The physiological response of plantation trees at Kamarooka to Black Saturday, 7 February 2009

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On 7 February 2009 at 7.14 am the sun rose over northern Victoria and the light of the new day fell on the trees in the Northern United Forestry Group (NUFG) plantation at Kamarooka. The overnight stillness of the sapwood was disturbed as the trees awakened.

At dawn, the atmosphere contained much less water than the moist interior of the inner leaves. The young eucalypts, driven by osmosis and photosynthesis, began their familiar routine. Exposed to the light, they pumped potassium into the guard cells surrounding each of the tiny water valves (stomata) in their leaves causing them to swell and open allowing carbon dioxide to enter and moisture to escape to the atmosphere. Water lost to the air was replaced by water pulled up the stem and roots and out of the soil below via thousands of tiny tubes in the xylem (sapwood).

NUFG measures the upward flow of water through the stem of trees in the plantation using some clever instrumentation (sap flow sensors) installed with the support of an Australian company called ICT International. ICT specialises in measuring the water use of vegetation. Three tiny probes about 50mm long are placed in the sapwood of the trees. The central electrode injects a pulse of heat every 30 minutes and the two probes immediately above and below sense the heat transfer as water moves up the tree via the xylem tubes. The velocity of the sap is reported to a large database powered by a small solar panel.

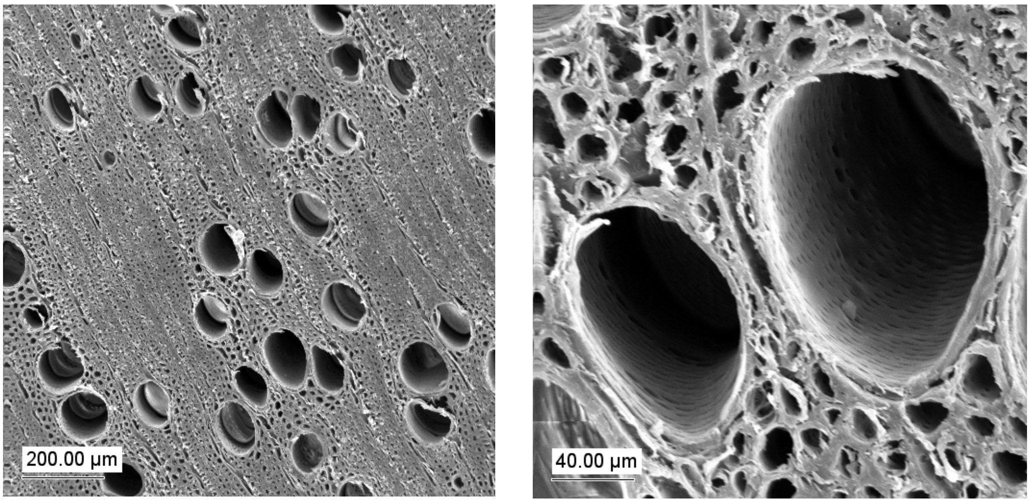

Figure 1 - Electron micrographs showing the xylem tubes in the stem of *E. cladocalyx* from the NUFG plantation at Kamarooka (courtesy of Dr. Sabine Wilkens - Latrobe University)

On the morning of 7 February I used remote access technology to log in to the Kamarooka plantation database and watch the trees as the day progressed. I also watched the live data from the climate station at the Bendigo airport. By 9.00 AM the temperature had reached 30 degrees and the relative humidity was falling rapidly.

Water began moving up the stems of the plantation trees as soon as the sun came up. Within 45 minutes after sunrise the trees were close to their usual maximum daily transpiration rates. As the temperature rose above 30 degrees from 9 am, and the relative humidity plummeted, the Kamarooka trees continued to pump water out of the soil.

By 10 am the temperature was escalating and the relative humidity continued to fall rapidly. The atmospheric demand for water became much greater than the trees could supply and in the face of enormous stress they called on a survival technique learnt through more than 20 million years of experience with drought. Soon after 10 am the trees released a hormone-like substance called abscisic acid that allowed enough potassium to leak from the guard cells for the stomata to shrink and reduce transpiration by about 50 percent.

