUNCTIONS

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The soil property maps are usually provided at a high resolution and they need to be aggregated to a low resolution in applications such as climate and hydraulic modeling. Some basic soil properties including sand, clay, organic carbon and bulk density are used to estimate soil hydraulic parameters by pedotransfer functions. In this study, we used five up scaling methods and two aggregation orders to aggregate a polygon-based derived soil dataset and a kring derived soil dataset. The datasets are at 30 second resolution. They were aggregated to the resolution of 1°, 30', 20', 10', 5', 3' and 1'.The up scaling methods were Window Average (WA), Widow Median (WME), Widow Modal (WMO), Arithmetic Average Variability-Weighted method (AAVW) and Dominant Class Variability-Weighted method (DCVW). The aggregation can be done before the estimation of soil hydraulic parameters or after. The difference between aggregation first and aggregation after was up to 30%, while differences between aggregation methods were about 0.1%. The aggregation did not change the original dominant features of probability density distribution. The performances of different aggregations were close according to root square mean error (RMSE). The RMSE increased rapidly when the widow size was less than 40 pixels. The RMSE of the kring derived data is much smaller than that of the polygon-based data.

HYDROLOGICAL CORRIDORS FOR LANDSCAPE AND CLIMATE RESTORATION: PROOF OF CONCEPT AND IMPACT ASSESSMENT

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Drylands worldwide are increasingly affected by desertification. Desertification includes the reduction of transpiring green area, causing higher temperatures and dryer air. In the atmosphere this may cause longer dry periods and extreme precipitation. All in all less water becomes available for infiltration in the top soil, starting its destructive road downwards the slopes into the river.

Naga, a Netherlands-based foundation (www.nagafoundation.org), is promoting and implementing durable re-greening interventions over large areas with both local impact, regional spinoffs and atmospheric effects. Naga's vision is to restore degraded lands on a large scale using rainwater harvesting and other ways to increase soil moisture and water availability. This will lead to an increase of vegetation retaining fertile soils, slow down runoff and improve infiltration. Higher groundwater will serve base flow, and avoid floods. When doing this on a large enough scale these landscape changes also may affect local climatic conditions (evapotranspiration, temperature, cloud formation), which in turn can lead to positive regional climate impacts. To achieve this Naga wants to re-green 15 large areas in Eastern Africa, each 20 km^2, within a so-called hydrological corridor of 20-30.000 km2.

Four potential hydrological corridors have been identified in Kenya and Tanzania, all four of them around Mount Kilimanjaro. For a proper selection it is important to determine the highest potential for restoration and the biggest impact in terms of sustainable land restoration and climate. This will be determined based on information concerning: soil, water, climate and social institutions.

Models coupling the above components can give valuable insights in the effects of interventions in time, including scale requirements and optimal site planning. Monitoring of the projects will be carried out to determine the impact of these projects on both landscape restoration, local and regional climate and the actual use of the resources.

Session Water Resources 2

THE LANDSCAPE OF BIOPHYSICAL INTERACTIONS

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Leonardo da Vinci said "Water is the driving force of all nature". In the field of ecohydrology, the link between water and nature is through vegetation at the land surface. Vegetation plays an essential role in the hydrological cycle, as it regulates the water flux to the atmosphere through evapotranspiration, while it is dependent on adequate water supply. Vegetation shapes the land surface by changing infiltration characteristics as a result of root growth, and controls soil moisture supply, which in turn affect runoff characteristics and groundwater recharge.

Abiotic stresses and their influence on plants have become a major research priority as a result of the predicted impact of global climate change on rainfall distribution. In developed agriculture, crop losses due to poor water availability already exceed those from all other sources. Drought stress in plants will be aggravated by related problems, such as changes in temperatures, salinization of agricultural lands by irrigation, depletion of groundwater aquifers, and the need to increase agricultural productivity. Studying plant water status unites several abiotic stresses in their detrimental impact on plant metabolism and crop production. A better understanding of the impact of drought on plants is essential for improving management practices and breeding efforts in agriculture, and for predicting the fate of natural vegetation under climate change.

Another important issue is that vegetation and the underlying geology are in constant interaction, wherein water plays a key role. The resilience of the coupled vegetation-soil system critically depends on its sensitivity to environmental changes. The understanding of the sensitivity of vegetation-soil system is at present poor and needs to be improved. The essence of emerging patterns at large scales often originates from micro-behaviour in the soil-vegetation-atmosphere system. We argue that shedding light on vegetation-soil dynamics calls for an integrated biophysical approach, and will present examples.

QUANTIFICATION OF THE IMPACT OF HYDROLOGY ON AGRICULTURAL PRODUCTION AS A RESULT OF TOO DRY, TOO WET OR TOO SALINE CONDITIONS

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For calculating the effects of hydrological measures on agricultural production in the Netherlands a new climate proof method is being developed: *WaterVision Agriculture*. End users would like a new method that considers current and future climate, that can quantify the differences between years and also the effects of extreme weather events. Furthermore they would like a method that considers current farm management and that can distinguish three different causes of crop damage: drought, saline conditions or too wet conditions causing oxygen shortage in the root zone.

WaterVision Agriculture is based on the hydrological simulation model SWAP and the crop growth model WOFOST. SWAP simulates water transport in the unsaturated zone using meteorological data, boundary conditions (like groundwater level or drainage) and soil parameters. WOFOST simulates crop growth as a function of meteorological conditions and crop parameters. Using the combination of these models we will derive a set of easily applicable tools and simplified relations for assessing crop growth as a function of soil type and groundwater level. We will base these tools on multiple model runs for at least 72 soil units and the possible groundwater regimes in the Netherlands, starting with the crops silage maize and grassland. For this assessment, the soil characteristics (soil water retention and hydraulic conductivity) are very important input parameters as well as the uncertainty of these characteristics for all soil layers of these 72 soil units. These 72 soil units cover all soils in the Netherlands.

We will present the method that we used to arrive at the simplified relations and also show some of the results. We will also show how *WaterVision Agriculture* can be used by farmers, regional government, water boards and others to assess crop damage as a function of groundwater characteristics or as a function of the salt concentration in the root zone for the various Dutch soil types.

EFFECTS OF MITIGATION MEASURES ON PHOSPHORUS LOSS ACROSS THE TRANSFER CONTINUUM FROM SOIL TO WATER IN A MONITORED DAIRY GRASSLAND CATCHMENT

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In many countries with intensive agriculture, water quality is a major issue and phosphorus (P) loss from soils to water is a major pressure. In Ireland, the EU Nitrates Directive Regulations aim to minimise these losses. This study measured the effects of P source management on P transfer across the nutrient transfer continuum from soils to water and subsequent water quality and agronomic impacts in a dairy-dominated, highly stocked and intensively monitored 7.6 km^2 grassland catchment with mostly free-draining soils over three years. Monitoring included farm P management, surface soil P concentrations, ground- and stream-water concentrations and stream flow. Reduced P source pressure was indicated by: a) lower farm-gate P balances (2.4 kg ha^{-1} yr^{-1}), higher P use efficiencies (89%) and lower inorganic fertilizer P use (5.2 kg ha^{-1} yr^{-1}) relative to previous studies, b) almost no P application during the winter to avoid incidental P transfers, and c) decreased proportions of soils with excessive P concentrations (32% to 24%). Over the same period, milk outputs of 14,585 l ha^{-1} and gross margins of €3,130 ha^{-1} indicated that production and profitability remained comparable with the top 10% of dairy farmers nationally. Declines in delayed flow and interflow pathway P concentrations during the winter months indicated some response in P delivery in surface water. However, delayed baseflows in the wetter third year resulted in elevated P concentrations and, overall, there were no clear trends in stream biological quality. This suggests that the impact of policy measures may be felt sooner closer to the source end of the nutrient transfer continuum, in soil P concentrations, for example, and a time lag may occur at the other end in P delivery to streams and stream biological quality, with implications for time frames of policy efficacy and policy monitoring.

OPTIMIZATION OF IN-SITU DRAINAGE LYSIMETERS FOR FERTIGATION EFFICIENCY

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Irrigation with brackish water must satisfy both evapotranspiration and leaching needs. Leaching requirements are commonly based on response functions of crops determined for full seasons, and may not be relevant to temporal field conditions. Miscalculation of actual evapotranspiration leads to inefficient use of water and fertilizers resulting in economic losses and groundwater pollution. Such consequences can be minimized by proper irrigation and fertilization scheduling based on in-situ water and solute balances. Lysimeters can close solute and water balances as well as monitor movement of different solutes into deep layers of the soil profile. Low cost in-field drainage lysimeters to aid fertigation decision making by practitioners could optimize water and fertilizer inputs. When storage is assumed to be negligible, lysimeters are more affordable since weighing is not a requirement. The main challenges for application of such low cost lysimeters is determination of: lysimeter size, temporal resolution for water and solute balance, and the certainty that the lysimeter represents field conditions. The objective of this study was to optimize drainage lysimeters as in-situ agricultural tools for water and solute balances to aid fertigation decision making.

- For two years, bell peppers were grown in drainage lysimeters having two different depths and three different surface areas in a semi-commercial greenhouse with loamy sand soil. Evapotranspiration calculated using the drainage lysimeters was successfully compared to that calculated using weighing lysimeters; drainage quality was monitored during the growing season; and plants in the lysimeters were compared to those growing in the field. It was found that a medium sized ($1m^2$) deep (0.6m) lysimeter best represented field conditions and best exemplified actual evapotranspiration. Time resolution was calculated using temporal correlations between ET calculated with and without storage and it was found to be optimal for a period of 4 to 11 days.

ADSORPTION OF COPPER, NICKEL, AND ZINC AS RELATED TO SOIL CONSTITUENTS AND TIMING OF ADDITION OF DISSOLVED ORGANIC CARBON

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Heavy metals (HMs) impose a serious health risks to human beings and the environment worldwide. In a study using batch adsorption experiments we used the Initial Mass (IM) isotherm model to describe the sorption behavior of Cu, Ni and Zn to several clay rich Egyptian soils. In particular, we studied the influence of the presence of dissolved organic matter (DOM) as well as the timing of its addition (prior to metal addition or simultaneously). As such we mimicked potential metal pollution that might occur e.g. from the common use of polluted irrigation water alone or in combination with manure. We found that the addition of DOM played an important role in determining the affinity for uptake of Ni, Zn and Cu from soil suspensions. The affinity of the tested soils for Ni and Zn was always enhanced by the presence of DOM. In contrast, for Cu the timing of DOM addition played an important role. The soils affinity for Cu increased strongly when DOM was added first, followed by the HMs. However, when both were added simultaneously, the affinity for Cu binding of Fe-(hydr)oxide rich soils decreased. The difference can be explained by differences in binding mechanisms of Cu on the one hand and Ni and Zn on the other. The study has important implications for the assessment of HM pollution in Egypt as well as the potential use of the abundant clay rich soils in crude, cheap water pre-treatment setups.

ASSESSING THE RISK OF TILE-DRAINED WATER POLLUTION WITH PESTICIDES

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Climatic, orographic and soil conditions determine the prevailing types of soil water flows, which are the main paths of pesticide transfer to surface and ground water. The field application of pesticides presents a potential diffuse source of water pollution and necessitates careful evaluation and revision of agronomic practices to limit negative environmental effects. Adequate methodology for pollution risk assessment is needed to evaluate the exposure of the environment to the harmful chemical compounds from pesticides.

Assessing the risk of water contamination with pesticides is a complex task that combines knowledge and data about soil management, crop type, application time, the characteristics and environmental fate of the applied pesticides.

For assessing the ecological risk of contamination of tile-drained waters with pesticides, we took a new methodological approach using data mining techniques, which we applied on data from the experimental site La Jaillière, situated in Western France and run by the technical institute ARVALIS - Institut du végétal. It is one of the ten representative agricultural areas in the EU chosen for the purpose of assessment of the Predicted Environmental Concentration of active substances in surface water under Directive 91/414/EC and Regulation (EC) No 1107/2007. The models induced by data mining predict the risk of water pollution with pesticides at the outflow from tile-drained agricultural fields. The highly imbalanced data posed an additional challenge in combining and evaluating the results and choosing the best models. Taking into account the accuracy, precision and recall, as the main evaluation criteria, we selected the most promising models for predicting the risk of soil water pollution by pesticides. The assessed level of risk provides information critical for risk management decisions, i.e., for selecting the most efficient mitigation measures that will minimize or eliminate soil water pollution by pesticides.

Theme 3
Governance and Policy

Keynote
Ronald Vargas-Rojas

SOIL GOVERNANCE: A PRECONDITION FOR SUSTAINABLE DEVELOPMENT

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Global soil resources provide key ecosystem services that enable life on earth. Among them, the provision of healthy food is a core function as approximately 95% of the food is produced in soils. With the current challenges posed by population growth and their change on life style, the need for producing more food and provide further ecosystem services is of concern. It is estimated that food production should be increased by 60% by 2050 and most of this production should come from developing countries. At the same time, the issue of food quality and its nutritious value has been subject of debate during the recent second international conference on nutrition. Recent studies estimate that around 33% of global soil resources are subject to degradation in their various forms ranging from moderate to severe status.

Although the importance of soil resources is literally recognized by various stakeholders, yet the soil agenda was not fully part of any specific intergovernmental decision making process. It was only subject of occasional thematic discussions and actions at the UN conventions and UN organizations where soils have an impact in their mandates. Considering the challenges and the soil threats, in 2012 FAO members established the Global Soil Partnership aiming to improve the governance of this resource and promote its sustainable management for various functions. Soil governance refers to the decision making process including the development and execution of - legal frameworks, policies, strategies and actions - employed by stakeholders ranging from global, regional, national to plot levels regarding the use of soil resources. Since 2011, various institutions have realized the need for action towards stopping soil degradation and reverting degraded soils, and thus a positive momentum for soils has emerged. Starting in 2013, an annual Plenary Assembly is organized by the Global Soil Partnership where governments, NGO, civil society, private sector and academia convene to debate on how to promote sustainable soil management and contribute to the different agendas where soils play a role. As part of it, an Intergovernmental Technical Panel on Soils has been established and plays a key role in providing scientific advice and guidance to the Global Soil Partnership and its members. Its work resulted on updating the World Soil Charter that was endorsed by Governments at the FAO Conference in June 2015 and has also contributed to the development of the new Sustainable Development Goals. Awareness raising on the importance of soils is vital and as such, the Global Soil Partnership was the epicentre for requesting FAO members and then the United Nations General Assembly to endorse the World Soil Day (5th December) and the International Year of Soils (IYS) 2015. These two platforms and the Global Soil Week have triggered an unexpected soil momentum. However, the challenge remain on how to keep it beyond 2015.

2015 constitute a historic year for soils as apart from the IYS, governments will agree in new Sustainable Development Goals (SDGs) that will mark the path towards sustainable development for all. Notably and due to the effort of various institutions and soil scientists around the world, soils are present in these new goals at target and indicators levels, therefore the soils community should be proud and should be ready to assist on its implementation. Soil governance at global level is currently functional as there is a World Soil Charter (with its agreed principles), a Global Soil Partnership as a neutral venue for decision making on soils, a current undertaking for developing Voluntary guidelines for the sustainable management of soil resources and an Intergovernmental Technical Panel on Soils. The challenge beyond 2015 is on how to use these global elements for the implementation of actions towards supporting the strengthening of soil governance at regional and especially national level in order to promote sustainable soil management for the provision of multiple ecosystem services, so to achieve Sustainable Development for all and by all.

Keynote
Gerda Verburg

WE NEED COLLABORATION AND CONCRETE RESULTS

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Good food begins with good soils. Soil resources represent the basis for food security and provide key ecosystem services, including climate change adaptation and mitigation. However, global soil resources are limited, non-renewable, and degrading. Soils need to be managed in a sustainable manner, taking into account their production, regulatory and system functions. All stakeholders should contribute to this in three ways.

1. Soils need results-oriented action, a narrative and a strong lobby. The United Nations has declared 2015 the International Year of Soils. In order for this year to have real added value, we need a plan of action with concrete objectives and targets that can be measured. This plan should serve as the basis for lobbying in preparation of the climate conference in Paris and the Sustainable Development Goals (SDGs) defining the Post-2015 development agenda.
2. We need research that leads to practical outcomes. Research needs to be applicable not just in a lab but on the ground and at scale. The Global Soil Partnership, established by FAO and others, plays an important role in the renaissance of soil conservation activities through capacity building, facilitating and contributing to soil science and technologies for sustainable soil management. However, it should prove its added value in practice by not only producing papers, but ensuring that soils are included in the SDGs and in climate change adaptation and mitigation. The setting up of a working group within the Intergovernmental Technical Panel on Soils to address soils in the SDGs from a food security perspective has proved fruitful, as the panel's work has led to soil being currently mentioned in three SDGs. But that is only a start.
3. We need to use a multi-stakeholder approach including making use of 'farmers' wisdom'. The top-down approach of international commitments needs to be complemented by a joint bottom-up trajectory. The views and interests of all stakeholders related to agriculture and food security should be recognized and taken on board in designing and implementing policy, as they will need to implement the policies and win-win situations are possible. It should lead to providing farmers with the tools to improve and manage soils in a sustainable manner, while at the same time producing better.

Session Governance and Policy 1

SOIL ORGANIC MATTER FOR FOOD, WATER, CLIMATE, ENERGY AND HEALTH

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It is generally known that soil organic matter content is an indicator for soil fertility. However, soil organic matter offers solutions to multiple challenges, related to food, water, climate, energy and health. A working group of the Dutch TCB Soil Protection Committee wrote a report on soil organic matter, to raise awareness on the importance of soil organic carbon management in policy and practice. Robust agricultural systems are needed that deliver enough and healthy food for a growing world population, biomass to replace fossil carbon sources in a biobased economy, on soils that store carbon and are resilient to increasingly occurring weather extremes (draught or excess rainfall) and sustain clean groundwater stocks. Due to these multiple interests, many stakeholders are involved in organic matter management of soils, at different scales. Soil organic matter consists of a heterogeneous mixture of simple and more complex organic molecules of different age. More carbon is stored in soils than in the atmosphere. Many soil functions are not so much dependent on stocks, but more on the dynamics of soil organic matter.

Soil organic matter is part of a complex living soil ecosystem that can be managed in such a way that multiple functions can be realized. Not all functions can be realized at all locations. Dutch farmers fear a deterioration of their soil organic matter. A decrease of stocks is not observed from data analysis. Despite the apparent constant soil organic matter quantity, their concerns might be caused by a change in soil organic matter quality, something that could not be analysed in this study. Management of soil organic matter in order to optimize the different soil functions in an increasingly demanding world needs thorough knowledge of the soil-water-sediment system, knowledge of relevant local processes and the circumstances that influence these processes.

ASSESSMENT AND MAPPING OF SOIL SERVICES FOR SPATIAL PLANNING PROCEDURES

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The protection of soils against soil sealing and other soil threats is back on the political agenda in Switzerland, like in many other countries. However, in contrast to other European countries the remaining soil resources per capita are relatively small in Switzerland, and soil sealing continues at high level, especially in areas with most fertile soils. In addition, stakeholders in spatial planning are still rarely aware of the essential services that soil provides for humans and the environment, i.e. regulation of water and nutrients, filtering or buffering of inorganic, organic or acidic compounds or producing food. In Switzerland even best soils have not been spared from construction planning and sealing; about 30% of the arable soils have been sealed in the last 30 years.

To support decision-making in spatial planning procedures that account for soil services, we conducted an in-depth literature study for assessing and mapping soil services separately for a) the ecosystem service community and b) soil science community. Very briefly, the former community barely considers soil services in their studies (n = 169 papers), most of these focussing on soil organic carbon (n= 54) and/or soil suitability for agriculture (n=42). In contrast, geological survey institutions in some European countries developed detailed assessment methods for soil services, but the methods can only be found in grey literature, and thus, are hardly well-known. We present a condensed overview of the soil assessment approaches used in both disciplines, and conclude that ecosystem service frameworks will benefit greatly from soil science-based assessment methods. Furthermore, we illustrate the assessment and mapping of selected soil services for a regional case study (60 km^2) processing almost 4'000 soil profiles. The assessment and mapping of soil services provide a promising instrument in increasing awareness about soils and communicating the required soil information to spatial planners.

MAKING THE MOST OF OUR LAND: MEETING SUPPLY AND DEMAND OF SOIL FUNCTIONS FROM FARM TO EUROPEAN SCALE

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The twin challenges of food security and sustainability have resulted in a plurality of demands on land within the European Union; we expect our soils to provide food, purify water, sequester carbon, and provide a reservoir for biodiversity and recycling of nutrients. All soils perform these five functions, but the degree to which these are delivered varies by soil type and land use. Functional Land Management (FLM) is a framework to support policy making and is aimed at satisfying the demands for these functions, by incentivising management practices that selectively augment specific soil functions.

We launched the concept of FLM at the first Wageningen Soil Conference in 2011. Since then, we have applied it at a national level in Ireland to map soil functions and to assess trade-offs between them. Moreover, FLM now forms the basis of the new European LANDMARK (LAND Management: Assessment, Research Knowledge Base) Consortium, funded by Horizon 2020.

In this paper, we explore how the *supply* of each soil function is largely defined by local soil conditions and land-use management, with large variations at local and regional levels. We show that contrasting *demands* for soil functions, as framed by EU policies, may apply at very different spatial scales, from farm-to-European scale. We demonstrate that this variation in supply and demand has implications for soil management. Some soil functions, such as water purification, must be managed at local (i.e. farm) level through targeted soil management. Others, such as carbon-sequestration may be offset between regions with a view to primarily meeting national targets, largely through land-use management.

We review the diversity of existing European policy instruments available to address the challenge of maximising the delivery of soil functions across these spatial scales, and propose a coherent framework that brings these policy instruments together.

SIGNIFICANCE OF SOIL PARAMETERS IN EVALUATING THE FARMING PRACTICES: A SYSTEMS APPROACH

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Traditionally, the notion of farm productivity is associated only with the crop yield which is often linked with the amount of fertilizer applied to the field. In many developing countries, this misconception has led to the inappropriate use of synthetic fertilizers helped in part by the high subsidies provided for synthetic fertilizers. This has resulted in negligence of the other management practices such as mulching, manure application etc., leading to degradation of soil health. In this study, we use the concepts of Stock and Flow from System Dynamics to illustrate the significance of soil parameters in assessing the farm practices. Conventional indicators like yield and income are the flow variables that capture only the immediate outcome of a crop production system but fail to capture the sustainability related parameters such as soil health which has strong inertia and changes slowly with time. Conceptualization of the crop system using stock and flow models and identification of feedback loops in the system, help us to capture the importance of soil parameters and identify the key factors affecting the soil health. Using this model, we select a set of minimal indicators and aggregate them into a composite index to evaluate the performance of different farming practices. We apply this framework to the data collected from 60 chemical and 60 organic farmers in two states of India (Tamil Nadu and Odisha). Our analysis shows that, in spite of higher yield and income, composite index of certain farm practices are lower than their counterparts due to their impacts on the soil parameters and other system parameters. Further, the results indicate that the compost and organic nutrient application has a crucial role in maintenance of soil health, independent of the synthetic fertilizer application, suggesting the need to revisit the fertilizer subsidy policies.

THE SCOTTISH SOIL FRAMEWORK: IMPLEMENTING SOIL PROTECTION POLICY AT REGIONAL SCALE

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In many countries, including Scotland, there is no explicit soil protection strategy. This in part reflects the multi-dimensional nature of soils which impacts on a large number of policy areas. The view in Scotland was a Framework was required to enable more dialogue between different sectors and ultimately a better cross-sectoral approach to soil policy, regulation and management. This was based initially on a strong evidence base on the state of Scottish Soils followed by the publication of the Scottish Soil Framework, after consultation with stakeholders. Two of the key components of the Framework were a set of desired soil Outcomes and a number of agreed Actions required to achieve them, both within an enabling rather than a restrictive ethos. Several of these were assigned to the soil research community in Scotland, often in partnership with other organisations, including reviewing the Land Capability for Agriculture classification, increasing the availability of soil data to interested parties, developing a soil monitoring action plan and research into soil management techniques to optimise soil carbon sequestration. The Framework helped raise awareness of soil in other policy areas of government and in particular the role of peatlands as part of Scotland's climate change mitigation strategy. The action to raise awareness of the importance of soil has led to the development of some novel techniques to capture the public imagination and has led to Scottish based soil scientists being actively involved in European and Global initiatives, including the Global Soil Partnership. The Soil Focus Group which oversaw these activities and monitored progress, will be reconstituted in early 2015, in response to soil continuing to move up the policy agenda in diverse policy arenas such as climate change, food production and planning.

BUSINESS-AS-USUAL WILL NOT SUFFICE WHEN CONTRIBUTING TO THE SUSTAINABLE DEVELOPMENT GOALS

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The newly proposed UN Sustainable Development Goals offer excellent opportunities to demonstrate the crucial contributions that the soil science profession can make in realizing these goals. Based on their considerable expertise soil scientists can well articulate their contributions to promoting sustainable agriculture (goal 2), sustainable use of water (goal 6), sustainable production patterns (goal 12), tackling climate change (goal 13) and promoting sustainable use of terrestrial ecosystems and halting land degradation and biodiversity loss (goal 15). But when providing scientific contributions to the realization of the goals, not only interdisciplinary cooperation between different scientific disciplines is essential but without continuous involvement of stakeholders and policy makers in a transdisciplinary context, realizing the seventeen goals will remain elusive. Theoretically analysing inter- and transdisciplinarity in literature has been easier than its practical implementation. The first challenge for soil scientists is therefore to become accepted as members of transdisciplinary research teams. This requires studies demonstrating that soil input significantly improves research results, made possible by including baseline studies without or with only elementary soil input. Transdisciplinarity is time consuming and researchers should have enough time for interaction, requiring a different internal research organization. Knowledge brokers can play an important role and soil scientists are in an excellent position to fill such positions in environmental studies, as most of them are land related. Soil scientists should be prepared to discover that many SDG related problems can be successfully approached by knowledge assembly, applying legacy data. How to keep soil science vital by new basic research, that ideally originates from an observed lack of knowledge when studying the SDG's, forms a key challenge at a time when curiosity is not anymore a politically effective driver for new research. The capabilities are there. Now is the time for effective framing and application of soil expertise.

Theme 4
Biodiversity

Keynote
George Kowalchuk

EXPLORING AND EXPLAINING THE MAGNITUDE OF SOIL-BORNE MICROBIAL DIVERSITY

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Soil-borne microbial diversity is vast. Indeed, soil-borne microbial diversity probably represents the largest source of biological diversity on the planet. While much recent research has been directed at trying to elucidate the functionality of diverse communities of soil microbes, or the activities of specific microbial players within the soil, far less attention has focused on the underlying ecological questions related to the development and maintenance of this vast soil-borne microbial diversity. For instance, several studies have suggested a very large degree of functional redundancy within soil microbial communities (Vigdis & Øvreås, 2002; Yin et al 2000), however, we still have little knowledge of how functionally redundant populations might be maintained within soil communities. With the emergence of new experimental platforms and especially high-throughput methods to interrogate soil-born microbial communities, it is now becoming possible to examine the underlying ecological drivers that explain the extremely high biodiversity within soil microbial communities.

Recent studies have started to reveal patterns of microbial diversity and biogeography across numerous environmental gradients such as pH, moister, vegetation patterns and nutrient load (Ref). Indeed, large amounts of data continue to accrue that provide insight into the gross drivers of microbial diversity as related to general ecological theories related to species-area relationships, biotic and abiotic drivers of microbial diversity, biogeographical patterns such as distance decay and intermediate resource and disturbance paradigm (*e.g.* Fierer & Jackson, 2006). However, we still have a rather crude understanding the forces that drive patterns of microbial diversity in soil environments (Hanson et al 2012). To a large extent, this knowledge gap may be attributed to the general failure to appreciate the scale at which the majority of microbial interactions occur and our inability to sample microbial communities to sufficient depth (Vos et al 2013).

To tackle these limitations, we have adopted two general approaches: (a) fine-scale sampling and deep interrogation of patterns of microbial diversity, and (b) laboratory experiments using artificial soil systems (Wolf et al 2014) to track the impact of fine-scale soil structure on patterns of bacterial interactions and the maintenance of biodiversity. Micro-scale patterns of microbial diversity were revealed via the dissection of individual soil grains and high-throughput pyrosequencing. Furthermore, manipulation of soil structure and moisture, and therefore connectivity, impacted bacterial and fungal diversity, community structure and the potential for the colonization of new soil habitats. Combining survey-based and experimental approaches, allowed for a more microbe-centric examination of soil-borne microbial diversity, facilitating a better understanding of the drivers of microbial composition, diversity and function.

My presentation will examine how general ecological drivers of biodiversity apply to soil-borne microbial communities, as well as discuss how our understanding of microbial diversity can be advanced by adopting more microbe-centric perspectives that take the spatial structure and scale of microbial cells and populations into account.

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Keynote
Laurent Philippot

LINKING SOIL MICROBIAL DIVERSITY, NITROGEN CYCLING AND GREENHOUSE GAS EMISSIONS

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Microbial communities have a central role in ecosystem processes by driving the Earth's biogeochemical cycles (Falkowski et al. 2008). However, the importance of microbial diversity for ecosystem functioning is still debated. This talk will highlight how trait-based approaches can help understanding the role of microbial diversity in soil functions. For this purpose, denitrification, a microbial process involved in N-cycling, was selected as a model functional trait. Denitrification is a microbial respiratory process during which soluble nitrogen oxides are used as alternative electron acceptors when oxygen is limiting. It is involved in ecosystem services such as filtering but also disservices. Thus, denitrification can results in considerable losses of nitrogen, which is the most limiting nutrient for crop production in agriculture. It is also responsible for emissions of nitrous oxide, which is one of the six greenhouse gases considered by the Kyoto protocol and the predominant ozone-depleting substance (Ravishankara et al.,2013). Using both naturally assembled and artificially manipulated microbial communities, I will show how the denitrifier diversity relates to process rates and N_2O emissions and how the analysis of spatial patterns of traits can help bridging microbial community ecology and ecosystem process in terrestrial environments (Philippot et al. 2009; Welsh et al. 2012; Philippot et al. 2013). Unlike other greenhouse gases such as carbon dioxide (CO_2) or methane (CH_4), the ability of soils to eliminate N_2O and thus act as a sink for this greenhouse gas has been very little studied hitherto. Our results also showed that the large variability between EU soils in this capacity to eliminate N_2O is linked to a new group of N_2O-consuming micro-organisms, which underline the importance of the biodiversity of soil micro-organisms to the functioning of soils and the services they deliver (Fig. 1) (Jones et al. 2014). Network analysis further identified several recurring communities comprised of co-occurring N_2O reducing bacterial genotypes that were significant indicators of the soil N2O sink capacity across different European soils. All these findings underline the importance of microbial biodiversity for soil functioning and the services that soil delivers.

