

Stem trait spectra underpin multiple functions of temperate gymnosperm and angiosperm tree species

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Abstract

A central paradigm in comparative ecology is that species sort out along a global economic strategy spectrum, ranging from slow to fast growth. Many studies evaluated plant strategy spectra for leaf traits, but few studies evaluated stem strategy spectra using a comprehensive set of anatomical, chemical and morphological traits, addressing key stem functions of different stem compartments (inner wood, outer wood and bark). This study evaluates how stem traits vary in the wood and bark of temperate tree species, and whether a slow-fast growth strategy spectrum exists and what traits make up this plant strategy spectrum. For 14 temperate gymnosperm and angiosperm species, 20 traits belonging to six key stem functions were measured for three stem compartments.

Both across and within gymnosperms and angiosperms, a slow-fast stem strategy spectrum is found. Gymnosperms have slow traits and showed converging stem strategies because of their uniform tracheids. Angiosperms have fast traits and showed diverging stem strategies because of a wider array of tissues (vessels, parenchyma and fibers) and vessel size and arrangements (ring-porous versus diffuse porous). Gymnosperms showed a main trade-off between hydraulic efficiency and safety, and angiosperms showed a main trade-off between 'slow' diffuse porous species and 'fast' ring porous species. The slow traits of gymnosperms allow for a high hydraulic safety, an evergreen leaf habit and steady but slow growth makes them successful in unproductive habitats whereas the fast traits of angiosperms allow for high conductivity, a deciduous leaf habit and fast growth which makes them successful in productive habitats.

Full Text

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Tables

Due to technical limitations, table 1-2 is only available as a download in the Supplemental Files section.

Figures

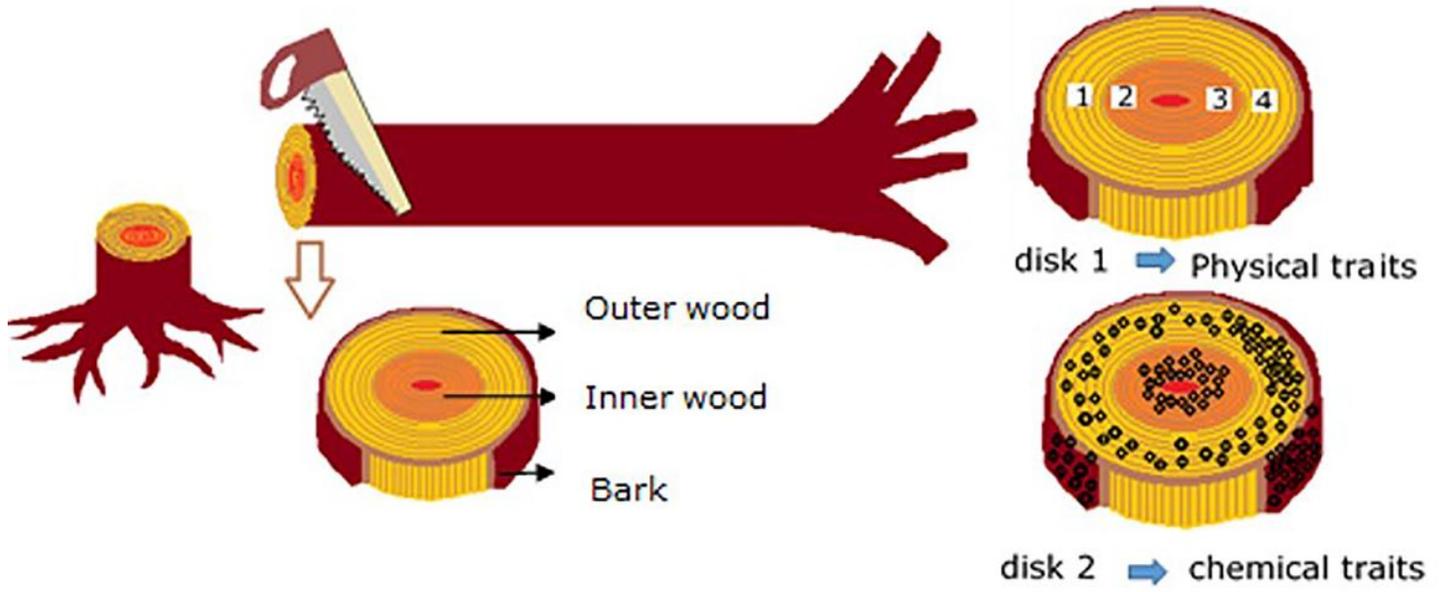


Figure 1

Sampling design for measuring physical and chemical traits.

