Riparian trees as common denominators across the river flow spectrum: are ecophysiological methods useful tools in environmental flow assessments?

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ABSTRACT

Riparian tree species, growing under different conditions of water availability, can adapt their physiology to maximise their survival chances. Rivers in South Africa may flow perennially, seasonally or ephemerally (episodically). Different riparian species are adapted to survive under each of these different flow regimes by making use of surface, ground, soil, rainwater, or some combination of these. These water sources are available to varying degrees, depending on local climatic, hydrological, geohydrological and geomorphological conditions. This paper tests physiological differences among trees along rivers with varying flow regimes. In this study 3 parameters were selected and tested, namely wood density, specific leaf area and water use efficiency through stable carbon isotope measurements. All three parameters are quick, simple and cheap to determine and as such their value for standard-procedure river monitoring programmes or environmental flow requirement procedures was tested. *Acacia erioloba* is an arid-adapted riparian tree along the ephemeral Kuiseb (Namibia) and Kuruman (South Africa) Rivers that shows decreasing specific leaf area and increasing wood density correlating with deeper groundwater levels. Intraspecific changes for specific leaf area and carbon isotope values were demonstrated for *Acacia mellifera* and *Croton gratissimus* at varying distances from the active channel of the seasonal Mokolo River (South Africa). No significant differences in physiology were noted for *Salix mucronata*, *Brabejum stellatifolium* and *Metrosideros angustifolia*, growing along the perennial Molenaars and Sanddrifskloof Rivers (South Africa) under reduced flow conditions. Only the measurement of specific leaf area recurrently showed that significant physiological differences for trees occurred along rivers of the drier flow regime spectrum (seasonal and ephemeral). As such, this physiological measurement may be a valuable indicator for water stress, while the other measurements might provide more conclusive results if a larger sampling size were used. Specific leaf area, in conjunction with other carefully picked water stress measurement methods, could be considered for monitoring programmes during environmental flow assessments, river health monitoring exercises and restoration projects. This would be particularly valuable in rivers without permanent flow, where there is little species-specific knowledge and where current monitoring methods are unsuited.

Keywords: ecophysiology, stable $\delta^{13}C$ isotopes, wood density, specific leaf area, EFAs, river flow regimes, trees

INTRODUCTION

Aquatic and riparian community structure of rivers are primarily shaped by a river's flow regime (Jacobson, 1997; O'Keeffe, 2000) as the life histories of riparian plants are intimately tied to a river's natural flow regime (Meritt et al., 2009). Riparian species disperse, reproduce and survive in response to river flow timing, frequency, magnitude, duration and predictability (Mahoney and Rood 1998; Moser, 2006; Merritt et al., 2009). River flow also influences other environmental attributes important for riparian plant growth, such as groundwater recharge, nutrient deposition, sediment transport and substrate deposition (Merritt et al., 2009). These cause-and-effect relationships must be understood in order to successfully specify environmental water requirements (EWRs) that will sustain riparian communities (Merritt et al., 2009). The amount of water available as surface flow or groundwater must be understood in relation to how water is sourced to meet a plant's water needs and avoid drought-tolerance thresholds. This is especially important where water availability is reduced due to climate change, human abstraction or diversion of flow (Stromberg and Patten, 1990; Tabacchi et al., 2000; Hou et al., 2007; Merritt et al., 2009).

Rivers are frequently classified according to flow regime (Uys and O'Keeffe, 1997), or based on a scale of flood days per annum (Poff and Ward, 1990; Jacobson, 1997). Classifications of river seasonality vary between countries, but an internationally accepted one is perennial (100% flow), semi-permanent (> 75% flow), intermittent streams (10–25% flow), and ephemeral (< 10% flow) (Hedman and Osterkamp, 1982; Jacobson, 1997; Boulton et al., 2000). Rivers in South Africa are located in a wide range of rainfall regimes; rainfall increases eastwards from the northwest to the mesic southeast of the country. Consequently, river flow across the country varies hugely. In addition, South African catchments convert a relatively small percentage of the mean annual precipitation to mean annual runoff: 8.6% when compared to (for instance) Canada at 67%. Further, South African rivers have one of the highest coefficients of variation about the mean annual runoff, which describes the overall flow variability in the world (Poff and Ward, 1989). So flow varies across the country, and for any one river flow in any one year varies considerably.

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