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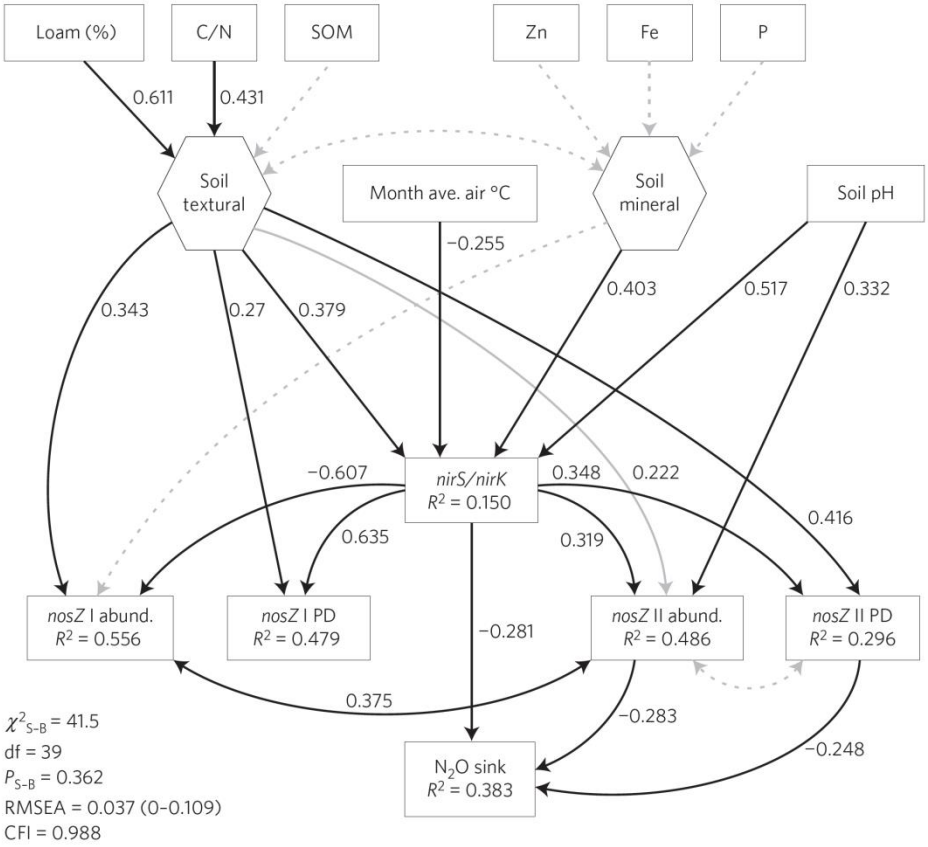

Fig. 1. Structural equation model showing the relative influence of soil abiotic and denitrifier community factors on the soil N_2O sink capacity. Amount of variance explained by the model (R^2) is listed for each response variable, and measures of overall model fit are shown in the lower left.

Session Biodiversity 1

IMPACT OF MICROBIAL SPECIES LOSS ON RHIZOSPHERE MICROBIOME ASSEMBLY

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Plant growth may respond positively or negatively to the soil microbial community, depending on the balance between pathogens and mutualists. Growing plants repeatedly in the same soil may result in increase of pathogens (negative plant soil feedback) or increase of mutualists (positive plant-soil feedback). While the concept of plant-soil feedback is well-known, there is a gap in the knowledge of microbial community development during feedback. Here we tested to what extent loss of microbes will affect the development of plant-soil feedback. Inoculation of sterilized soils with serial diluted suspensions from two soil origins and subsequent incubation resulted in soils with similar microbial biomass but differences in microbial community. Pyrosequencing of 16S rRNA was used to track how dilution and incubation affected microbial community composition directly after incubation and after one or two cycles of plant growth. Dilution decreased species richness and similarity as compared to the original field soil. Growing plants on the inoculated soils once or twice increased similarity of the bacterial community to that of the field soil. While the most diluted communities showed the least overlap with the original field soil, the similarity between replicates was high. Also the similarity between microbial communities after one and two growing cycles was highest in the most diluted community. On basis of the sequence data and literature we identified potential pathogens and mutualists of the host plant *Triticum aestivum* and followed how those bacteria species reacted to a second growing cycle with the same host plant. The potential pathogens increased after the second growing cycle and appeared more sensitive to microbial species loss than the potential mutualists. Soil origin interacted with the response of genera to repeated plant growth. We conclude that loss of species will make microbial community dynamics more predictable.

ASSESSMENT OF SOIL MICROBIAL DIVERSITY WITH FUNCTIONAL MULTI-ENDPOINT METHODS

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Soil microbial diversity provides the cornerstone for support of soil ecosystem services by key roles in soil organic matter turnover, carbon sequestration and water infiltration. However, standardized methods to quantify the multitude of microbial functions in soils are lacking. Methods based on CO_2 development by the microbes such as substrate induced respiration (SIR) on specific substrates have lead to the development of MicroResp™ and Community Level Physiological Profile (CLPP) with Biolog™ plates, and soil enzymatic activity assayed by Extracellular Enzyme Activity (EEA) based on MUF-substrates. These methods have been proposed to fill the gap. The techniques vary in how close they are to in situ functions; dependency on growth during incubation; and whether it is only bacteria or also fungi and /or extracellular enzymes. Also they vary in the functions tested and the number of functions. In addition to the lack of principle methods, the data obtained from these substitute methods are currently not used in classification and assessment schemes, making quantification of natural capital and ecosystems services of the soil a difficult venture.

In this contribution, we compare and contrast the three techniques of assessing soil microbial functional diversity in a European transect consisting of 81 soil samples covering five Biogeograhical Zones and three land-uses and compare with the vast amount of data delivered in other projects (BISQ, RMQS-bioindicateur). Based on experimental results with these methods, microbiological reasoning and ecological theory, we will perform a qualitative comparison between the multi endpoint methods of determining soil microbial communities functional diversity, and will suggest standardized classification and assessment options for practical application and data assessment.

UNDERLYING MECHANISMS DRIVING EARTHWORM-INDUCED INCREASES IN PHOSPHORUS AVAILABILITY

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Phosphorus (P) is an essential nutrient for plant growth. Its availability for plant uptake is often a growth-limiting factor, as many soils are unable to supply it at a sufficient rate. Past fertilization practices have led to large quantities of "residual" soil P that are difficult to access by plants. With decreasing global P fertilizer reserves, it becomes essential to find new ways to make this residual soil P better available to crops. Recent studies by our group showed that P availability can considerably increase in earthworm casts, which might result in increased plant P uptake. However, the exact mechanisms through which this increase of available P occurs remain elusive. In a greenhouse pot experiment we tested whether the presence of the anecic earthworm *Lumbricus terrestris* in a soil with a low P availability resulted in an increase in growth and P uptake by Italian ryegrass (*Lolium multiflorum*) and studied the underlying mechanisms for such an effect. We found that *L. terrestris* significantly increased yield from 164 to 188 g dry matter m^{-2} ($p=0.044$) and P uptake from 0.21 to 0.27 g m^{-2} ($p=0.002$). We also collected earthworm casts and analysed them for water extractable P as well as for most other common ions. Concentrations of total dissolved P as well as dissolved inorganic P in earthworm casts were 7-9 times higher than in bulk soil. In a batch experiment, we showed that the pH increase in the casts (from 5.9 to 8.1) was not the main driver for the increase in P availability. We hypothesize that the main driver was competition for adsorption sites between orthophosphate and the elevated dissolved organic carbon concentrations in the casts. This hypothesis is tested using advanced surface complexation modelling (the CD model), and results will be discussed.

LAND USE INTENSITY IMPACT ON FUNCTIONAL DIVERSITY IN EARTHWORMS REGARDING REGULATION OF SOIL STRUCTURE AND WATER INFILTRATION

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Earthworms can be distinguished into three groups that represent different clusters of morphological and behavioural traits. These so-called ecological groups (sensu Bouché 1977) have traditionally been considered to represent different functional groups with respect to soil processes. In this context, one aim of our study was to assess the impact of agronomic intensification across a range of land-use systems on the relationships between earthworm community composition and soil processes. Secondly, we quantified the relationships between earthworm ecological groups and individual species with soil aggregate formation, macroporosity and water infiltration capacity. In a comparison between permanent grassland, permanent arable land with conventional ploughing, and a 3:3 years rotation system the stability of soil aggregates in the top layer was higher under grass cover, and the stability of 2-4mm soil aggregates significantly increased with increasing biomass of both anecic and endogeic earthworms. Earthworm burrow distribution over the soil profile was strongly impacted by land management (e.g. total number was higher under grassland vs crop), and specific relationships were identified between some earthworm species and larger macropores. Water infiltration rates significantly increased with increasing earthworm biomass, and this effect was significant for the group of anecic species. The role of endogeic species appears to be inconsistent between sites or management practices. We discuss the functional ecology of earthworms at the level of functional group and the individual species, focussing on burrow morphology and vulnerability towards agricultural management practices. Results contribute to the understanding of the linkage between soil biodiversity and provision of ecosystem services. Our quantitative results can be used in ecohydrological modelling (forecasting) and economic valuation studies.

MAPPING EARTHWORM COMMUNITIES IN EUROPE

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Existing data sets on earthworm communities in Europe were collected, harmonized and modelled to illustrate our current knowledge on their European diversity and geographical distribution. Digital Soil Mapping was applied using multiple regression techniques relating relatively low density earthworm community data to soil characteristics, land use, vegetation type and climate factors, that had a greater spatial resolution. Statistically significant relationships were used to build habitat-response models to construct earthworm maps for abundance, species richness, and diversity data. Although a number of environmental predictors were significant in our multiple regressions, geographical factors alone were less relevant than climatic factors. Despite differing earthworm sampling protocols, land use and geological history were the main factors determining demography and diversity of the earthworms across Europe. Case studies from country-specific data sets (France, Germany, Ireland and The Netherlands) demonstrated the importance and efficiency of these large databases for the detection of large spatial patterns that could be subsequently applied at smaller (local) scales. Additional datasets have been later incorporated (e.g. Portugal, Italy, England, Wales, Belgium, Finland, Austria and some countries from Eastern Europe) to improve our predictions of earthworm geographical patterns. The improved maps will be submitted for publication in the Global Soil Biodiversity Atlas.

ECO-FINDERS: DEFINING BIOLOGICAL INDICATORS OF THREE SOIL FUNCTIONS ACROSS EUROPE

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Soil organisms are considered drivers of soil functions (primary productivity, nutrient cycling, carbon cycling, water regulation and biodiversity) that we associate with sustainable agricultural production. Soil biodiversity was highlighted in the soil thematic strategy as a key component of soil quality. The lack of quantitative standardised data at a large scale has resulted in poor understanding of how soil biodiversity could be incorporated into soil protection policies. In 2011, the EcoFinders (FP7) project sampled 76 sites across 11 European countries, covering five biogeographical zones (Alpine, Atlantic, Boreal, Continental and Mediterranean) and three land-uses (arable, grass, forestry). These sites provided a spectrum of soil properties; soil organic carbon (SOC), pH and texture. Seventeen biological indicators were measured; **microbial diversity:** Archaea, Bacteria, Fungi (TRFLP), phospholipid fatty acids, arbuscular mycorrhizal fungi; **micro fauna diversity:** nematode feeding guilds; **meso fauna diversity:** enchytraeids, acari and collembola species; **microbial function:** nitrification, extracellular enzyme assays, MicroResp, Biolog and ammonia oxidiser/nitrification functional genes. Using network analysis techniques to identify co-occurence of different taxonomic groups and regression models, the contribution of soil biota to three ecosystem functions was assessed; biodiversity, carbon cycling and nutrient cycling.

The highest density networks were found in forest soils followed by grasslands and arable. In forest systems, the most connected species were archaea and enchytraeids, while in grassland and arable sites, bacteria and fungi and archaea and bacteria dominated, respectively. To assess C cycling, a regression model using basal respiration, molecular microbial biomass and fungal richness, accounted for 82% of the variance. Nutrient cycling was represented by N mineralisation and P availability in soils. Molecular microbial biomass, potential denitrification and fungal richness described 48% of variation. Utilising soil biota, we can describe the role of key taxonomic groups in soil ecosystem functioning for contrasting land uses.

Session Biodiversity 2

SOIL BIODIVERSITY AS A DRIVER OF ECOSYSTEM SUSTAINABILITY

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Soil organisms can play a key role in ecosystems by enhancing nutrient uptake, plant productivity and plant diversity. The importance of soil biota for the sustainability of ecosystems is still unresolved. Here we show that soil organisms and soil biodiversity can enhance the sustainability of natural and agricultural ecosystems by reducing nutrient leaching losses after rain and promoting nutrient uptake. Experiments performed in indoor mesocosms and in outdoor lysimeters, showed that an increased abundance of mycorrhizal fungi and other soil biota, reduced leaching losses of nitrogen and phosphorus. The reduction of nitrogen leaching losses in outdoor lysimeters was substantial (a reduction of up to 80 kg N/ha/year) pointing to the key role of soil biota in nutrient cycling. Further experiments showed that denitrification rates and the production of the greenhouse gas N_2O is reduced in lysimeters where soil complexity is high. Mesocosms experiments with experimental grassland further revealed that nutrient losses depend on the composition of fungal communities and were reduced in microcosms with enhanced soil biodiversity. Our results indicate that changes in soil communities and the loss of particular groups of soil biota threatens ecosystem multifunctionality and sustainability. These results are important in view of increasing evidence that land use intensification reduces the abundance and diversity of several key groups of soil biota.

SOIL BIODIVERSITY AND SUSTAINABLE VINEYARDS: HINTS FROM THE ANALYSIS OF MICROARTHROPOD AND CILIATED PROTOZOA COMMUNITIES

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Soil biodiversity constitutes one of the main components of agroecosystems, being involved in the delivery of several essential ecosystem services such as, among others, nutrient cycling, soil formation, pest and pollution control. Thus, soil biodiversity indicators can be used by governments and farmers to monitor soil quality and ecosystem functioning under various land uses and management practices. In this scenario, the aim of our study was to assess the long-term effects of organically managed vineyards on soil quality by means of two bioindicators: protozoan ciliates and microarthropods. The study was realized in the *terroir* of *Verdicchio di Matelica* (Marche, Italy), on three vineyards that were organically managed since 1992, 1998 and 2009 respectively. In each vineyard, soil samples (0-10 cm depth) were taken every month from March to October 2011. In addition, soil chemical-physical (texture, soil moisture, pH, NPK, OM, C/N, Cu), were measured in each site. For microarthropods, the measured biological parameters were: the Soil Biological Quality (QBS-ar) index, abundances of Biological (BF) and Euedaphic forms (EF) and diversity indices. Soil samples were collected in both disturbed (tillage) and not-disturbed (no-tillage) inter-rows. For ciliates: abundances and diversity indices were measured and soil samples were randomly collected in the whole sampling area. The results of the multivariate data analysis (Cluster Analysis, CA; non-metric Multi-Dimensional Scaling, nMDS) and diversity indices (*H',J,d*) indicate that the most stable habitat for ciliates and microarthropods is represented by the "older" (V92) followed by the V98 and the "younger" V09 vineyards. Collectively, the data seem to indicate that the long-term organic management of the soil contributes to global soil quality in vineyards at least in this particular pedoclimatic area and for the investigated bioindicators. Furthermore, this study helps in the definition of possible biotic baseline values to evaluate soil quality/health in vineyards.

SOIL BIODIVERSITY AND NUTRIENT CYCLING IN AN AGRICULTURAL LAND ABANDONMENT CHRONOSEQUENCE

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Land abandonment is considered an effective tool for restoring biodiversity and ecosystem functions. However, thus far little attention is given to the role of soil biodiversity. Here, we present results of a soil biodiversity development and ecosystem functioning from a chonosequence of ex-arable fields in The Netherlands. These fields are typically managed by low-intensive grazing while undergoing a transition from an arable system into a species-rich grassland. We manipulated soil biodiversity to be able to couple biodiversity loss to loss of soil functions. We hypothesized that biodiversity loss would lead to less N uptake by plants and slower C transfer to microbes. A greenhouse mesocosm experiment was performed in which sterilized soils from the chronosequence were re-inoculated with a dilution series of soil suspensions (filtered to include only bacteria, fungi and protozoa) to manipulate soil diversity. These mesocosms were planted with a community of plants that naturally occur in all of the grasslands along the chronosequence. We measured microbial community development, plant C, N and biomass and used 15-N and 13-C-CO2 dual-labeling to assess the short term fate, turnover and retention of recent plant assimilated carbon and nitrogen in soil. The faith of the C and N were followed by sequential sampling of aboveground and belowground plant tissues and soil bacterial and fungal PLFA and NLFA biomarkers. With the first method the role of microbial diversity and soil on plant carbon assimilation and nitrogen uptake was evaluated. This was further related to the amount of recently photosynthesized carbon plants allocated to different microbial groups in soils. Microbial end-communities were pyrosequenced to evaluate the end diversity. In this study we showed the effects of the loss of soil biodiversity to C and N cycling in plants and microbes.

IS REDUCED TILLAGE SYSTEMS A SUSTAINABLE ARABLE FARMING?
AN INTEGRATED ASSESSMENT OF SOIL PROPERTIES, SOIL ECOSYSTEM SERVICES, AND SOCIO-ECONOMIC ASPECTS

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In response to soil structural degradation and soil organic matter decline associated with arable crop production, alternative approaches including no tillage or reduced tillage systems have been developed. According to the agroecological context, farmers, researchers and policy makers in Europe are increasingly interested in exploring the possible benefits of these systems. Many studies worldwide have analysed the impact of tillage systems on different soil functions, but without an overview of the impact of these systems. The SUSTAIN project (European SNOWMAN programme), performed in France and the Netherlands, proposes an interdisciplinary collaboration. The goals of SUSTAIN are: (i) how reduced-tillage systems impact on ecosystem services such as soil biodiversity regulation (earthworms, nematodes, microorganisms), soil structure maintenance (aggregate stability, soil erosion), water regulation and quality (run-off, transfer of pesticides) and food production, (ii) what are the socio-economic drivers of reduced-tillage systems, (iii) which monitoring tools, such as soil-disturbance indicators for system sustainability, can be disseminated? Data have been collected from long term experimental fields within conventional and organic farming managements (from 5 up to 13 years), and have been complemented with data from farm networks. The impact of different reduced tillage systems (direct seeding, minimum tillage, non-inverse tillage, superficial ploughing) have been analysed and compared to conventional ploughing. Measurements (biological, chemical, physical, agronomical) have been done at several dates which allow an overview of the evolution of the soil properties according to climate variation and crop rotation. Sociological approach has been performed on several farms covering different production types, different courses (engagement in reduced tillage systems) and different geographical locations.

The study will present results and conclusions of this collaborative work, thereby shedding light on the benefits and trade-offs related to reduced tillage systems in NW Europe. Recommendations are provided for soil sustainable management aiming at ecological intensification of agricultural land.

EFFECTS OF LONG-TERM CROP RESIDUE APPLICATION ON SOIL BIOTA, SOIL AGGREGATION AND ORGANIC MATTER ALLOCATION IN OIL PALM AGROECOSYSTEMS

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Empty fruit bunches (EFB), the oil palm residue left after extraction of the palm oil, are used as an organic fertilizer and mulch substrate in oil palm plantations. EFB addition to the soil has been shown to increase nutrient availability and crop yield compared to conventional chemical fertilization. However, it is still largely unknown whether EFB also affects soil biota, leading to changes in soil nutrient conditions, soil structure and soil carbon allocation. We examined the long- term effects of EFB application on soil biota, soil aggregation and organic matter allocation in an Indonesian oil palm plantation. EFB was added to replicate field plots at rates of 30, 60 and 90 ha^{-1} yr^{-1} 15 years prior to this study, with comparison plots receiving conventional chemical fertilization. EFB application did not result in significant changes in earthworm biomass but a reduction in earthworm abundance. The majority of earthworms belonged to the invasive species *Pontoscolex corethruru.* EFB application significantly increased soil fauna feeding activity and soil microbial respiration. Soil aggregate stability was significantly increased and bulk density was decreased by EFB application. Soil organic carbon concentration did not show significant responses to EFB application. In addition, EFB application significantly increased soil pH and base saturation, while soil exchangeable Al was significantly reduced. Our results suggest that EFB application has positive impacts on soil fauna activity, microbial respiration, soil structure and nutrient availability compared to conventional chemical fertilization after 15 years of the application. While EFB application is not widely implemented within the oil palm industry, this study suggests that it has the potential to become an important method of increasing soil fertility and reducing dependence of chemical fertilizers, in-line with sustainable oil palm production and certification.

FOREST MANAGEMENT ADAPTATION TO CLIMATE CHANGE – SOIL BIODIVERSITY AND ECOSYSTEM FUNCTIONING RESPONSE TO STAND DENSITY REDUCTION

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Global warming induces new constraints on forest ecosystems and requires forest management adaptation. The reduction of stand density is currently debated in France as a potential tool to face increasing climate change-induced tree mortality risk due to summer drought by improving forest resistance to water stress. Our study aimed to assess the potential impact of this forest management adaptation on soil biodiversity, *i.e.* the detrital food web, and ecosystem functioning, *i.e.* litter and soil organic matter decomposition processes. We took advantage of a large-scale, multi-site experimental network of long-term forestry trials experimentally manipulating oak stand density through thinning operations in contrasted stand age and local abiotic context. Our results provide evidence that reducing stand density will have substantial impacts on the detrital food web structure, with cascading effects on soil functioning. While microbial biomass had little response, the effect of stand density on microbial-feeding nematodes was much more contrasted. Microarthropods such as collembolan and oribatid mites as well as diplopoda and anecic earthworms were depleted by stand density reduction. In contrast, endogeic earthworms were beneficially affected. Litter quality and decomposability decreased with stand density reduction while standard litter decomposition increased. Therefore, *in situ* litter decomposition was lower and carbon sequestration higher at intermediate stand density. Exploratory analysis using causal diagrams, *i.e.* path analyses, highlighted that those changes were mainly related to understory vegetation, microclimate and soil pH conditions alterations Overall, our study emphasizes that managing stand density of oak forests at intermediate level appears as the best way to optimize the trade-off between improving forest resistance to drought and preserving soil biodiversity and ecosystem functioning.

Theme 5
Land Functions

Keynote
Gerard Govers

DEVELOPING NEW VISIONS FOR SOIL CONSERVATION

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The global terrestrial surface provides important services to humanity and this is largely possible because soils are present on this land. These soils provide the necessary rooting space for plants, hold water, store carbon and nutrients, and are host to an important fauna whose diversity is, by some measures, larger than that of its aboveground counterpart.

Given its obvious role in the Earth system, one would expect that clear insights and information would exist on the status of the global soil resource, how human impact may have impacted this resource and what can be done to stop soil degradation due to human action and/or mitigate the consequences. Here we explore to what extent this is indeed the case. We argue that adequate soil management is not only lacking because of a lack of scientific understanding and/or data, but that, if we want soils to be protected, we also need to revamp our vision on how a more sustainable and effective soil management can be achieved. Throughout this paper we will mainly focus on soil erosion, which is considered as a major threat to soils, but we will also touch upon other aspects of soil management. Soil erosion is important because soils cannot be rebuilt over a timescale that is relevant to humans: soil erosion must therefore be seen as soil mining and needs to be virtually eliminated in a sustainable system.

Soil erosion has been extensively studied for more than 50 years now and one may state that the processes that cause removal of soil by different agents (water, wind, tillage) are well understood, resulting in rather sophisticated models that allow to simulate erosion and deposition over various temporal and spatial scales. However, the quality of our estimates of soil erosion rates by water over large areas is often debatable and sometimes overly alarmist: published rates for large areas are sometimes off by an order of magnitude. This is mainly due to two interrelated reasons: (i) the models that are used to make such estimates are often improperly calibrated, i.e. model parameters are set to values that are not appropriate for the location under consideration and (ii) the model parameterization may be correct, but the spatial data used to drive the model are inappropriate. Erroneous predictions do not only make it difficult to identify the most vulnerable areas in which conservation measures are most urgent: they may also invalidate the cost-benefit evaluations of soil conservation programs and lead to disinformation of the general public about the extent and severity of the problem.

The lack of good data partly explains as to why we struggle to have the erosion problem cured, despite the fact that a set of conservation tools which is known to effectively reduce erosion to acceptable levels does exist. However, the non-adoption of soil conservation is related to other factors as well. Studies on the economics of soil conservation show that the possible benefits for the farmer implementing conservation measures are small, if they exist at all. This observation holds for large-scale mechanised agriculture as well as for marginal hillslope farming in developing countries. In both cases, potential savings are offset by additional costs: in mechanized systems the cost of machinery and agrochemicals offsets savings in fuel costs while in hillslope farming extra work hours are needed to maintain conservation structures and some land has to be sacrificed to implement these structures. Crop yields, on the other hand,

do not rise significantly in conservation systems if no additional inputs are provided. As a consequence, farmers do have very few direct incentives to implement soil conservation.

One may argue that benefits should not only be considered at the level of the individual farmer, but also at the societal level, where soil conservation may generate co-benefits. Often carbon storage and biodiversity protection under conservation systems are mentioned as an important services for which farmers could be paid. Research in the last decade has consistently shown that carbon storage gains in conservation systems are lower than anticipated and that paying farmers to store carbon would only be viable at much higher carbon prices than the current market prices. On the other hand, soil conservation generally has a positive impact on biodiversity on the farm land as soils are less frequently disturbed. Where agriculture is interspersed with densely populated areas, additional co-benefits may consist of a reduction of flooding and/or siltation of sewage systems and water treatment plants. These benefits, however, are difficult to convert to financial income for the farmer, partly because the reduced reduction in flooding will not be considered as a benefit, but rather as damager repair, given that flooding was caused by agriculture in the first place.

How then should we proceed to stimulate a rapid adoption of soil conservation measures to protect our soils ? This problem cannot be seen separately from the vision we develop on farming systems in general. Here we argue that a well thought-out intensification of farming systems in developing countries is a prerequisite to the successful implementation of soil conservation systems. Intensification will not only increase the capital value of the land under production making its preservation economically more viable, but will also lead to the preservation of larger carbon stocks, more biodiversity at the landscape level and increased water efficiency. As intensification also implies that less land is necessary, the efforts necessary for soil conservation will be reduced as the poorest land, which is often subject to the most intense erosion rates, can be taken out of production.

Even though soil conservation may become more attractive in intensified systems, implementing them will require a long-term effort. Changes in agricultural practices are partly economically driven, but often also require changes in socio-cultural patterns which may take a considerable length of time. In some cases regulation will be a necessary part of a sustainable solution. Continuing the debate between the various stakeholders will be essential to make the transition to soil-friendly agriculture as quickly as possible.

Keynote
Jetse Stoorvogel

WHAT IS THE WINDOW OF OPPORTUNITY FOR OUR SOIL FUNCTIONS? A GLOBAL AND HISTORICAL PERSPECTIVE

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The global community increasingly recognizes the role of land. Good examples are the UN sustainable development goals, the seven soil functions identified by the European Union, and the declaration of 2015 as the international year of the soil. Globally, land use has resulted in considerable changes in soil conditions. Surprisingly, global changes in soil conditions received little attention compared to e.g., climate change. A possible explanation is that soils are considered to be under human control through e.g., agricultural management. Nevertheless, soil changes can be irreversible and management can only change soil properties to a certain extent depending on some, more permanent, soil properties like soil texture and clay mineralogy. Recently, a global inventory of soil properties (S-World) took place in which the Harmonized World Soil Database was disaggregated to a 30 arc second resolution using the concepts of digital soil mapping. The analysis is grounded in observed ranges in soil properties for each of the soil types using the ISRIC-WISE soil profile database. Actual soil conditions on the earth's surface are subsequently determined on the basis of climate, topography, land cover, and land use. S-world provides global maps of soil properties, but also the window of opportunity of these properties. In other words, the analysis shows to what extent soil properties can be influenced by land cover and land use. Particularly the window of opportunity is of interest as it shows that the possible changes in soil properties vary considerable in space. The results can also be interpreted in terms of soil functions. Key soil functions like the storage of soil carbon, the water holding capacity, and agricultural productivity also have a window of opportunity within which we realistically move. These ranges in soil properties and the derived ranges in soil functions have important repercussions for defining realistic targets for soil functions. In addition, they can help us to identify where interventions are most effective. The discussion leads to a new look on soil functions with increased attention to the spatial variability in soil conditions and the opportunities for change.

Session Land Functions 1

EVALUATION OF CHANGES IN SOIL QUALITY IN COFFEE AGROECOSYSTEMS (ECOLOGICAL AND CONVENTIONAL) WITH DIFFERENTS SCORES OF RESILIENCE TO CLIMATIC VARIABILITY IN ANOLAIMA, COLOMBIA

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Advancement of agroecological production systems is becoming an increasingly relevant aspect in Latin America. Particularly in Colombia, ecological coffee farming systems are being implemented, which seek to achieve sustainability of these agroecosystems. Despite the advancement of these production systems, however, there are many discussions at the academic community level regarding the impacts and possible modifications that conventional agriculture generates, compared to ecological agriculture, on relevant soil quality and health indicators. In this context, this research aimed to evaluate possible changes in soil quality indicators in coffee farming systems in Cundinamarca, Colombia. In order to achieve this, physicochemical parameters, enzyme activities of different biogeochemical cycles (urease, protease, β-glucosidase, acid and alkaline phosphatase), and diversity of functional groups of soil microorganisms (cellulolytic, phosphate solubilizers, and nitrogen fixing) were determined in ecological and conventional agroecosystems with previously reported resilience scores in response to climate change and variability. Univariate and multivariate statistics were applied to the data. PERMANOVA and Nonmetric Multidimensional Scaling (MDS) analyses were applied. Canonical Analysis of Principal coordinates (CAP) and Principal Components Analysis (PCA) were also applied. The results indicate that organic carbon, nitrogen, and boron, as well as urease, alkaline phosphatase, acid phosphatase, and β-glucosidase activities showed significant increases in ecological agroecosystems compared to conventional agroecosystems. MDS of bacteria and cellulolytic fungi and global functional groups analysis showed clustering in relation to management (ecological and conventional). Enzyme activities and diversity of functional groups of soil microorganisms were significantly affected by sampling season, which represents a relevant situation given current climate change and variability processes. Enzyme activities and cellulolytic microorganisms exhibited the greatest relationships with resilience parameters in response to climate variability, such as: biodiversity use, non-application of plaguicides and chemically synthesized products, main agroecological structure, and knowledge of soil microorganisms.

AFFORESTATION OR INTENSE PASTURING IMPROVE THE ECOLOGICAL AND ECONOMIC VALUE OF ABANDONED TROPICAL FARMLANDS – THE SOIL PERSPECTIVE

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The re-utilization of abandoned farmlands is an important option to mitigate the increasing pressures on natural forest ecosystems worldwide. So far research focused on the ecological, economic or social consequences of afforestation. To promote sustainable future land use not only afforestation but also restoration of agricultural potential should be considered. In our study area, the South Ecuadorian Andes, already 35% of the pasture land has been abandoned, mainly due to the invasion of the tropical bracken fern. As consequence further tropical rainforest is lost by slash-and-burn practice for the establishment of pastures.

Four restoration options for abandoned pasture land in the tropical Andes of Ecuador (afforestation with native alder or exotic pine, pasture restoration with low-input or intense management) were assessed based on a normalization of 23 ecological, economic and social indicators. These indicators include soil quality and biomass production as supporting ecosystem functions as well as carbon, climate and hydrology as regulating functions. Provisioning (timber and food) and social benefits (acceptance by the local peoples) were also considered.

Interestingly, averaged ecological and socio-economic indicators both favour afforestation of abandoned lands followed by pasture restoration with intense management as land-use option. Single indicator perspectives such as soil quality and biomass production favour pasture restoration with intense management.

Knoke, T., Bendix, J., Pohle, P., **Hamer, U.**, Hildebrandt, P., Roos, K., Gerique, A., Sandoval, M.L., Breuer, L., **Tischer, A.**, Silva, B., Calvas, B., Aguirre, N., Castro, L.M., Windhorst, D., Weber, M., Stimm, B., Gunter, S., Palomeque, X., Mora, J., Mosandl, R., Beck, E., 2014. Afforestation or intense pasturing improve the ecological and economic value of abandoned tropical farmlands. Nature communications 5, 5612-5612.

