HFD8 Heat Field Deformation Research

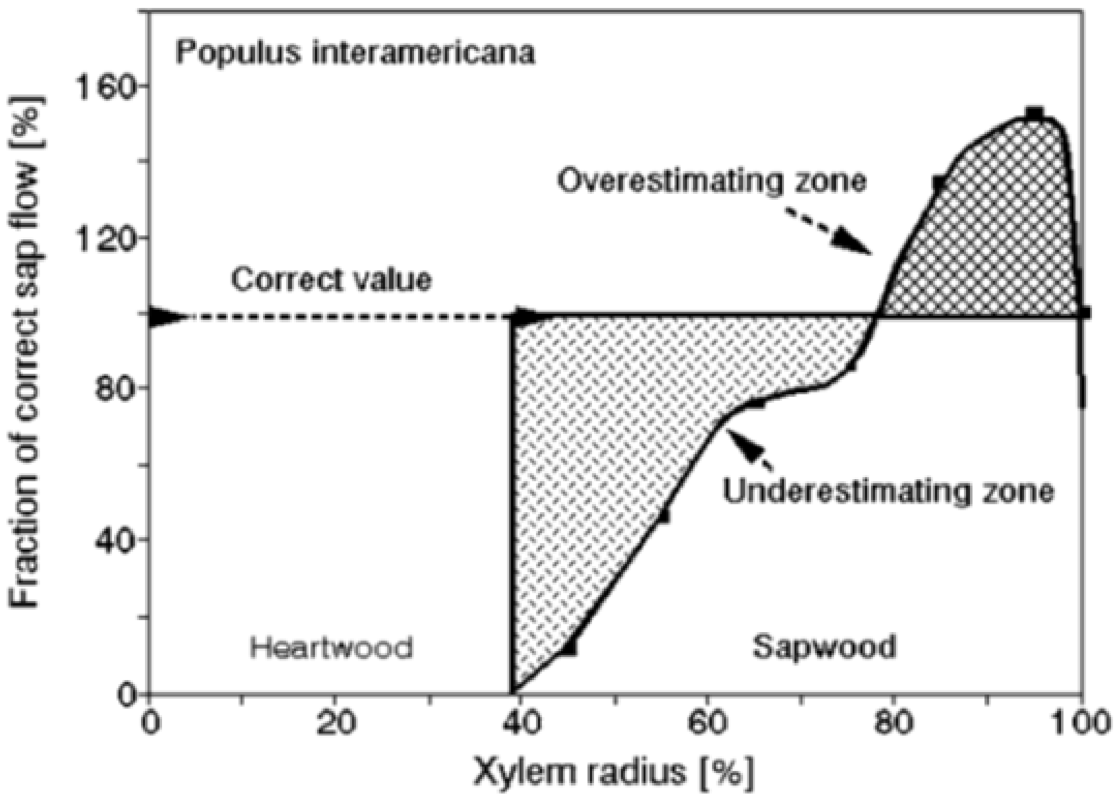
Introduction

The HFD method has been in use by scientists since the 1990's. Over the years many scientific studies have been published in leading international journals such as New Phytologist and Tree Physiology. A brief snapshot of some this research is presented in this application note.

