Geophysical Research Abstracts
Vol. 12, EGU2010-15345, 2010
EGU General Assembly 2010

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ABSTRACT
Through unsustainable land use practices, mining, deforestation, urbanisation and degradation by industrial pollution, soil losses are now hypothesized to be much faster (100 times or more) than soil formation – with the consequence that soil has become a finite resource. The crucial challenge for the international research community is to understand the rates of processes that dictate soil mass stocks and their function within Earth's Critical Zone (CZ). The CZ is the environment where soils are formed, degrade and provide their essential ecosystem services. Key among these ecosystem services are food and fibre production, filtering, buffering and transformation of water, nutrients and contaminants, storage of carbon and maintaining biological habitat and genetic diversity. We have initiated a new research project to address the priority research areas identified in the European Union Soil Thematic Strategy and to contribute to the development of a global network of Critical Zone Observatories (CZO) committed to soil research. Our hypothesis is that the combined physical-chemical-biological structure of soil can be assessed from first-principles and the resulting soil functions can be quantified in process models that couple the formation and loss of soil stocks with descriptions of biodiversity and nutrient dynamics. The objectives of this research are to

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

The experimental design studies soil processes across the temporal evolution of the soil profile, from its formation on bare bedrock, through managed use as productive land to its degradation under longstanding pressures from intensive land use. To understand this conceptual life cycle of soil, we have selected 4 European field sites as Critical Zone Observatories. These are to provide data sets of soil parameters, processes and functions which will be incorporated into the mathematical models. The field sites are 1) the BigLink field station which is located in the chronosequence of the Damma Glacier forefield in alpine Switzerland and is established to study the initial stages of soil development on bedrock; 2) the Lysina Catchment in the Czech Republic which is representative of productive soils managed for intensive forestry, 3) the Fuchsenbigl Field Station in Austria

which is an agricultural research site that is representative of productive soils managed as arable land and 4) the Koiliaris Catchment in Crete, Greece which represents degraded Mediterranean region soils, heavily impacted by centuries of intensive grazing and farming, under severe risk of desertification.