AREAS AT RISK OF CROP YIELD LOSSES IN EUROPE DUE TO LOW OR DECREASING SOIL ORGANIC CARBON LEVELS

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Soil Organic Carbon (SOC) is a key parameter to many soil functions and services, such as water retention, nutrient buffering and mineralization and soil biodiversity. Consequently, loss of SOC or low SOC levels might threaten soil quality and productivity. A significant share of the agricultural soils in the EU have low or critical SOC levels, which potentially can have a negative effect on crop yields. However, a clear direct relation between crop yield and SOC level is not straightforward. The objective of this study is to assess which arable areas are at risk of crop yield losses due to low or decreasing SOC levels. First we identified areas with low or decreasing soil organic carbon levels by modelling the SOC balance for arable land based on a combination of MITERRA-Europe, an environmental impact assessment model, and the soil carbon model Roth-C. We developed a new SOC balance approach for which we quantified the actual input of carbon (manure, crop residues, and other organic inputs) and the losses of carbon through decomposition. For the actual soil carbon stocks we used data from the LUCAS soil sample survey, which collected soil samples at about 22000 locations across the EU in 2009.Second we quantified the potential yield reduction effect due to low soil organic carbon levels, composed of a crop health effect, a crop establishment effect, and a soil water supply effect. For each of these effects we derived simple functions based on SOC content and some other soil and climate parameters. The overall yield reduction effect was quantified at regional level using the MITERRA-Europe database. Combining both results gives clear indications of which regions in Europe are most at risk. These results are relevant for policy makers for defining region specific strategies for reducing soil organic carbon losses.

COST ESTIMATE OF AGRICULTURAL LAND DEGRADARATION IN RUSSIA APLYING DIFFERENT METHODOLOGICAL APPROACHES

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Land disturbance leads to degradation of an entire landscape and loss of human life quality. Economic assessment of reasons and consequences of land degradation is highly important for development of the algorithm for optimal land resources management. Traditionally, in Russian Federation such assessment is performed by means of evaluation of land damage cost, caused by such degradation processes as: erosion, dehumification, contamination, salinization, etc. Thereby, the damage cost should include costs for recovery of the territory and the value of lost profits. There are developed and approved western methodologies for land degradation assessment, including those based on the conception of lost ecosystem services (Costanza et al., 1997, 2014) and on the cost comparison of activity and inactivity during degradation processes (von Braun et al., 2013). Land degradation assessment was carried out at two agricultural enterprises located in Moscow region by means of damage evaluation (federal Russian methodologies were applied), economic interpretation of ecosystem services and costs assessment of activity and inactivity during degradation processes. Water erosion (surface and gully), agricultural exhaustion and soil contamination are the major types of degradation identified in frames of this investigation. Land degradation decree of all soil types was assessed using approved in Russia 5-point grade scale. Land degradation level of the agricultural enterprises, assessed by erosion and agricultural exhaustion parameters, was higher than the level of degradation, evaluated by using parameters of soil contamination with heavy metals, oil compounds, and benzo(a)pyrene. NDVI value was used as one of the land degradation parameters for the cost estimation of activity and inactivity. Economic evaluation of services for maintaining ecosystems' life, for protection, for direct resources supply, and cultural services was performed. Sustainable land management systems were developed based on the obtained results of different types of economic assessment of land degradation at the agricultural enterprises.

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HOW SERIOUS IS SUBSOIL COMPACTION?

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Compaction is one of the soil threats as defined in the European Soil Strategy, however, it is not well known how serious this threat is. Questions raised are: Which soils are most at risk? What is the percentage of overcompacted agricultural soils? What is the impact of subsoil compaction on Eco System Services such as crop production and infiltration capacity?

We constructed a map on risk on subsoil compaction and measured actual subsoil densities at random points in The Netherlands. The subsoil compaction risk map is based on the soil map of The Netherlands and landuse maps. The soil map was used to determine the soil strength of wet and moist soil from the subsoil texture at a depth of 30 – 40 cm. This strength is compared with soil stresses exerted by wheel loads and tyre equipment of machinery typically used in all land uses presented in the landuse maps. We also considered the soil recovery potential based on clay content and soil organic matter (SOM) content. According the Dutch Soil Information System (BIS) about 30 – 50% of all subsoils in The Netherlands are overcompacted. Because more recent data was needed we randomly sampled 125 subsoils in the Netherlands. The impact of subsoil compaction on crop production was determined from a literature study and modelling results. Modelling was used to determine the impact of subsoil compaction on infiltration capacity and run-off during rain storms. We concluded that the subsoil compaction risk is medium to high on soils in agricultural use. About 45% of all subsoils are overcompacted. The impact on yields is in the range of at least 10% up to 35% depending on climatic conditions. Run-off can be doubled due to the reduced infiltration capacity by subsoil compaction. Results were evaluated in the perspective of subsoil compaction on European scale.

IMPACTS OF REVISION OF FERTILIZER POLICIES ON SOIL BALANCES OF COPPER, ZINC, CADMIUM AND LEAD IN EU-27

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Metal balances at regional level were calculated within EU-27 with the INTEGRATOR model. Main aim was to identify regions where cadmium and lead accumulation occurs, potentially affecting either soil, water or crop quality and regions where essential nutrients (zinc and copper) are depleted resulting in sub-optimal levels in soil and hence food or fodder. Results are presented for the current situation (data from 2010). Additionally two scenarios are included reflecting proposed changes in acceptable metal levels in fertilizers as listed in the EU regulation relating to fertilizer (EC No 2003/2003; scenario "revised legislation", or RL) and related to the proposed re-use of organic waste in agriculture (scenario 'End of Waste", or EoW).

Estimates of current (2010) metal balances shows that, at EU-27 level, current inputs exceed outputs, here defined as plant uptake and leaching. On average, accumulation rates at the EU level are near 50% of the inputs for copper and lead and near 35% for cadmium and zinc. On a regional scale however, differences in accumulation or depletion rates are large, and reflect differences in cropping systems, intensity of animal husbandry, soil type and climatic conditions. In case of the RL scenario a substantial increase of cadmium and lead loads across the EU is predicted while effects for copper and zinc are less pronounced, whereas the reverse is true for the EoW scenario. In the RL scenario, cadmium and lead loads increase on average twofold, whereas copper and zinc loads increase up to threefold in the EoW scenarios. Consequently, the soil metal content will increase, resulting in an increase in crop uptake and leaching, which potentially can lead to excess levels of metals in food or fodder (for cadmium) or excess levels in surface waters (for copper and zinc).

Session Land Functions 2

SOIL AGGREGATION AND SOIL ORGANIC CARBON REDISTRIBUTION IN A MEDITERRANEAN HILL-SLOPE AFFECTED BY FOREST FIRES, EROSION AND DEPOSITION

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According to the International Panel on Climate Change, there is higher degree of confidence that meteorological conditions associated to climate change will be propitious to increasing extreme events. Impacts on land degradation will also be manifested in bigger and more frequent wildfires. In the Mediterranean area, forest fires are a significant problem since they can change precious forest top soils with drastic consequences for important ecosystem services, such as water availability, plant growth and carbon sequestration. Erosion processes are also enhanced, increasing soil losses, together with its organic matter (OM).

Whereas it is well documented that wildfires produce significant changes on hydrological and erosion processes, the associated redistribution of OM has received considerably less attention. This research assesses this gap by studying the transport, stabilization and fate of organic C in a recently burned forest hill-slope (28/08/2014) at the Natural Park of Sierra de Espadán, municipality of Azuébar, Spain (39°50'45.11"N, 0°22'20.52"W). To this end, soil samples were taken from the foot's slope (depositional), middle part (transport) and top (eroding) at two depths (< 2 cm and 2-5 cm). Sediments were collected from four sediment fences constructed at the foot's slope, and together with soils samples, analysed with regard to the type of organic matter and its role in soil stability. Main objective of this work is to increase the understanding on the fate of organic C, in Mediterranean burned areas experiencing soil erosion and deposition, with special attention to the role of aggregation and disaggregation in redistribution processes. It is hypothesized that soil erosion exposes unburned OM to mineralization processes increasing organic C losses caused by wildfires in eroding sites, but can decrease such losses by sediment accumulation and burial in depositional sites.

MAPPING TEMPORAL CHANGE OF SOIL ORGANIC CARBON: IMPACTS OF DEFORESTATION IN TROPICAL HUMID AND DRY SOIL-LANDSCAPE

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Soil organic carbon (SOC) plays an important role in climate change regulation notably through release of CO2 following land use change such a deforestation but data on stock change levels are lacking. This study aims to empirically assess SOC stocks change between 1991 and 2011 at landscape scale with no prior knowledge and using easy-to-access spatially-explicit environmental factors. The study area was located in southeast of Madagascar, in a region that exhibit very high rate of deforestation and characterized by both humid and dry climate. We estimated SOC stock on 0.1-ha plots for 98 different locations in a 40,000 ha reference area covering both dry and humid conditions and representing different land cover including natural forest, cropland, pasture and fallows. We used the Random Forest algorithm to find out the environmental factors explaining the spatial distribution of SOC. We then predicted SOC stocks for two 30cm and 100 cm soil layer over a wider area of 400,000 ha. By changing the soil and vegetation indexes derived from remote sensing images we were able to produce SOC maps for 2011 and 1991. Those estimates and their related uncertainties where combined in post-processing stage using Minimal Difference Detection criteria to map significant SOC variations. Results show that the geologic variables, precipitation, temperature, and soil-vegetation status were strong predictors of SOC distribution at regional scale. We compared the SOC change map with published deforestation maps. Results confirmed a rapid loss of SOC within the first 5 to 10 years following deforestation, with a maximum loss of 13.7% and 18.7% for the 30 cm and the 100 cm layers respectively under humid climate. No significant variations were observed for the dry region. This study provides important inputs for national emission levels and solutions for a better integration of soil resource in land management policies.

FACTORS OF ABIOTIC ENVIRONMENT INFLUENCING DISTRIBUTION AND GROWTH OF PEAT BOGS IN FLYSCH MOUNTAINS, AS EXEMPLIFIED BY THE POLISH CARPATHIANS

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It has been often argued that the formation of peat bogs in the mountains is predominantly influenced by a humid climate. In mountain areas where precipitation greatly exceeds evaporation during the vegetation growth season, vast blanket bogs develop, covering ridges, slopes and the feet of the slopes. Although in many mountains precipitation during this season is greater than evaporation, bogs (especially of the raised type) do not cover all gently sloping areas and often develop only within certain landforms. By many authors for a bog to develop specific climatic, geological, geomorphological, hydrographic and hydrogeological conditions must be met. In the flysch Carpathians local hydrological conditions determined by land relief and structure are the most crucial factor in the development of peat bogs. Peat bogs of the Polish Carpathian Mountains demonstrate that bogs, irrespective of altitude, develop most frequently in concave landforms, where outcrops of poorly permeable rocks offer numerous low-capacity but stable outflows of groundwater that continuously humidifies the slopes lying below thus supporting the formation of habitats for hydrophilic plants. By analysing the relief of raised bogs in the Polish Carpathians some of the characteristics of bogs were examined which had not been previously addressed. Considering the geomorphological criteria for their occurrence, all the bigger bogs examined are of the valley type, although they developed within different mesoforms. Raised bogs with an extensive dome may develop across the range of altitudes of the areas under study, yet hollow landforms, such as spring niches, paleochannels, scarp bases of higher terraces and alluvial fan edges are favored in this respect. Stable outflows of shallow groundwater, which are the most intensive in such places, guarantee the development of low bogs, and then, as raised bogs expand, they keep the fringe area highly humidified.

A NEAR INFRARED SPECTROSCOPY METHOD TO MONITOR CHANGES IN C CONTENT OF SOILS IN RESPONSE TO LAND USE CHANGE

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The afforestation of semi-natural habitats is one of the most significant land use changes occurring in Scotland since the 1940s and there is a desire to quantify subsequent changes in the carbon stocks. A set of 39 profiles sampled bewteen 1961–1988 (183 soil horizons) were revisited to determine changes in C stocks resulting in a set of 227 resampled horizons. Bulk density is a key component in the calculation of C stocks but was not measured during the original sampling, therefore, we developed and applied a near infrared (NIR) spectroscopy method to quickly and non-destructively predict soil Db of the original (and archived) soil horizons. Calibrations were developed by regressing laboratory derived Db values against NIR spectral data of a set of 118 recent soil samples profiles using modified partial least squares regression (with a second derivative math treatment and SNVD scatter correction). Validation on a test set of 86 resampled forest soil samples showed that NIR could successfully predict Db of forest soils (r^2 predicted vs. measured Db of 0.81, standard error of prediction of 0.26 g cm^{-3}). A further approach was taken to optimize the accuracy of the predictions and involved the application of calibrations previously developed —using spectral data from soils within the National Soils Inventory of Scotland— to predict Db of archived and recent forest soils split in two sets according to their carbon content. Standard errors of prediction were 0.034 g cm^{-3} and 0.284 g cm^{-3} for forest soils with carbon content >37% and <37%, respectively. NIR successfully predicted Db and predictions derived from this work helped demonstrate that long-term afforestation of soils leads to an increase in soil carbon that can largely be accounted for by the increase in thickness and carbon content of the litter layer.

CHANGES IN SOIL ORGANIC CARBON STOCKS AT THE EUROPEAN SCALE DUE TO CHANGES IN CLIMATE, LAND USE AND MANAGEMENT PRACTICES

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Soils are an important carbon stock: more than twice as much carbon is held in soils as compared to the storage in vegetation or the atmosphere. Soil organic carbon (SOC) stocks are dynamic and changes in land use, land management and climate all have significant impacts. Both the European Commission (EC) and the Intergovernmental Panel on Climate Change (IPCC) identify the decline of SOC worldwide as an environmental risk that undermines not only soil fertility and productivity and hence food security, but also the progressive stabilisation and subsequent reduction of atmospheric CO2 concentration levels. Changes in agriculture, forestry, grassland and peatlands greatly influence the organic matter stock and loss.

The SOC stocks across the EU were quantified for agriculture, forestry and peatlands under different land use and management scenarios taking into account climate change and using a coupled regional land balance. Abolishing permanent grassland would have a negative effect on SOC stocks, which at the EU level can be quantified in a 30% loss. Promoting the afforestation of 10% and 25% former set-aside land in the EU-15 would reduce the loss of SOC stock by 2030 by 19% and 65% respectively compared to conversions to arable land. An increase of the current afforestation rates by 2% would result in a 10% increase in carbon stock levels by 2030.

Land use and climate change have a significant influence on SOC stocks across the EU-27. Larger variations between Member States in Europe than between scenario options stem from regional differences in bio-geography, soil types and climatic regimes.

EARTHWORMS ARE PLASTIC TRANSPORTERS

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The increase of plastic waste has worldwide let to strong environmental problems. Attention is mainly focused on microplastics in the aquatic ecosystem whereas studies on microplastics in agricultural soils – as a degradation product of plant protecting plastic folia - are missing. In spring 2015, we studied the effects of microplastics on the mortality and behaviour of earthworms under laboratory conditions over a period of 2 weeks. We tested mortality rate and fugitive behaviour of *L. terrestris* in a column experiment with a litter layer on the top polluted with 10 concentrations of microplastics ranging from 0-57% (4 replicates).

Earthworms of all treatments showed a high survival rate of about 92%. Even the highest concentration did not lead to a significant increase of the mortality. However, the earthworms avoided the litter at the treatments with concentrations > 28%.

In a second experiment we excluded avoiding behaviour and tested survival rate and microplastic intake of 3 earthworm species (anecic, epigeic and endogeic) in petri dishes with litter or soil that were polluted with 5 concentrations of microplastics (0, 7, 28, 45 and 60%) over a period of 5 days. The survival rate was high for all species and in all treatments (84-92%). The concentration of the microplastics in the earthworm casts increased with the concentration in the litter and varied between 5-30%.

The effect of incorporation of microplastics into the soils by earthworm cast and the potential for leaching and groundwater contamination should urgently be studied.

Session Land Functions 3

HOW DO SOIL PROPERTIES CHANGE AFTER LAND ABANDONMENT IN MEDITERRANEAN AREAS?

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As a result of global climate change and land use changes, many ecosystems are currently affected by changes on several temporal and spatial scales. Different studies have indicated the impact of afforestation, on the soil properties dynamics but, so far, none has covered the Mediterranean mountain areas. The MED-AFFOREST project aims to gain more insight into the discussion by exploring the following central research questions: (i) What is the impact of afforestation on soil properties?, and (ii) how do soil properties change after land abandonment? The main objective of this study is to assess the effects of afforestation on physical and chemical soil properties, and compare them to adjacent areas without trees, meadows, natural revegetation areas (secondary succession) and with native forests. A field work campaign was carried out in September 2014 to collect soil samples at different depths at eleven microsites. We systematically collected top soil samples (0-10 cm) and deep soil samples (10-20 cm). These properties were analysed: (i) soil texture, (ii) bulk density, (iii) pH and electrical conductivity, (iv) total SOC, (v) total nitrogen, (vi) organic matter, and (vii) CaCO3. Soil water properties were estimated using pedotranfer functions. Analysis of variance was used to compare the differences among the microsites, and principal component analysis (PCA) was also performed to determine first correlations among the measured variables and to elucidate major variation patterns in terms of microsites. Our results showed that secondary succession and afforestation soils showed a slight recovery in some soil properties compared with bare areas and cultivated soils. Nonetheless, these values are still low compared to the natural area, reflecting that 50 years after land abandonment and afforestation practices was not long enough to achieve a significant recovery in soil properties. Implications of land use changes and afforestation practices on soil properties will be discussed.

MEDITERRANEAN LANDSCAPE DYNAMICS: SOIL FORMATION PROCESSES LONG-TERM

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Soil formation is a complex process that depends on factors such as bedrock, climate, relief, vegetation and time. Despite of the great effort dedicated to explore these processes, little is known there is not a precise about the quantitative relationship between geomorphology and soil formation, especially on long timescales. In order to understand this complex interaction is important to investigate some quantitative aspects of the processes that drive pedogenesis. The integration of quantitative aspects by means of modelling will help us to understand better the soil formation upscaling this information at large scales of time. In this study the effect of aspect and relative elevation on long- term soil formation has been studied on two converging slopes. The geometry generates microclimates that can structure ecosystems and affect depth and surface processes regimes.

In our study area, located in Sierra Morena, in Cordoba, S Spain, we studied 10 soil profiles along a catena distributed in various topographic conditions: plateau area, north and south facing slope. These profiles were sampled each 10-20 cm depth in order to study the quantitative differences in physical and chemical soil properties. A new, spatially explicit model is presented of water infiltration and redistribution, temperature coupled to soil forming processes as a function of properties such as topographical variables, like aspect, slope, climate variables and vegetation. This model is based on a simple soil water balance model and runs at a daily time step. As paleoclimate data for rainfall and temperature is generally only available at the yearly or seasonal time scale, a weather generator was used in order to generate the necessary input data. Model output, for example mean annual water percolation, are then compared against field observations to evaluate whether the model can explain important soil properties, such as for example total weathered soil depth or texture. This model allows to compare for different topographical positions the importance of water and energy fluxes, erosion and soil formation and incorporate in a simple way their interactions quantitatively.

RESOLUTION EFFECTS ON FEEDBACKS BETWEEN SOIL REDISTRIBUTION AND LAND USE CHANGE IN THE GUADALHORCE VALLEY, ALORA, SPAIN

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Landscape processes such as erosion by water and ploughing, are related to land use changes. They are controlled and influenced by multiple bio-physical and socio-economic driving factors, resulting in a complex multi-scale system. Consequently in landscapes where water driven and or gravity driven processes are very active, land use changes should not be analysed in isolation without accounting for both on-site and off-site effects of these landscape processes. To investigate the interactions between land use, land use change and landscape processes, a renewed case study for the Álora region in southern Spain is carried out, Starting from a baseline scenario of land use change, different levels of interaction and feedbacks are added to the coupled model framework: i) effects of land use change on soil erodibility, ii) a perception feedback mechanism including the influence of farmers' perception of erosion features on the (re-)location of land use activities, and iii) a bio-physical feedback mechanism where bio-physical restrictions resulting from landscape processes. Quantities and spatial patterns of both land use change and soil redistribution are compared between the baseline scenario without interactions and with each of the interaction mechanisms implemented consecutively. All as a function of spatial resolution.

On-site land use changes triggers major off-site soil redistribution dynamics. These off-site effects are attributed to down slope or downstream changes in sediment transport rates and or discharge caused by changes in surface characteristics. This study provides insight into the interactions between different processes at different spatial and temporal scales combining biophysiscal and socio economics drivers within landscapes and the influence of different feedbacks on the landscape development. The linked model representation and calibration and validation of the coupled modelling system is a major difficulty. Rather than focusing on detailed disciplinary processes within the sub-systems themselves, specific research focussing on the interactions between sub-systems is needed to better understand the importance and representation of the dynamics in landscapes, especially in the context of spatial and temporal resolution and extent.

LORICA: A NEW SOIL-LANDSCAPE CO-EVOLUTION FRAMEWORK

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Soils and landscapes develop in tandem. Soil development changes erodibility which affects geomorphic processes, and erosion and deposition affect soil development. This co-evolution is sometimes dominated by mainly vertical pedogenic processes, sometimes by mainly lateral geomorphic processes, but most often by both at the same time. Either way, a full understanding of the effects of land use and climate change on storage of carbon in the landscape, on geo- and pedodiversity and on agricultural productivity requires a joint consideration of landscape dynamics and soil dynamics.

We present a recently developed soil-landscape model, LORICA. The model manipulates a digital landscape (DEM), in which for every cell a user-specified number of soil layers exists. Per layer, soil properties such as the mass of various texture classes and organic matter are stored. Pedogenic processes such as bioturbation, clay translocation and weathering affect these properties within and between layers. Geomorphic processes such as water erosion and deposition, and tillage affect these properties for the top layers between different grid cells. We illustrate the interface and the working of the model with several key example outputs such as maps of soil properties, timeseries of sediment export and transects through the evolving digital landscape.

It is foreseen that the model is not only useful to visualize and evaluate pedological and geomorphological hypotheses, but also as a robust landscape-scale framework in which other processes or variables can be simulated. This could include ecological modelling of vegetation and biodiversity development and assessments of the effect of historical or future land use change on soils and landscapes.

DIGITAL SOIL MAPPING OF AN ARGENTINIAN PAMPA REGION USING STRUCTURAL EQUATION MODELLING

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The most productive soils of the Argentinian Pampas are Phaeozems formed over loess-like sediments. Soil maps of this region were developed through conventional soil mapping, but the poor updateability of these maps, the lack of uncertainty information and the demand of high spatial resolution incite the application of Digital Soil Mapping (DSM) as an alternative approach. However, current DSM methods are highly empirical and have difficulty to predict many soil properties simultaneously, while preserving relationships between properties and including pedological knowledge. Therefore, we investigated the use of structural equation modelling (SEM), which has not yet been applied in DSM. SEM integrates empirical information with mechanistic knowledge by deriving model equations from known causal relationships, while estimating the model parameters using the available data. It distinguishes between endogenous and exogenous variables, where, in our application, the first are soil properties and the latter are external soil forming factors (e.g. climate, relief, organisms). We applied SEM to a 22,900 km^2 region in the Argentinian Pampas. First, we identified the main soil forming processes and main soil properties involved. Next, we incorporated these processes and properties in a conceptual model and converted this to a SEM graphical model. Finally, we derived the SEM equations and implemented these in R code. The model was calibrated using a dataset of 350 soil profiles and environmental covariates. After calibration spatial predictions were made of over 12 soil properties, among others base saturation, thickness and organic matter content of the A horizon, and presence of natric and E horizons. We compared maps obtained with SEM and regression-kriging DSM using a validation dataset of 100 soil profiles collected through stratified simple random sampling. This allowed to quantify the accuracy of both prediction methods and test whether accuracy differences were statistically significant.

EXPERIMENTAL AND NATURAL CHANGES IN SEMI-ARID VEGETATION PATTERNS AFFECT RUNOFF PRODUCTION AND SHRUB-HERB INTERACTIONS

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Introduction: Semi-arid regions are under risk of degradation following unsustainable land-use and climatic variability. The relations between drivers, vegetation structure, and runoff were studied in a long-term experiment in a patchy semi-arid northern Negev shrubland, an area under seasonal grazing for decades. Runoff was measured in 4m x 16m plots for over 20 years after initial manipulations including top-soil scraping, herbicide spraying, and mowing. We used a time-series of landscape photographs to assess changes in shrubs and herbaceous vegetation cover, and to examine their effects on connectivity and runoff production. Ten years after the manipulations, consecutive dry years in 1999 and 2000 caused widespread shrub mortality, resulting in further change in vegetation patterns.

Results: biocrust-covered surface in the inter-shrub (source-area) cover and connectivity controlled runoff production in the first 8 years of the experiment, with significant differences between treatments. Vegetation pattern was based on shrub patches with herbaceous vegetation appearing mostly within shrub patches. 15 years after the manipulations, source-area cover and runoff production had decreased substantially, and their correlation has weakened. Cover by herbaceous plants was no longer dictated by shrub vegetation, and differences among treatments became very small. Eight years later, herbaceous and shrub cover were negatively correlated, signifying suppression of shrub recruitment and growth by the herbaceous vegetation that led to a shift from shrubland to grassland.

Conclusions: In the shrubland state, vegetation cover and patchiness control runoff generation and rain use efficiency. The shrubland structure disintegrated within two decades following secession of grazing, while mowing hastened the shift. The drought-driven shrub mortality event played a significant role in the structural shift, by decoupling the herbaceous from the shrub vegetation. Resource leakiness and structural connectivity are significantly lower in the current grassland state.

Theme 6
Climate Change

Keynote
Pete Smith

SOILS AND CLIMATE CHANGE

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Climate change has thrust soil science to the forefront of policy relevant international science, and soils are also prominent currently because of the International Year of Soils in 2015.

Climate change has impacts on soils. Increasing temperatures will tend to increase decomposition but this will be limited where the soil water balance becomes very low. Where increasing temperatures increase net primary production (NPP), carbon inputs to the soil may increase which will work to decrease the direct impact of climate change on soils and may increase soil carbon. Results from modelling studies will be presented to show how climate change is projected to change soil carbon stocks in Europe over the next 75 years, and how the projections have changed over recent decades. Overall, global mineral soil carbon stocks are projected to increase, though there are regional variations. There is still disagreement over the temperature sensitivity of soil carbon decomposition. Implications of different temperature sensitivities will be discussed.

As well as soils being affected by climate change, improvements in soil management can be used to reduce greenhouse gas emissions or increase soil carbon stocks. Soil management can therefore be used as a climate mitigation option. Results from a recent global analysis of greenhouse gas mitigation options in agriculture, conducted for the IPCC Fifth Assessment Report, will be presented, showing that there is significant potential for soils to mitigate GHG emissions, but that the realisation of this potential will depend on the price of carbon. Drawbacks of using carbon sequestration as a mitigation option will also be discussed.

Keynote
Ingrid Kögel-Knabner

UNDERSTANDING ORGANIC MATTER SEQUESTRATION FOR SUSTAINABLE MANAGEMENT OF SOILS

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The amount and type of organic matter (OM) accumulated in soils is controlled, among other factors by intrinsic soil properties, specifically soil texture and the associated aggregate structures. Soil development leads to the formation of aggregated structures composed of a highly complex mixture of different mineral and organic constituents. The resulting soil type specific carbon sequestration can strongly be affected by soil management, varying greatly with the type and intensity of land use. The processes of formation and stabilization of OM through organo-mineral interactions in aggregated soil structures are controlled at the sub-µm scale. Understanding the binding of OM in these fine soil structures is thus key to elucidate the biogeochemical soil processes that are part of the carbon cycle as well as to evaluate the effects of soil management on the C cycle. I will discuss the state-of the art, open questions for understanding these processes and how we can approach them by combining novel analytical techniques with innovative experiments.

Mechanisms for the accumulation of organic matter in labile and stable pools
Separating soil samples into fractions according to particle-size and/or density has increasingly been used as a technique to differentiate particulate OM derived from plant residues and OM associated with minerals. Characterization of the isolated fractions then allows to investigate the mechanisms behind OM stabilization and the association of organic materials with the mineral matrix. Long-term stabilization of labile compounds, especially polysaccharides and proteins shows the importance of active stabilization mechanisms. Some consensus has been reached that the process types which determine long-term stability and lead to long turnover times of soil OM are spatial inaccessibility (due to aggregation) and chemical (sorptive) interactions with mineral particle surfaces and metal ions. Recent results show that OM is associated with only a limited proportion of the total clay-sized mineral particle surfaces (Vogel et al., 2014). It remains to identify the reactive part of the mineral surfaces in soils in order to quantify the OC sequestration potential of a soil. This is specifically important because sequestration in the clay fraction does not only affect OC but also N turnover in soils, as C and N mineralization are closely coupled processes during the decay of plant residues on or in the soil. However, it seems that they are decoupled in the mineral-associated fractions of the soil, as the interactions of both C and N containing components with the mineral matrix strongly modulate the mineralization dynamics (Bimüller et al., 2014).

Contribution of different mineral components to OM sequestration in soils
Observations of matured soils and the study of chronosequences in the field provide many valuable insights into soil formation and development over long time scales. However, these studies are limited by the availability of suitable field sites, natural heterogeneity in e.g. parent material and environmental conditions and uncertainties in the development history. A novel approach is therefore to perform carefully designed laboratory studies with the goal of understanding a specific process under simplified conditions (Pronk et al., 2012). We designed

an artificial soil incubation experiment, and used extensive interdisciplinary characterisation covering both soil physical and chemical properties, and the establishment and functionality of a microbial community to elucidate the effect of mineral composition and charcoal presence on the formation of a soil-like system. The type of clay mineral was decisive for microbial community composition and macroaggregation, but the amount and quality of the OM bound to the minerals was similar. The effect of phyllosilicate minerals seemed to become evident only in developed soil-like systems (Vogel et al., 2015). After several OM additions, clay minerals seem to be important for the differentiation of newly formed biogeochemical interfaces, whereas charcoal and iron oxides had no effect. The results found in early artificial soil experiments compared to the differences in more mature artificial soils indicated that freshly added pure minerals react differently compared to minerals already incorporated in a soil-like structure. The comparison of the artificial soils with the natural soil showed that the produced soil-like systems have OM dynamics comparable to natural soils and thus offer a valuable experimental system for further studies with defined mineral materials.

Management of soils and OM sequestration

Soil management, especially the type and intensity of land use, affect the carbon cycle to a high extent as they modify carbon sequestration in a specific soil. Understanding the binding of OM in the fine soil structures then provides a means to evaluate the effects of soil management on OM binding. Examples for such management-induced controls on carbon sequestration are tillage in cropland soils (Wiesmeier et al., 2014), grazing management in steppe soils (Kölbl et al., 2011), and paddy soil management for rice production (Kalbitz et al., 2013).

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Session Climate Change 1

SOIL FAUNA: KEY TO SOIL ORGANIC MATTER DYNAMICS AND MODELLING

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Soils play a fundamental role in carbon cycling, acting both as source of greenhouse gases (GHG) and sink (C sequestration). They are an essential element of global carbon models. These include abiotic parameters and microorganisms as central players yet hardly ever address soil animals. We point out that soil animals play a key role in carbon dynamics through their manifold activities such as digging, litter comminution or grazing on soil microorganisms. The composition of soil animal communities varies extremely with climatic, soil and landuse conditions, and the executed effects vary accordingly. We therefore propose that inclusion of site-specific animal activities should fundamentally improve the presision of global carbon models. Finally, we introduce the new COST Action ES1406 „Soil fauna: key to soil organic matter dynamics and modelling (KEYSOM)" which was brought into being in cooperation with a core consortium involving scientists from Austria, France, Germany, Ireland, Moldava, Russia, Spain, The Netherlands and the United States. The Action runs from 2015-2019. Central objectives are (1) to improve the communication between soil ecology and biogeochemistry, (2) to compile data on soil fauna – soil organic matter interactions and to identify existing data gaps, (3) to review existing global carbon models according to their potentials and limitations for including fauna effects, (4) to set up a meta-database for further analyses and (5) to disseminate the collected knowledge. Interested participants are welcome to contribute to this challenging activity

PLANT RESIDUE DECAY IN DIVERSE CANADIAN SOILS

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The decay of plant residues is tied to many ecosystem functions, affecting atmospheric CO_2, plant-available nutrients, microbial diversity, soil organic matter quality, among others. The rate of decay, in turn, is governed by a range of management, soil, and environmental variables, some of which may be changing in coming decades. To describe mathematically the importance of these variables across a broad scale, we established in 2007 a long-term study at 10 sites across the agricultural regions of Canada, spanning a range of climate and soil properties. At each site, barley straw enriched with ^{13}C (10 atom%) was applied at 200 kg C m^{-2} to soil microcosms (15 cm long, 10 cm diam.) inserted to 10 cm depth. All microcosms received additional unlabelled residue every fall (200 kg C m^{-2}) and ammonium nitrate every spring (40 kg N ha^{-1}). Hourly soil temperature was logged throughout the year at each site, and soil water content was also monitored during the frost-free period at one of the sites (Ottawa). Four replicate microcosms were removed from each site about 0, 0.5, 1.0, 2.0, 3.0 and 5.0 years after applying residue to estimate decay using isotopic analysis. At all sites, recovery of applied ^{13}C initially declined quickly – roughly half of the ^{13}C was lost within a year – but the rate of loss then slowed. After 3 years, the amount of applied ^{13}C remaining ranged from 13 to 28%. Much of the difference in observed loss among sites was related to variation in soil temperature. These findings illustrate the differences in initial decay rates across diverse sites, but suggest that prediction of decay rate can be improved with a simple algorithm based on cumulative thermal units. Future research, involving additional sites in an international network, will explore ways of including mathematically also other variables such as soil moisture and clay content.

