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The beautiful and the dammed

The Arctic tundra is one of the world's most extensive ecosystems, and the frozen soil known as permafrost, which underlies it, can be hundreds of metres deep. But as the world warms up in response to the millions of tonnes of carbon dioxide and other greenhouse gases being poured into the atmosphere each year, so does the permafrost. As the permafrost thaws, bacteria start chewing up the organic matter it contains. This releases yet more carbon dioxide, as well as methane, another greenhouse gas, which has 25 times the warming potential of CO_2. Edward Schuur of the University of Florida in Gainesville, a doyen of the field, estimates that the world's permafrost contains twice as much carbon as its atmosphere. If even a fraction of that were released as CO_2 and methane, it would be bad news.

Nor is that all. Thawing permafrost also leaks nitrates and phosphates into the tundra, allowing novel plant species to get a foothold in what was, to start with, a fairly spartan habitat. It distorts the Earth's surface, too, creating a landscape of domes and pits known as thermokarst because of its resemblance to the karstic terrain of limestone-rich parts of the world. This changes the tundra's ecology. It also plays havoc with human structures, such as buildings, roads and pipelines, that sit on top of it. For all of these reasons, then, more research is needed into this icy realm. And that is the object of a project with the unsnappy name of Spatial and Temporal Influences of Thermokarst Failures on Surface Processes in Arctic Landscapes, which was kicked off by a group of scientists who gathered in late June at the Toolik Field Station in northern Alaska.

Karsting the first stone

The project, which is led by Breck Bowden of the University of Vermont in Burlington, involves 17 research groups from America and Canada. To start with, they will use a combination of aerial photography, field measurements, and ground- and satellite-based sensors to compile a map of all the thermokarstic areas of Alaska. This will provide a reference point from which changes can be measured.

The team will then try to work out how the development of features such as “retrogressive thaw slumps” and “active-layer detachments” (different ways in which thawing permafrost can cause a hillside to slip) are associated with the local climate, geology and vegetation. They will look, too, at the amount of ice in the ground, and the temperature and the moisture of the soil. All these data will be fed into computer models which, the researchers hope, will allow them to develop an automated way of predicting where and when new features will form, and to monitor them when they appear.

Dr Bowden and his colleagues also hope to understand the impact of thermokarst activity on the structure of the soil, and its nutrient content. They will concentrate on a few sites that can be studied intensively and which are affected by different types of activity. They will measure the amount of carbon, phosphate and nitrate in the soil, together with the rate of plant growth and microbial decomposition. That will let them work out just how “leaky” thawing permafrost is and thus how big its contribution of greenhouse gases to the atmosphere might be, should the worst come to the worst.

It will also help them forecast changes in the tundra’s vegetation. The softening of the soil and the consequent release of nutrients is likely to encourage the growth of shrubs on land that is now dominated by grass, moss and lichens. The researchers will monitor the growth of this vegetation around newly formed thermokarst features and use experimental field plots to test how conditions mimicking such features affect which species will thrive.

Last, the project will try to work out how thawing permafrost will affect the numerous streams, rivers and lakes of the Arctic. Together, these amount to the biggest acreage of water on “dry” land. As water moves through affected areas, it picks up both nutrients and sediment that would otherwise be held in the permafrost’s icy grasp. These, paradoxically, have opposite effects on the growth of algae. The phosphates and nitrates stimulate it whereas the extra sediment suppresses it by trapping nutrients in the beds of such bodies of water.

Muddy waters

It is not only natural habitats and future generations that are threatened by the thawing of the permafrost. People in the here and now are affected, as well. Sediments from a huge thermokarstic area have, for example, dammed the Selawik River in north-western Alaska, interfering with fish and threatening the livelihood of nearby villages. Elsewhere in the state, a combination of melting sea ice and thawing permafrost has exacerbated the erosion of several coastal villages, which will have to be relocated at a considerable cost.

Whether anything short of reversing climate change can be done about all this is a moot question. But at least when the project reports, in five years’ time, the size of the threat will be clearer. The news it brings may not be welcome. But it is surely better than living in ignorance about one of the world’s most important habitats.