

Bark chlorophyll fluorescence: a novel way of measuring vitality in mature urban trees

Leaf chlorophyll fluorescence (CF) has been used to assess the effects of physiological stress in trees in urban environments for many years. This presentation describes a method for assessing tree vitality that has been used for plantation trees (Johnstone et al 2012) but has not been previously used in urban trees. The tree species tested in this study were street and park trees; *Ficus macrophylla* (Morton Bay Fig), *Platanus x acerifolia* (Plane Tree) and *Ulmus parvifolia* (Chinese Elm). Bark and leaf fluorescence were compared with an urban visual vitality index in autumn and summer. Bark and leaf fluorescence were compared with predawn water potentials in summer.

Bark CF testing was done in a 350 mm strip in cross section at the North (most sun exposed) half of the trunk, with individual measurement points 35 mm apart (Johnstone et al 2012). The test area on the bark was circular and 4.5 mm in diameter, utilizing leaf clips that had been pulled apart and stuck on a neoprene strip with adhesive. 10 tests were done on each tree after being dark adapted for 30 minutes in the autumn 2011 season. Both dark adaption and duration of darkening sensitivity were measured for all three tree species for the summer data set in 2012 according to protocols described in the manual (Hansatech 2006). Bark CF testing was done between 6am and 8am in summer and autumn. A flash of red light onto the bark again induced the time dependent fluorescence kinetic known as the Kautsky effect (Govindjee 2004; Percival 2005). The saturated light level of the instrument was set at $1500 \mu\text{mol m}^{-2} \text{s}^{-1}$, signal gain at x 1.0 for the autumn 2011 season. After the sensitivity of bark chlorophyll to light intensity was assessed for the summer 2012 season, the *Platanus x acerifolia* bark tissues were measured at $2000 \mu\text{mol m}^{-2} \text{s}^{-1}$, *Ficus macrophylla*, at $3500 \mu\text{mol m}^{-2} \text{s}^{-1}$ and *Ulmus parvifolia* at $3000 \mu\text{mol m}^{-2} \text{s}^{-1}$. For all trees signal gain was set at x 1.0. The bark tissue was measured at a 1 second duration of light exposure and a 2 second light exposure in summer (2012) to ensure CF measurements were reaching maximum. The bark was not damaged or removed in any way. Areas of bark damaged, decorticating or recently exposed were excluded from testing. No lichen or algae were observed to be present. The height at

which trees were measured was variable as it was necessary to measure above or below rough or damaged bark.

The urban tree visual vitality index was a method created by Callow et al (2014) based originally on a method for assessing forest trees by Grimes (1978) and dead and dying trees by Lindenmayer et al. (1990). Grimes (1978) method was further developed by Martin et al. (2001) and Johnstone et al (2012) and finally refined by Callow et al (2014). The method incorporates 3 individual scores for; 1. Crown size, 3. Crown density and 3. crown epicormic growth (Callow et al 2014). Each attribute can be assigned any number within the appropriate range, whether described directly in the diagram or not. As with the method used by Martin et al. (2001) scores were totalled to give an estimate of the urban tree visual vitality of the tree and scores have a nominal range between 1 and 17. Trees with values at or below 10 have very low visual vitality. The urban tree visual vitality index was assessed in the trees in autumn (March, 2011) and summer (January, 2012). Predawn water potentials were compared with the urban visual vitality index in January 2012 as a way of determining the cause of physiological stress in the plants.

Relationships between bark chlorophyll fluorescence readings and urban tree visual vitality were almost non-existent in the *Ficus macrophylla* and *Platanus x acerifolia* trees. On the other hand statistical relationships were significant between bark chlorophyll fluorescence and the urban tree vitality index in *Ulmus parvifolia*. In a reversal of this trend statistical relationships were present between bark chlorophyll fluorescence and pre-dawn water potentials in *Ficus macrophylla* and *Platanus x acerifolia*, but were not as consistent within the *Ulmus parvifolia* trees.

Bark chlorophyll fluorescence may become a useful tool for tree vitality assessments, but further work needs to be undertaken to clarify and understand the responses of different species.

References

- Callow, D., D. Johnstone and P. May. 2014. Methods to assess and improve the vitality of drought stressed mature urban trees. Unpublished.
- Govindjee. 2004. Chlorophyll a fluorescence: a bit of basics and history. *In* Chlorophyll a Fluorescence. A signature of Photosynthesis Eds. G.C. Papageorgiou and Govindjee. Springer, Dordrecht, pp 1-41.
- Grimes, R. 1978. Crown assessment of natural spotted gum (*Eucalyptus maculata*), ironbark (*Eucalyptus fibrosa*, *Eucalyptus drepanophylla*) forest. Queensland Department of Forestry. 7:1-16.
- Hansatech. 2006. Operations Manual Handy PEA Pocket PEA and PEA Plus Software. Hansatech Instruments, Norfolk, England. 85 p.
- Johnstone, D., M. Tausz, G. Moore and M. Nicolas. 2012. Chlorophyll fluorescence of the trunk rather than leaves indicates visual vitality in *Eucalyptus saligna*. *Trees-Structure and Function*. 26:1565-1576.
- Lindenmayer, D., T. Norton and M. Tanton. 1990. Differences between wildfire and clearfelling on the structure of montane ash forests of Victoria and their implications for fauna dependent on tree hollows. *Australian Forestry*. 53:61-68.
- Martin, R.A.U., M.A. Burgman and P.R. Minchin. 2001. Spatial analysis of eucalypt dieback at Coranderrk, Australia. *Applied Vegetation Science*. 4:257-266.
- Percival, G.C. 2005. Identifying tree decline using "fluorescence fingerprinting". International Society of Arboriculture Australia Chapter, Hobart.