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Carbon and nitrogen dynamics in a soil profile: Model insights and application to a restored Swiss riparian area

Alessandro Brovelli (1), Jordi Batlle-Aguilar (1), Jörg Luster (2), Juna Shrestha (2), Benjamin Huber (2), Pascal Niklaus (3), and D. Andrew Barry (1)

(1) Ecological Engineering Laboratory (ECOL), Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland (alessandro.brovelli@epfl.ch, jordi.batlle@epfl.ch, andrew.barry@epfl.ch) , (2) Soil Structure and Function Group, Swiss Federal Research Institute (WSL), Birmensdorf, Switzerland (juna.shrestha@wsl.ch, benjamin.huber@wsl.ch, joerg.luster@wsl.ch), (3) Institute of Grassland Sciences, Swiss Federal Institute of Technology (ETHZ), Zürich, Switzerland (pascal.niklaus@ethz.ch)

The key environmental importance of natural, healthy ecosystems has been progressively recognized and restoration of degraded lands towards their former natural state has become an area of active research worldwide. During restoration, environmental conditions (such as vegetation type and water availability) are manipulated to create ecological conditions suitable for the successful establishment of a target composition of species. Often, ecological restoration induces changes to adjacent ecosystems. This is the case of riparian ecosystems, and their restoration to their original undisturbed situation is likely to cause changes in nutrient cycles. For example, following the restoration of a riparian zone, microbial communities adapted to one set of environmental conditions have to acclimatize to another, and the subsequent changes in the composition of the biomass populations might induce changes in soil organic matter mineralization and soil respiration rates. Since the biogeochemical cycles are tightly interconnected, these changes can trigger nutrient storing or release, therefore inducing changes in nutrient cycles of adjacent ecosystems. Overall, the effects of the restoration activities on the hydrologic regime, soil properties and vegetation are still largely unknown and poorly understood.
Within the RECORD project (http://www.cces.ethz.ch/projects/nature/Record), a large collaborative research effort undertaken to monitor and understand the changes in ecosystem functioning in riparian areas undergoing restoration, a numerical model has been developed to simulate the vertical transport of the mobile C and N components in a soil profile (model development discussed in the companion submitted abstract Batlle-Aguilar et al.). In the model, microbial decomposition of the soil organic matter drives biogeochemical transformations of C and N, while the activity of the soil biota is primarily controlled by the soil moisture content.
The temporal evolution of the soil properties measured at one location of the RECORD experimental site, in a mixed forest dominated by ash and maple characteristic for the transition from riparian to upland forest, was used to validate the model and to gain insights into the key factors controlling the nutrient turnover. The site is located next to the Thur River where a revitalization project involving removal of levees has been implemented to create more natural conditions in the riparian zone. Soil water content and temperature at several depths were monitored continuously between October 2008 and October 2009. In October 2008, January 2009 and in biweekly frequency between April and October 2009, topsoil and soil solution at several depths were sampled. The soil solution samples were analysed for major carbon and nitrogen species, and the soil samples for denitrification enzyme activity, potential nitrification and related properties. In addition, soil respiration and N2O emissions were measured at each sampling event. Preliminary modelling results are shown, together with a discussion of the most influential parameters and processes controlling C and N turnover in riparian soils.