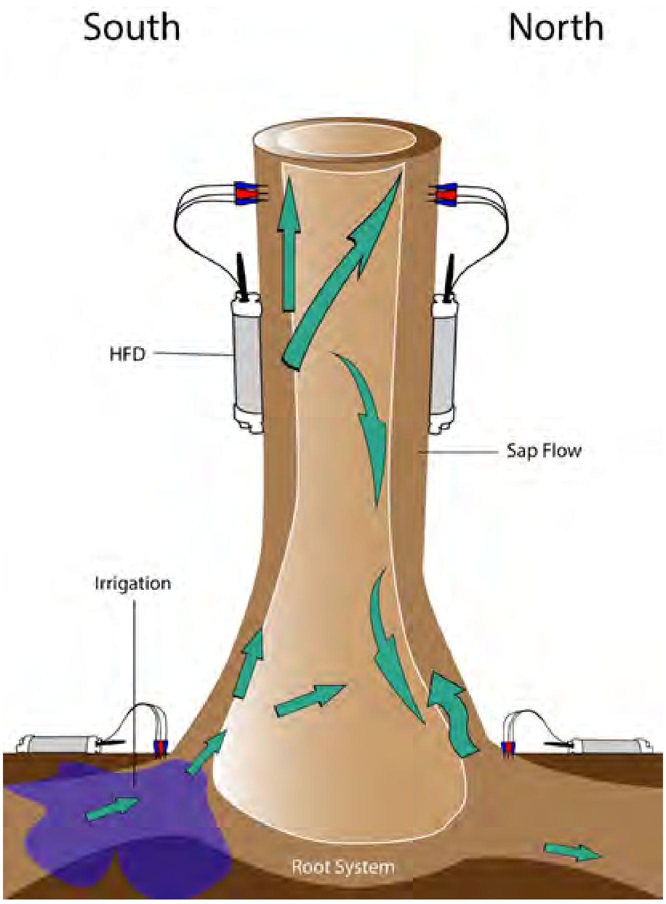
Multi-Point Sensors more Accurate than Single-Point Sensors

Sap flow is not consistent across sapwood. HFD sensors have 8 measurement points along a 10cm long needle therefore the sapwood radial profile can be accurately measured. Cermak et al (2004) emphasised the importance of employing multi-point sensors over single-point sensors such as the thermal dissipation probe (TDP) or Granier method. Installing a single-point sensor too shallow in the sapwood will lead to an overestimation and installing it too deep will lead to an underestimation of total sap flow. The certainty of correctly measuring total sap flow with a single-point sensor can never be known. Measuring sap flow with a multi-point sensor is always preferable.

Reference: Fig 4b; Cermak et al. 2004. Trees, 18: 529.



Hydraulic Redistribution in Douglas Fir



It is now known, thanks largely to sap flow research with HFD measurements, that water in trees can move upwards, downwards and sideways. Known as hydraulic redistribution, this is water movement due to gradients of water potential in plants. To test this hypothesis, Nadezhdina et al (2009) installed HFD sensors on a southern root and trunk, and northern root and trunk of a Douglas Fir tree.
The soil was homogenously dry and then irrigated on the southern root. Subsequent measurements observed that the water moved up the stem, across to the northern stem, down to the northern root and out into the dry soil on the north side of the tree. This study clearly demonstrated hydraulic redistribution in this tree.

Reference: Fig 2b; Nadezhdina et al. 2009. New Phytologist, 184: 932.

Radial Profiles during Wet and Dry Season

Stem

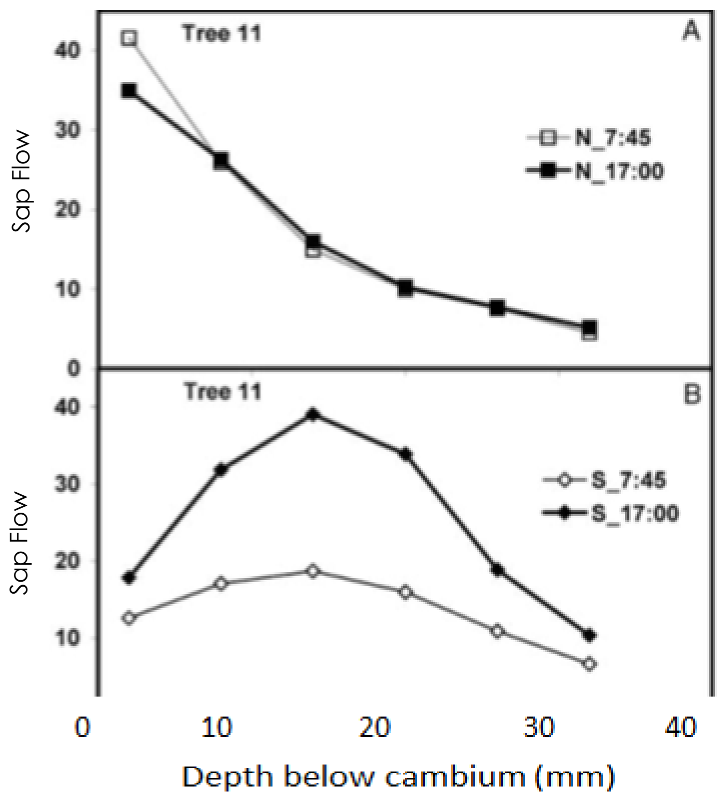
HFD research has improved our knowledge of how the radial pattern of sap flow is dynamic. Research by Nadezhdina et al (2007) showed that at the end of the wet season, sap flow in the outer and inner profile of a tree trunk was similar. After 3.5 months of no rain the inner profile had higher sap flow than the outer profile. The wet season root activity was primarily in the shallow roots, yet during the dry the activity shifted to deeper roots where soil moisture was presumably more abundant. This research showed that the inner stem is related to deep roots and theouter stem is related to shallow roots in this tree.