DOES THE EFFECT OF EARTHWORMS ON THE SOIL GREENHOUSE GAS BALANCE DIFFER BETWEEN FARMING SYSTEMS?

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Earthworms are among the most important soil dwelling invertebrates and their ability to increase plant production has long been recognized. Their effect on the soil greenhouse gas (GHG) balance, however, is less clear. On the one hand, earthworm activity can stimulate carbon storage in soil through increased litter- and root production and through stabilizing fresh residue into stable soil organic carbon (SOC) fractions. On the other hand, studies have reported earthworm-induced GHG emissions. In two meta-analyses, we determined the effect of earthworm presence in agroecosystems on GHG emissions and plant productivity. Subsequently, we analysed whether the effect of earthworms on the soil GHG balance is likely to differ between farming systems. In the first meta-analysis we analysed 237 observations from 57 studies and concluded that earthworms significantly increase both CO_2 (+33%) and N_2O emissions (+42%), whereas they do not significantly affect SOC stocks. In the second meta-analysis, we analysed 462 data points from 58 studies and concluded that earthworm presence increases crop yield with 26% and aboveground biomass with 24%. The magnitude of these effects depends on type and rate of fertilization and crop residue management, as well as on earthworm density. In conventional farming systems, the role of earthworms is unlikely to be important as both yield and GHG emissions are dominated by high N application rates. Earthworm activity might be most beneficial in tropical subsistence farming systems, where yield effects are likely to be high and GHG effects low. Finally, for temperate organic farming systems there appears to be a tension between a potentially large benefit to crop yield on the one hand, and considerably increased GHG emissions on the other. We conclude that more research on the role of earthworms in these systems is most urgently needed.

EXPLORING THE RELATIONSHIP BETWEEN SOIL MESOFAUNA, SOIL STRUCTURE AND N_2O EMISSIONS

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The rising concentration of nitrous oxide (N_2O) in the atmosphere has significantly contributed to the greenhouse effect and the depletion of stratospheric ozone. Soils are a main source of N_2O, producing two-thirds of global emissions. Nitrous oxide production and emissions are to a large extent controlled by soil aeration, which is in turn influenced by soil structure (porosity, pore size distribution and pore connectivity to the soil surface). Soil mesofaunal species can affect these soil structural parameters and have been shown to either accelerate, delay, increase or decrease N_2O emissions. Interactions between species can even cause a dramatic increase in N_2O emissions, but it is unclear whether this should be attributed to trophic interactions or to their effects on soil structure. We hypothesized that mesofaunal interactions can affect N_2O emissions through changing the soil structure, and that this can be detected by using advanced X ray tomography (XRT). In a 70 day microcosm experiment with loamy sand soil and hay residue mixed in, we studied the effects of mites, predatory mites and potworms on soil structural properties (porosity, mean pore size, soil pore distribution) using XRT and linked this to soil N_2O emissions. The presence of potworms accelerated the peak of N_2O emissions by 10 days ($P<0.05$). During this first peak of N_2O emissions potworms also significantly increased the total number of pores ($P<0.05$), the mean porosity ($P<0.05$) and the number of pores ranging from 0.5–1.0 mm in diameter ($P<0.05$), which is consistent with their body width. Cumulative emissions after 70 days remained unaffected. We conclude that X-ray tomography can be used to quantify structural changes in the soil, and that potworms have an effect on N_2O emissions as well as on the soil structure at the relevant scale for gas diffusion.

APPLICATION OF A TWO-POOL MODEL TO ECOSYSTEM CARBON DYNAMICS UNDER GLOBAL CHANGE

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Soils contain about twice as much carbon (C) as the atmosphere and three times as much C as live vegetation, and soil respiration forms a main component of the global C cycle. The soil C pool may therefore play an important role in determining the rate of climate change, but its response to future atmospheric conditions is uncertain. Elevated atmospheric CO_2 concentrations, warming and nitrogen enrichment are known to affect plant productivity and soil microbial communities, with possible consequences for the turnover rate of soil C pools. In a previous analysis, we combined meta-analysis with data assimlation and showed how elevated CO_2 increases the decomposition rate of soil organic C in a one-pool model. However, two-pool models may better represent long-term soil C dynamics. We refit our data to a two-pool soil C model, and found that CO_2 enrichment increases soil C input rates, and decomposition rates of both fast and slow C pools. In addition, elevated CO_2 decreased the carbon use efficiency of soil microbes (CUE), thereby further reducing the potential for soil C storage. These findings are consistent with numerous empirical studies and corroborate the results from our previous analysis. We also present preliminary results from a two-pool analysis on the effect of warming and nitrogen enrichment on soil C dynamics. To rule out the possibility of artifacts associated with simplified model structures, we suggest that future data-assimilation efforts on soil C dynamics be done using multi-pool models with variable decomposition rates.

USE OF LIPID BIOMARKERS TO TRACE THE SOURCE OF SOIL ORGANIC CARBON IN AFFORESTED SOILS ACROSS EUROPE

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Afforestation projects have been developed to mitigate climate change by increasing carbon (C) stored as biomass and as soil organic carbon (SOC). Whereas C stored as biomass visibly increased after afforestation, changes in SOC stocks were rather variable among different studies. We need more information about the amount of SOC that is derived from planted forests in comparison to SOC originating from previous land use. Biomarkers are considered as a useful approach to trace the source of SOC. They are organic compound with a defined structure indicative of its producer, e.g. different plant species and tissues. In our study we used n-alkanes and base hydrolysis products derived from cutin and suberin monomers to trace the source of SOC in afforested soils. Suberin-derived compounds are supposed to be indicative for roots whereas cutin-derived compounds are indicative for leaves. Biomarker distributions were studied in soil samples of coniferous and deciduous forests, which were compared with control samples of cropland and grassland soils across six different sites in Europe. Using a principal component analysis it was possible to distinguish between the two forest types and between litter and root samples, based on specific types of alcanoic acids, alcohols and n-alkanes. With ratios of cutin- and suberin-derived compounds it was possible to separate possible sources of SOC (e.g. leaf litter, roots, O-horizon, mineral soil). These ratios indicated a higher contribution of roots to SOC compared to leaves. Using cutin-derived parameters we were able to distinguish leaves and roots and the two forest types. Soil samples were more difficult to differentiate. We can conclude that our biomarker approach was partly successful to separate potential sources of SOC. We only found minor traces of forest-derived SOC after afforestation. That might indicate weak afforestation effects on SOC sequestration or transformations of biomarkers after entering the mineral soil.

Session Climate Change 2

CARBON NEUTRAL? CHANGES IN MINERAL SOIL CARBON STOCK UNDER OIL PALM PLANTATIONS DERIVED FROM FOREST OR NON-FOREST IN INDONESIA

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Sustainability criteria for oil palm production guide new planting towards non-forest land use histories on mineral soil, to avoid large carbon (C) debts caused by forest and peat conversion. Effects on soil C_{stock} of land use change trajectories from forest and non-forest to oil palm on mineral soils include initial decline and subsequent recovery, but modelling efforts and life-cycle accounting are constrained by lack of comprehensive data sets; only few case studies underpin current debate. We analysed soil C_{stock} (Mg ha^{-1}), soil bulk density (soil BD, g cm^{-3}) and soil C concentration (soil Corg, %) from 155 plots in 20 oil palm plantations across the major production areas of Indonesia, identifying trends during a production cycle on 6 plantations with sufficient spread in age. Plots were sampled in four management zones: weeded circle, interrow, frond stacks, and harvest paths; three depth intervals 0-5, 5-15 and 15-30 cm were sampled in each zone. Compared to the initial condition, increases in soil C_{org} (16.2%) and reduction in soil BD (8.9%) in the frond stacks zone, was compensated by decrease in soil C_{org} (21.4%) and increase in soil BD (6.6%) in the harvest paths zone, with intermediate results elsewhere. For a weighted average of the four management zones and after correction for equal mineral soil basis, the net temporal trend in soil C_{stock} in the top 30 cm of soil across all data was not significantly different from zero in both forest - and non-forest-derived oil palm plantations. Individual plantations experienced decline, increase or U-shaped trajectories. The 2% difference in mean soil C_{stock} in forest and non-forest derived oil palm plantations was statistically significant ($p<0.05$). Unless soil management changes strongly from current practice, it is appropriate for C footprint calculations to assume soil C_{stock} neutrality on mineral soils used for oil palm cultivation.

ON THE RISE AND FALL OF CARBON BALANCES IN A MANAGED HEATHLAND

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Traditional management practices in heathlands produce even-aged stands of *Calluna vulgaris*. Assessment of a chronosequence 0, 12, 19 and 28 years after vegetation cutting allowed for reconstruction of the Carbon (C) cycle during ecosystem development. The effect of 14 repeated annual droughts on this developing ecosystem was also assessed, using the long-term climate change experiment established on the oldest heathland stand. Carbon fluxes were determined through measurement and modelling of Heterotrophic Soil Respiration (R_H), Total Soil Respiration (R_S), Net Ecosystem Exchange (NEE), Ecosystem Respiration (R_E) and Gross Photosynthesis (P_G). The chronosequence exhibited an S-shaped recovery curve after disturbance, with two shifts between C sink and C source over 28 years. At 0 years, R_H from bare ground was the dominant contributor to C flux (0 year: 351 g C m^{-2} $year^{-1}$). As plant growth and P_G increased, the ecosystem became a C sink (12 year: -410 g C m^{-2} $year^{-1}$) but shifted back to a C source as plants aged (28 year: 120 g C m^{-2} $year^{-1}$). The annual drought ecosystem was also a C source (28+Drought: 70g C m^{-2} $year^{-1}$) although C loss was suppressed compared to the Control. There was no stand age effect on R_H. However, if microbial decomposition rates had increased, such as under warmer temperatures, the minimum C influx must also increase for an ecosystem to become a C sink (and vice versa). Therefore, R_H rates control the ecosystem C source/sink strength. Vegetation characteristics, such as growth rate, determine the curve dynamics and the annual drought predominantly affected these characteristics. This study type is crucial as a reality-check for carbon models, as many large-scale models assume constant vegetation C balances through time. This stationary assumption is not applicable for managed landscapes and this study emphasizes the highly non-linear C balance pattern across a three-decade timescale for a typical managed landscape in north-western Europe.

A ^{15}N TRACER EXPERIMENT SHOWS LONG-TERM STABILIZATION OF N DEPOSITION IN ORGANO-MINERAL COMPLEXES IN THE MINERAL SOIL OF A FOREST ECOSYSTEM: CONSEQUENCES FOR C SEQUESTRATION

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Practically all carbon (C) and nitrogen (N) accumulating in terrestrial ecosystems is stored in N containing organic substances. Consequently, the fate of N inputs, such as atmospheric N deposition affects the amount of C sequestered as a result of that N deposition. Crucial is the ratio between C and N in the sink pools of N and the stability of those pools. In 1992/93, ^{15}N was added to N deposition in a Scots pine forest with low and high N deposition. This study reports the results of the sampling 19 years. At that time, the retention of ^{15}N from the labeled deposition in woody biomass was small (< 2.0% of applied). Whereas initially after labelling the organic soil layer was the major ^{15}N sink, after 19 years the mineral soil (0-50 cm) contained the major part (28% of applied at low N deposition). Density fractionation of the organic matter in the mineral soil revealed that a large part of the ^{15}N was in the stable heavy-density fraction. This fraction consists of organo-mineral complexes with low turnover rates and CN ratios of 25 to 40. Ecosystem C sequestration as a result of the labeled N deposition was 14.7 and 23.3 kg C kg^{-1} N at high and low deposition, respectively. The vegetation contributed the most (37 and 41% of total) due to a low recovery but high CN ratio. However, the contribution of the organo-mineral associations in the mineral soil was substantial with 20% at both deposition levels. If this process of retention in this very stable fraction continues, it might strongly influence long-term C sequestration as a result of atmospheric N deposition.

ASSESSING THE POTENTIAL OF SOILS FOR CLIMATE CHANGE MITIGATION AND ADAPTATION IN WEST AFRICAN DRYLANDS

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Despite the recognition of soil as the largest terrestrial store of carbon, not enough emphasis is placed on its crucial role in climate change mitigation and adaptation strategies. Current investigation was designed to assess the contribution of soils to climate change mitigation and adaptation in the West African dry lands. Soil carbon sequestration was referred to as a strategy to mitigate climate change, while nutrient stocks were used as indicators of sustainable agriculture. The study sites are agro-ecological landscapes in semi-arid zones of Ghana, Burkina Faso and Mali, where the Land Degradation Framework (LSDF), a nested hierarchical sampling design, was used. In each landscape, a biophysical survey was conducted and soil samples collected using a sampling unit of 100 km^2 stratified into 16 clusters and 160 plots. Soil parameters were analysed using MIR spectroscopy. Results showed significant variations in soil organic carbon (SOC) stocks in both topsoil (0-20 cm) and subsoil (20-50 cm) in Ghana (Lambussie: 49±2.8 Mg C ha^{-1}; 40.4±1.9 Mg C ha^{-1}), Burkina Faso (Bondigui: 58.7±3.9 Mg ha^{-1}; 40.7±2.0 Mg C ha^{-1}) and Mali (Finkolo: 37.5±3.0 Mg C ha^{-1}; 28.7±2.0 Mg ha^{-1}) with significant depletion caused by land management in the topsoil at Lambussie and Finkolo. As for soil nutrients, total nitrogen stock followed the same trends as SOC both across sites and in managed lands with values ranging between 1.06±0.07 Mg N ha^{-1} (subsoil, Finkolo) and 2.0±0.1 Mg N ha^{-1} (topsoil Bondigui). Stocks of available cations not only varied across sites, but showed marked depletions in magnesium (Mg), potassium (K), phosphorus (P) and calcium (Ca) in the topsoil across sites, while only the subsoil at Finkolo revealed deficit in Mg and sodium (Na). These outputs provide new insights into the role of soils in mitigating CO_2 emissions and site-specific recommendations for resilient cropping systems in dry lands.

SUBSIDENCE AND CO_2 EMISSIONS OF PEAT SOILS IN AGRICULTURAL USE

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The area of drained peat soils in agricultural use in the European Union is about 3.6 million hectares. GHG-emissions of agricultural peat soils are 20 – 40 ton CO_2 per ha/year. This totals in the EU to 100 Mton CO_2-eq per year (the CO_2-emission of Belgium!). Peat soils are extremely vulnerable to climate change because the biological decomposition of peat strongly depends on temperature and in dry summers groundwater levels will lower and air and oxygen can enter deep into peat soils. We calculated that end of this century the oxidation and subsidence rates will be 1.5 – 2 times higher than at the moment. We expect in this century a subsidence due to peat oxidation in the western part of the Netherlands of 1.5 meters. These peat areas are situated well below sea level and the subsidence will more than double the impact of sea level rise. Effective and efficient mitigation and adaptation strategies are needed to minimize peat oxidation and so CO_2 emissions and subsidence and to increase the resilience of peat soils to climate change.

We will present an overview of the research in The Netherlands on subsidence and CO_2 emissions and ways to mitigate these and present possible adaptation measures. This includes the development and use of models to run climate scenarios and the use of infiltration via submerged drains to reduce CO_2-emissions and subsidence markedly. We include an overview on the European level and the role of European policy measures on reduction of CO_2 emissions.

SOIL CARBON STOCK IN SUB-OPTIMAL LAND DUE TO CLIMATE CHANGE ON DEVELOPMENT *CYMBOPOGON NARDUS* L. AT SIMAWANG VILLAGE, WEST SUMATERA, INDONESIA

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Simawang area is one of the critical areas (sub-optimal) that experienced drought from climate changes. Potential dry land belonging to sub-optimal in Simawang, West Sumatera, Indonesia not been fully utilized for agricultural cultivation. Simawang village, West Sumatera, Indonesia is formerly known as the rice barn, due to the climate change area is experiencing a drought, so the rice fields that were once productive now a grazing paddock because of lack of water. This study aims to calculate the soil carbon stock in Simawang village, West Sumatera Indonesia. The study was conducted in Simawang village, Tanah Datar regency, West Sumatera from October 2014 until December 2017. The study was conducted on sub-optimal land to be planted with *Cymbopogon nardus* L. (Sereh wangi in Indonesian language). Composite soil sampling conducted at a depth of 0-20 cm, 20 – 40 cm. Based on the depth of soil carbon stocks gained higher ground 6473 T/Ha at a depth of 0-20 cm at a depth of 20-40 cm. Efforts to increase soil carbon is expected to be cultivated through *Cymbopogon nardus* L. planting has been done.

ISRIC Session: Optimizing Soil Information Services for Solving Global Issues

SOIL DATA NEEDS FOR A GLOBAL FRAMEWORK FOR SOIL CARBON MODELLING

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Intergovernmental Panel on Climate Change (IPCC) Tier 1 methodologies commonly underpin project-scale carbon accounting for changes in land use and management, and are used in frameworks for Life Cycle Assessment and carbon footprinting of food and energy crops. These methodologies were intended for use at large spatial scales. This can introduce error in predictions at finer spatial scales. There is an urgent need for development and implementation of higher tier methodologies that can be applied at fine spatial scales (e.g. farm/project/plantation) for food and bioenergy crop GHG accounting to facilitate decision making in the land-based sectors.

Higher tier methods have been defined by IPCC and must be well evaluated and operate across a range of domains (e.g. climate region, soil type, crop type, topography), and must account for land use transitions and management changes being implemented. Furthermore, the data required to calibrate and drive the models used at higher tiers need to be available and applicable at fine spatial resolution, covering the meteorological, soil, cropping system and management domains, with quantified uncertainties. Testing the reliability of the models will require data either from sites with repeated measurements, or from chronosequences.

Here I present current global capability for estimating changes in soil carbon at fine spatial scales, and present a vision for a framework capable of quantifying land use change and management impacts on soil carbon, which could be used for addressing issues such as bioenergy and biofuel sustainability, food security, forest protection, and direct/indirect impacts of land use change. The aim of this framework is to provide a globally-accepted standard of carbon measurement, data infrastructure and modelling appropriate for GHG accounting that could be applied at project to national scales (allowing outputs to be scaled up to a country level), to address the impacts of land use and land management change on soil carbon.

NEW GRIDDED DATA SETS FOR GLOBAL SUSTAINABILITY STUDIES — WISE30SEC AND SOILGRIDS

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There is a growing demand for quality-assessed soil information in support of studies of environmental, societal and economic sustainability. Nonetheless, soil remains one of the least well described data in global land models and uncertainties remain large. To address this gap, with (inter)national partners, ISRIC is developing a range of derived soil products that take into consideration differences in user needs. This work is underpinned by a growing selection of quality-assessed, geo-referenced soil profiles that are managed in ISRIC's centralised database (WoSIS); both conventional and digital soil mapping approaches are being developed. The former consider the soil-geographical delineations of the Harmonised World Soil Database (HWSD) and taxotransfer procedures that draw on statistical analyses of harmonised soil profiles held in WoSIS. Unlike the HWSD, the forthcoming WISE30sec[a] product will include estimates of the uncertainty in the predictions (mean ± std) for 7 layers up to 2m depth. Complementary to these efforts, major progress has been made with the development and implementation of the Global Soil Information Facilities (GSIF), a framework for collaborative digital soil mapping. The initial global product (SoilGrids1km)[b] drew on analytical data for ~110,000 soil profiles and ~75 covariate layers representing soil-forming factors; global regression models were used to predict property estimates (mean and 90%-interval) to 2m depth. Subsequently, for Africa, predictions have been generated with significantly higher accuracy and spatial detail (SoilGrids250m)[c]. As GSIF serves as a framework for collating/harmonising soil data it allows for regular updates of world soil information, at user-defined resolutions (from 250m to 50km), using increasingly large data sets and evolving models. The international community can help to **improve the methodologies and products by submitting validation reports, sharing additional geo-referenced soil profile and covariate data and by expanding the present range of models, thus sharing ownership.**

[a] http://www.isric.org/projects/world-inventory-soil-emission-potentials-wise
[b] http://www.isric.org/content/soilgrids
[c] http://www.isric.org/content/next-generation-soil-information-system-africa-250-m-resolution-published

COMPARATIVE ANLYSIS OF OPTIONS FOR THE SPATIAL FRAMEWORK OF YIELD GAP ANALYSES: A FOCUS ON SOIL DATA

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Water-limited yield potential is the yield of an adapted crop cultivar when grown without nutrient limitations and biotic stresses effectively controlled, while yields can be limited by water supply during the growth period. To estimate the difference between water-limited yields and actual farmer's yields, the so-called yield gap, it is essential that information about soil properties that determine plant-available soil water is available. Recently, a high-resolution gridded dataset (AfSoilGrids, 250m and 1km resolution over 2m depth) has been developed, which provides the required information for Sub-Saharan Africa, indicating per gridcell the effective root zone depth (cm) and available water capacity (%v). Combined with weather and management data, this information can be used by crop models to simulate water-limited yields. The application of a high-resolution dataset might however be limited due to computation capacity and the limited capacity for collecting relevant local crop management data for the simulations and evaluating the simulations. To investigate the effects of different spatial coverage of soil information we compared several spatial frameworks, which differentiate in the degree of considered spatial variation in soil data. The basis of the frameworks is the climate zonation developed within the Global Yield Gap Atlas (www.yieldgap.org). Per climate zone one or more weather stations are identified. For sorghum in Burkina Faso and Ethiopia, crop simulations are carried out considering i) all soil data available per climate zone, and ii) all soil data available within a 100km buffer zone around the weather stations. Next simulations are carried out considering, based on harvested areas, the three most dominant effective root zone depth and available water capacity combinations per iii) climate zone and iv) buffer zone. It is hypothesized that, especially if weather stations are located in minor crop growth areas and for arid regions, simulated yields will differ significantly between the frameworks.

ARCHETYPAL ANALSYIS OF SOIL FERTILITY INDICES (SOIL TESTING RESULTS) AS BASIS FOR SOIL IMPROVEMENT STRATEGIES: EXAMPLE FOR THREE KENYAN COUNTIES

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To feed the increasing world population, food production on agricultural land should increase considerably. One of the major factors determining crop growth and crop yield is the soil fertility status of the rooting zone. Soil fertility comprises the chemical, physical and microbial characteristics of a soil. We state that from an agricultural, economic, environmental and sustainability point of view the soil characteristics should be in an optimal range. When the actual status of one or more soil characteristics deviates from the desired range correction towards the optimal status is recommended. SoilCares Ltd has implemented a mobile laboratory for soil testing using infrared technology in Kenya. This technology is quick, precise and affordable for smallholder famers. In 2014/2015 SoilCares Ltd has carried out three soil mapping projects in the Kenyan counties Busia, Uasin Gishu and Trans Nozia. About 4000 soil samples were analysed on the major soil characteristics. Results of the study show that soil fertility status is not optimal for most agricultural fields This confirms the necessity of field specific soil testing and fertilizer strategy. We derived different soil fertility archetypes using the full data set of 4000 samples. Each archetype turned out to have its own specific strategy of restoration, maintenance or lowering the status of organic matter, pH, P and K towards the optimal range. In contrast to general soil maps we found that even at a sub-location level there is a high variation in soil fertility archetypes. This might be caused aside geological traits by farm type and farm management. The resulting aggregated regional "archetype" maps can be used on a broader scale as a basis for county specific soil fertility policy actions or fertiliser blends market access planning.

ESTIMATING TOPSOIL ORGANIC CARBON STOCKS IN EUROPE USING GEO-REFERENCED HARMONISED TOPSOIL AND LAND COVER DATA

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At the European Union scale, the only stock estimates available were derived from harmonised national soil surveys data on OC content estimates combined with bulk density and rock fragment data. In this study, we propose baseline estimates of topsoil (0-20 cm) OC stocks in Europe for the year 2009. Predictions for 23 countries and seven main land cover classes were generated using 20,000 topsoil OC measurements and 200,000 land cover observations from the land use/cover area frame statistical survey (LUCAS). Several regression models were tested to predict OC content in mineral soils; whilst average OC measurement values were used for organic soils. A logistic regression model was built to predict the probability of a soil to be mineral or organic, and to thereafter classify an unknown location as organic or mineral topsoil. Whilst measurements of gravimetric proportion of rock fragment were available, bulk density values had to be derived by pedo-transfer rule. Values of stocks were calculated at 200,000 locations where land cover observations were available and then extrapolated to countries and land cover classes. A 95% confidence interval was calculated by bootstrap. The total estimate, for a 0-20 cm reference depth, is 38.3 Gt (CI: 34.9 -42.4 Gt). Our results showed that 35% of Europe's total OC stock are stored in Sweden and Finland. In addition, as far as land cover classes were concerned, woodlands were given as the largest topsoil OC pool in Europe, with a total of 20.6 Gt (CI95% = ± 7%). The baseline OC stocks are the first estimates derived from a harmonised soil and land cover database at EU scale. The re-conduction of the LUCAS survey in 2015 will allow up-dating the estimates and assessing the effect of a potential land cover change on topsoil carbon pools.

Poster sessions

Theme 1
Food Security – Posters

CADMIUM AND LEAD TRANSPORT ASSESSMENT IN THE SOIL AND PLANTS UNDER SEWAGE SLUDGE APPLICATION

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The transport and transformation measurement of heavy metals in the pilots of experimental woks is investigated in this study. Cd and Pb are considered as representatives of heavy metals in the region. One-dimensional transport is considered for measuring the transport in the soil depth. Agricultural lands of Varamin in the centre of Iran are chosen for the experimental works. Five pilots are filled with the silt-loam soil of agricultural lands. A 150 day period is selected for the irrigation of the pilots by the wastewater of Tehran-south wastewater treatment plant, rivers and canals. Samples are collected from the soil surface to the depth of 100 cm one day after the last irrigation. Five pilots with different patterns of irrigation are provided and several plants are cultivated within the pilots. Results show that the concentration of Pb and Cd increase in the surface layers and gradually reduces in lower depths. Soil properties don't have a decisive effect on the transport phenomena. It is concluded that the maximum absorption is accomplished by spinach and radish respectively. The application of the wastewater is not recommend for irrigation because of the low concentrations of residual heavy metals are appeared in the soil column and plants.

KINETICS OF ZINC DESORPTION FROM CALCAREOUS SOILS: INFLUENCED BY CONCENTRATION AND TIME OF POULTRY MANURE

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The addition of organic matter may be various effects on zinc desorption of soils. The rate of Zn desorption from soil surfaces into soil solution is a dynamic factor that regulates its continuous supply to growing plants. Four sample soils (A, B, C and D) were incubated with poultry manure at 10, 25 and 50 mg kg^{-1} for 30, 60 and 90 days, after incubation Zn desorption was studied via DTPA extraction. Results showed that simple Elovich, the parabolic double diffusion and the two constant rate equations adequately described Zn desorption from soils. Zinc desorption from treated soils increased with increase in application level of poultry manure, but after 90 days incubation, this increase stopped and even decreased as compared to the 60 days incubation. According to double diffusion equation, the rate of Zn desorption was rapid initially, nevertheless gradually declined with time. Generally, concentration of manure, time of incubation and soil properties (especially organic carbon) were affected on desorption of Zn.

ENHANCEMENT OF PHOSPHATE ACQUISITION AND DELIVERY TO PLANTS USING THE CYANOBACTERIUM *NOSTOC PUNCTIFORME*

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Microorganisms are integral to the soil phosphorus cycle and as such play an important role in mediating the availability of P to plants. Understanding the microbial contribution to plant P nutrition and the opportunities for manipulating specific microorganisms to enhance P availability in soil is therefore of considerable interest. We propose that the cyanobacterium *Nostoc punctiforme* plays a significant role in enhancing plant growth by enhancing phosphate availability. Further to this, its robust nature and competence to form symbiosis with a broad range of hosts, which potentially includes wheat and canola as well as rice, makes it a potentially more attractive option for commercial development over other bacterial species. The role *N. punctiforme* potentially plays in enhancing phosphate bioavailability to its host during symbiosis are possibly through the two following pathways: (i) phosphate is transferred through *N. punctiforme* into the host, (ii) phosphate is chelated from the silicates in soil where it is bound by extracellularly excreted bioactive enzymes. To determine the mechanisms facilitating phosphate trafficking by *N. punctiforme* to its hosts, we have produced mutants that are deficient of an imperative phosphate transport system component (PstB-) and mutants over-expressing the PstB system component, potentially resulting in respective phosphate deficient and over-accumulating phenotypes. The genetically manipulated N. punctiforme phenotypes are to be investigated for their capacity to alter cellular phosphate levels in *Geosiphon pyriformis*.

BENEFICIAL SOIL MICROBES REDUCE PLANT DISEASE, WITH IMPLICATED IMPROVEMENTS IN FRUIT FLAVOR PROFILES, NUTRITIONAL VALUE AND HUMAN HEALTH

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Microbial communities in the field are influenced by the properties of the soil and local environmental conditions at the given location. Plants exploit the available complexity and enormous diversity of microorganisms occupying these spaces. A healthy microbiome is crucial for plant health, growth and survival through the incumbent biotic and abiotic pressures. VESTA is a fermented product, which has been applied for decades on broad acre fields in the U.S. VESTA is known to be highly effective in disease protection for a range of crops in multiple environments. We tested VESTA against corky root rot of commercial Iceberg and Romaine lettuce grown on plots at eight separate field sites in Salinas between August and October 2014. Corky root of lettuce is an economically costly disease, and can cause between 30% and 70% losses in yield. At two of the Iceberg field sites, the diseased plants were decreased by more than 60% under VESTA treatment. Microbiome profiling revealed that VESTA treatment altered the presence and abundance of several different bacterial taxa. The family Sphingomonadaceae was among those that were higher in control samples compared to VESTA-treated fields. Several strains of *Sphingomonas* spp. have been shown to cause corky root of lettuce. Treatment with VESTA may alter local soil microbial communities through inoculation with VESTA-born microbes and / or treatment with VESTA might alter the soil microbiome by modifying abiotic properties of the soil itself. Soil health is essential for optimal nutrient uptake and improved fruit quality. I-Cultiver, Inc. is a consortium of leading plant and food scientists working together to determine the potential implicaations implications of superior soil biota foron improvements in fruit flavor, nutritional value and ultimately a healthier gut microbiome. Soil health is directly connected to food quality and human health.

QUANTITATIVE ASSESSMENT OF LINEAR SORGHUM RESPONSE FUNCTIONS TO COMBINED SALINITY-UREA

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Salinity and low soil N availability are both limiting factors for plant growth and yields. The objectives of this study were to quantitatively study the interactive effects of salinity-Urea and to compare two linear models. A randomized complete block factorial experiment with two factors of irrigation salinity (7 levels) and urea fertilizer (5 levels) with three replicates was conducted in the greenhouse. The shoot dry matters (Y) and the relative yield (Y_r) were measured at the end of growing season. The combined experimental effects of the two factors at all levels were then evaluated based on the LS and the LS-Dirksen models.

