Boreal forest dieback may cause runaway warming

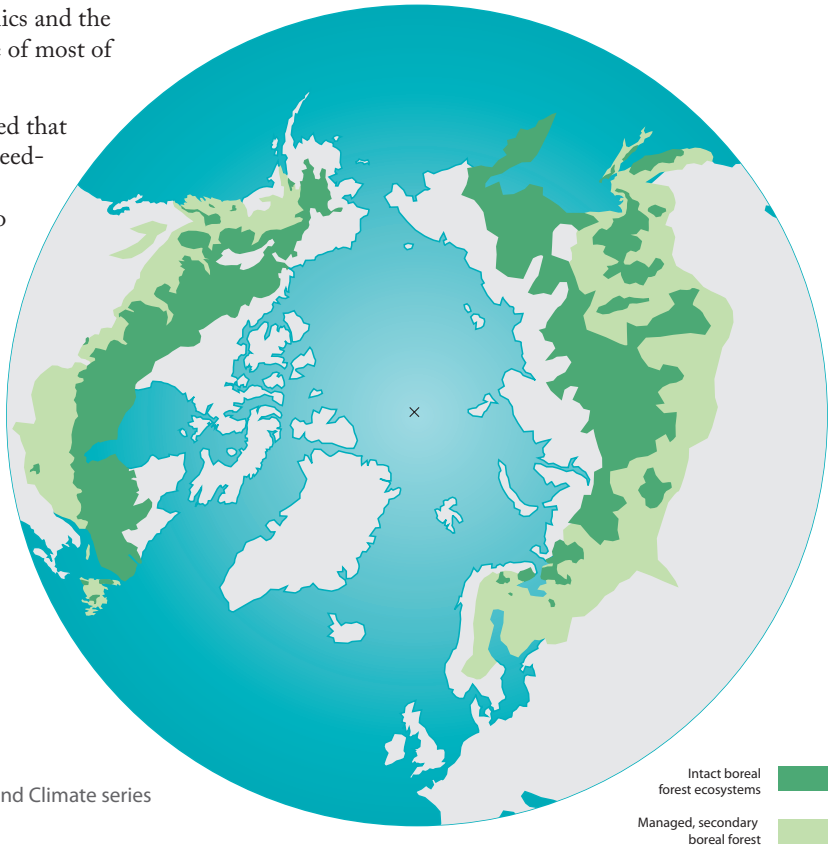
The boreal forests, one of the largest carbon stocks on earth, will not be able to respond to global warming by migrating northwards. Massive forest dieback, causing runaway warming, is a more likely scenario.

Under the Kyoto protocol, nations have to account for changes in carbon stock by afforestation, reforestation and deforestation, while leaving old-growth forests intact is not an activity considered to affect the carbon budget. This probably reflects the common perception that old forests do not sequester carbon.

They do, according to a new report from AirClim[1]. Many old-growth forests in the northern hemisphere continue to serve as carbon sinks for centuries and thus hold vast quantities of carbon. Roughly speaking, the boreal forest belt contains about one third of the world´s vegetative carbon and the same amount again of soil carbon. Whether or not this carbon stock can be maintained is not a matter of forest management, since half of the boreal forest belt consists of remote primary forests. Even though the timber frontier is constantly moving north, natural forest dynamics and the response to climate change will decide the fate of most of these forests for the foreseeable future.

In its fourth assessment, the IPCC concluded that for increases in global average temperature exceeding 1.5–2.5˚C, forests globally face the risk of major transformations. Boreal forest is likely to be especially affected, because of its sensitivity to warming and the high rates of projected warming in high northern latitudes. Based on a review of recent scientific knowledge on boreal forest and climate change, the AirClim report confirms this and outlines in some detail which transformations can be expected under different climate scenarios. While doing so, the report debunks a number of myths or misconceptions about the interaction between climate change and boreal forests. The idea that old-growth forests are carbon neutral is one such misconception, and the notion of forest management as a cure for the climate threat is another. There are more.

Since temperature is a limiting factor in boreal forest, it might seem reasonable to assume that moderate levels of warming would be beneficial for tree and forest growth. However, the actual response so far is not unequivocal. Warmer temperatures over the last few decades have either improved or decreased tree growth. Inverse growth responses are widespread all over the boreal region and have been recorded for most tree species. Growth decline occurs more frequently in warmer parts of the distribution area of each species, indicating that direct temperature stress might be a cause. Drought stress has also been suggested as a contributing factor. Negative effects on tree and forest growth may be even more widespread as global warming increases.