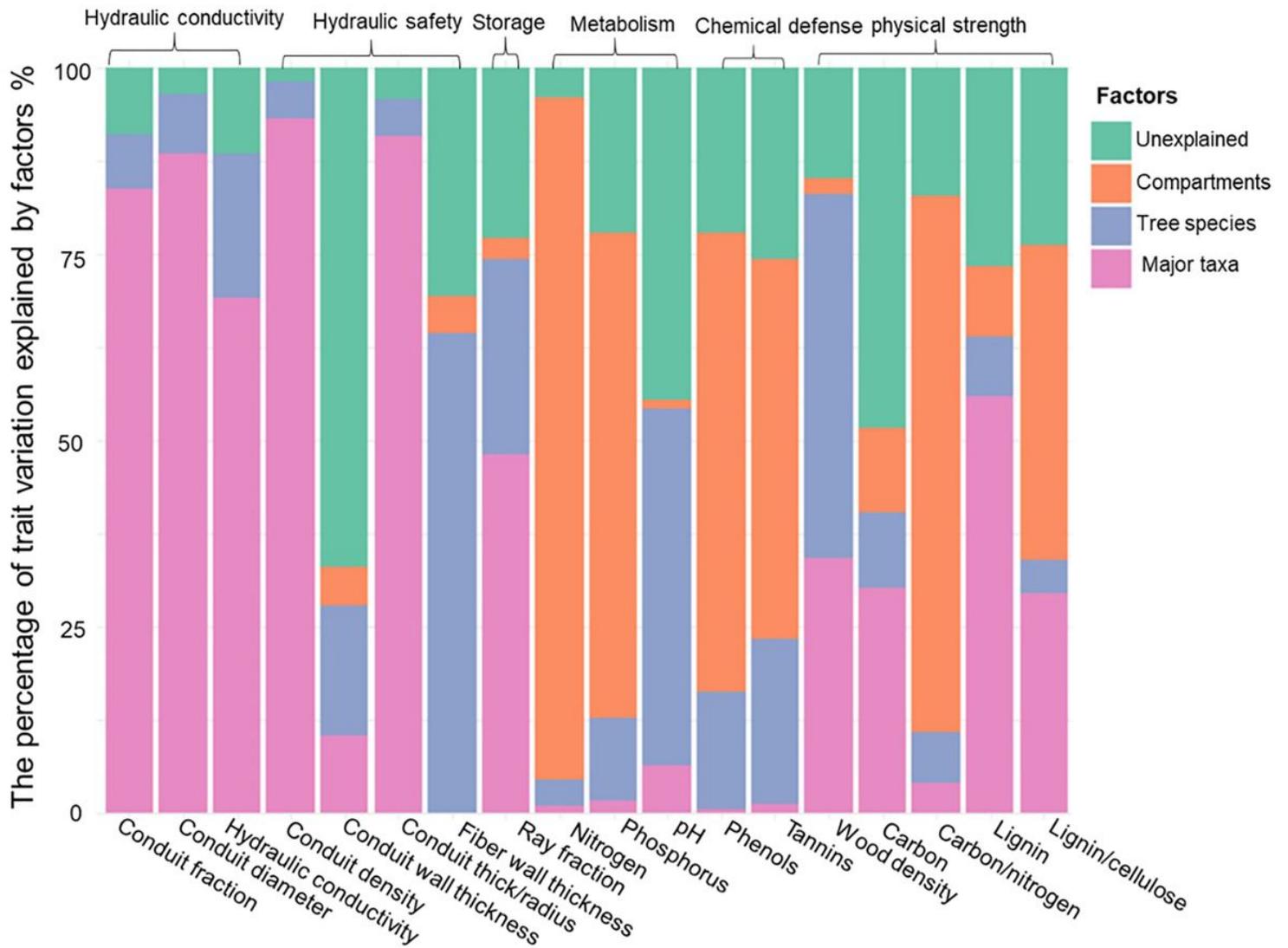


Figure 2

The percentage of trait variation explained by major taxa (angiosperms vs gymnosperms; pink), species within major taxa (blue), and compartments (inner wood, outer wood and bark, orange), and the unexplained variation (green). The traits are grouped into six stem functions.