Sap Flux Density (g cm^2 hr^{-1})

Reference: Fig 9; Nadezhdina et al. 2007. Tree Physiology, 27: 105.

Different Radial Profiles in Trunks v Branches

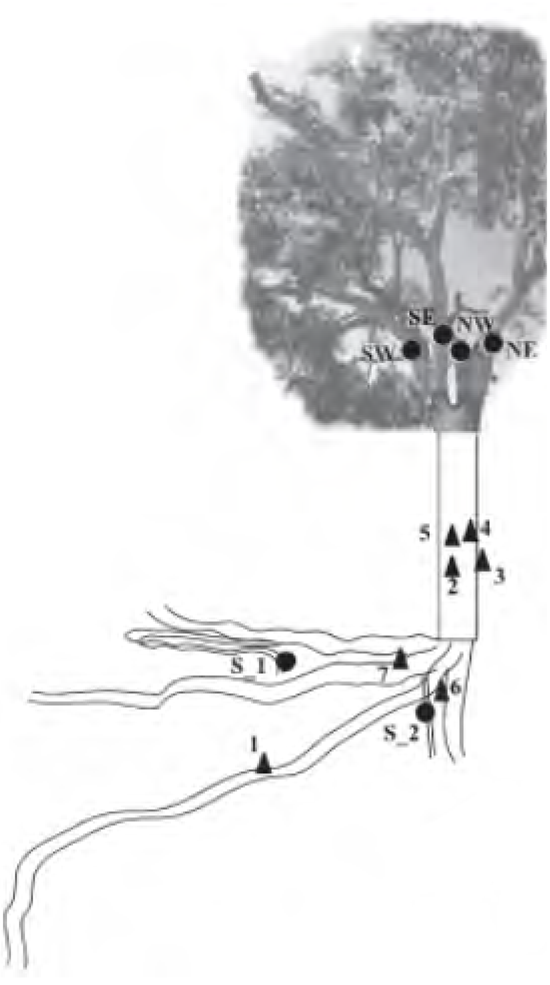
Radial patterns of sap flow are not consistent across species or even within species or individual trees. A "normal" radial profile has peak sap flow approximately 15mm beneath the bark with a linear decrease to the heartwood. However, Nadezhdina et al (2007) observed two asymmetric types of radial patterns in an olive tree. They labelled Type 1 as the "normal" radial profile. Type 2 however had a maximum just below the bark with a linear decrease to the heartwood. Type 1 was found more often in branches and small trees of their measured olive trees. Type 1 and Type 2 patterns were observed in the same trunk but at different circumferential positions, for example at a north versus south position.



Reference: Fig 5; Nadezhdina et al. 2007. Tree Physiology, 27: 105.

Hydraulic Integration & Sectorality

Installing HFD sensors at various locations around the roots, trunks and branches of a cork oak tree, and then systematically removing branches on certain aspects of the tree, allowed David et al (2012) to observed how xylem in the roots, trunk and branches were connected. When north-western and south-eastern branches were removed, sap flow in the trunk on those respective axes decreased to zero. However, root sap flow on those axes did not change. The authors suggested that the trunk xylem was sectored, or isolated, and the root xylem was integrated. This pattern of xylem development has survival and evolutionary benefits to the tree.



Reference: Fig 1; David et al. 2012. Functional Plant Biology, 39: 103.