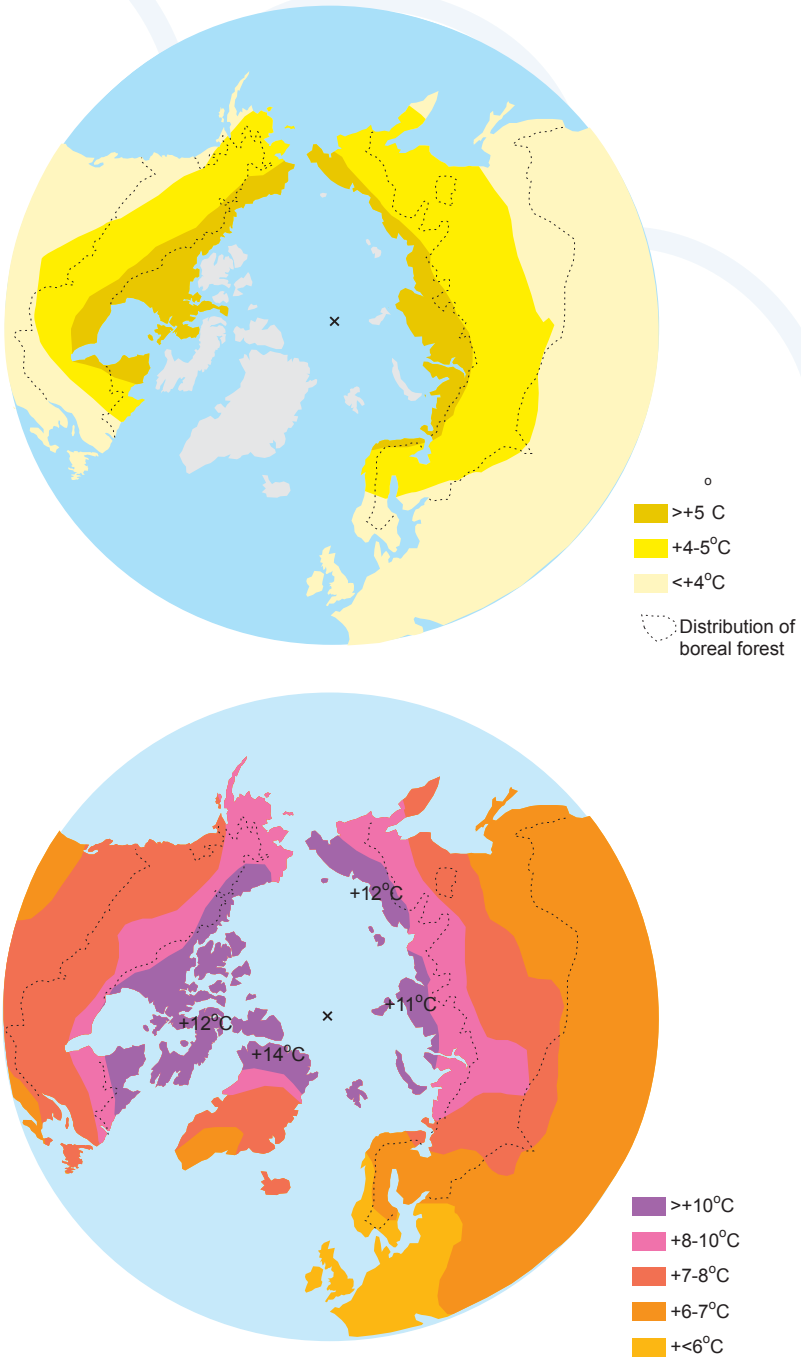
1 Boreal Forest and Climate Change. Air Pollution and Climate series #23. Available at www. airclim.org.

Vegetation modelling studies generally project that the boreal forest will respond to warming by migrating northwards along with the shift of climate zones. What is generally overlooked is that climate models project the potential distribution of species and plant communities under different climatic conditions, not current conditions. In reality, a wholesale redistribution of forest zones further north is not likely to happen, at least as far as primary, unmanaged forests are concerned. One obvious reason for this is that even with warming of just 2°C, climate zones will shift northwards at a rate of five kilometres per year, which exceeds the recorded migration responses of trees by a factor of ten.

Furthermore, any attempt to predict the future of boreal forest must take into account the impact of natural disturbances, predominantly fire. The disturbance regime is fundamental to boreal forest dynamics and is, in turn, affected by climate. An increase in the frequency and area of wildfires has already been recorded in the boreal region. If global warming exceeds 4°C the area burned in North America could double. Windthrow and insect outbreaks are also expected to increase in frequency with projected changes in global climate.

Thus, the most likely scenario for the boreal forest is a non-linear response to warming, resulting in the creation of hitherto unseen ecosystems and the extinction of species with limited capacity to adapt. Even at moderate levels of warming, extensive decline can be expected in forests and woods. If global warming exceeds 2°C, vast areas of boreal forest may be transformed into open woodland or grassland. The critical limit for large-scale forest dieback may be a rise of 3–5 °C. This has been identified as one of the critical tipping points in global change, through which positive feedback effects on the climate may cause runaway warming – in this case the release of most of the enormous boreal carbon stock into the atmosphere.

The report can be downloaded at. http://www.airclim.org/reports/documents/APC23_borealforest.pdf



Two projections of warming in the boreal region by the end of this century.

Top: At +2.8°C global mean warming (the IPCC A1B scenario). Data from IPCC's fourth assessment.

Bottom: At +4°C global mean warming according to a more recent projection by the UK Met Office.

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