Modelling soil acidity and soil carbon and nitrogen pools in Irish forests under nitrogen deposition and forest harvesting scenarios

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Objective: In many areas, whole-tree harvesting (WTH) – the removal of stems, branches, treetops and needles, is being examined as a means to reduce dependency on fossil fuels. However, WTH would greatly increase nutrient export (Ca, Mg, K, N) in comparison to stem-only harvest (SOH). Atmospheric inputs of these elements can make an important contribution to the ecosystem budget. For example, nitrogen (N) deposition alters ecosystem N cycling leading to changes in C cycling, plant diversity and soil water chemistry. In this study we used a biogeochemical model (VSD; Posch & Reinds, 2008) as a first attempt at simulating changes in soil chemistry (base saturation, N and C pools) under different N deposition and harvest scenarios.

Methods: The Very Simple Dynamic (VSD) model has been designed to simulate recovery from acidification of forest soils. VSD consists of a set of mass balance equations describing soil input-output fluxes as well as equilibrium reactions (Posch & Reinds, 2008). The model was applied at 30 forest stands. Input data consisted of observations of soil physical and chemical characteristics. Uptake and removal was based on observations of standing biomass and growth functions. Mineral weathering was estimated using PROFILE (Warfvinge & Sverdrup, 1992) while atmospheric deposition was estimated from regional maps.

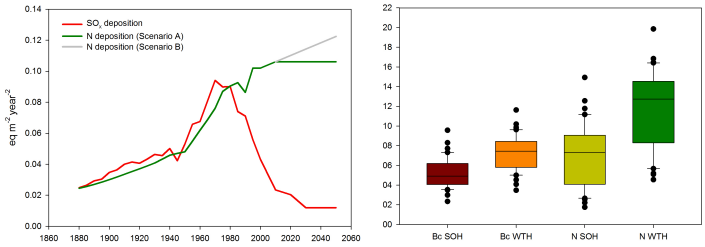

Fig.1 SOx and N deposition times series (left) and base cation (Bc) and N uptake under stem-only (SOH) and whole-tree harvest (WTH) (right).

Scenarios: we compared measured soil base saturation (bsat) and N pools with simulated values under two scenarios of N deposition and harvesting (Fig. 1) as follows:

Scenario A: current N deposition and stem-only harvest
Scenario B: +20% N deposition and stem-only harvest
Scenario C: +20% N deposition and whole-tree harvest

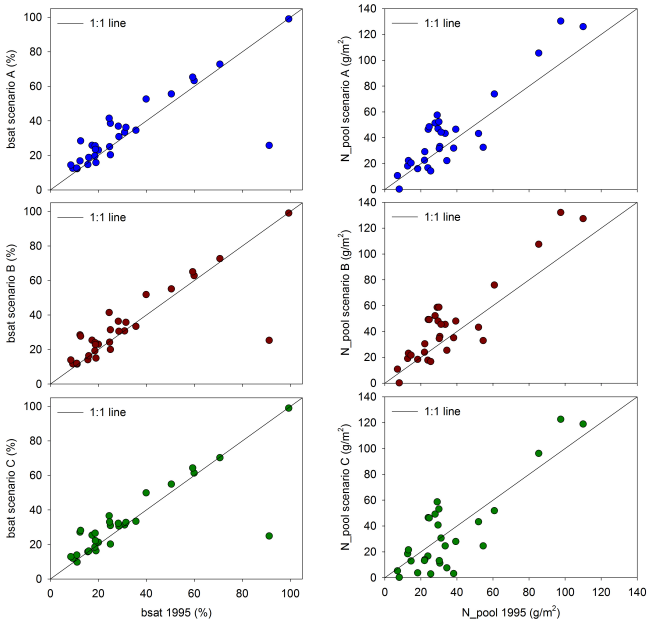

Fig.2 Simulated values of base saturation (left) and soil N pools (right) under Scenario A (current N dep, SOH), top, Scenario B (+20% N dep, SOH), middle, and Scenario C (+20%N dep, WTH), bottom, compared with observed values from 1995.

Results

Base saturation: There was little change in soil base saturation (bsat) under the three scenarios (Fig. 2, left). In most cases, base saturation increased slightly due to the reduction in SOx deposition. WTH did result in a small decrease in bsat at the more acidic sites.

Nitrogen pools: Under Scenario A, N pools increased on average by 22% over 1995 levels (Fig. 2, right). When N deposition was increased (Scenario B) the increase in N pools was only 28%. Although the model increases N immobilization it keeps C pools constant. As a result C:N declines and incoming N is lost to leaching. Under, WTH and elevated N deposition (Scenario C), soil N pools declined by an average 7% with considerable variability between sites depending on N deposition.

Outcome: The results, although preliminary, indicate that WTH has the potential to impact soil N pools but not base saturation. Modelling of changes in these pools will require further work including application of the VSD+ model (Bonten et al. 2009), which incorporates more detailed C and N cycling processes.

References:
Posch M., Reinds G.J., 2009 A very simple dynamic soil acidification model for scenario analyses and target load calculations. Environmental Modelling & Software 24, 329–340
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Bonten L., Posch M., Reinds G.J., 2009 The VSD+ Soil Acidification Model. Model Description and User Manual

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