To compare the models outputs, the related statistics were calculated according to Homaee et al., (2002) including modeling efficiency, root mean square error, coefficient of determination and mean error. The R^2 and P-value were calculated by using an updated version of SPSS software.

The obtained results indicate that both models have the same P-values that are significant at 0.01 confidence level. The R^2, ME and RMSE values for the both models are almost identical. Therefore, they can successfully predict the relative yield when plant exposed to simultaneous salinity and nitrogen stresses. However, the statistics (CD=0.72) and (EF=0.82) in LS model were larger than the LS-Dirksen model, indicating a better performance for the LS model.

SOIL QUALITIES OR SOIL PROPERTIES? A NOVEL APPROACH FOR SOIL DATA TO ADDRESS FOOD SECURITY

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Population growth and climate change continue to threaten food security. Information on soil resources is essential to address food security in combination with climate change. Simulating food production under alternative climatic conditions requires quantitative data of the soil profile and a description of the spatial soil variability. We developed a novel approach for soil data that specifically focuses on the data requirements by mapping key land qualities like nutrient availability and water availability using regression kriging. This study is performed at the Nyando-Katuk Odeyo (Kenya) research site of the CGIAR research program on Climate Change, Agricultural and Food Security (CCAFS). Conventional soil surveys provide qualitative descriptions of soil variability and quantitative descriptions of representative soil profiles. An alternative, more cost effective, approach is digital soil mapping (DSM) resulting in quantitative, continuous maps of soil properties. Standard DSM often makes use of regression kriging and interpolates individual soil properties. However, simulations often require a description of the entire soil profile with a large number of soil properties. This makes regression kriging impractical. Like in standard DSM, the novel approach makes use of a limited number of field observations. However, instead of interpolating individual soil properties a limited number of land qualities are first derive from the individual soil properties. These land qualities are interpolated by regression kriging generating continuous, quantitative maps of nutrient availability and water availability. These maps now provide the basis for the simulation of food production. A SWOT (strengths, weaknesses, opportunities and threads) analysis gives an overview of the usability of land quality maps for food security studies. An improvement in the supply of soil data for addressing food security is made, because proposed analysis of land qualities is more efficient than the standard DSM based on individual soil properties.

EFFECT OF AGROSOL TREATMENT AND PHOSPHORUS LEVELS ON PEA PLANTS *(PISUM SATIVUM L.)*

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Two field experiments were conducted to evaluate the effects of phosphorus level and Agrosol treatment on pea (Pisum sativum L.) yield quantity and quality, under drip irrigation system, during 2012 and 2013 seasons. Experiments were carried out in the Research and Production Station, National Research Centre, El-Nobaria Site, Beheara Governorate, Delta Egypt. Phosphorus fertilizer was applied at rates of 0, 40, 80 and 120 kgP2O5 ha-1 before planted and Agrosol at three levels (0, 2, 4 and 6 mg L-1) as foliar spray. Plants were sprayed two times with Agrosol in intervals of 30 and 45 days from sowing. The obtained results could be summarized in the following:

Growth and yield parameters were significantly increased by increasing phosphorus levels. Dry weight, weight of 100 seeds and yield were significantly increased by increasing of Agrosol levels. The combination between phosphorus at 80 kgP2O5 ha-1 and Agrosol at rate 6 mg L-1 gave the highest growth and production as well as minerals composition (N, P, K, Fe, Mn, Zn and Cu) and protein content compared to other treatments. Agrosol fertilizer decreased soil pH and increased the availability of phosphors and micronutrients.

USE OF RGB AERIAL PHOTOGRAPHS FOR ASSESSMENT OF SOIL ORGANIC CARBON DISTRIBUTION IN AGRICULTURAL FIELDS

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For quantitative estimation of soil properties by means of remote sensing, often hyperspectral data are used. But these data are scarce and expensive, which prohibits wider implementation of the developed techniques in agricultural management. For precision agriculture, observations at a high spatial resolution are required. Colour aerial photographs at this scale are widely available, or can be acquired at low costs for example by using Unmanned Aerial Vehicles. Therefore, we investigated whether available aerial photographs can be used to estimate levels of organic carbon and their spatial distribution.

We selected five study areas, including 15 fields, within the Netherlands and Belgium that cover a large variance in soil type (peat, sand, loam and clay). For the fields of interest, RGB aerial photographs with a spatial resolution of 40 cm were extracted from a publically available data provider or acquired using an Unmanned Aerial Vehicle. Since the images originate from different sources and are potentially acquired under unknown illumination conditions, the exact radiometric properties of the data are unknown. Therefore, we used spectral indices to emphasize the differences in reflectance and normalize for differences in radiometry.

Regression analysis between a number of soil properties and the derived indices shows that organic carbon is the major explanatory variable for differences in index values, but the achieved accuracy is variable and depends on the soil type. Found relations do not hold for large regions, indicating that local models will have to be used, which is an issue that is also still relevant for hyperspectral remote sensing data.

With this research, we show that low-cost aerial photographs can be a valuable tool for quantitative analysis of organic carbon. Since a lot of data are publically available or can easily be acquired, this offers great possibilities for implementing these techniques in agricultural management.

EVALUATING RESOURCE USE EFFICIENCY AND STOCK BALANCES OF FERTILIZER INPUTS: THE EFFECT OF SOIL SUPPLY CAPACITY IN TIGRAY (ETHIOPIA)

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In Sub Saharan Africa crop productivity is generally low, which affects food security and livelihoods. The application of fertilizers is often seen as a straightforward way to improve crop productivity. In Tigray, our study area in Northern Ethiopia, local agricultural bureaus recommend to apply considerable amounts of fertilizers. Different indicators are available to evaluate application of fertilizers. We used 6 different indicators (Agronomic Use Efficiency, Value-Cost-Ratio, Recovery Efficiency, Capture Efficiency, Soil Supply Capacity and Partial Nutrient Balances) to explore trade-offs and interactions between efficiency, nutrient balances and the capacity of soils to supply nutrients. On-farm experiments were conducted for 4 years in 37 sites distributed over 16 different locations. The crops involved were wheat, teff and hanfets. Wheat appeared to be the most extractive crop. Correlations between Soil Supply Capacity and N-total, Recovery Efficiency and N-uptake were significant for all crops involved. Interactions between Soil Supply Capacity, Recovery Efficiency and Partial Nutrient Balance demonstrated a significant trend for wheat: soils with a higher Supply Capacity had lower Partial Nutrient Balances and higher Recovery Efficiency than soils with lower Supply Capacity. We concluded that a dynamic trade-off existed between nutrient stock sustainability and fertilizer use efficiency. As a consequence, achieving efficient use of fertilizer was at the cost of nutrient stock sustainability. In response to fertilizer application Soil Supply Capacity will change and consequently crop production systems move back and forth from more to less fertile states. The presence of such complex feedbacks requires Integrated Soil Fertility Management-strategies to arrive at a sound balance between efficiency and sustainability of fertilizer use. Within the context of Tigray these feedbacks are witnessed by the frequently heard statement that the use of fertilizers leads to "addiction" and by the long term sustainability of the traditional farming system.

FOUR YEARS OF FARMER EXPERIMENTATION ON SOIL FERTILITY IN TIGRAY, NORTHERN ETHIOPIA: TRENDS IN RESEARCH STRATEGIES

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Low crop productivity in Tigray is one of the causes of food insecurity. Interventions increasing productivity had only limited success and farmers often hesitated to adopt recommended practices. A participatory experimentation approach was followed to arrive at recommendations matching with local preferences, complexity and context. In total 16 groups of farmers were involved in a participatory experimentation process during 4 consecutive years. We hypothesized that groups based their research strategy on previous experimentation and systematically selected the more responsive treatments, achieving in this way progression. We monitored treatment selection of the groups by considering (1) the type of treatments selected, (2) the inclusion of responsive treatments of previous years, (3) the actual responses achieved and (4) the treatments perceived optimal by the groups. We found that (1) farmers based their strategy on outcomes of previous experiments, (2) in the second experimentation year an average response of about 85% for their best 3 treatments was achieved, (3) due to frequent changes in fields and crops this response was not progressive and stabilized around 70%, (4) the treatments considered optimal by the farmer groups achieved significant higher responses for straw than for grains, (5) over the four years of their involvement groups changed their strategy by more including combinations of organic and mineral fertilizers (from 20 % to 100% of the groups), (6) the inclusion of both solely mineral and solely organic fertilizers became less and (7) treatments suggested by the scientific team were only included for a longer period if these were sufficiently responsive. We concluded that the involved farmer groups followed a very rational context-rooted strategy and that defining research strategies in joint experimentation processes was a location specific and tailor-made task which required the involvement of farmers to deal with local preferences and context.

SOIL INFORMATION TO FEED THE AFRICAN SOIL, CROP AND PEOPLE

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The ongoing debate about improving food security in Sub-Saharan Africa (SSA) is about how to enrich its soils. A core challenge within the risk-averse smallholder farming systems prevailing in SSA is to judiciously combine mineral with bio-organic nutrient applications and close nutrient cycles to improve soil health, hence crop productivity, with high and preferably known yearly likeliness of direct return on investment. Adequate soil information (maps) will support extrapolation of crop response to management measured at few experimental site conditions to much wider areas, using validated models. The Africa Soil Information Service (AfSIS) project compiled georeferenced and standardised legacy soil profile observation and measurement data for over 12,500 sites (Africa Soil Profiles database; AfSP) to generate soil property maps for SSA at 1-km resolution over 2-m depth. Subsequently, with the AfSP database expanded to 18,500 sites combined with newly sampled topsoil data for 9,600 clustered sites and revised geo-statistical modelling, revised maps were presented with enhanced accuracy at 250-m resolution for physical (drainage, depth, gravel, texture, bulk density, EC) and biochemical (pH, CEC, exchangeable bases and acidity, organic carbon, nitrogen) properties. Soil water retention was next derived by using pedotransfer functions and effective rooting zone depth, for maize, by rules and thresholds established together with the Global Yield Gap Atlas (GYGA) project. These soil data were used in GYGA to model water-limited yield potentials, including temporal variation, in ten African countries. The resulting information reflects the site-specific crop demand for nutrients which, relative to nutrient supply from soil fertility effects, sets the reference to quantify nutrient deficiencies and thus efficiency and likeliness of crop response to nutrient additions. The collaborative work developed a consistent and updateable high-resolution soil information basis for agronomic modelling in support to both long- and short-term goals of millions of smallholder farmers.

IMPACT OF A LEGUME LIVING MULCH ON WINTER WHEAT YIELD AND ITS NITROGEN NUTRITION

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Sowing wheat crop in living mulch seems to improve cropping systems in some cases. Sowing cover crops in the previous crop can allow a strong biomass production in spite of short intercropping periods. Positive impacts on wheat such as nitrogen release (Bergkvist, 2003) or soil structure improvement (Carof et al., 2007) could be expected. In a field trials network in France, winter wheat was established directly on legumes living mulch which were mainly established in the previous crop. The impact of living mulch on wheat yield was variable, from -17% to +15% as compared to wheat managed as a sole crop. As living mulch was terminated in the wheat crop cycle, mostly in winter with herbicides, the impact on wheat yield has been on average positive. In one case, black medic showed a negative impact on wheat development at the end of winter. This cover crop did not stop growing in winter 2013/2014 that has been mild. It has not been enough suppressed by herbicides. For other legume species terminated in the wheat crop, we had neutral to positive impact of living mulch on wheat yield. Nitrogen supply to the crop seems to explain this trend. In one experiment, a mixture of three clovers allowed an increase of 10% of wheat yield, without modifying the optimum amount of nitrogen necessary to obtain the best yield. It is supposed that cover crops improved soil structure and helped to reduce waterlogging in a drained loamy soil during a rainy winter. We also had three trials in which the legumes living mulch stayed alive during the entire wheat crop cycle. Results varied depending on the situation. In one case, wheat was established late in autumn 2013 after a grain corn. Wheat establishment was poor. Wheat has not been able to suppress white clover development because it was not enough competitive for light. Cover crop decreased wheat biomass and nitrogen status from the stem elongation and yield by 17%. In another case, wheat has been drilled directly on Lucerne living mulch as compared to a control situation. The optimum yield was the same in any case but nitrogen supply from the soil+lucerne system to wheat was improved from 30 to 60 kg $N.ha^{-1}$ as compared to the control. In the last field trial with bird's foot trefoil living mulch, we got an increase of wheat yield. Birdsfoot trefoil dormant variety showed a small development in winter and in spring. Wheat crop was very competitive on this cover crop, except in July when wheat has become senescent. Due to rainy conditions, the cover crop produced much biomass (2.7 $t.ha^{-1}$ of dry matter) in July, before harvest. Some field trials are currently carried out by ARVALIS - Institut du vegetal in order to optimize living mulch practice and to assess its impact.

INTERPOLATION AND VALIDATION OF SOIL FERTILITY DATA IN THREE AGRICULTURAL COOPERATIVES IN COSTA RICA

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The analyses of the variability of soil properties through geo-statistical methods of interpolation represents one potential applicability of the Geographic Information Systems (GIS) to contribute towards the achievement of the goals of soil conservation and food security. Farmers, researchers and other interested stakeholders, can use this information to support their decision making process, optimize the right allocation of fertilizers and diminish the negative effects of the agriculture in the environment. In Costa Rica, the apparent "high implementation cost" and the lack of training and information have constrained the accessibility of these technologies to smallholders and medium farmers. In this study, we generated and validated maps of soil fertility variables (pH, exchangeable acidity, Ca, K, P and % saturation of acidity), in three agricultural cooperatives dedicated to the production of coffee and sugar cane in Turrialba, Costa Rica. For this, 138 soil samples were taken from 1011 hectares with a variable topography (altitude range 640-960 MASL). Maps were created through ordinary kriging interpolation, and then, they were validated through two methods: 1) cross validation (CV), using the original set of soil samples; and 2) field validation (FV), using an independent set of 15 samples. Correlation coefficient (r) and prediction efficiency (PE) were estimated for both validation methods between real and prediction values. The highest r values were obtained for Ca (0.78 and 0.66, $p<0.05$) and pH (0.87 and 0.83, $p<0.05$) when using FV and CV respectively. These variables also had the highest PE values for both validation methods. We concluded that the interpolated maps were useful for predicting the variability of soil fertility characteristics, particularly for Ca and pH. Available information about these variables has improved the decisions carried out regarding the management of soil fertility in this region, as applications of lime materials according to specific conditions.

A NEW AGRO-ECOLOGIC PARADIGM FOR FOOD SECURITY IN THE SUDANO-SAHELIAN ZONE

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To face the soil degradation and the loss of fertility in the Sudano-Sahelian zone, more agronomists think of a new paradigm bases on agroecology. The agroecological revolution provides scientific bases and new standards to address the functioning of the agrosystems. In particular the introduction of conservation agriculture with the diversification of cultures and the use of traditional mixed cropping that mimic natural processes is well adapted to small farming units.

The main thrust of this research is to provide a diagnostic of these proposals as a function of the environmental conditions (pedoclimatic conditions) and the peasant farms characteristics within the framework of the BIOSOL multidisciplinary scientific program (soil science, agronomy, geography) which aims at understanding and promoting agro-ecological practices among peasant communities in Burkina-Faso.

In this work, the pedological, geochemical and microbiological characteristics of agricultural soils were investigated together with the study of both traditional and agroecological agricultural practices in order to make an inventory of soil fertility and crop yields in contrasted pedo-climatic contexts and for different cultural systems.

The effects of agricultural practices based on some Eco-Systemic Services on crop yield and several soil fertility indicators whether physical (water transfer functions), chemical (e.g. nutriment availability) or biological (soil biomass, community structure and activity of micro-organisms) were investigated in parallel with the determination of various pedo-physical and chemical parameters.

Results from this study showed that some Eco-Systemic Services in the soil ecosystem have significantly influenced the crop yields, soil fertility including the functions of soil microbial community and hence probably its composition. This may indicate that the efficiency of soil quality restoration is under the control of many factors which could be further investigated.

YIELD RESPONSES TO NUTRIENT MANAGEMENT AND SOIL QUALITY IN LONG-TERM FIELD TRIALS IN CHINA

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Quantitative understanding of yield responses to nutrient management and soil quality is key to improving the productivity and sustainability of cropping systems. Here, we quantified the effects of fertilizer (NPK) inputs and soil properties on yields of wheat, maize and rice, using a large database of long-term field experiments conducted in 21 agro-ecological stations in China. Each experiment had three treatments: unfertilized control (CK), optimal-fertilized and farmers' practice.

Soils differed greatly between sites. Soil pH ranged from 4.4 to 9.1, soil organic carbon (SOC) from 1.8 to 37.4 g kg^{-1}, and the mean C/N ratio was 9.5±1.3. Mean SOC contents were higher in fertilized treatments than in the CK treatments. Mean pH showed the opposite trend. Fertilized treatments had much higher yield than CK treatments, on average 3.5, 4.5, and 2.9 ton ha^{-1} yr^{-1} for wheat, maize and rice, respectively. Interestingly, crop yields were similar in farmers' fields and nearby experimental fields, and also showed similar variations between years, suggesting that the management by farmers was as good as at the experimental stations. Wheat and maize yields were significantly ($p<0.01$) related to N fertilizer inputs and to soil P status. Rice yields were significantly related to both K fertilizer input and total soil K; most of the rice is planted in south China where many soils are deficient in K. Increasing N and K inputs increased yield responses of maize and wheat to P input, suggesting positive interactions between N, P and K inputs. These interactions were negative in rice.

In conclusion:

- Yields were 2.8, 2.1 and 2.0 times higher in fertilized treatments than CK for wheat, maize and rice, respectively.
- Difference in mean yields between experimental fields and nearby farmers' fields were not significant.
- Fertilizer applications increased SOC content and decreased soil pH.

DIGITAL MAPPING OF SOIL NUTRIENTS FOR THE REPUBLICS OF BURUNDI AND RWANDA

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Lack of awareness of various soil fertility constraints, including soil acidity and nutrient deficiencies, is a major limitation to developing sound liming and fertilizer recommendations in sub-Saharan Africa, including Burundi and Rwanda. Detailed maps of soil nutrient concentrations and soil acidity can help to alleviate to identify areas with soil fertility constraints. This information can be used to better target fertilizer applications for a more balanced provision of crop nutrition. For this purpose, maps of primary (P, K), secondary (Ca, Mg, S) and micronutrients (Cu, Zn, B), as well as pH, soil acidity (Al+H), effective CEC and organic matter were generated for the 0-20 cm soil layer by means of digital soil mapping using random forest models at a 250 m spatial resolution. The models were calibrated with over 1000 field observations on soil fertility parameters for each country. Over 100 environmental GIS data layers were used as covariates in the models. These included land cover, soil, climatic maps and MODIS satellite imagery. Prediction accuracy was quantified with 10-fold cross-validation and prediction uncertainty was quantified by the 90% prediction interval. For Burundi, the models explained between 12% (K) and 49% (organic matter) of the variation in the observed data. For the micronutrients, the explained variation was 39% for Cu and B, and 20% for Zn. For Rwanda, the models explained between 21% (K) and 46% (Ca) of the variation. The explained variation for Cu was 41%, for B 39%, and for Zn 25%. Covariates related to climate and terrain proved to be the most effective predictors. The soil maps present a significant update of the currently available nutrient maps and can support soil fertility management programs, including better targeted fertilizer and lime recommendations, regional quantification of requirement amounts of balanced fertilizers for agro-dealers, and information for policy decision making.

A QUANTITATIVE APPROACH ON VISUAL SOIL ASSESSMENT: VALIDATION AND REPRODUCIBILITY

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Many agricultural soils around the world suffer from soil structure deterioration and a decline in soil organic matter, due to e.g. land use change or intensive farming practices. Visual soil assessment (VSA) can play an important role in monitoring soil quality and identifying soils that are in an early stage of degradation. VSA is becoming increasingly popular among farmers, organisations and companies aiming at sustainable crop production. Current methods for VSA, however, are subjective and have not been fine-tuned for differences between soil types. We aim to develop and validate a VSA method that is based on quantitative visual observations. Also we assess the reproducibility of this method when used by different types of observers. For validation of visual observations, we performed VSAs and took soil samples at 26 dairy farms (one field on each farm), located on sandy, clayey and peaty soils in the North of the Netherlands. Field observations were validated through laboratory analyses: the estimated number of biopores was validated with soil bulk density; the number of roots with root dry weight; the soil colour with soil organic matter content and the soil structure with aggregate size and stability. Furthermore, the estimated pasture cover was validated using image analysis of the soil surface; the number of gley spots with distance to ditches and drains; and the degree of soil compaction with measured penetration resistance. The reproducibility, i.e., the variance of visual estimates, was assessed by having eight farmers and nine soil scientists carrying out VSA on five different sites, located at sandy, clayey and peaty soils. Building on the validation and the reproducibility of the VSA, we will illustrate how visual soil assessment can contribute to a quantitative evaluation of soil functioning at dairy farms and thereby to sustainable crop production.

COMPARABLE AND RELIABLE DATA FROM LABORATORIES WITHIN GLOBAL SOIL RESEARCH

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Good data are always the basis for good science and are also used to advise farmers and to do risk assessments in case of soil pollution. Research moves from application of a laboratory analysis for a single site to application of the result in regional studies and even for global use. This increases the need that the laboratory analysis results are correct and moreover comparable with other laboratories worldwide.

The Soil Science groups at Wageningen University began a programme to facilitate laboratories to improve their quality by starting WEPAL ((Wageningen Evaluating Programmes for Analytical Laboratories) almost 60 years ago. WEPAL organises proficiency testing schemes that contribute to maintaining and improving the quality of laboratories worldwide which specialise in soil quality and related fields. It has developed into a world-leading organiser of proficiency testing programmes in the fields of plants, soil, sediments, biomass and organic waste, with over 500 participants worldwide.

Parameters to be analysed in the different matrices varies from soil characteristics and nutrients to contaminants like heavy metals and organic contaminants. Wepal has developed a system that guarantees that all laboratories do receive a sample with the same composition. Participating laboratories receive four times a year samples having a different origin. They submit their results by a web based application and receive a report within two weeks after the proficiency test deadline. The report contains all relevant statistical data and information on the applied methods. Laboratories use their result to show customers that their results are comparable or if not to improve their performance. Participation in a proficiency testing programme is a must for laboratories having an accreditation.

WEPAL cooperates with Quasimeme, which is another proficiency testing programme focussed on research in the marine environment.

VALIDATION OF SOIL FERTILITY AND PRODUCTIVITY IN THE CZECH REPUBLIC

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For the identification of main relations of soils in the Czech Republic, the systems of soil categorization are developed that contain the main specific features of individual groups of soils. Categorization of soil-climatic conditions provides sufficiently accurate definition of the soil productivity level for individual commodities and the need for production inputs. Crop yields and soil inputs were assigned to individual crops by the use of statistical methods based on the main parameters: soil texture, level of fertilization, weather and climate history, soil depth, slope, stoniness, exposure, technological way of tillage and other specific habitat-related conditions that are defined by the categorization of soil-climatic characteristics using so-called valued soil-ecological units (BPEJ). The level of individual yields and costs is attached to each of the main crops that are arranged according to their suitability to individual habitat-related conditions. Production costs are derived from the soil inputs according to operational surveys, applied processes and machinery costs. Valuation of potential soil productivity is as an economic input-output difference could be on plots and farm examined. Calculation parameters will be modified in accordance with previously weather conditions on the base of regression models for main crops and of forecast for sales crop price. Regression functions are developed from production data of 500 plots with standardized soil – climatic conditions in years 2002 – 2010 and enable calculating of yield with respect of forecrop, level of nitrogen fertilization, development of weather and condition of the soil. Regression functions for weather conditions were actualised on the base of extended results of about 300 farms from 2005 – 2012. Universal on-line advisory system for production on different conditions in the Czech Republic was created.

CHARACTERIZATION OF SOIL ORGANIC MATTER BY NEAR INFRARED SPECTROSCOPY – DETERMINATION OF GLOMALIN IN DIFFERENT SOILS

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Determining and characterizing soil organic matter (SOM) cheaply and reliably can help to support decisions concerning sustainable land management and climate policy. Glomalin, a glycoprotein produced by arbuscular mycorrhizal fungi, was recommended as one of the most promising indicators of SOM quality. But extracting and determining glomalin from soils using classical chemical methods is too complicated and time consuming and therefore limits the use of this parameter in large-scale surveys. Near-infrared spectroscopy is a very rapid, non-destructive analytical technique that can be used to determine many constituents of soil organic matter. A representative set of different soil samples was used to calibrate NIRS in order to determine glomalin. Calibration was validated and optimized by leave-one-sample-out-cross-validation (LOSOCV) and by the external validation. No statistically significant differences were found between the classical and NIRS method for different soils with relatively wide range of SOM. The parameters of the NIRS calibration model (RMSECV = 0,70 and R = 0,90) proved that glomalin can be determined directly in air-dried soils (fraction <2mm) by NIRS with adequate trueness and precision.

Theme 2
Water Resources - Posters

SHORT DROUGHT IRRIGATION BY SMALL-FARM RESERVOIR AT RAINFED LANDS

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Water scarcity in agricultural can be occurred in dry season and short drought or break season during wet season, especially at rainfed land and it can be solved by irrigation from rainfall harvesting. Small-farm reservoir or SFR is a method to collect water and used for irrigation when short drought occurred. Research was located at Gondangrejo, Karanganyar, Central Java, Indonesia and have been constructed 5 SFRs with radius area around a kilometre and directed from December 2013 to June 2014. Seepage and infiltration were assumed zero or could be ignored because SFR had been layered by tarp plastic (tarpaulin). Climatic data was recorded by automatic weather station that had been installed in research location. Short drought along of observation was occurred fourth times in 1st crop season and early of 2nd crop season. Irrigation was used for paddy field, except at SFR1 where cropped onion was. The irrigation timing and amount were determined by farmers depending on their own consideration about the weather and crop conditions. SFR1 was used for manual irrigation of an onion farm of small area intensively and sufficiently with 2 m^3 of water for each irrigation in the 1st crop season and fallow in the 2nd crop season because the labor shortage. SFR was capable of irrigating a paddy field during short droughts in the rainy season and during the early dry season even in the critical period of rice cultivation. SFRs were advantageous because they enabled farmers to cultivate rice in the second crop season. A proper design of the SFR volume and the size of the irrigation area were important in order to get the most out of an SFR.

DETERMINATION OF HYDRAULIC CONDUCTIVITY IN UNSATURATED SOIL SAMPLES

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The aim of this study is the experimental determination of the hydraulic conductivity (K) in unsaturated soil according to the pressure (h) of soil water. As is commonly known, this process is difficult and time-consuming, but indisputably is the most accurate method for determining the K(h). Moreover, because of this difficulty, various models have been proposed by many researchers for the approximation of experimental data. In the Laboratory of Agricultural Hydraulics of the School of Agricultural Sciences at the University of Thessaly, there is the infrastructure for conducting similar experiments, so the conductivity was measured in three unsaturated soil samples with the help of a water pump which has provided different water supplies to the soil sample surface. The water pressure was measured with the help of a pressure transducer which was placed in the soil samples. Also, the saturated hydraulic conductivity and the moisture at saturation point of the samples were measured. The determination of the above hydraulic parameters is essential for the studying of the movement of the soil water into the ground. The next step of this study is to simulate the experimental points and compare them with different models.

This study was supported by IKY FELLOWSHIPS OF EXCELLENCE FOR POSTGRADUATE STUDIES IN GREECE-SIEMENS PROGRAM.

CHANGES IN SOIL INFILTRATION RATES AFTER WILDFIRES INTHE SERRA DE GROSSA AND THE MASSÍS DEL CAROIG, EASTERN SPAIN

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Wildfires are recurrent under Mediterranean climatic conditions due to summer droughts, vegetation characteristics and human activities. Fire disturbs soil properties and removes vegetation and covers the soil with an ash bed for some weeks.
Water infiltration is the key hydrological process to understand the impact of wildfires on the hydrological cycle, as infiltration is the process that partitions rainfall into surface and subsurface flow. Fire affects the soil water relationships and contributes to the changes in soil infiltration rates. Although this process is already well-know, there is a lack of long-term measurements, which is the objective of this research.
In order to determine how fire and post-fire changes control the soil properties we selected 10 research sites in the study area of La Costera inthe Serra Grossa and the Massis del Caroig in Eastern Spain, that all suffered from recurrent wildfires for decades. The parent material is Limestone and the mean annual rainfall ranges from 480 to 550 mm. Vegetation is characterised by dense scrubland (maquia, Quercus coccifera, Pistacia lentiscus, Juniperus oxycedrus, etc.), and Pinus halepensis (Aleppo pine). The study sites were selected in the middle parts of the slopes (straight tram) and rainfall simulation experiments (55 mm h-1 during one hour) and cylinder infiltration measurements were carried out. At each research site 10 measurements were carried out. Each site was selected upon the last registered fire: 0, 1, 5, 9, 16, 24, 33, 44, 51, and 63 years ago. The measurements were carried out in August 2014 under very dry conditions. The results show that immediately after the wildfires the infiltration rates were higher due to the ash cover (45.6mm h.1 as Steady-State Infiltration rate (fc in the Horton Equation), but that after one year the infiltration rates were reduced to very low values (22.45 mm). After this low infiltration rates recovered due to vegetation recovery which contributes to an increase in the infiltration rate which showed to be stable after 16 years.
The research projects GL2008-02879/BTE, CGL2013- 47862-C2-1-R,LEDDRA 243857, RECARE-FP7 (nº 603498, http://recare-project.eu/) and iSQAPER **(**H2020-SFS-2014-635750-2) supported this research.

RICE STRAW AS A COVER MULCH TO REDUCE OVERLAND FLOW IN OLIVE PLANTATIONS IN THE ENGUERA MUNICIPALITY. EASTERN IBERIA PENINSULA

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Water losses in Mediterranean orchards are high, and non-sustainable in terms of available water resources. Olives orchards are characterized by an intense ploughing or a widespread use of chemicals to remove weeds. These management strategies results in bare soils, that contributes to high erosion rates, and the loss of water resources due to intense and recurrent surface runoff.

Rice straw was used as animal fodder for millennia, but in the last two decades the rice is no longer used as fodder due to the industrial production of meet; and is now seen as waste in many farms in Spain. The Valencia lagoon region (L'Albufera) is a traditional producer of rice and the straw is now seen as a unwanted waste which is difficult to dispose of from their farms as burning the material is forbidden due to the associated smoke that damages the health of the urban citizens of the nearby cities.

This research tests the use of rice straw mulch to reduce water losses on olive orchards of the Enguera municipality, Eastern Spain. Forty control and forty rice straw covered paired plots were selected on 20 olive orchards, and rainfall simulation experiments were carried out on small plots (0.25 m2, buffer are of 1 m2) during one hour at a rainfall rate of 45 mm h-1 during the summer 2013 under very dry conditions (no rainfall for more than one month). The runoff was collected from each plot at 1-minute interval. This allows us to measure the runoff rates and calculate the infiltration rate and infiltration envelope for each experiment.

The results show an average runoff coefficient of 45.68 % for the control plots, while the plots covered with straw (0.1 Kg per m2) reduced the runoff coefficient to 37.45%. The straw rice cover intercepted on average 1.24 % of the rainfall (measured as a weight before and after of the water intercepted), which means that an additional 6.01 % of the rainfall infiltrated in the mulch covered plots compared to the control plots. This increase in infiltration rate is due to the reduction of raindrop impact and the forming of a sealed soil, and due to the reduction of the overland flow velocity and the development of ponds.

The research projects GL2008-02879/BTE, LEDDRA 243857 and RECARE-FP7 (nº 603498, http://recare-project.eu/) and iSQAPER **(**H2020-SFS-2014-635750-2) supported this research.

