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Will more intensive forest harvesting for bioenergy cause unacceptable depletion of base cation pools - a modelling study using the Heureka decision support system

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Intensive forest harvesting has the potential to remove base cations (BC; Ca, K, Mg and Na) from ecosystems more rapidly than they can be replaced through mineral weathering. For this reason, whole tree harvesting (i.e. branches and needles harvested) for biofuel production in Sweden and elsewhere may not be ecologically sustainable. Under some circumstances, excessive BC removal may lead to re-acidification of soil and surface waters and a reduction of the growth potential in subsequent forest rotations.

There is considerable uncertainty in all components of stand-scale BC mass balance estimates associated with forest harvests. Estimates of weathering rates from a single site can range over more than an order of magnitude, deposition estimates are often poorly constrained and tree element concentrations can show considerable variation. Despite these uncertainties, BC dynamics play a key role in forest management and planning.

The Heureka decision support system has been developed in Sweden for multi-criteria analysis of forest management scenarios. Heureka can be used to estimate timber production and economic return under a series of user-specified constraints. Here, we present a model application based on Heureka, a database of tree element concentrations, published weathering rate estimates and long-term monitoring data to estimate BC budgets and their associated uncertainty under a series of forest harvest scenarios at the Strömsjöliden production park in northern Sweden.

We evaluated BC budgets under four long term forest management scenarios associated with “business as usual”, more intensive production, nature conservation and reindeer husbandry. Despite the large amount of uncertainty, a number of trends emerged. Nature conservation and reindeer husbandry scenarios were, in general, more sustainable than the other scenarios. Model results suggested that stem-only harvest could remove BC more rapidly than they could be replaced by weathering at some stands in Strömsjöliden. Estimated BC removal rates were highest under the more intensive production scenario which was associated with the use of exotic species and higher fertilization rates. Simulated BC removal rates associated with whole tree harvesting were consistently higher than those associated with conventional harvesting and often exceeded the range of estimated weathering rates.

We believe this model application is the first of its kind to incorporate weathering related ecosystem services into an existing forest production model. While there is a high degree of uncertainty associated with estimates of BC cycling in forest landscapes, the use of models such as the one presented here can aid in assessing the environmental consequences of more intensive forest harvesting for bioenergy production.