Long-term Drivers of Aboveground-Belowground Linkages and Ecosystem Functioning

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All terrestrial ecosystems consist of communities of aboveground and belowground organisms, which interact with each other over short time scales, but which both drive and respond to processes that operate over much longer time scales, including those that are relevant to ecosystem biogeochemistry. Here I illustrate the linkage between short-term interactions between aboveground and belowground biota, and long term biogeochemical processes, through four examples that involve contrasting temporal scales. The first example shows how invasion by mammals in New Zealand has impacted on plant-soil linkages and nutrient cycling and supply rates over the order of several decades. This involves both invasive deer on the New Zealand mainland and invasive rats on replicated offshore islands. The second example demonstrates, for a group of lake islands in northern Sweden that differ greatly in fire history, that time since disturbance is a powerful driver of plant-microbe associations which in turn drive ecosystem carbon storage and nitrogen (N) and phosphorus (P) cycling over centuries to millennia. The third example involves ecosystem 'retrogression', which is the process through which nutrient availability and thus ecosystem processes decline over geological time scales as a consequence of both abiotic and biotic factors. This involves demonstrating that changes in N:P stoichiometry during retrogressive processes impair both aboveground and belowground processes in a consistent manner in contrasting (boreal, temperate and subtropical) regions of the world over millennia and beyond. The fourth example involves elevational gradients in mountains that have developed over geological time. It shows how long-term variation in temperature across each of several temperate elevational gradients around the world impact on plant N:P stoichiometry through its impact on soil processes over the geological timescales that these mountains have been present. In combination, these four examples highlight that understanding aboveground-belowground linkages offer many insights about the abiotic and biotic drivers of ecosystems, including those that operate over much longer time scales that the linkages themselves operate, such as climate and geology, as well as those that are relevant to understanding the ecosystem impacts of human-driven global change.