MODELLING SHALLOW GROUNDWATER IN SUGARCANE FIELDS USING HYPERSPECTRAL SATELLITE IMAGERY

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Shallow water table and soil salinity are two main factors which negatively affect the sugarcane yield in the southwest of Iran. Therefore, assessment and monitoring of these factors are necessary in this area. This research was carried out in order to assessing the capability of spaceborne hyperspecteral data for estimating groundwater depth in sugarcane fields. Groundwater level was measured in 74 installed observation wells within the study area (40 points for modelling and 34 points for validation), from the beginning of May 2010 till end of September 2010, twice per week. In a same time with measuring the ground data, a Hyperion image was acquired on September 2, 2010. After apply necessary pre-processing on the image, in order to obtain appropriate models for estimating soil salinity and groundwater depth, three new vegetation indices (SWSI-1, SWSI-2 and SWSI-3) were developed. The obtained results of these indices were compared with the results of others 21 vegetation indices related to deferent regions of spectral reflectance of crops. Results of estimating groundwater depth using vegetation indices show that, obtained models from the NDWI, SWSI-3 and SWSI-1, yield the best results with R2 of 0.47, 0.48 and 0.48 and root mean square errors of 7.98cm respectively. Therefore, using satellite imagery for monitoring sugarcane fields can be very helpful for decrease the operation time and costs and improve the management of sugarcane fields for achieving more yield and income.

ASSESSING CATCHMENT CONNECTIVITY USING HYSTERETIC LOOPS

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Sediment connectivity is a concept which can explain the origin, pathways and sinks of sediments within landscapes. This information is valuable for land managers to be able to take appropriate action at the correct place. Hysteresis between sediment and water discharge can give important information about the sources, pathways and conditions of sediment that arrives at the outlet of a catchment. "Hysteresis" happens when the sediment concentration associated with a certain flow rate is different depending on the direction in which the analysis is performed –towards the increase or towards the diminution of the flow. This phenomenon to some extent reflects the way in which the runoff generation processes are conjugated with those of the production and transport of sediments, hence the usefulness of hysteresis as a diagnostic hydrological parameter. However, the complexity of the phenomena and factors which determine hysteresis make its interpretation uncertain or, at the very least, problematic.

Many types of hysteretic loops have been described as well as the cause for the shape of the loop, mainly describing the origin of the sediments. In this study, several measures to objectively classify hysteretic loops in an automated way were developed. These were consecutively used to classify several hundreds of loops from several agricultural catchments in Northern Spain.

The data set for this study comes from four experimental watersheds in Navarre (Spain), owned and maintained by the Government of Navarre. These experimental watersheds have been monitored and studied since 1996 (La Tejería and Latxaga) and 2001 (Oskotz "principal", Op, and Oskotz "woodland", Ow). La Tejería and Latxaga watersheds, located in the Central Western part of Navarre, are roughly similar to each other regarding size (approximately 200 ha), geology (marls and sandstones), soils (fine texture topsoil), climate (humid sub Mediterranean) and land use (80-90% cultivated with winter grain crops). On the other hand, Op (ca.1,700 ha) is covered with forest and pasture (cattle-breeding); while Ow (ca. 500 ha), a sub-watershed of the Op, is almost completely covered with forest. The predominant climate in Op/Ow is sub-Atlantic.

Furthermore, antecedent conditions and event characteristics were analysed. The loops were compared quantitatively and qualitatively between catchments for similar events and within the catchments for events with different characteristics.

EVALUATION OF PESTICIDE'S LEACHING UNDER DRAINAGE CONDITIONS IN A LABORATORY TRACING EXPERIMENT WITH CONTROLLED CONDITIONS

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The diversity of processes involved in pesticide's fate in the groundwater resulted in a large variety of studies. While 1 dimension leaching has been evaluated many times with various models, subsurface drains have an influence on the watertable shape and consequently the drained flow might differ from a classical vertical water transfer. In order to understand the characteristics of pesticide leaching under drained soils, a tracing experiment with 28 different molecules was realized under controlled conditions. The selection of the pesticides was based on agricultural practices for cereals, corn and rapeseed crops and therefore the concentrations applied were calculated to reproduce the practices on the field, as for the period of application which depended on the watertable height in the experimental device. The study was mainly focused on the hydraulic part of the drained flow and the modelling using HYDRUS software combined with the use of an ideal fluorescent tracer helped to set up the leaching specificities. Then concerning the pesticide behaviour, efforts were put on the sorption potential while degradation was expected to be negligible due to low organic matter (0.2%) and controlled conditions (short time experiment, water inlet, molecules, soil profile). After a consequent drained water volume which corresponded to almost 13 years on the field (>4500 mm), only 18 molecules were detected at the oulet of the experimental device, and the average mass recovery was 70%. The best hydraulic model found with the modelling was a Physical Non-equilibrium model for solute transport with 12% of immobile water. Leaching velocities, quantities recovered and sorption's release of each molecule detected are discussed.

LONG TERM IMPACT OF NO TILLAGE ON WATER AND SOLUTE FLUX IN DRAINAGE

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Impact of conservation tillage on water dynamic and solute flux is complex and is till uncertain (Alletto2011, Strudley2008) mainly because variability of practice induces variability of results. Moreover, pesticides exportations are to be related to climatic conditions and soil context (hydrodynamic), especially for long term modification of tillage practices. Ours main objectives were to observe how a 25 years (1987-2011) no-tillage (NT) practices (i.e, direct drilling) impacts water dynamic and consequently solute flux. Soils are described as stagniv luvisol developed on an impermeable schist layer. Tiled drainage are 0.9 m depth and 10 m spaced. This context represents the typical French drainage situation used to prevent winter's soil waterlogging and to help crop growth. Two plots (1 ha) with identical agricultural management, excepted tillage, were used for comparison. Water flow was hourly recorded and pesticides were samples every 5 m^3 and collected every week for analysis. Results shows significant annual water balance difference after ten years of NT, with more drainflow under conventional tillage (CT). Based on hourly data analysis, untilled plot shows higher flows rate and shorter depletion phase compared to CT, especially during the second period (2000-2011). Such behaviour becomes similar to runoff events in undrained plot. During beginning of drainage season, drain flow also starts earlier under NT practices. On one hand, nitrogen fluxes which are correlated with cumulative drainflow are greater under CT than NT. On the other hand, most of pesticides fluxes are significantly higher under NT than CT despite identical exportation dynamics. Differences were assigned to stronger impact of preferential flow on NT plot due to soil compaction, better connectivity of macropores, biological activity and aggregate stability. Finally, although NT has reduced total drain flow and nitrogen flux, hydrodynamic modification has led to greater pesticides losses. Consequently, in this context, NT practices are not suitable to reduce contamination by pesticides, and new agricultural management such as reduced tillage and intercropping may be interesting opportunities.

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WATER INFILTRATION PATTERNS UNDER IN-FIELD WATER HARVESTING TILLAGE IN THE SEMI-ARID LIMPOPO PROVINCE OF SOUTH AFRICA

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In-field rainwater harvesting (IRWH) tillage technique consists of the micro-catchment and the basin area. The amount of runoff water that is generated by the micro-catchment is determined by its infiltration capacity. A rainfall simulator was used to determine infiltration characteristics of IRWH micro-catchments (1 m^2) at the University of Venda Experimental Farm. The data was compared with those obtained from conventional tillage (CT). Rainfall simulation was conducted using constant rainfall intensity of 23, 33 and 52 mm h^{-1}. Simulation was run for a period of 60 minutes. Indicators used to study the infiltration process were time to the start of runoff (min), initial infiltration (mm), final infiltration rate (mm h^{-1}) and cumulative infiltration (mm). Results of the simulation study indicated that the time to runoff was influenced significantly ($P<0.05$) by tillage and rainfall intensity and their interaction, leading to doubling the time in CT compared to the IRWH treatment. Initial infiltration was influenced by tillage, possibly resulting in initial infiltration of 51% and 48% of cumulative infiltration in the first 30 minutes of rainfall event in CT and IRWH, respectively. There were no significant differences in both final infiltration rate and cumulative infiltration in the two treatments, suggesting that the two soil management practices had similar infiltration behavior by the end of the rainfall simulation. Rainfall intensity had significant effect on cumulative infiltration, likely causing a marked increase in rainfall intensity to yield a two-fold increase in cumulative infiltration.

HYDROLOGICAL CONNECTIVITY DYNAMIC AND TEMPORAL STABILITY IN AN AFFORESTATION AREA IN THE CENTRAL SPANISH PYRENEES

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The concept of hydrological connectivity is increasingly being applied in hydrological and geomorphological studies and is a key factor to understand the redistribution and accumulation dynamics of overland flow in the different compartments at hillslope and catchment scales. Runoff generation is an important process, related to connectivity. Afforestation reduces connectivity between hillslopes and channels and also human-made structures, such as ditches, agricultural terraces and paths, influence hydrological connectivity. The aim of this study is to simulate different spatial patterns of hydrological connectivity related with the different temporal response of soils to the rainfall events during 7 hydrological years (Oct'2007-Sep'2014) in a small afforested subcatchment (Central Spanish Pyrenees). The IC model of Borselli et al. (2008) was run with different flow accumulation algorithms to simulate concentrated (runoff events of high magnitude) and dispersed (runoff events of low magnitude) overland flow. Only 13.6% of the total rainfall events (1339) were identified as erosive events (ee) (24 ee per year) and this percentage was higher between May and October (18% on average). The maximum rainfall intensity (I30) during this erosive period (maximum runoff generation) was of 16 mm / h on average and reached more than 29 mm / h in August. Between November and March I30-ee kept below 5 mm /h. Values of runoff connectivity at the hillslopes and near the main stream were calculated with the different maps generated with the IC model and results were analyzed considering the temporal stability of the rainfall and runoff dynamics during the 7 years. The hydrological response measured at the outlet was variable and complex, showing a seasonal pattern, with alternation of wet and dry periods, and two transitional periods (wetting up and drying down). The mean annual runoff coefficient measured at the outlet was 0.21.

WATER BALANCE ASSESSMENT OF A RIVER BOUNDED AQUIFER USING VISUAL MODFLOW® APPLICATIONS, EASTERN PUNJAB, PAKISTAN

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The fate of agriculture in Pakistan is highly concerned with excessive water mining threat to the subsurface water resources. Present paper integrates Visual MODFLOW-2000 application to estimate the water balance of an aquifer bounded by river Chenab in the West and Ravi in the East which comprises of an area about 2.98Mha. STRM (Shuttle Radar Topography Mission) DEM of 1km in 43N zone and a mesh of descretized cell size (2500m) were incorporated in model design. Conceptual model for the aquifer involves trifold vertical boundaries (initial fold thickness set up to 150m). Hydraulic boundaries for the model are: no flow boundary (set on northern side), river boundary (set on eastern, western and southern sides), recharge boundaries (recharge through water courses, return flows of the pumping and precipitation). Model Input parameters are: precipitation, seepage through irrigation, return flow, recharge, hydraulic conductivity and evapotranspiration. The empirical relation $S=0.03Q^{6.71}$ is applied for canal discharge input. Model is calibrations about steady state evolves normalized RMS values about 4.9% for 50 data points. Model results for water balance depicts a negative flow for the river leakage (-4.55E10m^3) and evapotranspiration (-8.39E10 m^3) while a positive flow regarding recharge (+5.39E10 m^3). It is found that return flows from the irrigation canals are a significant source of recharge along with precipitation.

SIMULATION OF LEACHING AND ROOTZONE SALINITY CONTROL AT TSUNAMI AFFECTED RICE FEILDS IN MIYAGI, JAPAN

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After the 2011 Tohoku earthquake, thirteen thousand hectares of farmlands were damaged by massive Tsunami near coastal sites in Miyagi, Japan. Some eighty percent of the damaged farmlands have been recovered in 2014, but subsidence and high salinity groundwater make it difficult to completely remove salinity from the soil. We monitored soil moisture, electrical conductivity (EC), groundwater level, and EC of groundwater with the sensor network system for field investigation at tsunami damaged paddy fields. To evaluate the effect of leaching on desalinization due to rainfall and underdrain, simulation of two dimensional water flow and salinity transport was carried out. The field monitoring site was a paddy field in Higashimatsushima, Miyagi (38°25'38.6"N 141°14'46.4"E): a costal side, 2.5 km away from the Pacific Ocean. After the disaster, co-seismic subsidence of 50-60 cm of the land was reported, and the area was covered by the top of 40-50 cm thick sediment layer consisting of sand and/or mud. Soil moisture and bulk EC were measured with Time Domain Transmission (TDT) sensors at depths of 10, 20, and 40 cm. Groundwater level and EC of groundwater were monitored by a CTD sensor (Decagon Devices, Inc). In 2013, our findings were high EC of groundwater (> 35 dS m^{-1}) at a paddy field near coastal site where severe subsidence occurred. The shallow groundwater provided salinity to the soil surface. The groundwater level reached the soil surface after heavy rainfall, so the leaching effect due to rainfall was not investigated. In the regions, installation of underground drainage pipes is planning. Using the Hydrus 2D, simulation results show how underdrain facilitates desalination process due to rainfall and fresh water irrigation.

WHEN DO SOIL HYDRAULIC PROPERTIES MATTER FOR ROOT WATER EXTRACTION?

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Plant transpiration is a key process in plant assimilation, micro-meteorology, carbon cycle and hydrology. On a daily basis plant transpiration is equal to the extraction of soil water by plant roots. Therefore proper simulation of root water extraction is essential for many ecohydrological, meteorological and climate models.

Main factors that influence root water extraction are: soil water status, soil hydraulic properties, root density, plant hydraulic resistances of roots, stems and stomata, and meteorological conditions. In scientific literature many concepts for root water uptake are available. We may classify them as macroscopic models, in which the root zone is considered as a continuum of soil water and roots, and microscopic models in which soil water flow is calculated towards individual roots. In practice macroscopic models are much more popular than microscopic models, as they are more easy to use. Also the cumbersome collection of suitable data on soil hydraulic properties and root density profiles favours the use of macroscopic models. However, macroscopic models can be inaccurate as they don't account for soil texture, heterogeneous root density profiles and root compensation mechanisms.

This study analyses for various climates, soil textures, root density profiles and drainage conditions when soil hydraulic properties do matter for root water uptake. The hypothesis is that macroscopic root water uptake models are relatively accurate in case of temperate regions, medium soil textures, thick root zones, and fairly homogeneous root densities. Recently a detailed microscopic module for root water uptake (De Jong van Lier et al., 2013) has been added to the ecohydrological model SWAP (Soil Water Atmosphere Plant). This module is used to test the accuracy of a popular macroscopic module for various biosphere environments.

Theme 3
Governance and Policy - Posters

GET INSPIRED – HELP SHAPE THE EUROPEAN STRATEGIC RESEARCH AGENDA ON SOIL, LAND USE AND LAND MANAGEMENT

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The aim of the H2020-project "INSPIRATION" is to create a funder and end-user demand-driven research agenda for land use, land-use changes and soil management in the light of current and future societal challenges. Main objectives are:

- Formulate, consult on and revise an end-user oriented strategic research agenda (SRA),
- Scope out models of implementing the SRA,
- Prepare a network of public and private funding institutions willing to commonly fund the execution of the SRA.

INSPIRATION's mission is to improve the supply and effectiveness of science/knowledge take-up by those who really need it. The proposed methodology is based on a multi-stakeholder, multi-national and interdisciplinary approach that covers the variety of stakeholders (public bodies, business, science, citizens and society). The session we propose aims to:

- Illustrate how the soil-water-sediment system is interconnected, influenced by land use and land management (the connectivity concept) and thus impacts solutions of great societal challenges such as climate change adaptation and resource efficiency;
- Share information about the H2020-project INSPIRATION: a coordination and support action aiming at developing a Strategic Research Agenda (SRA) for Europe on Integrated Spatial Planning, land use and soil management;
- Exchange information on the main societal challenges in Europe related to the sustainable use and management of land's soil-water-sediment system (using results from sessions on the Berlin Soil Week April 2015, Aquaconsoil June 2015)
- Outline shared national research priorities and potential funders and stakeholders;
- Contribute to the formation or strengthening of transnational networks on similar themes and to anticipate on possible cooperation within consortia for Horizon 2020.

The results of the discussions will be gathered as important input for the INSPIRATION SRA. The attendants will be invited to become part of the wider INSPIRATION Coordination and Support Action (CSA).

VALUING AND MANAGING URBAN SOIL RESOURCES FOR FOOD PRODUCTION

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Food production in urban and peri-urban communities is set to assume greater importance in response to the rapid growth of cities, high demand within these for fresh salad and other vegetables and the increasing costs of and timescales for transportation from rural areas. New investment in large-scale indoor commercial production is expected, but growth in small-scale soil-based production is also anticipated and this can provide valuable income for citizens, as well as contributing to urban food security. This paper explores and defines the value of and requirements for soil management to support growth in the quantity and quality of urban food production.

The socio-economic value of soil-based urban food production is assessed, drawing on examples of current production practices and trends in large cities. As well as the direct value of food provisioning from soil-based urban food production, its potential contribution to other ecosystem services, such as via urban water regulation, is identified.

The key requirements for optimising urban and peri-urban soil resources for food production are identified as including: appropriate spatial planning; identifying existing and avoiding future soil contamination; biosecurity and control of human pathogens; and ensuring that soil hydrological performance allows efficient use of water resources for irrigation.

While residual 'natural' soils exist in the urban environment, many urban soils exploited for food production are highly modified, sometimes by the deliberate addition of beneficial materials but often from spreading of wastes. Additionally, new soil systems are being created in green roofs and other infrastructure. A typology of these different urban soil resources is proposed, their relative extent and distribution in different urban and peri-urban settings is explored and the specific management needs for each type are described. This leads to policy recommendations aimed at securing future soil resources for the sustainable production of healthy food in urban communities.

MICROBIAL COMMUNITIES AND NITROGEN CYCLE IN RECLAIMED OIL-SAND SOILS

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The Athabasca oil sands deposit, located in the boreal forest of Northern Alberta, is one of the largest single oil deposits in the world. To date, an area of about 715 km^2 has been disturbed by oil sands mining activity. Following surface mining, companies have the legal obligation to restore soils so that they can support the previous land capabilities. Nitrogen availability is fundamental to site productivity; therefore, re-establishment of the nitrogen cycle between these reconstructed soils and plants is one of the most critical factors required to insure long-term sustainability of this reclaimed boreal landscape.

Soils from a series of 20 sites, covering different vegetation treatments both in reclaimed and naturally fire-disturbed sites were investigated. Gross nitrogen transformation rates were measured using 15N pool-dilution (Müller et al. 2007). Microbial communities were characterized using next-generation sequencing method (Illumina – MiSeq).

Reclaimed sites had significantly higher levels of nitrogen, most in organic forms, and higher microbial biomass-C. However, reclaimed sites did not have higher gross rates of N-transformation than natural sites. Reclaimed sites had higher rates of ammonification and immobilization from recalcitrant organic-N compared to natural sites. However, natural sites had higher rates of ammonification from the labile organic-N pool, while both natural and reclaimed sites immobilize the same amount of NH_4 into labile organic-N. No differences among sites were found for gross nitrification rates. However, reclaimed sites produced more NO_3 than they immobilized, resulting in positive net nitrification rates in the reclaimed sites. Natural sites had null net nitrification rates. We hypothesize that microbial community composition varies between natural and reclaimed sites, which explain differences in the N-cycle. Microbial community analyses will be discussed.

The oil sands will be Canada's environmental legacy. Recreating functional soils is fundamental to our ability to restore boreal ecosystems after disturbance. We consider that soil microbial communities are key to that endeavour.

Theme 4
Biodiversity - Posters

INTERACTIONS BETWEEN TILLAGE AND CROP GENOTYPIC DIVERSITY

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Soil tillage is an important crop management practice and a major factor in the managements of plant-microbe interactions in agro-ecosystems. Tillage effects may result into changes in physical, chemical and biological environment of soils leading to modification of soil habitats for most species, or disruptions of soil biota which reduces their groups, depending on intensity. Most breeding trials in Europe including Scotland are based on soil cultivated under conventional tillage system, disturbing soil to at least 20 cm depth. However, most studies on potential impacts of tillage and barley genotypes in Scotland have focused mainly on growth, yield and disease resilience of the system. In this study, the interactions between tillage and different crop genotypes or their combinations were evaluated to assess plant nutrient acquisition, shoot and root biomass and mycorrhizal colonization of different barley genotypes in agricultural soil from North East Scotland. Four barley genotypes were manipulated on soil cores collected from minimum or conventional tillage systems in a plant bioassay experiment for four weeks in a greenhouse (to gain better control of the system). The results showed that, tillage and genotypic diversity differentially affect plant nutrient acquisition and biomass accumulation of barley grown in tillage affected agricultural soils at early growth stage. Further, the presence or richness of either spring or winter genotypes among different combination or single genotype populations shapes the functioning and productivity in terms of nutrients acquisition and biomass accumulation. Although, minimum tillage increased tissue nitrogen(N), phosphorus(P) concentration and uptake by plants, a significant finding in this study is the increased tissue concentration of phosphorus in barley genotypes grown in conventional tilled soil. Further study is recommended to better understand the P dynamics and microbial community composition since there is no quantifiable evidence of mycorrhizal fungi activity in the soils from these tillage systems.

THE ROLE OF SOILS IN THE DISTRIBUTION OF FOREST AND SAVANNA VEGETATION IN AN ECOTONE. FIRST RESULTS FROM A FIELD STUDY IN THE FOREST- SAVANNA ECOTONE OF GHANA

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The global distribution of forests and savannas is often explained in terms of Climate. However in forest- savanna-ecotones climate variation is small and in recent publications the role of soil chemistry has been emphasised as an important co-determinant of vegetation structure (i.e. forest versus savanna). More fertile soils may hold a greater vegetation cover and biomass than less fertile soils. In addition soil physical characteristics such as soil type and soil depth may also be of importance. To understand the relative importance of these factors we studied the soil conditions in small forest, savanna and transitional vegetation patches in the forest savanna ecotone of Central Ghana in the Strict Nature reserve of Kogyae. Here we have a unique opportunity to disentangle soil chemical factors. In this poster we report on our results on differences between vegetation formation types in terms of stand structure, biomass and composition and link these to ambient soil chemical and physical determinants. We hypothesise that soil factors may be an alternative explanation to e.g. fire behaviour mof of forest, transitional or savanna patch occurrence in the savanna-forest ecotone of Ghana.

SULFAMETHOXAZOLE SORPTION IN SOILS OF THE BOLIVIAN ALTIPLANO AND IMPACTS ON BACTERIAL POPULATIONS

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The fate of antibiotic contaminants in soils depends on several processes: sorption, mobility, speciation and biochemical transformations. Their sorption is affected by pH, organic matter, ionic strength and the presence of inorganic compounds. Soil pollution by antibiotics can lead to selective proliferation of resistant bacteria, which can further pose public and animal health problems.

In a subcatchment of the Titicaca Lake, significant concentrations of Sulfamethoxazole (SMX) were detected in river waters and in soils irrigated with wastewaters close to El Alto City. Ten soils were sampled according to the altitude gradient, to the two main soil types of the subcatchment (Regosol and Cambisol), and to the main soil usages. Static (batch) and dynamic (repacked columns) experiments were performed to study SMX sorption and mobility in these soils. Both studies were conducted at constant ionic strength. Column studies were performed in saturated conditions and breakthrough curves were analyzed by inverse modelling with the CXTFIT code. Impacts on bacterial populations and presence of resistance genes to SMX (*sulI*, *sulII*, and *sulIII*) were assessed by molecular techniques applied to one month batch experiments.

Sorption kinetics studies showed that equilibrium was reached in 48h. Sorption isotherms were well fitted with linear or Freundlich models depending on soil types. SMX sorption was influenced in a positive way by (decreasing order): organic matter content > cation exchange capacity > silt content > clay content. Soils located upstream of the watershed (Regosol) showed a higher adsorption capacity than soils located downstream (Cambisol). The presence of resistance genes (*sulI* and *sulII*) was observed only in one soil regularly receiving wastewaters. SMX impacts on bacterial diversity varied between soils and were interpreted in the light of soil physical chemical properties.

GLYPHOSATE DECAY IN LOESS SOIL: IS GLYPHOSATE A MAJOR RISK FOR SOIL CONTAMINATION?

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Soil contamination is a major concern for soil quality and one of the most pressing soil threats. For more than 50 years, herbicides have been used to increase crop production, however, monitoring of pesticide residues in soils and the related risk to the environment and human health is rarely practiced. Glyphosate-based herbicides lead the worldwide market, and are the most commonly used herbicide in Argentinean agribusiness, especially in the loess pampean region, where GM Soybeans are intensively cultivated. Glyphosate (N-(phosphonomethyl)glycine) is a non-selective, systemic, broad spectrum, post-emergent herbicide. Data on its half-life vary widely (4-180 days), depending on soil type, soil binding extent, phosphate levels, microbial breakdown and temperature. Knowledge regarding glyphosate behaviour in Argentinean loess soil is lacking. For a realistic risk assessment, persistence studies in the soil are required.

We studied glyphosate decay in loess soil, as affected by temperature, soil moisture, and photodegradation. Active and sterilized soil samples were spiked with 16 mg/kg of glyphosate, subjected to 3 different soil moisture contents (20%, 60% and 100% of water holding capacity (WHC)), and incubated at 5°C and 30°C, under dark and light conditions. Control soil samples (without glyphosate) were also used, and soil microbial respiration was monitored. Glyphosate and its main degradation product (AMPA) were analysed by HPLC-MS/MS.

Our results show that: 1) glyphosate decay is first influenced by temperature and then by soil moisture, with the half-life ranging from 2 days, at 30°C and soil moisture of 60% or 100% of WHC, to >30 days at 5°C and soil moisture of 20% of WHC; 2) glyphosate decay is similar under light and dark conditions.

Since drought stress and low temperature significantly delay glyphosate decay, repeated glyphosate applications under dry and cold conditions in the Argentinean loess region could lead to soil pollution.

CENTRE FOR SOIL ECOLOGY (CSE)

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The Centre for Soil Ecology (CSE) is a virtual cooperation between Wageningen University and Research centre (WUR) and the Netherlands Institute of Ecology (NIOO-KNAW). In total fifteen research groups participate in the centre. CSE wants to stimulate interactions between soil ecologists, to promote research opportunities and to cooperate with private companies and other stake holders. CSE organizes a number of activities, including annual meetings, seminars, discussion groups, BSc, MSc, PhD, and Post-doctoral courses, dissemination meetings, and members of CSE participate in joint externally funded projects. Some examples are presented in the present poster.

BIOCHAR IN SOILS: EFFECTS ON SOIL MICROARTHROPODS

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The use of biochar in soils is nowadays a promising tool in the context of climate change mitigation. Its use as a soil conditioner in agriculture seems to improve productivity and soil physical-chemical properties. Despites several benefits that literature outlined, the effects of biochar application on soil fauna are still poorly investigated both in the potential toxicological consequences and in shifts of the community structure.

The investigated site was one of the EUROCHAR project, located in Prato Sesia (NO), in northern Italy. In a poplar short rotation forest, four plots amended with biochar, obtained by a fixed-bed gasifier from maize residues at the rate of 30 t/ha, were compared to four control plots in three different periods (July and October 2014, March 2015). Soil microarthropod communities were characterized by taking a top soil core (10 cm^2 and 10 cm in depth) from each plot. The specimens, extracted using Berlese-Tüllgren funnels, were identified, counted and soil biological quality indexes (QBS-ar and QBS-c) were calculated. Other soil samples were taken for the physical-chemical parameters characterization.

The results outlined some differences in microarthropod communities and in some physical-chemical parameters induced by biochar application. In terms of soil quality, the plots amended with biochar seemed to have higher values, while some taxa, such as Collembola, appeared to be affected by the biochar presence.

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EARTHWORM COMMUNITIES IN RELATION TO ARABLE MANAGEMENT IN A LANDSCAPE CONTEXT

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Agricultural intensification has homogenised arable fields and landscapes resulting in a decline of earthworm biodiversity, possibly affecting associated soil ecosystem services. Agri-environmental schemes, such as field margin strips adjacent to arable fields, are being implemented to boost agrobiodiversity, but their effects on earthworm diversity remain unclear, especially regarding the spill-over potential to arable fields. Within agricultural landscapes, we studied earthworm communities at the arable field and margin scale, as influenced by three groups of drivers: i) soil properties, ii) present and past arable management, and iii) surrounding landscape. We hypothesized that earthworm communities differ between margins and fields. In the arable fields arable management was expected to override the landscape effect, but the surrounding landscape was expected to have a larger effect on the communities of the margins.

Earthworms and soil properties were determined in 26 arable fields and 15 field margin strips in an intensively cultivated region in the Netherlands (Hoeksche Waard). Standardized questionnaires were used to obtain information from farmers about the present and past management of the surveyed habitats. The landscape surrounding the sampled sites was characterized using official topographic maps. Forthcoming results will illustrate the relative importance of the three drivers on earthworm communities in arable fields, with or without adjacent margins, and in field margin strips. The acquired understanding will improve our understanding of earthworm communities and of factors that drive their assemblages not only at the field scale but also at the landscape scale. Such knowledge will improve our abilities to advise farmers and land managers regarding soil biodiversity management and conservation.

LINKING MICROBIAL DIVERSITY TO THE FUNCTIONING OF SOIL FOOD WEBS USING STABLE ISOTOPE PROBING

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Soil ecosystems contain a high trophic complexity and support huge amounts of biological diversity. Because of increased intensive land use, it is expected that the soil biodiversity will be impacted with negative impacts on these soil ecosystem services. The relationship between soil biodiversity and ecosystem functioning has been widely explored, but has up to know mainly focussed on the effects of biodiversity change within a single trophic level. Since soil organisms are part of a complex network of trophic interactions, a multitrophic approach provides a more ecologically relevant perspective to study the relationship between biodiversity and ecosystem functioning in soil.

Soil food web models are great tools to study this relationship on a multitrophic level, however, existing soil food web models cope with two major shortcomings. The first is the lack of chemical diversity of the soil organic matter, and the second is the lack of definition of biological diversity within the soil microbial community. Since litter type and microbial community structure and diversity are important drivers of multiple ecosystem processes, those aspects should be included to be able to describe accurate models.

This poster shows how we include microbial community structure and diversity, as well as diversity in litter type, into soil food web models using stable isotope probing (SIP). This is achieved by combining empirical SIP approaches with a theoretical modelling approach, whereby the outcomes of experiments are incorporated in food web models. In this way we are able to translate how soil-borne microbial diversity influences food web structure and soil ecosystem functioning, leading to a better prediction of soil ecosystem functioning in terms of carbon sequestration and nutrient cycling.

WAKING UP THE MICROBIAL SEEDBANK: WHICH RARE BACTERIA ARE OPPORTUNISTS?

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The steeply increasing resolution of sequencing techniques provides a better insight into the lower end of the rank abundant curve, which usually contains the majority of phylogenetic and functional diversity. Currently very little is known about the identity of rare species and the causes of rarity. Some species might be waiting for more suitable environmental conditions. If rare species are restrained by their environment, then modifying growing conditions should increase abundance of at least some of the formerly rare species. Species that increase rapidly after disturbance but decrease in abundance at the later time point are considered opportunists that can only grow when most of the competition has been removed. Our goal was to estimate which proportion of the rare species behave opportunistic. Soil microbial communities were exposed to a variety of abiotic conditions to test whether rare species are increasing in abundances after disturbances. First it was determined which microbes were rare by in the original field soil. Eleven of the detected phyla, including several candidate divisions, were consistently rare (<0.01%) in the field soil. To this soil a wide range of disturbances was applied: addition of wheat straw, addition of sugar, addition of copper, addition of nitrogen, heat shock, freezing-thawing, mechanical disturbance, microwave treatment and moisture fluctuations. The response of the soil microbial community was monitored by collecting soil samples 1, 3, and 7 days after disturbance and sequencing the 16S. For each disturbance it was estimated which proportion of the rare species in the original soil responded with a significant increase. Increase in abundance could be caused by a resistance in the rare species to that specific disturbance and/or a benefit from the decrease in overall abundance after the disturbance.

