Rainforests may pump winds worldwide

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THE acres upon acres of lush tropical forest in the Amazon and tropical Africa are often referred to as the planet's lungs. But what if they are also its heart? This is exactly what a couple of meteorologists claim in a controversial new theory that questions our fundamental understanding of what drives the weather. They believe vast forests generate winds that help pump water around the planet.

If correct, the theory would explain how the deep interiors of forested continents get as much rain as the coast, and how most of Australia turned from forest to desert. It suggests that much of North America could become desert - even without global warming. The idea makes it even more vital that we recognise the crucial role forests play in the well-being of the planet.

Scientists have known for some time that forests recycle rain. Up to half the precipitation falling on a typical tropical rainforest evaporates or transpires from trees. This keeps the air above moist. Ocean winds can spread the moisture to create more rain. But now Victor Gorshkov and Anastassia Makarieva of the St Petersburg Nuclear Physics Institute in Russia say that forests also create winds that pump moisture across continents.

How can forests create wind? Water vapour from coastal forests and oceans quickly condenses to form droplets and clouds. The Russians point out that the gas takes up less space as it turns to liquid, lowering local air pressure. Because evaporation is stronger over the forest than over the ocean, the pressure is lower over coastal forests, which suck in moist air from the ocean. This generates wind that drives moisture further inland. The process repeats itself as the moisture is recycled in stages, moving towards the continent's heart (see diagram). As a result, giant winds transport moisture thousands of kilometres into the interior of a continent.

Coastal forests create giant winds that push water thousands of kilometres inland

The volumes of water involved in this process can be huge. More moisture typically evaporates from rainforests than from the ocean. The Amazon rainforest, for example, releases 20 trillion litres of moisture every day.

"In conventional meteorology the only driver of atmospheric motion is the differential heating of the atmosphere. That is, warm air rises," Makarieva and Gorshkov told New Scientist. But, they say, "Nobody has looked at the pressure drop caused by water vapour turning to water." The scientists, whose theory is based on the basic physics that governs air movement have dubbed this the "biotic pump" and claim it could be "the major driver of atmospheric circulation on Earth". This is a dramatic claim. The two Russians argue that their biotic pump underlies many pressure-driven features of the tropical climate system, such as trade winds, and helps create intense local features like hurricanes.

To back up their hypothesis they show how regions without coastal forests, such as west Africa, become exponentially drier inland. Likewise, in northern Australia, rainfall drops from 1600 millimetres a year on the coast to 200 mm some 1500 kilometres inland. In contrast, on continents with large forests from the coast to interior, rainfall is as strong inland as on the coast, suggesting the trees help shuttle moisture inland (Ecological Complexity, DOI: 10.1016/j.ecocom.2008.11.004, in press). In the Congo, for instance, around 2000 mm of rain falls each year at the coast and the same amount falls inland. The same is true in the Amazon, the Siberian Arctic and the Mackenzie river basin in northern Canada. But the US, largely forested until recently, now seems be headed for desert. Makarieva and Gorshkov told New Scientist that without rapid reforestation "the degrading temperate forests of North America are on their way to desertification".

The Russians' ideas have languished since they were published in a small journal in 2007. "We are facing enormous difficulties in overcoming the initial resistance of the scientific community," they say. Antoon Meesters of the Free University in Amsterdam, the Netherlands, recently described it as "an untenable result of confused principles". Meesters does not dispute the physics behind the Russians' theory but claims the effect is negligible.

This week, a leading British forest scientist based at the Institute of Tropical Forest Conservation in Kabale, Uganda, came to the Russians' aid. In a review of the work in the journal Bioscience (DOI: 10.1525/bio.2009.59.4.12), Doug Sheil and his co-author Daniel Murdiyarso underline the importance of the idea. "Conventional models typically predict a 20 to 30 per cent decline in rainfall after deforestation," Sheil says. "Makarieva and Gorshkov suggest even localised clearing might ultimately switch entire continental climates from wet to arid, with rainfall declining by more than 95 per cent."

Sheil explains that current theory doesn't explain clearly how the lowlands in continental interiors maintain wet climates. "There is a missing element," Sheil says. The biotic pump "may be the answer". He calls the Russians' findings "a most profound insight into the impact of forest loss on climate. They will transform how we view forest loss, climate change and hydrology."

Many forest scientists are intrigued by the idea. "It makes perfect sense," says Andrew Mitchell, director of the Global Canopy Programme, Oxford, UK. "We know that coastal rainforests are critical to maintaining rainfall deep inland." He says it could offer a more convincing explanation for how Amazon rainfall is typically recycled six times.

The implications are global, he adds. "We think some of the recycled Amazon moisture is taken on a jet stream to South Africa, and more maybe to the American Midwest. Gorshkov and Makarieva are looking at the front end of an absolutely critical process for the world's climate." If their theory is correct, it means that large forests help kick-start the global water cycle. However, because forest models do not include the biotic pump, it is impossible to say what wiping the Amazon off the map would mean for rainfall worldwide.

The theory suggests that past civilisations could have had a much greater impact on global climate than we thought. Australia once had forests but is now largely desert. Gorshkov and Makarieva argue that Aborigines burning coastal forests may have switched the continent from wet to dry by shutting down its biotic pump.

Climatologists are already worried about the state of the Amazon rainforest. Last month, the UK's Met Office warned that if the planet warms by 4 degrees, 85 per cent of the forest could dry out and die. If Gorshkov and Makarieva are right, the Amazon will be gone before warming kicks in. They predict that even modest deforestation could shut down the pump and reduce rainfall in central Amazonia by 95 per cent.The same could happen in the world's other large rainforest regions, such as central Africa.

According to Richard Betts, head of climate impacts at the Met Office, "The jury is still out on whether the mechanism is significant or not. But the role of tropical forests in protecting us against climate change is severely underrated."

It's not all bad news. If natural forests can create rain, then planting forests can, too. Sheil says, if forests attract rain, then replanting deforested coastal regions could re-establish a biotic pump and bring back the rains. "Once forests are established, the pump would be powerful enough to water them. Could we one day afforest the world's deserts? Makarieva and Gorshkov's hypothesis suggests we might."