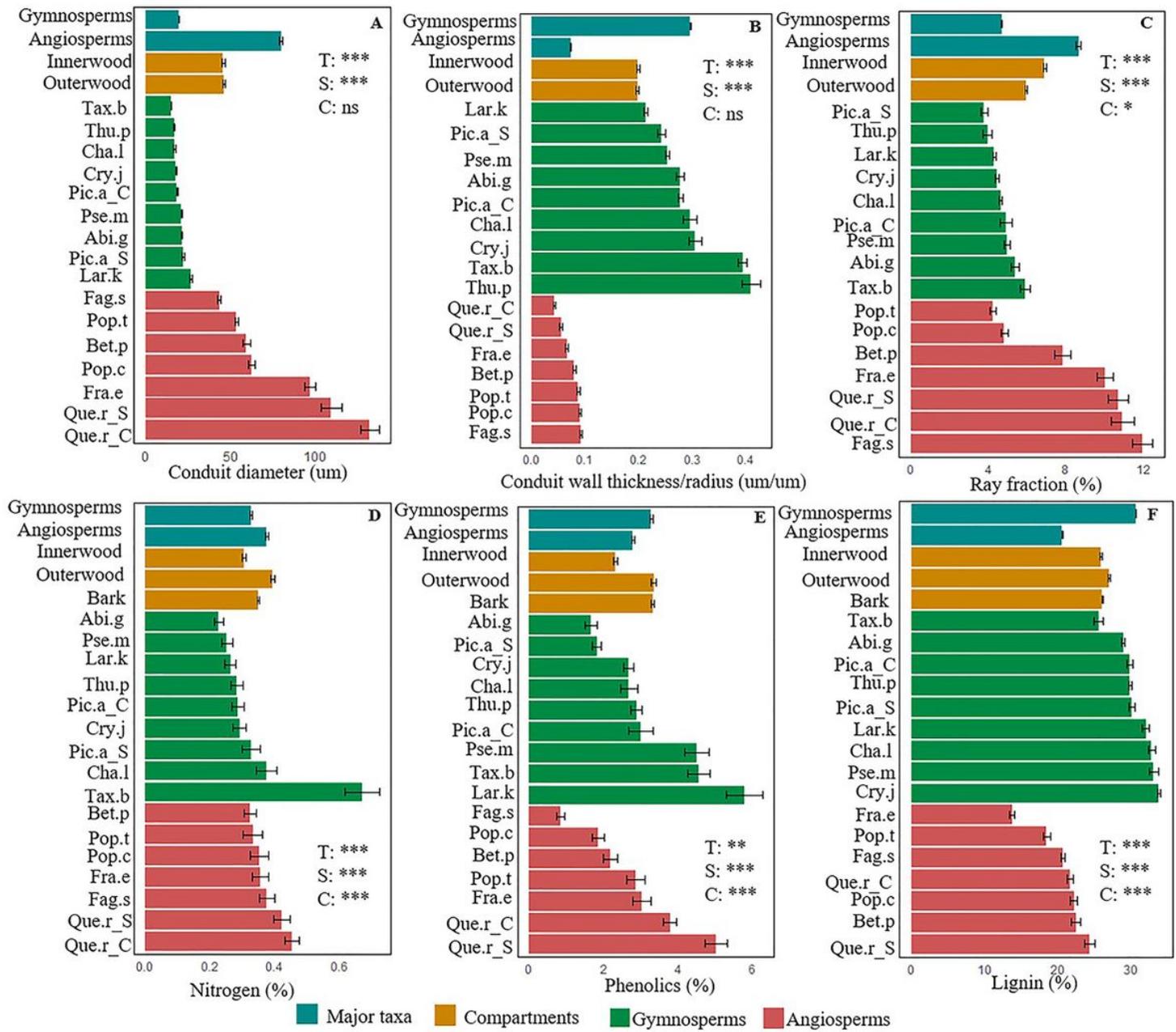


Figure 3

Trait variation between two major taxa (gymnosperms vs. angiosperms; blue-green), across different stem compartments (inner wood, outer wood and bark; brown) and species nested in major taxa (gymnosperms dark green, angiosperms reddish brown). For each of the six stem functions, one representative trait is shown: conduit diameter, conduit wall thickness/radius ratio, ray fraction, nitrogen, phenolics and lignin concentrations. Means and standard error of the mean are shown. T: Major taxa; S: Species nested within taxa; C: Compartments. Triple asterisks: $P < 0.001$, double asterisks: $P < 0.001$, single asterisks: $P < 0.05$, ns: not significant. For species abbreviations see Table S3 in Supplementary.

