Resilience and regime shifts in peatland microbial communities: implications for soil functioning

Humans rely on soils in many ways. They provide nutrients, water and anchorage for most of the crops that we eat, they filter and hold onto rainfall, and they store vast amounts of carbon, which helps to mitigate climate change. Soils also are home to a vast diversity of soil organisms, which play major roles in driving the biogeochemical cycles on which the functioning of Earth depends. Despite these important roles, a range of pressures, including changes in land management, land contamination, and climate change are threatening soils and the populations of microbes and animals that live in them. These pressures not only pose immediate threats to soil functioning, but also they could have longer-term impacts, for instance making soils more vulnerable to extreme climatic events, which are becoming more common worldwide as a result of climate change and can have devastating consequences for ecosystems. Evidence from studies of oceans, lakes and forests shows that extreme events, such as heat waves and drought, can trigger sudden and dramatic transitions, or regime shifts, from one ecosystem state to another. For example, reef communities off the western coast of Australia revealed a sudden and dramatic transition from extensive kelp forest to turf-forming seaweeds triggered by marine heatwaves. These regime shifts can have major consequences for the functions that these ecosystems provide. However, whether such regime shifts occur in soils is not really known.

In this small grant, we would like to tackle three so far untested questions of high relevance for Soil Security. First, we want to know if long term climate warming makes soils and their microbial communities more vulnerable to, and less able to recover from, extreme climate events, namely drought, which is increasing in frequency. Second, we want to test if long-term effects of climate on soils and their microbial communities make them more vulnerable to transitions, or regime shifts from one state to another, and whether these regimes shifts degrade the functions that soils perform, for example their ability to store carbon. Last, we want to see if these effects of climate change on soil functioning can be dampened, for instance through changing the management of vegetation.

We plan to make use of a unique warming and vegetation manipulation experiment that we set up several years ago on blanket peat at Moor House National Nature Reserve, northern England, funded by NERC. This experiment is ideally suited to this study because it has been running continuously since 2008, which puts us in a unique position to detect how long-term warming (9 years in 2017) has altered the resilience of soils and their microbial communities to drought, but also their susceptibility to regime shifts. The experiment also includes a vegetation manipulation treatment, which allows us to test if vegetation change, especially the presence of ericaceous dwarf-shrubs, can dampen effects of climate change on soils and their functioning. And finally, the experiment is on carbon-rich peatlands, which are not only of high relevance for UK Soil Security because they cover a large area of the UK land surface and store vast amounts of carbon, but also they add a distinct and highly complementary dimension to the NERC Soil Security Programme.

These questions are at the heart of the NERC Soil Security programme which seeks to resolve what controls the ability of soils and their functions to resist, recover and ultimately adapt, to perturbations, such as those caused by extreme climatic events. Also, by testing our questions, we will gain new, transformative understanding of the dynamics of microbial communities and their functioning in relation to on-going and rapid environment change, and produce knowledge that could help in the design of sustainable management strategies for maintaining resilience in peatlands.