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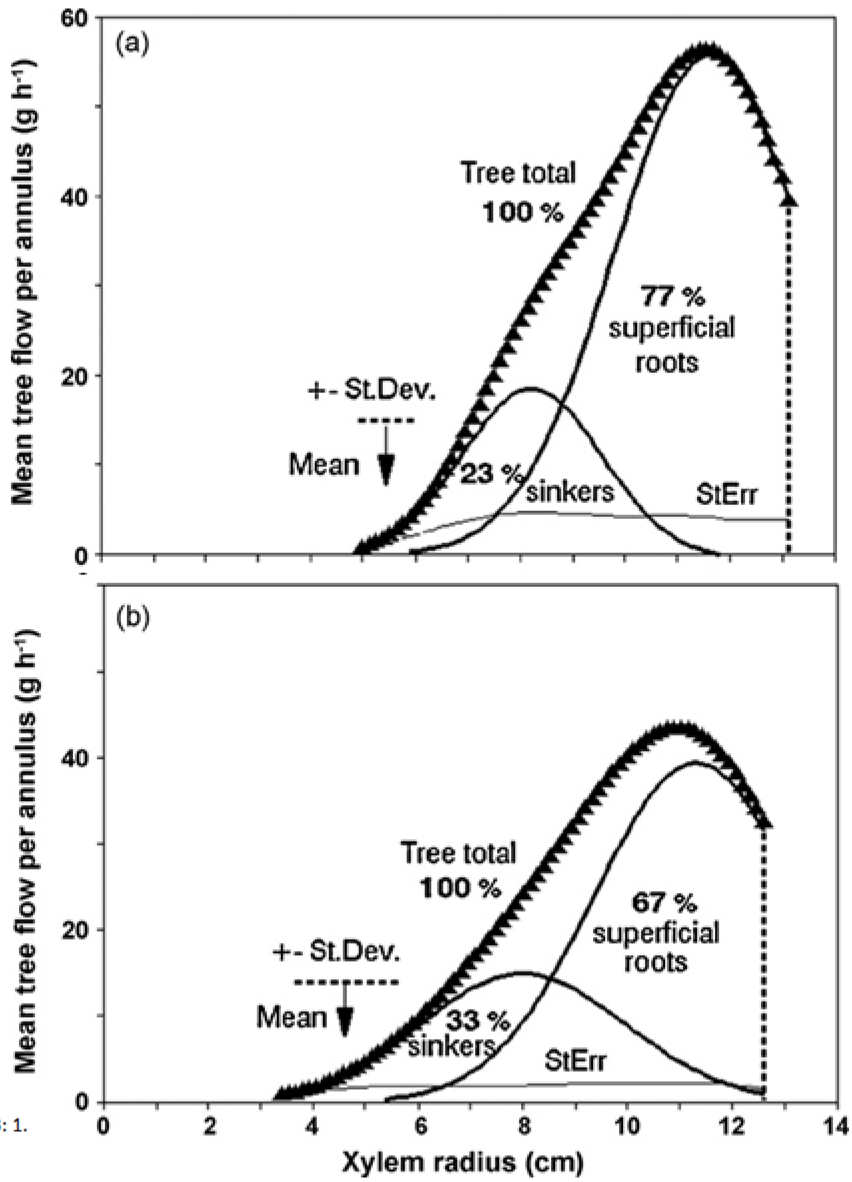
Radial Profiles and Deep and Shallow Soil

HFD measurements can determine whether a tree has shallow or deep roots extending into the soil. At a research site in Belgium, the soil in one part is sandy to 1.25m then has a clay layer (shallow profile). At another part the sandy soil extends to 2.5m and then there is clay (deep profile). By measuring the mean sap flow across sections of the stem radial profile (also called annulus), Nadezhdina et al (2007) showed that at the shallow site 77% of total tree sap flow came from superficial roots (roots near the soil surface). In contrast, in trees growing on the deep profile 67% of total tree sap flow came from the superficial roots. The sapwood was also wider in trees from the deep profile.



Reference: Nadezhdina et al. 2007. Forest Ecology and Management, 243: 1.

References

For a copy of any of the references mentioned in this application note please contact ICT International: sales@ictinternational.com