MULTIELEMENTAL STOICHIOMETRY: WHAT IS THE IMPACT OF FUNGI AND BACTERIA ON DECOMPOSING LITTER

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Decomposition of plant detritus is an important process facilitating the flow of energy and matter (elements) through terrestrial ecosystem. It is commonly accepted that detritivores invertebrates present in soil and litter enhance microbial decomposition of organic matter. On the other hand, the existing stoichiometric mismatch between detritivores and their potential feeder indicates a nutritional imbalance within this important trophic link. To get insight into this paradox we studied the changes in stoichiometry of decaying broadleaf and conifer litter, with regard to macro and microelements: C, N, P, K, Na, Ca, Mg, Cu, Zn, Fe, Mn. We found that most of these elements have elevated levels after decomposition. We suggest that decaying litter is enriched with elements via import from outside of this system. Probably the key players in this process are bacterial and fungal communities, interconnected with each other in a complex net of interdependencies. The increase of ergosterol levels, a common marker of fungal biomass, in samples of litter in subsequent stages of decomposition agree with the prediction of fungal engagement in balancing of stoichiometric mismatch between detritivores and litter. Analysis of PLFA in decomposing litter revealed that although broadleaf and conifer litters initially differ in fatty acid composition, they converge as they decay, presumably due to the increasing contribution of bacterial and fungal biomass. In effect, previously observed stoichiometric imbalance becomes significantly less pronounced.

DNA EXTRACTION FROM PISTACHIO ROOTS WITH THE AIM OF ENDOPHYTIC STUDIES

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Abstract

Optimization of an efficient DNA extraction method from different plant tissues has been considered as a critical step in successful endophytic biodiversity studies. Polymerase enzyme activity is often inhibited by co-purified contaminants of DNA, called pheniloc substances, hence the objective of this study was to modify and develop a reliable method to extract pure DNA from woody Pistachio root. Based on hot detergent, chemical flocculation, typically organic extraction/alcohol precipitation and finally denaturing electrophoresis purification, inhibitor substances were removed from DNA. This cost-effective and safe DNA extraction method involving purification step was useful for DGGE analysis of mycorrhizal fungi which endophically colonize trees.

EFFECTS OF SOIL CONTAMINATION FROM HISTORICAL INDUSTRIAL SOURCES ON PLANT BIODIVERSITY

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Contaminants from industrial sources can persist in the soil for decades, or longer, after the original contamination occurs. These contaminants have been shown to affect ecosystem functioning when they are found to be over a threshold dose. A country park in Kent, UK, was historically contaminated by a landfill, paper mill, sewage treatment plant and brickworks. Although remediation work was carried out by local government authorities in 2003, the current concentration of contaminants across the site was thought to be at risk of exceeding UK guidelines. Moreover, there is a lack of knowledge on the effects of contamination on plant biodiversity and species-specific plant tolerance to a range of common contaminants. In order to make a representative evaluation of soil contamination over the 52 ha site, a systematic grid sampling approach was adopted. For each for the 70 plots sampled, 5 soil cores each were taken at a depth of 0-10cm, 10-20cm and 20-30cm which were later pooled by depth. Soils were dried at 90^{o}C before analysis to determine the concentration of cadmium, chromium, nickel, copper, lead and zinc using atomic absorption spectroscopy. A number of other soil properties were also examined, including pH, organic matter content, and gravimetric soil water content. At three distinct areas of the site which were likely to have different concentrations of contaminants in the soil ranging from high to low toxicity, plant identification was carried out. For each area, 50x50cm quadrats were used to record individual plant species cover and total species richness at 20 plots. Results show a range of effects of increased concentrations of each contaminant on plant tolerance and species richness. These findings have implications for site management which aims to to promote biodiversity through increasing Biodiversity Action Plan (BAP) habitats and areas of high ecological value.

GLYPHOSATE DECAY AND TRANSPORT RELATED WITH SOIL EROSION IN LOESS SOIL, CHINA

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Concerning the intensive use of glyphosate in crop production, its potential risk to the environment, as well as its metabolic, aminomethylphosphonic acid (AMPA) has been debated. In this paper, decay characteristics and erosion related transport of glyphosate and AMPA at two slope gradients (10º and 20º) and two rates (360 and 720 mg m-2) in a plot (33.3 m2) on loess soil was studied during 35 d. The results showed that glyphosate decayed rapidly (half-life time, 4 d) in upper 2 cm soil following the first-order of decay. AMPA content in 0-2 cm soil layer, correspondingly, peaked at 3 d after glyphosate added and then declined gradually. The residues of glyphosate and AMPA significant declined with soil depth ($p<0.05$) independently of the slope inclinations and application rates. Glyphosate leaching was low due to the limit of glyphosate detected in deeper soil (2-10 cm) while AMPA punctually was detected in deeper soil. In addition, with one erosive rainfall event during observation days in 2013, 0.36% of the initial added glyphosate was transported from the plot, 29 and 71% of the total transported glyphosate accumulating in runoff and suspended load, respectively. However, at the same day, the content of glyphosate and AMPA in suspended load was much higher than that detected in plot soil. This suggested that even though the total of the transported glyphosate is limited, the risk of glyphosate and AMPA in suspended load is harmful for offsite. Consequently, concerning the rapid decay rate of glyphosate in loess soil, more attention should be paid on glyphosate transport related to soil erosion, especially on particulate facilitated transport in Loess Plateau with sever erosion issues.

EFFECT OF NO-TILL VERSUS PLOUGHING ON SOIL QUALITY AND WHEAT YIELD ON HEAVY CLAY SOILS

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The Oldambt is a region in The Netherlands with intensive wheat cropping systems on heavy clay soils. Besides farm size, yield and product quality, costs of production are an important determinant of farmers' income. Decreasing the production costs is therefore desirable. An option is to decrease the costs of soil cultivation. However, soil quality conservation is crucial in order to safeguard the sustainability of the cropping systems. This holds not only for traditional measures of soil fertility such as nutrient content, but also for biological and physical soil quality. Potentially, no tillage can contribute to enhance soil quality. Yet, farmers are concerned about yield reductions upon adoption of no-till. To assess the no-tillage strategy to maintain the ecological and economical sustainability of intensive grain cropping systems, an experiment was set up at seven conventional arable farms in the Oldambt region. A permanent wheat field was split up in two parts. One part was under conventional tillage (CT) and the other part was under no tillage (NT). On each field chemical, physical and biological soil quality properties and wheat yield were determined. Our results showed that no tillage resulted in moderately positive effects on chemical and biological soil quality in the upper 0-10 cm: SOM, Total-N, Total-C, bacterial biomass and potential mineralizable N were significantly higher under no-tillage than under conventional tillage and significantly more earthworm burrows were observed. However, soil structure parameters were positively influenced by ploughing, showing a higher percentage of crumbs and a lower percentage of angular elements. Crop yield was on average 4,5% higher under ploughing than under no tillage. Nevertheless, thanks to lower costs, in the case of continues wheat, no tillage seems to offer a cost-efficient perspective for the heavy clay soils in the Oldambt.

Theme 5
Land Functions - Posters

USING PLANT FUNCTIONAL TRAITS TO IMPROVE THE MITIGATION OF RUNOFF-EROSION EFFICIENCY OF HERBACEOUS HEDGES

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In Western Europe (WE), runoff and soil erosion occur for several months, especially in winter. Concentrated runoff management in upstream areas is a key feature to prevent off-site impacts by inducing particles deposition and reducing runoff amounts. Studies on the runoff mitigation by plants are usually based on species identification but they slightly refer to plant traits. This limits their applications to some pedological and geomorphological contexts. The objective of our study is to develop the first approach built on the functional traits of herbaceous plants in temperate climate. This allows to select the plant traits involved in the vegetation persistence and in the winter reduction of runoff and erosion. To improve the efficiency of herbaceous hedge, one of our goals is to design permanent herbaceous hedge with the higher plant cover and a height more than 20 cm (maximum height of the runoff flow). Stem density, stem bending resistance, height, area and width of vertical leaves, which are plant shoot traits reducing runoff and soil erosion, can be negatively correlated and would not be present in a same plant. Foremost, ten traits involved in vegetation persistence and reduction of runoff and erosion in hemicryptophytes and geophytes from WE were analysed by principal component analysis to test correlation and define trade-off amongst traits and association of traits for the herbaceous hedges. Then, associations of selected plant traits were compared to mono-trait condition with runoff simulator. The results indicate that including several plant shoot traits would be necessary to improve the efficiency of herbaceous hedges and results in a combination of plant species.

Further in-situ experiments will be performed on the herbaceous edge to measure soil surface infiltrability. This will give a better overview of the hydrologic processes related to plant traits at the hedge scale.

SPATIAL ANALYSIS OF SOIL'S SOME PHYSICAL AND CHEMICAL PROPERTIES IN SOUTHERN ANATOLIA

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Spatial analysis focuses on spatial data depending on space which became a very useful statistical method after having rapid developments in technology. The first law of geography "*everything is related to everything else, but near ones are more related than distant ones*" (Tobler, 1970) is very important matter when doing statistical analysis of spatial data. Because classical statistical models were found to be insufficient to explain the desired change when spatial data is analysed. Therefore, spatial statistical models are needed to describe the statistical changes on the location. In this study, in the Southern Anatolia Region as determined from the properties of the soil in the covering area of soil samples from 0-30 cm intervals; spatial dependence and spatial distribution patterns of particle size distribution, saturation percentage, pH, soluble salts, EC, CaCO3 content, exchangeable Ca+Mg and Na, and B contents were analyzed by using spatial regression and geostatistical methods. According to the research results; clay, silt, Ca + Mg, Na were found to have linear distribution, saturation, pH, EC, lime, clay and B were found to have exponential distribution. Spatial dependence of the variable with exponential distribution was found in the medium and high levels. The results were indicated that if the distance between the sampling areas that have linear distribution were reduced, then the spatial dependence would be much higher. In general, most of the characteristics of the soil revealed that they have middle and a high degree of spatial dependence. The relationship between the properties of the soil were observed in general that is better be represented by the spatial error regression model. Meaningful regression model for pH and B variables could not be established. Also it's been concluded that obtained kriging interpolation maps for the soil's characteristics are closely related to the soil's physical conditions.

ASSESSMENT OF DAMAGE CAUSED BY LAND DEGRADATION AT THE FARM LEVEL IN MOSCOW REGION, RUSSIA[4]

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Actual problem of assessment of ecological damage caused by pollution and land degradation was considered at the farm level: a pilot farm of Lomonosov Moscow State University called "Chashnikovo". There are various techniques for determining of damage caused to soils and lands, which were developed for separate subjects: Moscow City and Russian Federation in general, and separately for different types of the impact (pollution and degradation) on soils and lands. Determination of damage caused by pollution, degradations and wasting of the land plots, in particular, is one of type of an ecology-economics assessment of lands. The value of damage can be counted proceeding from costs of work on restoration of the polluted, degraded and wasted lands. The assessment could be made using the existing quotations of different types of recovery works, such as movement and warehousing of soil, or calculating the value of damage using the existing techniques. The level of pollution and extent of degradation were calculated based on the results of analyzes of chemical and physical properties of soils, including the comparison of these properties to the ecological standards ranged on 5 mark scale. The value of damage caused to soils and lands by pollution and degradation was calculated using various Russian techniques at the farm level. For each of techniques the advantages and shortcomings were revealed: for example, the ungrounded provenance of tariffs (rates) for pollution, degradation and wasting of soils and lands. The received values of damage were compared with the cost of remediation for the studied area.

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NEW DEVELOPMENTS IN CONTAMINATED LAND MANAGEMENT IN VIETNAM

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Vietnam has more than 1,000 POP (Persistent Organic Pollutant) pesticide contaminated sites. These sites include former storage facilities, sites with buried pesticides and sites with remains of pesticides. These sites vary in size from a hundred square meters to half a hectare. They were located outside the settlements but are now situated in, or close to properties of villagers. These sites are generally used for agriculture, although quite a few are restricted from agriculture use.

The topsoils at these sites have elevated concentrations of POP pesticides, mainly DDT and its metabolites, and HCH and its isomers, in varying concentrations up to 1,000 ppm to a meter depth. Often lumps of pure pesticides are at the surface. These contaminated sites are a constant threat to public health and the environment.

Until recently, a program to clean-up these sites in a cost-effective way was not available and experience was lacking. In 2010, UNDP launched a project to build capacity within the Vietnamese Ministry of Natural Resources and Environment on the sustainable management of pesticide-contaminated sites. One of the key elements is to structure the stages that a site goes through from (preliminary) site assessment to final remediation assessment, to remediation management, and ending with monitoring and aftercare. The management approach is risk-based and an evolving Conceptual Site Model for each site is the main tool to support the site management in all phases.

The resulting set of Guidelines for the sustainable management of these sites guide the user through the different standardized stages allowing: efficient verification of the site data; efficient monitoring; and saving time and money in the implementation of environmentally sound contaminated land management.

The guidelines have been issued in Vietnamese language and the methodology was quickly adopted, allowing Vietnam to manage contaminated sites in a structured and cost-effective way.

SOIL CHARACTERISTICS MAPPING IS A PRE-REQUISITE TO CONDUCT APPLIED AGRICULTURAL RESEARCH AND TRANSFER OF TECHNOLOGIES TO FARMERS

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On a worldwide basis, national and international research centers involved with agricultural research routinely have detailed soil mapping made for their experimental sites. Once the soil information is documented, these sites are used to conduct applied research transferable to, and beneficial for, scientists and the farming community through the establishment of guidelines for sustainable farming. Considering the importance of soil mapping we completed soil mapping and classified the soils at ICBA station at a grid (50mx50m) to a depth of 2 meter. With this completion, technologies developed at ICBA can be confidently transferred to other areas where similar soil and environmental conditions may be existing?. With the completion of soil classification we are now able to answer many questions about soil classes, their proportion, area occupied by soils with specified properties, spatial pattern of soil classes at or around a site, spatial pattern of soil properties etc..

Soil mapping revealed the dominant soil is *Typic Torripsamment Carbonatic, Hyperthermic, w*here carbonatic is the mineralogy class i.e., more than 40% CaCO3 in fine earth fraction, hyperthermic is soil temperature regime (the mean annual soil temperature is 22ºC or higher, and the difference between mean summer and mean winter soil temperature is more than 6ºC at a depth of 50 cm from the soil surface). Typic torripsamment indicates typical desert sandy soil at soil subgroup level of US Soil Taxonomy. On few sites *Typic Haplocalcids Carbonatic Hypertermic* was found (showing well developed calcic horizon. The native soil at ICBA is fine sand in texture, non-saline, moderately alkaline and strongly calcareous (53% $CaCO_3$). Organic matter is very low (<0.5%) and the Munsell Soil Color-dry is 10YR 6/4 pale brown. Available water capacity is low, suggesting careful water management plan to offset plant requirements and to avoid pressure on drainage system.

EXPLORING DOMINANT LAND USES AND THEIR ASSOCIATED SOIL-BASED AGROECOSYSTEM FUNCTIONS IN A HETEROGENEOUS AGRICULTURAL LANDSCAPE IN THE ANDES

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Over the past decades more and more studies have highlighted the fact that the ecosystems of agricultural landscapes, land-uses that account for significant portions of land in Ecuador (7.38 million hectares in 2013 according to INEC), provide multiple benefits to society beyond those of food, fibre and fuel provision (Fonte et al 2012; Posthumus et al 2010). However, most studies investigating these ecosystem functions have either only been conducted at the plot level or have been focused on a single ecosystem function (Balvanera et al., 2006). The current study will therefore take a more comprehensive approach by assessing different functions of the soil-based agroecosystems within the landscape (including soil physical, chemical and biological parameters, carbon storage, biomass production and yield). Moreover, within this research an attempt to assess the trade-offs in agroecosystem functioning will be conducted comparing different potential future land use changes developed in a participatory manner with the community. The main research steps include 1) participatory land use and soil mapping with the community using orthophotos 2) stratified sampling of the different land uses identified in the mapping 3) participatory mapping of potential future land use changes 4) statistical analysis using ANOVA to assess differences in biodiversity and agroecosystem functioning 5) assessment of impact of different land use change scenarios. It is expected that by describing and exploring the current land uses and their associated agroecosystem functions in a heterogeneous agricultural landscape a more nuanced insight will be provided into the influences, challenges and constraints faced by smallholder farmers and the agroecosystems upon which they rely as well as providing for a more integrative assessment to allow for better informed land use decisions and resource management planning.

EXPLORING THE INTER-RELATIONSHIP BETWEEN LANDSCAPE HETEROGENEITY AND WITHIN FARM VARIABILITY IN RESOURCE ALLOCATION IN THE ANDES

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The agricultural landscapes of the highlands of the Ecuadorian Andes are characterized by high degrees of heterogeneity and are known for a 'reversed' fertility and land degradation gradient where lower slopes are often more severely degraded than the higher slopes as a result of historical land uses. Understanding how farmers respond to and manage this gradient as well as their role in its perpetuation is important in the search for more contextualized and locally adapted interventions to achieve pathways to more sustainable forms of land conservation and aggradation. However, while a growing body of work is being developed to investigate this inter-relationship in Africa little has been developed in the Andean context (with some notable exceptions: Vanek et al 2013, Mayer 2002 and Brush et al 1989). The current research will therefore build on this existing literature by investigating the inter-relationship between landscape heterogeneity and within farm diversity within the Andean geographical, socio-economic and cultural context. Particpatory land use mapping workshops complemented by farming systems surveys, resource flow maps and ethnographic interveiws will tease out variations in how farmers manage their different fields located throughout the agricultural landscape. Assessments of soil-based agrecosystems and biodiversity will also be conducted. The resultant data will be analysed with cluster analysis and ANOVA to identify correlations between variables and the state of the soil-based agroecosystems. By doing so it is expected that a richer understanding of how smallholder farmers manage and allocate resources in such diverse agroecosystems will be developed. It is hypothesized that the smallholder farmers in the agricultural landscape will manage and allocate resources differently within farms as a result of a myriad of cultural, socio-economic and biophysical influences including micro-climates, soil types, elevation levels, slopes, states of degradation, perceptions regarding fertility, historical land uses, distance to homestead and resource endowment.

SOIL FUNCTIONALITY INDICATORS AND MULTIFUNCTION ASSESSMENT OF CERRADO - BRAZIL

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Ever-more-pressing demands on the land are driving unprecedented land-use change. In turn, unsustainable land use is driving soil degradation and loss of soil functions from which the full ecosystem recovery is unlikely and can only be reestablished in a long-term. Restoration might be the biggest problem of the Cerrado in Brazil since it requires greater and greater external inputs to repair. Because of strong interactivity, management to enhance some ESs can jeopardize others or lead to some adverse degradation processes. Hence, the use of soil quality indicators related to its functionality is an indirect way to measure the quality of the soil and is useful for monitoring changes in the environment. Globally and regionally, grasslands provide a number of key ecosystem services including support, provisioning, regulating, cultural, and biocontrol services. The Cerrado region holds the second largest biome in Brazil, which represents ca. of 25% of its total area, and has great prominence in the national and global agricultural scenario, while being an important reserve of biodiversity and food production potential. Ecosystem services and soil functions are of great importance and have been frequently discussed; however, there is a gap on between ecologists and soil scientists. Even though several studies state the importance of stablishing parameters to assess soil functions, none specify which parameters should be used. Therefore, this paper reviews publications on soil functions and indicators in the Cerrado region of Brazil and discusses its assessment using multifunction parameters. A review based survey was conducted, contemplating aspects of soil functions in Cerrado, including physical, chemical and biological parameters used as soil indicators. This paper is the first step of an ongoing PhD research, which aims at analysing the main studies regarding soil rehabilitation in Cerrado and then creating a rehabilitation guideline, that will give recommendations for soil regeneration.

REMOTE SENSING OF BURNED RESIDUE IN FIELDS USING LANDSAT-8 SENSOR IMAGERY

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Residue burning is usual in some agricultural regions of Iran, which creates negative impacts on agricultural soils obviously. Present research was carried out for finding an accurate and fast method for monitoring of residue management. In this research the ability of Landsat-8 sensor imagery for monitoring of burned fields was evaluated using Spectral indices and analysis of linear spectral separation. For this purpose, spectral indices include; Normalized Difference of Vegetation Index (NDVI), Burned Area Index (BAI), Normalized Burn Ratio (NBR), Normalized Burn Ratio Thermal (NBRT) was created for experimental lands and four soil surface condition as experimental plots were considered include; no planted field, residue covered field, green vegetation field and burned residue field. The comparison among means of indices was conducted using Duncan's multiple range test at a 1% probability level. In order to validate the ability of linear spectral separation in segmentation and determination of burned fields area, the area of burned fields was determined manually (ground-based method) in the farm and was represented as a function of linear spectral separation data. Result showed, there is the significant difference between four soil surface conditions about means of studied indices. And the mean of BAI index for no planted field (soil), residue covered field, green vegetation field and burned residue field (ash) was 10.86, 4.50, 4.84 and 148.1 respectively and BAI index was stronger than other indices in separation of burned fields from other fields. Considering standard deviation of BAI index, the range of 88.41 to 207.79 was determined as a threshold range for separation of burned residue from other field conditions. The area average of burned fields that had been separated from other fields by using BAI index had high correlation (R^2=0.89) with ground-based obtained area. Also area of burned fields that had been estimated by analysis of linear spectral separation, had a good correlation (R^2=0.81) with obtained data from ground-based method.

EFFECT OF FIRE FREQUENCY ON NUTRIENT LOSSES IN BURNED PINE FOREST OF NORTH-CENTRAL

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Post-fire nutrient losses in Mediterranean forested areas have been suggested as one of the key drivers for ecosystem degradation. This research emphases the gap in the study case in Portugal by assessing whether repeated wildfires in Maritime Pine. In the current study, focus is on the effects of repeated wildfires, due to fire-enhanced runoff generation and the associated losses of total nutrients (TN and TP).

Large wildfire occurred in early September 2013 and roughly affected 3000 ha in the municipality of Viseu in north-central Portugal. Shortly afterward, six Maritime Pine stands were selected within the burnt area. According to the available burnt-area maps, three unburnt sites over 35 years were selected as a Control (C) site, while the other sites had burnt four times before 2012, called Degraded (D) sites and Semidegraded (SD) sites with one fire. At each of these sites, three pairs of micro-plots of approximately 0.25 m^2 were installed on the upper, middle and lower halves of the slope after the wildfire.

Since the installation of the plots, runoff has been measured at weekly intervals depending on rainfall, and samples were taken for laboratory analysis for TN and TP concentrations. Result shows the burnt sites presented higher nutrient concentrations than the C sites after fire. In the second year, nutrient export in runoff was higher in the D sites than SD and C sites. High nutrient losses occurred in parallel to heavy rainfall events. Existence of vegetation was also quite important to reduce nutrient export and runoff when the litter component wasn't significant on soil surface. In the D sites there was a considerably decrease of nutrient export and runoff along with the increase of cover on soil surface.

DYNAMIC MODEL OF SOIL FUNCTIONING AND DEVELOPMENT

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Feasibility demonstration of a dynamic model of soil functioning and development interrelated to the environmental factors is based on a partial dissipation of energy and matter flows, that pass through the soil as radially differently lasted reciprocating movements. Synergistically soil is a dissipative system of a stream type. It was experimentally proved that the externally influenced subordinated processes of moisture redistribution in the soil pore space occur when changing the overall thermodynamic conditions of the system, which are of self-oscillating nature. At that the acidity of pore solution changes, phase transformations of matter occur along with its local redistribution and three-dimensional soil matrix zoning in the space. Soil meets all characteristics of an active kinetic medium, which is a key concept of synergy, in particular relative to the availability of distributed energy. It was determined the mechanism of thermodynamic imbalance of the bubbles of clamped in the soil pore dilatations air that reacts to the changes in temperature, atmospheric pressure and water saturation.

The externally influenced subordinated energy-consuming processes maintain a soil homeostasis to provide the main functions on preservation and accumulation of nutrition components (ecological function) and their availability for plants (productive function) because of their stabilization dynamics in the heterogeneous structure of three-dimensional soil matrix. The homeostatic processes have certain intensity, are the result of systemic thermodynamic interaction of soil and environmental factors and determine the dissipation level of external flows of energy and matter. The self-regulation and restoration of basic properties and structural organization of the soil environment are the results of these processes. The intensity of homeostatic processes and kinetic component of energy balance are the determining factors of productive soil fertility and provide the energy efficiency of soil functioning.

ANTHROPOGENIC CHANGES IN RELIEF OF RAISED BOGS IN THE POLISH CARPATHIANS

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Publications on the human impact on peat bogs pay a lot of attention to peat erosion, peat burning and changes in the physical and chemical properties of peat deposits that indicate pollution in the environment, but a more detailed analysis of current changes in the peat bog relief as a result of peat deposit extraction and drying is omitted. The best analyzed peat bogs in southern Poland are the raised bogs in the Carpathians. The dominant landscape element of post-peat areas is scarps, which are initially vertical or step-type, often forming zigzag-shaped sequences. Another important landscape element is numerous hollows filled with water. Older post-peat areas, deprived of peat cover, are used for agriculture. Younger post-peat areas are more frequently drained by manmade drainage systems than older post-peat areas. Active peat extraction fields that are being intensively dried possess the most diverse and dynamic morphology. Once peat extraction ends and the drying of the remaining peat deposits is discontinued, the landscape of a post-extraction peat bog is changed and the thickness of the remaining peat deposits is greatly reduced. The decline in the total area of peat domes in the study areas began as early as the 13^{th}-17^{th} centuries when settlers arrived in the region. The peat dome range decreased at the highest rate in the 19^{th} century and the first half of the 20^{th} century. In recent years, the peat dome range has begun to stabilize due to reduced interest in peat deposit extraction and reduced water management efforts. This has led to clearly visible restoration of post-peat areas. Rainfall in the early spring causes peat packets in scarps to turn to mud and fill peat hollows at the base of the scarp.

VALIDATION OF MODELS DESCRIBING RELATIONSHIPS BETWEEN MICROBIAL SOIL PROPERTIES AND CHARACTERISTICS OF STANDS IN CONIFEROUS AND DECIDUOUS FORESTS

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Validation of regression models describing the relationships between microbial and physico-chemical soil properties is a important step in their generalization but it is rarely done. Statistical models based on analysis of covariance were calculated to reveal how microbial biomass C (MBC), basal respiration (R_B), substrate-induced respiration (R_S), the microbial quotient (MBC/C_{org}) and the metabolic quotient qCO_2 (R_B/MBC) were related to the properties of stands (pH, total and extractable C and N, horizon (Of,Oh), forest type (coniferous, deciduous)) in soils from 22 localities in the Czech Republic. Nine of the stands was with deciduous forests, 13 with coniferous forests. The analyses were done separately for the organic horizons and for the upper mineral layer of 0-10 cm. Extractable C and N and pH were chosen using backward selection as significant explanatory terms for most microbial parameters. Different four localities with deciduous forests and six stands with coniferous forests were sampled within following two years to validate the regression models. Linear regression between calculated and analyticaly estimated data showed that criteria for the confidence limits of intercepts (if zero is included) and slopes (if the value one is included) were fulfilled in all cases except of qCO_2 and the metabolic quotient, in the latter case only in the layer 0-10 cm. The best fit of data into the regression model was found for R_S (r^2=0.91) and R_B (r^2=0.62) in the organic horizons followed by the same parameters in the layer 0-10 cm (R_S: r^2=0.59, R_B: r^2=0.54). It shows that the models for basal and substrate-induced respiration were the most reliable. More samples are probably necessary to reach satisfactory models for MBC, where relative lower value of r^2 (0.42) was found for the organic horizons and lack of fit for the layer 0-10 cm.

NATURAL AND INDUCED SUPRESSIVENESS OF *GLOBODERA ROSTOCHIENSIS* BY *POCHONIA CHLAMYDOSPORIA* ON A CHRONOSEQUENCE OF ABANDONED AGRICULTURAL SOILS

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The nematophagous fungus *Pochonia chlamydosporia* is one of the most studied biological control agents against plant endo-parasitic nematodes such as *Globodera. P. chlamydosporia* has been found in nematode suppressive soils to parasitize nematode eggs. As agricultural soils are known for their ability to build-up suppressive capacities against soil pathogens, these soils are perfect to study this plant-nematode-fungus interaction. We wanted to know whether legacy effects of *Pochonia* sp. remain so many years after cessation of agricultural practices, as the fungus survives as a saprophyte in soil in the absence of both plant and nematode hosts. On the Veluwe area in the Netherlands we used a chronosequence of small scale ex-arable fields that have been taken out of agricultural production 8 to 31 years ago. We have performed an experiment under controlled conditions using tomato plants (*Solanum lycopersicum*) on nine soils of this chronosequence inoculated with 5 densities of potato cyst nematode (*Globodera rostochiensis*) with or without extra addition of cultured *P. chlamydosporia*. We found no differences in tomato performance that could be subscribed to *Globodera* infection, although we checked the cyst formation. Also, we found no clear biocontrol effect of *Pochonia* addition. After harvesting, we plated tomato roots, soil and cysts, and we sequenced the soil and cyst colonizing fungi. Two nematode feeding fungi, *Pochonia suchlasporia* and *Paecilomyces carneus,* were found in the *Pochonia*-inoculated as well as the non-*Pochonia*-inoculated pots. Tomato plants performed best on sterilized soils. On the soils of some of the fields tomato plants performed relatively well, while on others they performed very poor. This was unrelated to the density (CFU) of nematophagous fungi in the soil and to time since land abandonment. In this system, field identity seems to play a much greater role in plant performance than potential suppression or damage of root parasitic nematodes.

COMPARING EROSION RATES IN TERRACED AGRICULTURE FIELDS AND FIRE-DISTURBED FORESTS IN A HUMID MEDITERRANEAN MOUNTAIN CATCHMENT

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In the last decades, the mountains of the NW Iberian peninsula have experienced large-scale replacement of traditional agriculture by commercial forest plantations with eucalypts and maritime pines. Traditional land management relies on intricate networks of terraces and irrigation channels to enhance water connectivity while breaking sediment connectivity and conserving soil in the fields. Commercial forest management, on the other hand, leads to regular disturbances of vegetation and soil (every 12 years in eucalypt plantations) which greatly enhance water and sediment connectivity during a few years. Recurrent forest fires enhance these disturbances. It is therefore possible that afforestation and forestry management has enhanced soil erosion when compared with traditional agriculture. However, the irregular nature of forest disturbances makes this problem difficult to perceive by land managers. This issue was assessed at the Macieira de Alcoba mountain catchment (1 Km^2), which was instrumented in 2010 in order to study soil erosion in terraced agricultural fields, but where a forest fire in 2011 allowed a comparison of erosion and sediment yield between both areas. Erosion in the fields and burnt slope was assessed by mapping and measuring rills after large storms; sediment dynamics in streams were assessed by monitoring bottom sediment deposition and ressuspension at key points; and catchment-scale sediment yield was assessed by the continuous monitoring of streamflow and suspended sediment concentration at the catchment outlet. The preliminary results from this assessment indicate that erosion rates in the burnt slope were two orders of magnitude higher than those for the agricultural fields, and that even when taking into account the infrequent nature of disturbances, erosion in forested slopes might be on the same order of magnitude as that of agricultural fields.

THE ROLE OF VEGETATION PATCHES AND SOIL MOISTURE CONDITIONS IN RUNOFF AND EROSION CONNECTIVITY IN A 4-TIMES BURNT PINE STAND

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After wildfires, vegetation tends to recover in a mosaic pattern of vegetated patches on a bare soil canvas (inter-patches). The connectivity of source areas of runoff in such mosaics is often considered as key driver in overland flow and associated soil losses at larger spatial scales. With time-since fire, post-fire vegetation recovery is expected to change connectivity markedly, but this has been studied poorly. In the framework of COST Action ES1306 (Connecting European Connectivity Research), this study aimed to assess how overland flow and erosion generated at inter-patches would be "handled" by downslope vegetation patches, consisting of a re-sprouted shrub, Pterospartum tridentatum.

