Arctic soils face the big thaw

Paradoxically, **Iain Hartley** and team found they needed to drop the temperature to understand some features of a warming globe.

In climate change biology we tend to face two kinds of questions – 'whats' and 'whys'. What happens when we manipulate a system, and why? 'What' questions are relatively easy to answer, but it is often only when tackling 'why' questions that real understanding emerges. I'd like to tell you how we tried to answer a particular 'why' question, and the sometimes seemingly illogical steps that must be taken in the pursuit of knowledge. To understand why things happen in a warming world, we had to cool things down.

When I tell someone that I work on soils, the first response is usually a wide yawn. Mention global warming and I get a little more interest. Then tell someone that soils are critical in regulating our climate, and perhaps I've got their attention. Soils represent a huge reservoir of carbon, which, if released into our atmosphere as carbon dioxide, would alter our climate substantially.

Every year, as part of the global carbon cycle, ten times as much carbon dioxide is released from soils as is emitted by man's activities. Worryingly, many experiments have shown that this release, known as soil respiration, rises steeply with temperature. So as the world warms, carbon loss from soils could raise levels of carbon dioxide in the atmosphere, and accelerate climate change.

Arctic soils are particularly interesting as they contain lots of carbon and are expected to warm rapidly. Working as part of the largest polar science project ever undertaken (International Polar Year 2007-08, ABACUS project, www.abacus-ipy.org), we collected soils from Arctic Sweden and investigated how they will respond to warming.

From 'What?' to 'Why?'

Soil respiration increases with temperature, but in the longer term respiration in warmed soils often falls back towards normal. So we know what happens but we don't know why, and critically, the two possible explanations for this phenomenon have very different implications for twenty-first century climate change. One possibility is that the microscopic organisms responsible for soil respiration are acclimatising to the new conditions, actively cutting back their respiration to compensate for the increase in temperature.

Alternatively, higher respiration rates may deplete soil carbon stores, leaving microbes with less to break down, so reducing respiration rates. While acclimatisation could preserve carbon stocks, the carbon depletion explanation implies increased carbon release from soils, which could speed up climate change.

Our challenge was to distinguish between these two explanations. The problem was that when a soil is warmed up, acclimatisation and carbon loss are both expected to reduce respiration rates, making it nearly impossible to distinguish between them. So we took an unusual step in global-warming research – cooling soil down. Initially, cooling will reduce activity, but acclimatisation, as a compensatory response, should then increase respiration rates.

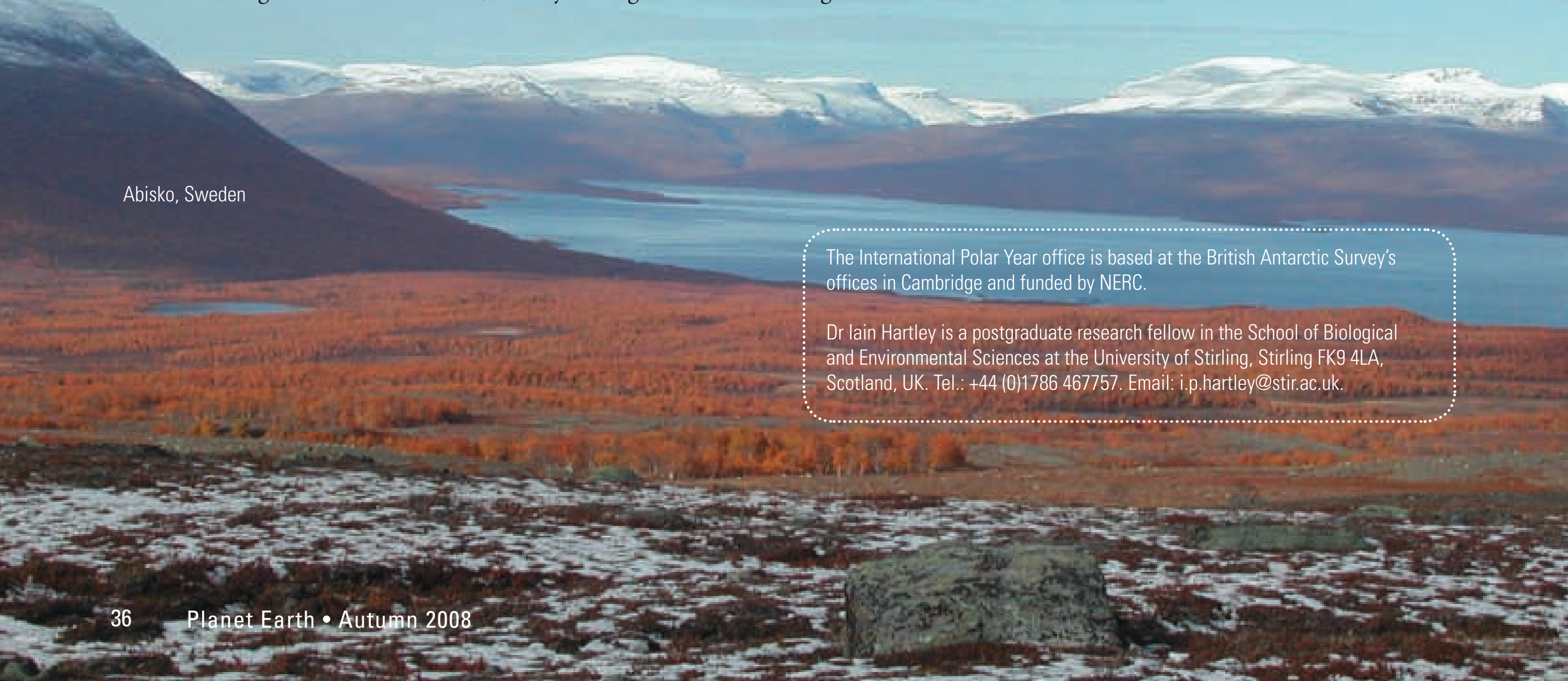
On the other hand, as carbon loss continues at low temperatures it cannot be implicated in any recovery of respiration. The processes are now working in opposite directions, letting us distinguish between them. So what happened when we cooled our Arctic soils?

Unfortunately, we didn't see any evidence of acclimatisation. After cooling, respiration rates showed no signs of recovery. So the answer to our 'why' question seems to be carbon loss rather than acclimatisation. Even more worryingly, we saw something that we hadn't expected. Many days after temperatures were reduced, respiration rates in the cooled soils continued to decline steeply.

Rather than a compensatory response, the effect of our cooling treatment was amplified over time. The most likely explanation for this is that the soil microbes were adapting to the colder temperatures by reducing activity.

Looking at this in reverse, a more active microbial community survived at higher temperatures. This research suggests that carbon release from the world's coldest soils could contribute disproportionately to a soil-driven acceleration of climate change.

So by stepping back and employing reverse logic we've been able to improve our understanding of how temperature controls carbon loss from Arctic soils, with potentially worrying implications for the regulation of our climate. ❖



Abisko, Sweden

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