Soil Transformation of European Catchments (SoilTrEC)- Project Fact Sheet (www.soiltec.eu)

Modeling Soil Functions and Services - Tools for achieving "Sustainability by Design" in agriculture

The SoilTrEC project developed a tractable and defensible mathematical model, the 1D Integrated Critical Zone (1D-ICZ) Model, that links the development and loss of soil structure to nutrient dynamics and biodiversity. Models of flow and transport (Hydrus 1D); bioturbation; Chemical equilibrium, weathering (SAFE); C/N/P dynamics and aggregate formation, CAST; and vegetation dynamics, PROSUM, were integrated to formulate the 1D-ICZ Model. The 1D-ICZ model simulates all major soil functions including biomass production, carbon and nutrient sequestration, maintaining soil biodiversity and water filtration and transformation, and thus is capable of quantifying soil ecosystem services. The model quantifies the dynamics of C, N and P sequestration in soils in relation to soil structure and protection of organic matter; the effects of exudates and mycorrhizae fungi on nutrient mobilisation and acquisition; above- and below-ground C stocks - including microorganisms, fungi and consumers; and water transformation and filtration in soils.

Quantifying Soil Functions

The model was able to simulate the carbon fluxes (Above-ground Net Primary Production, Soil Organic Carbon Sequestration, Biomass and Fauna Carbon Increase, CO_2 Production), soil structure indicators (% Water Stable Macroaggregates Increase, % Bulk Density Decrease) and carbon and nutrients (NO_3, PO_4, K) that leach to groundwater.

The model was validated using data derived from a plot experiment where tomato plants were grown using commercial fertilizers, compost, manure and 30% manure - 70% compost amendment. Detailed data have been collected over four growing seasons on soil and soil solution chemistry, aggregate formation, and plant production. These data were used to calibrate the 1D-ICZ model for the different treatments. The model was able to capture the dynamics of the water-stable aggregate formation, carbon and nutrient sequestration in the different sized aggregates (see Figure 1), and variability of water filtration and transformation efficiency in the different treatments.

Data from 10 sites, the 4 EU CZOs (Koiliaris CZO, Damma Glacier CZO, Lysina CZO and Machfeld CZO) together with five additional satellite CZOs (Plynlimon-UK, Kindla-Sweden, Strengbach-France, Clear Creek-USA and Black Soils-China) and an additional site in Crete, Greece (Milia) (the site had unique chronosequence data for a carbon addition cultivated soil) were used for the integration of modelling results. The 0D version and the 1D version of the ICZ model were applied to these sites and their results were assessed in a comprehensive way in order to deduce the sites state of soil function and/or degradation. The application of the ICZ model, to sites from around Europe and cover all major climatic gradients as well as the application to China's black soil and the US Clear Creek CZO, attested to the universality of the model to assess soil functions and soil threats.

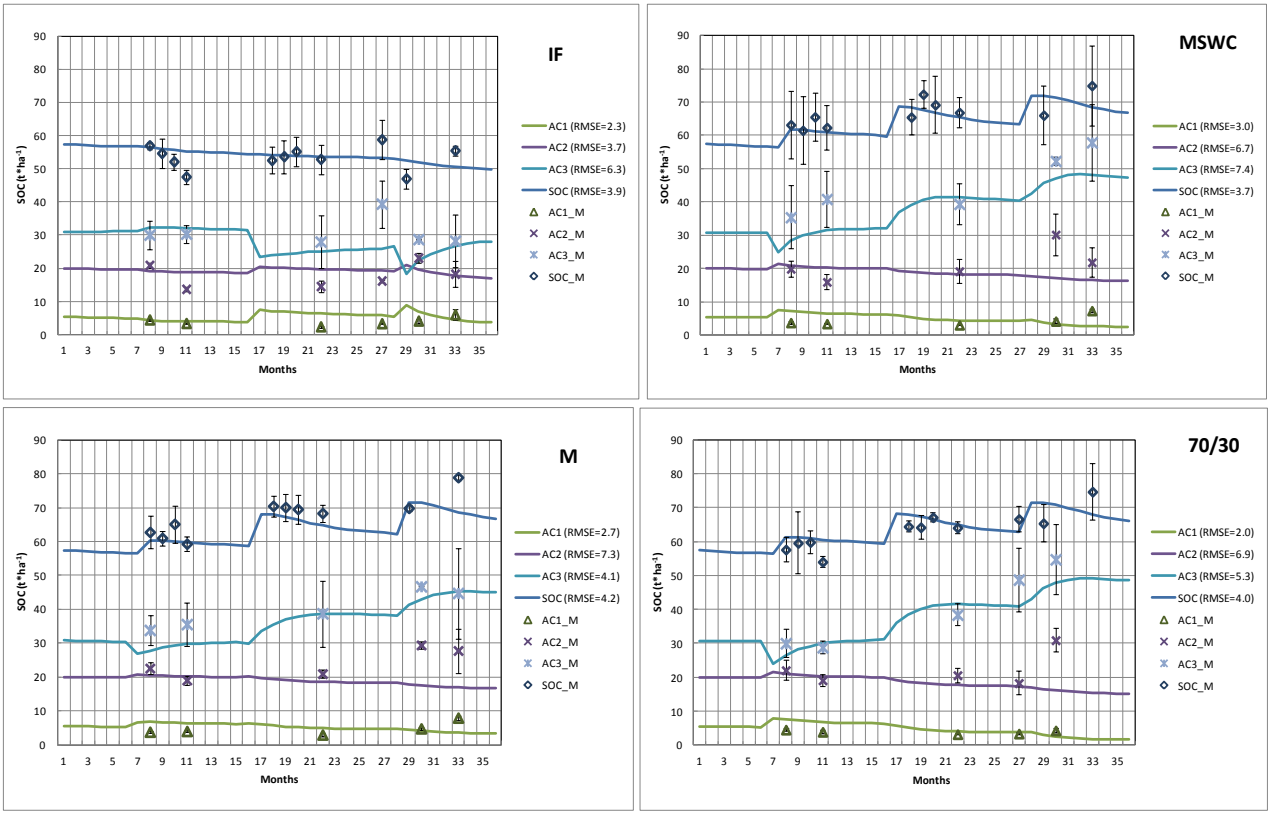

Figure 1: *Simulated evolution of soil organic carbon (total SOC, aggregate type 1, type 2 and type 3 plus the coarse particulate organic matter of the non aggregated pools in the inorganic fertilization "IF", municipal solid waste compost "MSWC", manure "M" and mixture "70/30" treatment. Points indicate field measurements.*

A tool for Sustainable Land Care

The application of the ICZ model, to sites around Europe, Asia and the North America cover all major climatic gradients and attest to the universality of the model, to assess soil functions and soil threats around the globe. The model can be used as a tool to demonstrate "sustainability by design" land management measures and support sustainable land care practices.

Modeling results can be used to assess the improvement of soil functions due to carbon amendment compared to inorganic fertilization. There are trade-offs that have to be taken under consideration when managing soil functions. The 1D-ICZ model was shown to be able to simulate the dynamics of soil functions and predict changes due to land management. The quantification of soil functions can be used to develop soil sustainability indices that can be used to evaluate the tradeoffs of agro-ecological and land management practices.

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