Drought Pushing World's Trees to Their Limits

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Most of the world's trees – including rainforest species – live close to their "safety threshold" for coping with water stress, leaving them vulnerable to effects of droughts caused by climate change.

That's the finding of a new study published today in the journal *Nature* by an international research team, including a University of Guelph professor. Hafiz Maherali of the Department of Integrative Biology and 23 scientists from 10 countries set out to predict how climate change will affect forests.

Scientists know that rising global temperatures are affecting forest ecosystems by increasing rainfall in some regions and increasing drought in others. One of the main causes of tree dieback in regions experiencing drought is hydraulic failure: drought stress creates air blocks in the plant's vascular system – similar to an embolism in the human circulatory system – and makes it harder for a tree to supply water to its leaves for photosynthesis.

Plants differ dramatically in their resistance to the problem. Without a clear understanding of how species and environments tolerate drought, researchers find it difficult to predict the effects of climate change. In this first-ever worldwide study, the researchers examined all existing measurements of plant embolism resistance in forest species.

"We wanted to know how resistant plants around the world are to embolism, which species are more resistant, and how much stress a plant is experiencing relative to its resistance threshold," said Maherali, whose previous research has examined plant hydraulic systems and survival.

They discovered that 70 per cent of 226 forest species from 81 sites worldwide live within narrow "safety margins" against potentially deadly levels of drought stress. Those safety margins are largely independent of rainfall, making all forest types equally vulnerable to drought. Trees seem to favour a "risky" hydraulic strategy that maximises growth against the risk of death.

"This explains why there are patterns of tree dieback in various ecosystems and not just in areas that are drier," Maherali said. "It shows how finely closely matched a tree species is to its environment."

With such a slim "safety margin," plant productivity and survival could be dramatically affected by increased drought. The study may help pinpoint which tree species will likely persist and which will suffer and potentially disappear.

"This is not a doom and gloom scenario," Maherali said. "Drought will most probably trigger changes in the species composition of a community; species could either evolve, acclimate, or migrate to a more suitable climate and be replaced with species that are more resistant. The most important implication of these findings is that it will help us predict which forests are most likely to experience change."

The new study was organized through the ARC-NZ Research Network for Vegetation Function in Australia, and was headed by Brendan Choat from the University of Western Sydney and Steven Jansen from Ulm University in Germany.

Contact: Prof. Hafiz Maherali, Department of Integrative Biology, maherali@uoguelph.ca

Climate Change Complexities in the Northern Hardwood Forests

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For residents of the northeastern United States, the abundant woodlands of the northern Appalachians provide an excellent getaway from the congested coasts. These woods are composed typically of hardwood trees like Oak, Ash, Maple, and Birch, changing to evergreen varieties at the higher elevations. Climatologists predict that the northeast will experience warmer and wetter conditions as the climate continues to alter. However, until now, there has been no exhaustive study conducted to see how the climate change will affect the biosphere of the northern hardwoods. A recent study found that this region will be susceptible to major disruptions to forest health, its maple syrup industry, the spread of wildlife diseases and tree pests, as well as changing timber resources.

The study was conducted at the Hubbard Brook Experimental Forest, located in the White Mountains of New Hampshire. It was led by Dr. Peter Groffman, microbial ecologist at the Cary Institute of Ecosystem Studies. His team looked at more than 50 years of long term data on environmental conditions, concluding that current climate change models do not take account for the surprises that take place in forests.

"Climate change plays out on a stage that is influenced by land-use patterns and ecosystem dynamics," said Groffman. "We found that global climate models omit factors critical to understanding forest response, such as hydrology, soil conditions, and plant-animal interactions."

The most noticeable change is the arrival of spring earlier in the year, and fall later in the year. There has been more rainfall and less snowfall, and the remaining snowpack is melting two weeks earlier than usual. This means that the snowpack melting in no longer in sync with the spring plant growth. This transitional period is critical, because the melting snow also takes away important soil nutrients for plants awakening from their slumber.

Also, the lack of snowpack exposes the soils to more freezing, potentially damaging tree roots. This hits the sugar maples very hard. Not only is the soil frost linked to tree mortality, but warmer winters also reduce the sap yield. On top of that, mild winters also encourage the spread of pests and diseases, which were once held in check by more frigid winter temperatures.

The lack of snow depth allows deer to forage more throughout the forest, damaging young trees and the forest understory. The deer also carry a certain parasite that is lethal to moose, threatening the northern moose populations.

For human activities, climate change in the northern hardwoods will also have a great impact. Ski resorts, which already rely heavily on manmade snow, will be challenged even more with the lack of snowpack. Logging operations will also become more difficult with the loss of snow-packed roads.

"Managing the forests of the future will require moving beyond climate models based on temperature and precipitation, and embracing coordinated long-term studies that account for real-world complexities," concludes Groffman. "These studies can be scaled up, to give a more accurate big picture of climate change challenges—while also providing more realistic approaches for tackling problems at the regional scale."

The study has been published in the journal BioScience