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Ecosystem thresholds in Lake Kälksjön, Sweden, in response to rapid climate cooling 8200 years ago

Linda Randsalu Wendrup (1), Daniel J. Conley (1), Dan Hammarlund (1), Ian Snowball (1), Jacob Carstensen (2), and Sherilyn C. Fritz (3)

(1) Lund University, Department of Earth and Ecosystem Sciences, Geology/Quaternary Sciences, Lund, Sweden (linda.randsalu_wendrup@geol.lu.se), (2) National Environmental Research Institute, Aarhus University, Roskilde, Denmark, (3) Department of GeoSciences, University of Nebraska, Lincoln, NE, 68588, USA

Commonly, ecosystems are thought to show a smooth response in relation to gradually changing conditions, shifting over long periods of time from one state to another, thus reflecting the continuum of change along environmental gradients for each set of conditions. The theoretical concept that ecosystems can experience regime shifts and shift abruptly from one state to another, producing changes in dominance of organisms and overall ecosystem behaviour has, however, existed for more than 30 years. The theory has been further developed and it has been demonstrated, in a number of different terrestrial, freshwater and marine systems, that ecosystems stressed by human or climate perturbations can undergo drastic changes, first reaching an ecological threshold and then switching abruptly to an alternative state.

The study of regime shifts in lakes as a result of climate change is complicated because lake biota and processes depend not only on regional climate changes but also on changes in the lake catchment and processes within the lake. Many factors in a lake will respond simultaneously and differently to the effects of climate change, resulting in complex synergy within the aquatic environment.

Nevertheless we want to bring together concepts generated in contemporary ecological studies to study and test hypotheses regarding sudden mode shifts and ecological reorganisations in lakes using paleoecological methods, using diatom and numerical analyses as the main analytical tools. We are investigating how lakes respond to climate, during periods of both cooling and warming, identifying thresholds at which regime shifts occur and trying to develop numerical methods to test for regime shifts in paleoecological data.

Here we present the preliminary results from a study of the ecosystem response to the "8.2 ka cold event" in Lake Kälksjön in west central Sweden. The lake is annually laminated (varved) and a series of nine radiocarbon measurements obtained at increments of 50 years have been used to wiggle match the sediments to the tree-ring derived radiocarbon calibration curve (Snowball et al., in press). Snowball et al. (in press) used the wiggle matching, organic carbon measurements, mineral magnetic parameters and XRF data and reconstructed a distinct period of enhanced erosion in the catchment from 8066±25 to 7920±25 cal. yr BP. Their results suggest that an abrupt onset of winter precipitation in west-central Sweden started at least 50 years after the onset of the "8.2 kyr cold event" as defined by oxygen isotope data from Greenland.

The lake has been sampled for diatom analysis at increments of 10 years over 500 years covering the 8.2 event. The wiggle matched chronology and presence of varves allows for a high resolution time constrained diatom analysis which we hope will reveal the response of the ecosystem to the rapid cooling and also allow us to work on developing and testing numerical methods for detecting and analysing regime shifts. A preliminary low resolution diatom study shows that the diatom flora displays a benthic response to the climate cooling. It also shows that the diatoms seem to react earlier than the previously measured parameters, suggesting that the diatoms and the lake ecosystem are affected by the rapid cooling rather immediately, for example due to changes in ice cover duration, while increased winter precipitation affects the ecosystem at a later stage.