The Kamarooka plantation trees help us to understand that trees are not static. In fact they are dynamic organisms that react and adjust to the climatic conditions they experience on a daily basis. They are programmed to deal with many different stresses in different ways. They have been around for a long time and have had the opportunity to adapt to past climatic conditions very different to those that prevail today.

By removing waterlogging in a saline environment some trees, previously thought to have been 'salt sensitive', will continue to thrive despite great masses of salt in their root zone. Turn up the heat and the atmospheric demand to unbearable levels and they shut down their water loss. Through a long history of evolution trees have clearly become programmed to deal with tough environmental conditions.

Evolutionary pressures are different in different landscapes and landforms. A tree adapted to the floodplain of a river is unlikely to experience the same stresses as a tree growing in a rock landscape on the side of a hill. However, we are yet to fully understand the extent of this evolutionary programming. We continue to wonder, for example, about the ability of different species to deal with different geochemical conditions in the vast range of Australian landscapes.

Perhaps the time has come for a more serious marriage between tree physiology and landscape morphology (geomorphology).

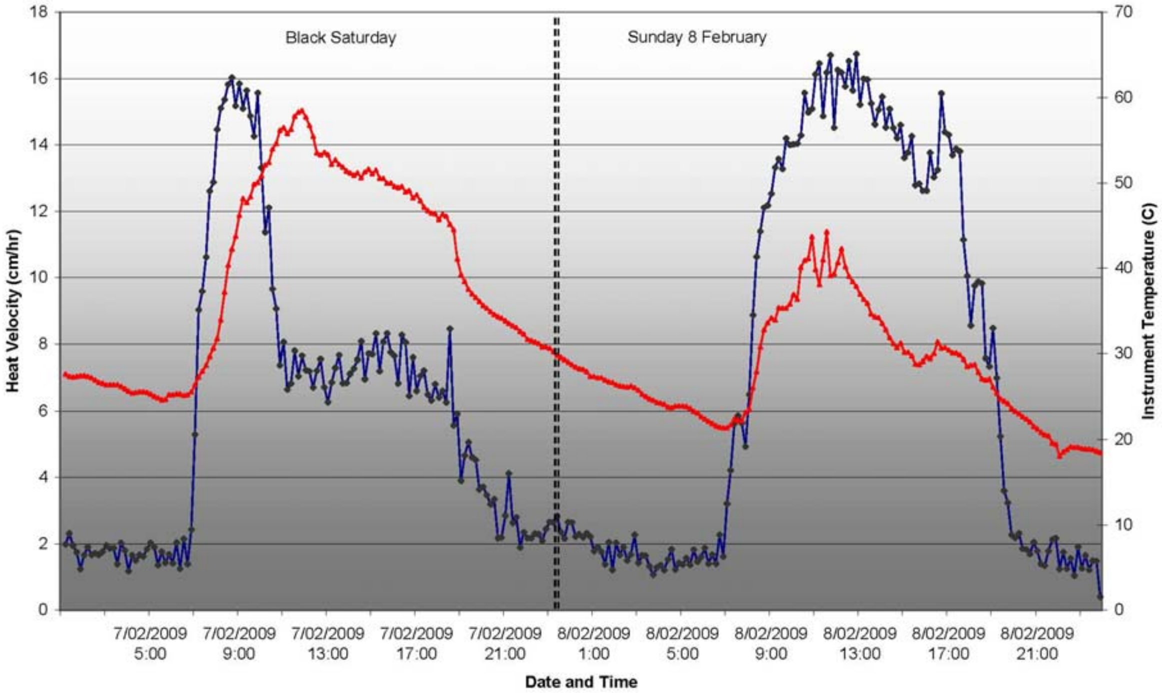

Figure 2 - Sap flow measured as raw heat velocity in *Eucalyptus cladocalyx* in the NUFG plantation on February 7 & 8 2009 – note instrument temperature is higher than actual air temperature