Britain's moorlands store carbon in vast quantities, but it may not stay put as the climate changes and people put the land to new uses. Sue Ward explains how researchers are setting up experimental plots to find out how different kinds of plants determine the fate of peatland carbon.

Gardening for greenhouse gases

Setting up a field experiment in one of the most exposed places in England wasn't without its trials and tribulations.

Richard Bardgett

Beneath the heather-clad British moorlands lie valuable stores of carbon, built up in layers of peat over thousands of years. These carbon stores are at risk, both from changes in climate and from changes in vegetation caused by land management practices such as grazing, burning and drainage. This could lead to the release of carbon in the form of gases like carbon dioxide and methane, and into water as dissolved organic carbon.

We want to know more about how shifts in the make-up of plant communities, which occur as a result of land-use change, affect our peatlands' ability to continue to store, or 'sequester', carbon. We also want to know how climate changes, such as warming, interact with peatland vegetation to influence carbon loss. To do this, we have set up a new plant manipulation and warming experiment high in the North Pennines of England funded by a NERC grant. Our experimental site is in the Moor House National Nature Reserve, one of four NERC Carbon Catchments run by the Centre for Ecology & Hydrology (CEH), where long-term measurements are used to produce annual carbon budgets. The area is also a flagship site for the UK Environmental Change Network.

Setting up a field experiment in one of the most exposed places in England wasn't without its trials and tribulations. We set off one sunny spring morning in April 2008, armed with tape measures and boardwalks, only to be greeted by an unexpected late season snowstorm! Undaunted, our small army of volunteers (fortified by hot tea and cakes) marched up the hill with 150 boardwalks to lay the foundations of our new experiment. We returned several more times in spring – fortunately in more clement weather conditions – to 'garden' the experimental plots.

In UK peatlands, plants belong to one of three main 'functional groups': dwarf shrubs such as the heather *Calluna vulgaris*, grasses and sedges such as cotton grass *Eriophorum vaginatum*, and mosses like *Sphagnum* and *Hypnum*. In our experiment we selectively removed plants by hand, to create all possible combinations of these three groups.

How is this relevant to carbon cycling? We know that the rate at which peatlands sequester carbon depends on the balance between inputs from plant productivity – plants taking in carbon as they grow – and outputs from decomposition, respiration and other physical losses, which release carbon back into the atmosphere. We also know that each of the three peatland plant functional groups has a different set of characteristics, or 'traits', such as nutrient content, growth rate and tissue lifespan, which affect how much atmospheric carbon a plant can absorb by photosynthesis.

These plant traits also govern how much carbon dioxide is lost through respiration and decomposition, by affecting the amount of nutrients below ground where the soil decomposers live. Finally, plant traits affect their ability to recover after disturbances like fire and overgrazing, with fast-growing, nutrient-rich grasses generally winning at the expense of slower-growing shrubs and mosses. Our new gardened plots mean we can now test which of the three plant functional groups, or which combination of them, is best for peatland carbon sequestration.

We also want to know how climate change will affect our moorland plant groups. To answer this question, the final part of our high-altitude gardening exercise was to build 'mini-greenhouse' warming chambers over half of the plots. These open-topped chambers are designed to increase temperatures by 1-2°C, mimicking the predicted effects of global warming. This experimental approach lets us test the impact of vegetation change and climate using a real ecosystem as our laboratory.

After many days of carrying, constructing and gardening, our site is finally ready. We have installed temperature, water-table and gas-monitoring equipment and now visit the site each month to measure a range of key carbon-cycling processes. We're measuring greenhouse gases like carbon dioxide, methane and nitrous oxide. We also measure concentrations of dissolved organic carbon in water, soil nutrients, the composition of the soil's microbial community and how fast litter decomposes.

Sue Ward

▲ The plant manipulation and warming experiment at Moor House National Nature Reserve, showing the passive warming chambers designed to increase temperatures by 1-2°C to mimic global warming.

Our results so far show that a warming climate does speed up peatland carbon cycling, and that the three plant groups do behave very differently. For instance, the lowest uptake and release of all greenhouse gases is by the slow-growing, water-retaining mosses. Woody, slow-growing heather absorbs the greatest net amount of carbon dioxide. Nutrient-rich cotton grasses are also good for increasing the overall intake of carbon dioxide, but their presence can also increase release of methane – a greenhouse gas that can cause more warming than carbon dioxide.

Work on this experiment on plant diversity and climate builds on our past research into the effects of land use on peatland carbon cycling. We did this work at a unique 50-year-old burning and grazing site, also at Moor House National Nature Reserve. Vegetation in areas regularly burned to manage moors for grouse had less heather, less mosses and more cotton grass than the unburned areas, but there was little difference in soil chemistry or the decomposer organisms that lived in the soil.

When we compared carbon dioxide fluxes, we found that burned areas were a bigger sink for atmospheric carbon dioxide. We also saw similar, but smaller, effects in grazed areas – long-term grazing meant these peatlands took up more carbon. We concluded that it was the differences in the plant community's composition that was responsible for making burned areas absorb more carbon dioxide. But in this study we couldn't completely discount the idea that this was the direct effect of the burning or grazing, rather than of the changes in plant life they caused, hence the need for our new plant-manipulation experiment.

This research gives us the opportunity to study the effects of peatland plant functional groups on carbon cycling, and how plant change interacts with climate. We still have a great deal to learn about moorland carbon cycling in a changing world, especially about the feedbacks between plant and soil processes that control greenhouse gas emissions. Our research continues to look into this fascinating subject, and we hope that in future we can help landowners maintain their peatlands for future carbon storage by managing the plants growing on them. So, if you are ever in the North Pennines and come across a set of greenhouses, or a group of scientists armed with gardening equipment, you'll know what we are up to.

MORE INFORMATION

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FURTHER READING

Ward et al. (2007), *Ecosystems* 10, 1069-1083 (work on burning and grazing)

Ward et al. (2009) *Functional Ecology* 23 (2), 454-462

Environmental Change Network
www.ecn.ac.uk

NERC carbon catchments
www.ceh.ac.uk/sci_programmes/CarbonExchangeattheCatchmentScale.htm