New study disproves Leonardo da Vinci's 'rule of trees'

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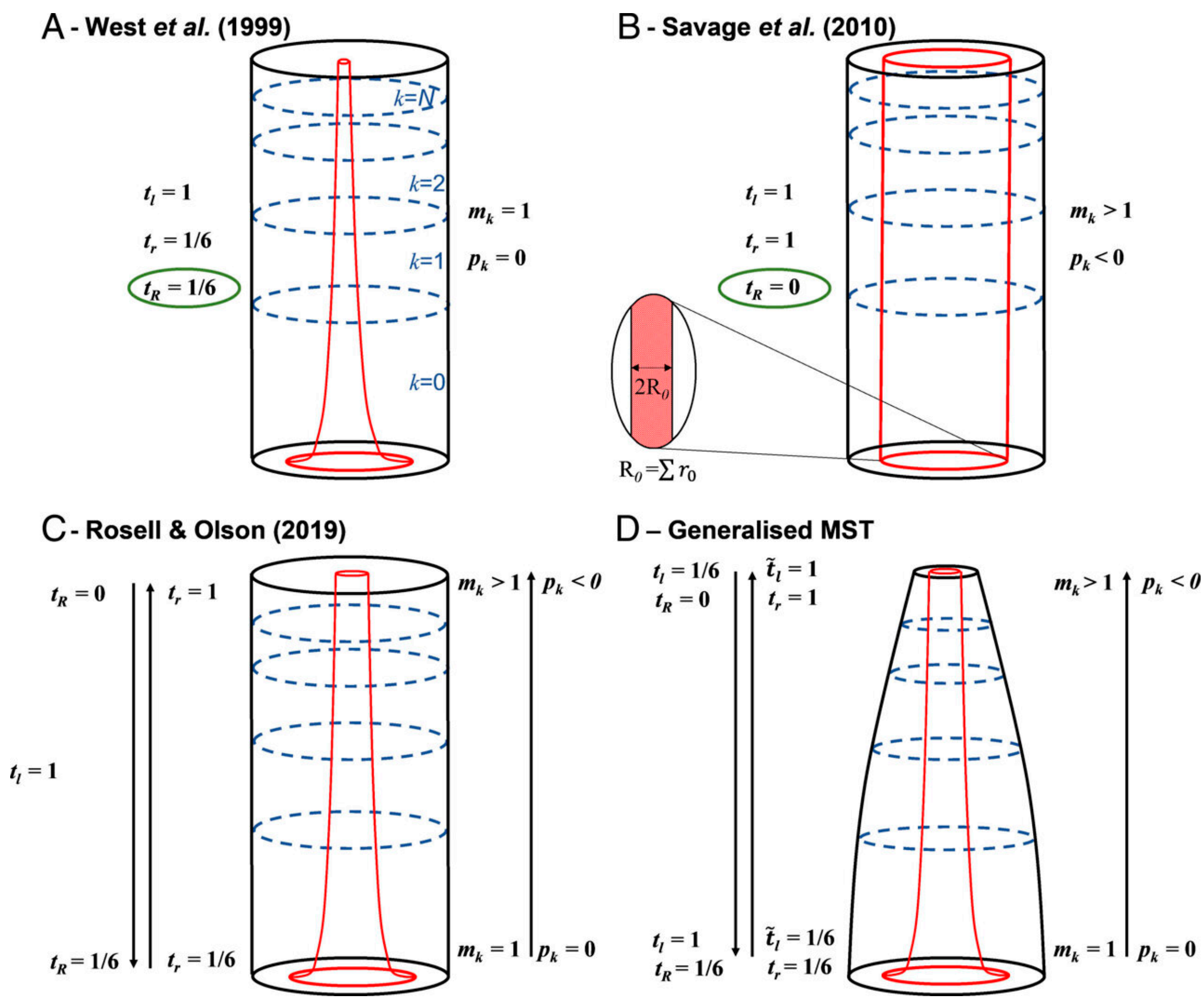

Models of summated branching network volumes, illustrating how total network volume (outer shape in black) and total conductive volume (inner shape in red) change with varying tapering coefficients (t_R, t_r and t_l), and coalescence rates (m_k and p_k). Four network models are presented, showing the differences between

(A) West et al, (B) Savage et al), (C) Rosell and Olson and (D) our gMST relationships of plant morphology, reaching from the plant base to the tip of the leaves. Values encircled in green are explicitly given as premises by the authors, while other values are inferred. Credit: *Proceedings of the National Academy of Sciences* (2023). DOI: 10.1073/pnas.2215047120

A "rule of trees" developed by Leonardo da Vinci to describe how to draw trees has been largely adopted by science when modeling trees and how they function.

Now, scientists at Bangor University in the U.K. and the Swedish University of Agricultural Sciences (SLU) have discovered that this rule contradicts those that regulate the internal structures of trees.

Da Vinci's interest in drawing led him to look at size ratios of different objects, including trees, so that he could create more accurate representations of them. To correctly represent trees, he perceived a so-called "rule of trees" which states that "all the branches of a tree at every stage of its height are equal in thickness to the trunk when put together."

It had been thought that Leonardo's "rule of trees" could also be applied to the vascular channels which transport water through a tree, with the individual channel sizes decreasing at the same ratio, as branches become narrower, while still adding up to the trunk's volume. This rule had been accepted as part of metabolic scaling theory.

But scientists from Bangor University and SLU have shown that this model isn't exactly correct when applied to the internal vascular structures of trees. The study has been published in the *Proceedings of the National Academy of Sciences*.

For water and nutrients to move efficiently through the tree, from root to leaf-tip, the vascular system has to maintain hydraulic resistance.

Ruben Valbuena and Stuart Sopp of Bangor University and SLU have calculated that for hydraulic resistance to work, there comes a point where the rule of trees can no longer hold true.

In order to efficiently transport liquids from roots to leaf-tips, a tree's vascular channels need to maintain a certain dimension to maintain hydraulic resistance. Therefore, the plant has to reduce in its volume as it reaches its extremities, causing a higher ratio of capillary to the surrounding plant mass.

As Dr. Ruben Valbuena (honorary professor at Bangor University and now professor at SLU) explains, "While a great 'tip' for artists, which is what da Vinci intended, Leonardo's rule of trees does not hold up at the micro level."

"We believe our calculations further refine metabolic scaling theory and improve understanding the plant system as a whole. Our re-calculations may also explain why large trees are more susceptible to drought, and may also be at a greater vulnerability to climate change."

Co-author Stuart Sopp, currently studying for his Ph.D. iN environmental science at Bangor University said, "One of our aims was to produce a ratio which could be used to estimate tree biomass and carbon in forests. This new ratio will assist in calculating global carbon capture by trees."

More information: S. B. D. Sopp et al, Vascular optimality dictates plant morphology away from Leonardo's rule, *Proceedings of the National Academy of Sciences* (2023). DOI: 10.1073/pnas.2215047120

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