The study site comprises a south-west facing pine slope in north-central Portugal, that was burnt, with moderate severity, in early September 2012 and three more times before that since 1975 (1978, 1985, 2005). The main hypothesis was that vegetation patches act as effective sinks for run-on and transported sediments from upslope inter-patches. The study site was instrumented with 12 bounded erosion plots in three slope sections (upper, middle and lower). Using micro-plots of ±0.25m^2 as building blocks, various slope lengths were targeted ranging from ±0.5-1.5m. Soil moisture (SM) was measured under shrubs and its upslope inter-patches in unbounded replicates. Samples were collected from October 2014 to February 2015. Total rainfall was 498mm and maximum rainfall intensity (15 minutes) ranged from 2-20mmh^{-1}. The preliminary results show that micro-plots with a vegetation patch at the bottom produce much less runoff and erosion than plots composed of only bare soil. This relation was most pronounced for plots with the longest inter-patch length, but differed between the slope sections and varied with plot micro-topography. The SM response to rainfall was quicker and stronger under the shrub canopies than in inter-patches. These results confirm that vegetation patches acted as sink for run-on.

LOW-LAND GULLY EROSION IN THE AMHARA REGION, ETHIOPIA

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Gully erosion as a form of land degradation is a prime issue in Ethiopia. Over the past decade, gullies have formed in the foothills of the Minizr sub-catchment in the highlands of North-Western Ethiopia. To halt and mitigate gully erosion in the foothills, this study looked at the gully formation process and three root causes: reservoir construction, land use change and the implementation of soil and water conservation measures in surrounding hills.

Three gullies were selected for detailed analysis, whose shape and volume were derived using terrestrial photogrammetry. The gullies were sampled for soil moisture over a 3-month period.

Results show that the erosion rate has indeed increased compared to pre-2010 rates, measuring 74 tons/ha/year in the 2014 rainy season. Extensive signs of subsurface flows are visible in and around research gullies. The following process is observed: after rains, water infiltrates and flows downhill through a permeable layer towards the reservoir. In the foothills of the study area, these flows become perched on a less permeable layer of dense grey clay. This leads to positive pore water pressures, which in turn cause dispersion of clay particles. As an end result, soil cohesion is greatly reduced. In these conditions, gully formation is easily triggered by overland flow and slumping. Expansion is mainly through bank collapse.

No evidence has been found that the reservoir construction has influenced the hydrology of the study area since its construction in 2011. Also, there were no signs of significant land use change between the 1980s and 2014. The implementation of contour barrier type soil and water conservation measures is the most likely root cause. Although these measures have decreased overland runoff on the hillslopes, it has increased ground water flows toward the study area and therefore made the area more susceptible to gully erosion.

SINGLE-GRAIN OSL AND IRSL DATING FOR RECONSTRUCTION OF SOIL FORMING PROCESSES IN A HILLSLOPE CATENA IN SIERRA MORENA, S SPAIN

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Soil formation depends on bedrock, climate, relief, vegetation and time. Bioturbation and colluvial soil re-location are important and significant processes that affect the mechanisms and rate of bedrock weathering. The estimation of the relative fraction of bedrock grains which has been mixed in the soil and transported either vertically or laterally to different depths gives an indication of the degree to which bedrock weathering is controlled by the latter processes. However, despite the great effort dedicated to the analysis of these processes, little is known about the quantitative relationship between geomorphological changes and soil formation, especially for long timescales. This study presents reconstruction of soil processes by single grain optically stimulated luminescence techniques (OSL) in several profiles sampled along a hillslope. The OSL analyses provide a direct measurement of soil forming processes (e.g. bioturbation, colluviation) and with them a more precise formulation of soil formation models at longer timescales.

Single-grain OSL techniques have been applied to quartz and feldspar minerals which were extracted from different soil horizons from a hillslope catena located in Sierra Morena, Córdoba, in the south of Spain. Four profiles were explored extracting twelve samples in order to study vertical and lateral mixing (e.g. soil creep, colluvial processes) of soils.

The suitability of three different OSL single grain approaches, quartz OSL, IRSL (infrared stimulated luminescence) and pIRIR (post-IRSL) feldspar, was tested on four samples. Statistical parameters deduced from single-grain OSL age distributions (e.g. number of zeroed grains, scatter and shape of the distribution) were used as indicators for bioturbation and/or soil-relocation. The most suitable approach was then applied to the several samples from hillslope catena. This study reveals the potential of OSL single-grain techniques in order to shed light on bioturbation and pedoturbation processes within soil formation and their interrelationship with geomorphological processes.

SOIL REDISTRIBUTION AND LANDSCAPE EVOLUTION MODELLING: LAPSUS

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Landscape evolution modelling can test, improve or at least visualize consequences of soil redistribution hypotheses (e.g. the effect of land use change scenarios). Ideally, landscape evolution models (LEMs) combine the results of all relevant soil redistributing processes into an ever-adapting digital landscape (DEM). These processes may act on different spatial and temporal scales. LAPSUS is an example of such a LEM. Different soil redistribution and landscape processes have been included in LAPSUS for different studies: water erosion and deposition, landslide activity, creep, solifluction, weathering, tectonics and tillage. Vegetation and landuse control on soil properties can be included in a spatially explicit way. Process descriptions are kept as simple and generic as possible, ensuring wide applicability of the modelling approach. Interactions between processes are turn-based: soil redistribution caused by one process are calculated and used to update the DEM and soildepth before another process is simulated. LAPSUS uses multiple flow techniques to model flows of water and soil material over the landscape. Though computationally costly, this gives a more realistic result than steepest descent methods. In addition, the combination of different processes may create sinks during modelling. Since these sinks are not spurious, the model has been adapted to deal with sinks in natural ways. This is crucial for several purposes and has already been used for studying damming of valleys by landslides, and subsequent infilling of the resulting lake with sediments from upstream. The LAPSUS modelling framework is an example of a LEM that has embedded multiple soil redistribution and landscape forming processes and their interactions in a generic tool that can be used to study many landscapes of the world at multiple temporal and spatial scales. LAPSUS is free and currently available at www.lapsusmodel.nl

EVALUATION OF METHODS APPLICATION FOR UREA FERTILIZER BY COMPOST ADDITION AND ITS EFFECT ON PEANUT PRODUCTIVITY, MINERAL CONTENT AND QUALITY UNDER THE NEWLY RECLAIMED SALINE SOIL

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A field experiment was conducted on sandy loam to study the evaluation of methods application for urea soil or foliar application with or without compost (10ton/ fed^{-1}) on some soil properties and peanut productivity and quality under the newly reclaimed saline soil. Treatments were the recommended rate of soil applied nitrogen fertilization viz., 10,20,40 kg N/fed^{-1} which applied as urea (46%N), in addition the other three treatments were the recommended rate 5,10,20, kgN (dissolved by400L. Water/fed.) as a foliar application. The results indicated that addition of compost increased weight of seeds, pods yield (kg/fed^{-1}), weight of 100 seeds (gm) as compared to plants which untreated with compost. Also, there was a markedly increase yield parameters, as well as Chlorophyll (a+b) except proline decrease when the addition of compost. Also, increasing concentration of nitrogen rates either soil or foliar application gradually increased all mentioned parameters if compared to control. Concerning the soil pH and Ec in soil after the peanut harvest decrease value when the rate of N fertilizer increase in the presence of compost fertilizer. In this respect the content of nutritional in soil after peanut harvest took the same trend.

Furthermore, increasing of N rate as foliar spraying with compost fertilizer was more effective and increased N, p, k content and quality parameters, i.e. oil and protein in seed, peanut plants if compared to with soil application methods or plants which untreated with compost. The Interaction between rates and methods of N treatments has not significant effect on peanut productivity, yield components and quality.

PESTICIDE DISTRIBUTION IN EUROPEAN SOILS RESULTING FROM DECADES OF APPLICATION AND RELATED RISK FOR THE ENVIRONMENT

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Pesticides are products used to eradicate pests or diseases and are mainly applied as plant protection products. In order to increase crops yields due to an increasing demand for food worldwide, the amount and variety of pesticides used in agricultural land has increased in recent decades. Nevertheless, less than 1% of pesticides applied reach the target organisms, while the highest amount of pesticides is released to the environment (atmosphere, soil and aquatic systems). This is of special concern since some of these pesticides, and/or their transformation products, present a high persistence in the environment, a tendency for bioaccumulation, and a high toxicity to non-target organisms. Therefore, it is crucial to clarify the fate and distribution of pesticides applied in the long term as well as identify the off-site impacts of the application of such products. It was adopted a concept to assess the risks of repeated applications of pesticides that include (i) a chemical assessment of the pesticides residues on soils, and in the connected water bodies, from crops of South-eastern Spain, north-west Portugal and the Netherlands for an evaluation of the degree of contamination caused by pesticide use, (ii) a toxicological assessment of environmentally relevant mixtures of pesticides with aquatic and terrestrial organisms for an evaluation of the risks of pesticides to non-target organisms and (iii) the assessment of pesticide bioaccumulation potential of these mixtures in order to evaluate the risks to human health by indirect exposure to pesticides. Preliminary results from the ongoing chemical assessment reinforce the concerns on pesticide-contaminated soils in agricultural areas. The outputs from the adopted concept should lead to a greater awareness of the impacts of pesticides on human health and environment and may contribute to an improvement on European pesticide monitoring programs and policies.

ECONOMICS OF LAND DEGRADATION AND IMPOVEMENT: CHALLENGES FOR REGIONAL-SCALE ASSESSMENTS[5]

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Global food security is jeopardized by the increasing land degradation, which is especially harmful in the poorest countries of the world. Several studies showed on the global and national levels that implementation of sustainable land management practices could significantly reduce the negative effects of land degradation. However, possible impacts and the costs of sustainable land management practices are site-specific, and still much research should be done at a regional and farm level to provide evidence-based recommendations to the decision-makers and farmers throughout the world. A case study was made to estimate of the prices for action and inaction in addressing land degradation in Rostov region, south of European Russia, and a farm located there. Our results showed that in the period 2000-2010, some part of perennial plantations, pastures, and forest areas has been transformed and began to be used for agricultural crops in the studied area. This resulted in a slight degradation with regard to ecosystem services. In the next 30 years, taking action, according to our estimates, will cost $ 37 million, but the cost of inaction will be 42% lower - $ 21.7 million. Calculations indicated that economic specialization in the area has been selected correctly and there is no significant influence of transformation of land on the degradation process with regard to ecosystem services. The use of sustainable land management practices could lead to a long-term positive effect on soil fertility and improve soil ecosystem services. The lessons learned from this study are: the methodology of the economics of land degradation can be successfully applied in peculiar socioeconomic conditions of Russia, but the lack of harmonization of methods and indicators brings uncertainty to quantitative assessment.

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PERFORMANCE OF FOREST SPECIES ON SUBSTRATES DERIVED FROM DISTURBED SOILS DUE TO PETROLEUM ACTIVITY IN THE ECUADORIAN AMAZON

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Oil explotation is considered the main industrial activity that caused the most severe edaphic impacts worldwide. The most profound and adverse impact of oil extraction in Ecuadorian Amazon has yield the total loss of biodiversity and the destruction of habitats largely due to subsequent soil degradation and soil erosion. For this reasons, the main aim of our study is to evaluate the effect of different growth substrates derived from petroleum extraction processes on the quality of species with potential for use in reforestation areas affected by oil activities. Seeds of each species were planted in cells of plastic germination trays filled with a germination substrate. Once seedlings reached a certain height, they were allocated to soil treatments containing red soil 1 (T1) obtained from mud and drill cuttings cells, red soil 2 (T2) obtained from oil-platforms and black soil (T3) in order to validate our procedure. During a 14-week acclimatization stage period, species survival has been determined besides other key parameters including the Dickson Index Quality (DQI). T1 and T2 susbtrates demonstrated clay texture, low nutrients and strong acidity. During acclimatization stage, only one out of 300 plants tested deceased in T3. Five species exhibited similar DQI values for three treatments, reflecting their high performance on oil-platforms and mud and drill cuttings cells soil conditions during acclimatation stage. Such studies, like ours improve the evaluation of forest species viability on petroleum-disturbed soils addressing the development of a comprehensive selection process regarding the most suitable species for reforestation and recuperation of previously heavily affected soils.

SOIL MAP PROVIDING BASIC INFORMATION FOR CROP AND SITE SPECIFIC WATER AND FERTILITY RECOMMENDATIONS IN ETHIOPIA

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To improve and sustain agricultural productivity in Ethiopia, crop and site specific soil water and fertility recommendations are essential. Soil maps reflecting the spatial distribution of the major agricultural soils, including their morphology and chemical and physical properties, is therefore key information. A large set of representative soil profiles was described in the field, analyzed in the laboratory and classified according to the World Reference Base for Soil Resources. Information on geology and landforms was combined with soil association distributions and the result was validated in the field. Collected soil profile data was combined with legacy soil survey data and with topsoil data from ongoing fertilizer experiments. Soil profile observations were soil and rooting depth, drainage status, color, mottling, particle size distribution, structure, consistency, pore size and presence of cutans, stones, nodules and pressure faces. Samples from each pedologically identified horizon were analyzed for texture, bulk density, pH, cation exchange capacity (CEC), exchangeable bases, electrical conductivity, organic carbon, nitrogen, phosphorus and micro-nutrients. Major identified soil types according to their landscape positions were Fluvisols, Vertisols, Cambisols, Luvisols, Nitisols, Regosols and Leptosols. Identified limitations for agricultural productivity are low contents in available phosphorus and nitrogen as well as surprisingly low organic matter contents especially in the topsoil where roots are concentrated. Manuring and mulching to provide nitrogen and application of phosphorous fertilizer are key soil fertility management recommendations to overcome deficits. Soil and water conservation on sloping to steep landscapes, preferably by hedgerows and/or grass strips, and incorporation of organic residues, are key soil water management recommendations. Soil-landscape relationships, as presented on the soil map, provided crucial basic information to guide practical, site specific soil water and fertility recommendations.

MONITORING SOIL STRENGTH DYNAMICS AT PLOT SCALE USING IMAGE TEXTURE ANALYSIS

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Aggregate breakdown under rainfall depends on soil strength and a raindrop kinetic energy. When a soil is exposed to the direct impact of raindrops, a rearrangement of soil particles occurs forming a structural crust affecting soil physical properties. While previously spectral information was used to assess the soil crust by compositional and colour changes, we designed in this research an outdoor experiment to monitor soil using a high spatial resolution digital camera. Ten trays (60x40 cm) filled with duplicates of 5 different soils (silty loam with different organic matter content, loam and sandy loam) were photographed twice per day. A customized Pocket Penetrometer apparatus was used for soil strength measurements, and a DAVIS weather station was installed to record data at 30 minutes intervals. We collected images from November 2014 till February 2015, together with weather and soil strength data. Image texture is concerned with the spatial distribution of gray tones. We used the Local Binary Patterns (LBP) gray-scale invariant local texture descriptor and the Gray Level Co-occurrence Matrix (GLCM) for texture feature extraction. This paper aims to present initial results on a relation between image texture changes in time, aggregate breakdown and change in soil strength.

Theme 6
Climate Change - Posters

CARBON STOCKS IN POLDERS SOILS DEVELOPPED IN INTER DUNES LANDSCAPE UNDER SEMI-ARID CLIMATE (LAKE CHAD)

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Soil organic carbon represents an important part of the terrestrial carbon stock, during last decades its fluctuation is mainly due to human perturbations including the land-use change. In another way, soil organic carbon is the key component of soil quality, ie. soil conservation and maintenance of soil fertility, maintenance of biodiversity and water efficiency. In arid and semi-arid regions, carbon management is inseparable of the control of thermo-hydric constrains. The concept and the behaviour ofof C sequestration for those regions is still too little known or understood, because of lack of knowledge and large set of data. Before a carbon balance, a correct evaluation of soil carbon stock is needed. We studied four inter dune polders, 10 to 65 years of construction, in the NE region of Lake Chad (Chad). These lands are highlighted as an intense agricultural region. Soil profiles, n=33, and 3 sites in alluvial zone as reference were sampled from surface to 1m deep, by 0.1m increments. Total carbon (dry combustion) and inorganic (carbonate volumetric measurement by calcimetry) were determined. Soil bulk density was determined by core method in fresh soils layers and by excavation/water volume method in dried layers. The stocks of organic carbon (0-1 m) for t0, t10, t60, t62 and t65 were estimated respectively: 200 ± 0.8 ; 241 ± 0.9 ; 183 ± 34 ; 174 ± 0.3 and 189 ± 1.1 tC. ha^{-1} ($p = 0.004$), while inorganic carbon stocks for the same depth were respectively 0.1 ± 1 ; 2 ± 0.005; 1 ± 0.1 ; 0.4 ± 0.002 and 6 ± 0.2 tC. ha^{-1} ($p = 0.03$). The stocks of organic and inorganic carbon presented a spatial variability between polders, we detailed the stocks in the uppers soils layers. The spatial variability is discussed in function of nature of soils layers and water regime in these lowlands.

EFFECTS OF FABA BEAN POSITION IN ROTATION SYSTEM ON ABUNDANCE AND DIVERSITY OF SOIL MICROORGANISMES AND NITROGEN AVAILABILITY

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The diversity of crops managed in rotation system plays a significant role in the modification of soil habitat. Including faba bean improves many agro ecological services such as soil physical and chemical quality, soil biodiversity and biological activity, and renewable inputs of nitrogen into soil. Nevertheless, the persistence of these positive effects of the faba bean pre-crop in the rotation has rarely been studied. In this context, our objective was thus to investigate how the faba bean position within the crop rotation affects soil microbial community and N availability under conventional (CT) and reduced (RT) tillage practices. For this aim, 36 wheat fields regularly distributed in the Upper- Normandy (north-western France) were selected and sampled on spring. Three rotation systems were examined with different position of this leguminous: previous crop (N-1), faba bean sown three year earlier (N-3) and rotation without faba bean (control). The abundance, diversity and the activity of microbial community were assessed thanks to the following variables: microbial biomass carbon, nitrogen gross flux, hospholipid Fatty Acids (PLFA) and four soil enzymatic activities involved in C cycle [b-glucosidase and Cellulase activites] and N cycle [N-acetyl glucosaminidase and Arylamidase activites]. In addition, soil physical and chemical characterizations were performed for each rotation systems under both conventional and reduced tillage practices..

Despite the variability in site geographical location, their soil physical and chemical characteristics showed no significant difference (pH, total C, texture). Rotation with previous faba bean and reduced tillage showed higher enzymatic activities in the following wheat compared to all other modalities. Abundance of bacteria and fungi community was statistically linked with soil pH and seemed to be more important in N-1, N-3 and Control under reduced tillage. In addition, their structure, described by PLFA, showed a significant variation between CT and RT and is different in tested modalities.

ESTIMATING SOIL CARBON: EXPLORING METHODOLOGIES

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Human activities add an estimated 8.7 billion tonnes of carbon (PgC) to the atmosphere annually, resulting in a net increase of 3.8 PgC after the amount absorbed by the biosphere is accounted for. Carbon is absorbed by the ocean reservoir, vegetation biomass and soils. An estimated 2400 PgC is stored in the upper 200cm of Earth's soils, with additional estimates of 300-700 PgC in wetland soils, and 1670 PgC in permafrost soils. If future projections of climate change are realised, Soil Organic Carbon (SOC) is likely to reduce (resulting in an increase of atmospheric CO_2) due to enhanced decomposition rates of plant matter. As part of international reporting obligations, Ireland currently employs default coefficients provided by the IPCC Tier 1 methodology to estimate carbon released from Irish soils which may result in erroneous SOC emission estimates. Plans to increase Irish agricultural productivity will increase emissions in the sector by an estimated 12% by 2020 while transport emissions are expected to increase by 12-22% meaning Ireland is poised to exceed 2020 emissions targets set by the EU by between 5-8 Mt of CO_2eq, potentially resulting in fines of €500m - €800m. It is therefore vital that emissions from each sector are accurately quantified in order to minimise waste and optimise efficiencies. In order to refine emission estimates, a review of the methods for assessing SOC fluxes internationally is presented, with gaps in research highlighted. Subsequent research which aims to address these gaps will also be outlined.

THE USE OF BIOMARKERS TO TRACE CARBON TRANSFORMATIONS AND INPUT IN SOILS

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Tracing the origin of soil organic carbon (SOC) is an important tool to unravel mechanisms that lead to its (de)stabilization. To this end biomarkers, i.e. (groups of) specific molecules that can be linked to (groups of) specific plant species or parts, are often used. However, the use of biomarkers to trace SOC origins is also subject of fierce scientific debate. There are those who see biomarkers as a cure-all solution, while others claim that the concept of biomarkers is intrinsically flawed and therefore useless. We believe neither vision is correct. In our presentation we will discuss the merits and drawbacks of using biomarkers to trace root versus leaf derived organic matter in soils. As a case study we will use a 1-year incubation experiment with fine root and leaf material of six temperate tree species, and discuss the abundance of root and leaf derived biomarkers and the development of their concentration over time. We will link this to our experience with application of biomarkers in podzols and plaggic anthrosols, and place it in the context of similar attempts by other groups. Thus we hope to stimulate a broader discussion about the use of biomarkers to trace SOC origins.

ROLE OF COBALT IN WHEAT WATER RELATIONSHIPS UNDER TWO DIFFERENT MOISTURE REGIMES

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Two experiments were carried out to study the role of cobalt in wheat water relationships under 100% and 80% regimes. The first was carried out at greenhouse National Research Centre. The second was carried out at El-Nobria Farm, National Research Centre, Delta Egypt. Cobalt was added once in the form cobalt sulphate in levels: 0.0, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5 and 20.0 ppm. The obtained results could be summarized as follows: cobalt at 10.0 ppm had a promotive effect on wheat growth and yield with water regime (100%) while the level of cobalt at 15.0 ppm gave a positive affect under 80% water regime. Cobalt increased wheat leaf water potential and reduced the evapotranspiration rate. Cobalt help wheat plants to resist stresses caused by low water content in the newly reclaimed soils. Cobalt save 20% water consumption. Cobalt can be used under conditions of water shortage caused by climate change.

SOIL RESPIRATION IN BIODIVERSE SEMI ARID ECOSYSTEMS: EFFECTS OF VEGETATION TYPE AND SEASONAL VARIATION

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Soil respiration (Rs) plays a decisive role in atmospheric CO_2 regulation and semi arid environments are increasingly becoming a major driver of C processes. Despite the relevance of Rs in these ecosystems, there is still limited knowledge of its responses to abiotic and biotic processes and its temporal variation. To address these critical knowledge gaps, we investigated the seasonal variations and controlling factors of Rs for different vegetation types in biodiverse ecosystems of the Pilbara region (Western Australia). This region, with a semi-arid climate and two main seasons (wet–summer and dry-winter), is known for its unique geology, climate, topography, and high levels of plant endemism.

This research was conducted in seven study sites across the Pilbara with similar native soils and analogous ecosystems. Soil sampling targeted the most representative and dominant vegetation cover types consisting of trees (*Corymbia* spp.), shrubs (*Acacia* spp.), grasses (*Triodia* spp.). Bare soil areas were also assessed. Soil sampling and field measurements were carried out in February 2014 (wet-summer season) and July 2014 (dry-winter season). Rs was measured with a portable soil CO2 flux chamber attached to a Li-Cor 6400. Soil temperature and moisture were also determined. Soil samples were collected at each site and analysed for physicochemical properties. Higher Rs rates were found in the wet-summer season in all vegetation types. Rs differed significantly between vegetation types and seasons ($P < 0.001$) and differences among vegetation types were larger in the dry-winter season (CV= 40 - 116%). Rs was poorly correlated with soil moisture, but significant relationships ($P < 0.001$) were found with soil temperature, air temperature and organic carbon (R Spearman values ranging from 0.32 to 0.41). Our results highlight the importance of the vegetation type and environmental factors as well as seasonal patterns for estimation of CO2 efflux in semi-arid ecosystems.

THE EFFECTS OF LAND USE CHANGES ON SOIL CARBON STOCKS

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The effects of land use changes on soil carbon stocks are a matter of concern stated in international policy agendas on the mitigation of greenhouse emissions because forests are a significant net carbon sink. Afforestation is increasingly viewed as an environmental restorative land use change prescription and is considered to be one of the most efficient carbon sequestration strategies currently available. Given the large quantity of CO_2 that soils release annually, it is important to understand disturbances in vegetation and soil resulting from land use changes. The main objective of this study is to assess the effects of land use changes and afforestation practices on C dynamics. The MED-AFFOREST project put forward this hypotheses for analysis: an increase in vegetation cover in Mediterranean mountain areas, after the abandonment of agricultural land and grazing activities, may lead to significant increases in soil C sequestration. For this aim, six different land uses (bare soil, cultivated soil, secondary succession *Pinus nigra* afforestation, *Pinus sylvestris* afforestation, and a natural forest), in the Central Spanish Pyrenees were chosen. Carbon dynamics will be studied in the bulk soil samples, and in the fractions separated according to two methodologies: (i) aggregate size distribution, and (ii) soil density fractionation. Rates of carbon mineralization will be determined by measuring CO_2 evolution using an automated respirometer (Respicond) in the laboratory.

THE EFFECT OF MOLE DRAINAGE ON N_2O EMISSIONS FROM A CLAY-LOAM SOIL UNDER GRASSLAND

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Nitrous oxide (N_2O) is a potent greenhouse gas produced by microorganisms in the soil. Land drainage alters soil moisture, which influences N_2O emissions. The objective was to investigate the effect of mole drainage on N_2O emissions. This study was conducted at Solohead Research Farm (52° 51' N, 08° 21' W, 95 m), with permanent perennial ryegrass/white clover grassland, clay loam soil, shallow water table depth (WT; <2 m), mean annual rainfall of 1036 mm and monthly soil temperature between 5.6 and 16.3ºC. Experiment A was laid down in 2011. It was a randomized complete block design with four treatments replicated four times. Treatments were (i) undrained control (ii) mole drains installed in January (iii) mole drains installed in July and (iv) gravel mole drains installed in July. Experiment B was laid down in June 2014. It was a randomized complete block design with two treatments replicated four times. Treatments were (i) control and (ii) gravel mole drains. Fertilizer N was not applied to either experiment. In experiment A soil N_2O flux, WT and water filled pore space (WFPS; top 10 cm) were measured between June and November 2011 and between January and June 2014. On experiment B the above set of measurements started in June 2014 and are on-going. Drainage (P<0.05) lowered WT and WFPS compared with the control in both experiments. There was no significant difference in cumulative N_2O emissions between the drained and control treatments during any of the sampling periods. On experiment A mean (SE) daily N_2O-N emissions were 39.2 (1.43) g/ha in 2011 and 23.1 (1.12) g/ha in 2014. On experiment B daily average emissions were 5.67 (0.67) g/ha between July and December 2014. Subsurface mole and gravel mole drainage lowered the WT and reduced the WFPS, however, they had no detectable effect on N_2O emissions.

ISRIC Session: Optimizing Soil Information Services for Solving Global Issues - Posters

RELATING VARIATIONS IN CROP YIELDS TO SOIL QUALITY; A CASE STUDY

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Land use and management have major impacts on soil quality. Conversely, the production of food, feed and biofuel highly depends on soil quality. This has been well recognized, and various land and soil evaluation systems have been developed. However, these systems are often expert-based and differ in outcome. As yet, there is little quantitative information on the relationships between soil quality and crop yield and yield stability over time. Also, spatial variations in yields and yield trends are rarely used to assess changes in soil quality, and most yield gap analyses consider soil quality only indirectly, largely because of the complexity of soil quality and the interactive effects with management.

Here, we report on a case-study aimed at relating spatial variations in soil quality to spatial variations in crop yields. The study was carried out at farmers' request; their main questions relate to the spatial variation in soil physical and soil chemical characteristics of the soil profile, and how these should be managed for sustaining high crop yields. Soil structure and soil water holding capacity, and the effects of these on seed germination, crop yields and trafficability during harvest are main issues. A main aim of the study was therefore also to derive at a quick, quantitative test for assessing soil structure.

Four fields were sampled, using a stratified random soil sampling design, based on existing crop yield maps and soil information. Both undisturbed and disturbed soil samples (100-150 per field) were taken at depth of 5-10, 30-35, 50-55 and 70-75 cm depth, and analysed for soil physical (Ksat, pF) and bio-chemical characteristics (pH, SOM, (micro)nutrients, respiration), using both standard methods and quick scans with NIR, MIR and XRF.

Results indicate that crop productivity and yield stability over time can be used as proxies of soil quality. Soil structure is a main yield defining factor, as it influence seed germination and root growth, and also harvest time. Proposals for quantitative tests for assessing soil structure will be discussed.

SOIL INFORMATION FOR EARTH SYSTEM MODELLING

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The Land Surface Model (LSM), as a component of the Earth system model, needs soil information as model parameters, initial variables or benchmark data sets for calibration, validation, and comparison. In recent studies, we developed soil datasets of China and the world to address this need. These datasets are at 1 km resolution with multiple layers. We used a standardized data structure and data processing procedures to harmonize the data collected from various sources. We used a soil type linkage method (i.e. taxotransfer rules) and a polygon linkage method to derive the spatial distribution of soil properties. Included soil information are soil particle-size distribution, organic carbon, nutrients, etc. We also used an ensemble of pedotransfer functions to estimate soil hydraulic parameters used in LSMs. We evaluated different spatial aggregation methods to simplify the map units and to lower the spatial resolution. Part of the datasets were implemented in the Common Land Model, leading to improvement in simulating soil water and energy balance. The produced datasets were downloaded hundreds of times at http://globalchange.bnu.edu.cn/ by users from various fields within the Earth sciences.

SOIL THREATS IN EUROPE

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Soil is one of our most important natural resources that provides us with vital goods and services to sustain life. Nevertheless, soils functions are threatened by a wide range of processes and a number of soil threats have been identified in Europe. Although there is a large body of knowledge available on soil threats in Europe, the complexity and functioning of soil systems and their interaction with human activities, climate change, and ecosystem services (ESS), is still not fully understood.

Within the ongoing RECARE project, an extensive literature review was carried out by a group of experts on soil threats at the European level. In total, 60 experts were involved in the process of reviewing and drafting the report and 11 soil threats were identified. The objective was to provide an improved overview of existing information on (the status of) soil threats and degradation at the European scale. These soil threats are soil erosion by water, soil erosion by wind, decline of organic matter (OM) in peat, decline of OM in minerals soils, soil compaction, soil sealing, soil contamination, soil salinization, desertification, flooding and landslides and decline in soil biodiversity. Interrelationships between soil threats and between soil threats ecosystems services are made, and will be presented. A synergy between the soil threats is made and the major climate, human and policy drivers are identified. An overview of the status of soil degradation at the European scale will be presented, with an attempt to combine the status of the soil threats in one European map.

PERENNIAL POLYCULTURES REPLACING ANNUAL MONOCULTURES? IMPLICATIONS FOR SOIL MANAGEMENT AND SUSTAINABLE AGRICULTURE

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Agriculture is the most environmentally destructive activity humanity has ever invented in terms of its contribution to biodiversity loss, climate change, land degradation and soil degradation. And yet agriculture does not deliver in food security for all, and it faces unprecedented challenges in the coming decades. In order to feed a growing population in a way that promotes sustainability, new methods of crop cultivation and soil management are required. To develop productive agriculture entirely grounded on organic principles, based on the use of perennials grown in polyculture rather than annual crops grown in monoculture, is a daring vision that could help us overcome a vast majority of the problems associated with modern farming and soil degradation. The boldest rethinking of agriculture and soil management involves a transition from predominantly annual crops in monocultures to perennial crops grown in polycultures. Such a transition has the potential of contributing significantly to addressing the host of problems suffered by our soils as a result of our current mode of food production. Our research aims to study the social and economic aspects of such a transition, as well as barriers to the dissemination of new methods and techniques.

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