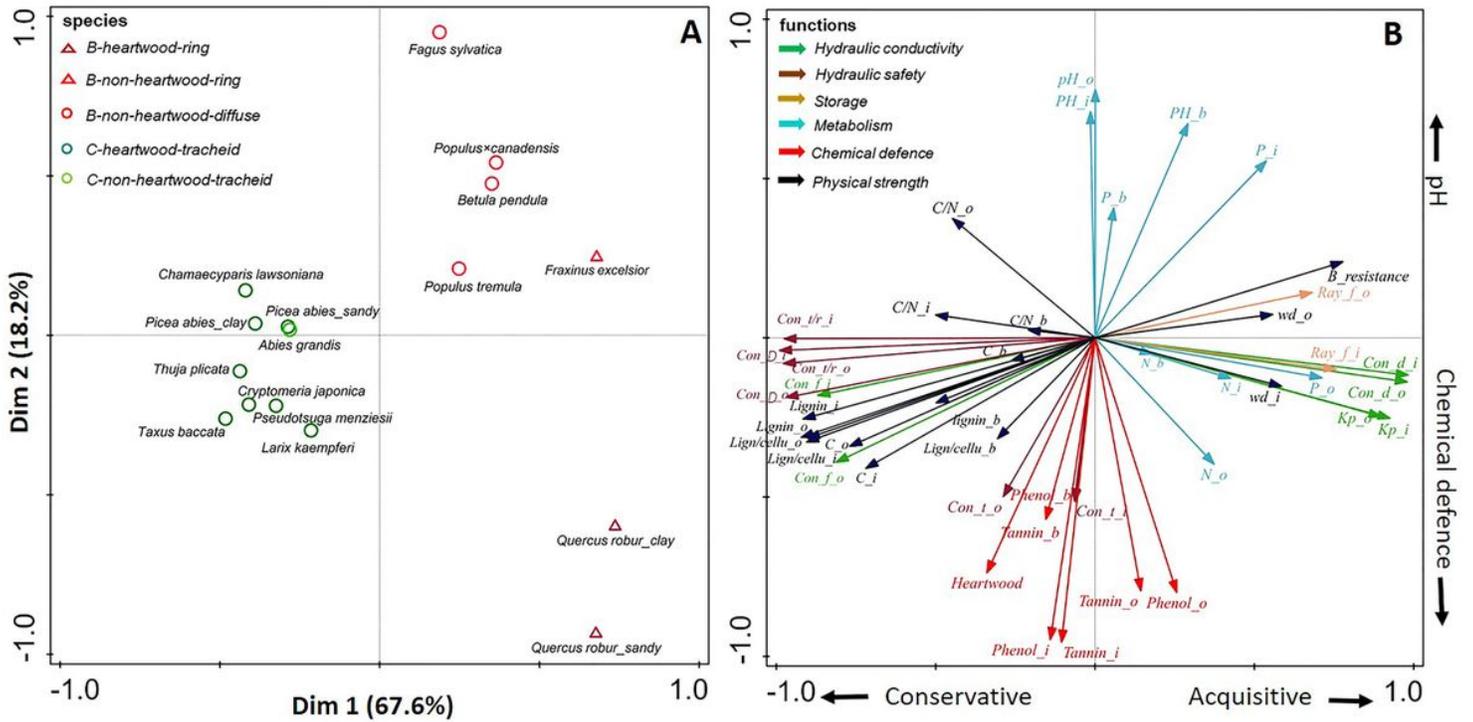


Figure 4

Principal-component analysis of 20 stem traits of three compartments (inner wood, outer wood, bark) of all tree species. Dark green circles show gymnosperms with heartwood; light green circles show gymnosperms without heartwood; dark red triangles show ring-porous angiosperm species with heartwood; light red triangles show ring-porous angiosperm species without heartwood; light red circles show diffuse-porous angiosperm species without heartwood. The traits (indicated with arrows) are grouped according to six functions: hydraulic conductivity (in green), hydraulic safety (in dark brown), storage (in light brown), metabolism (in blue), chemical defence (in red) and physical strength (in black).

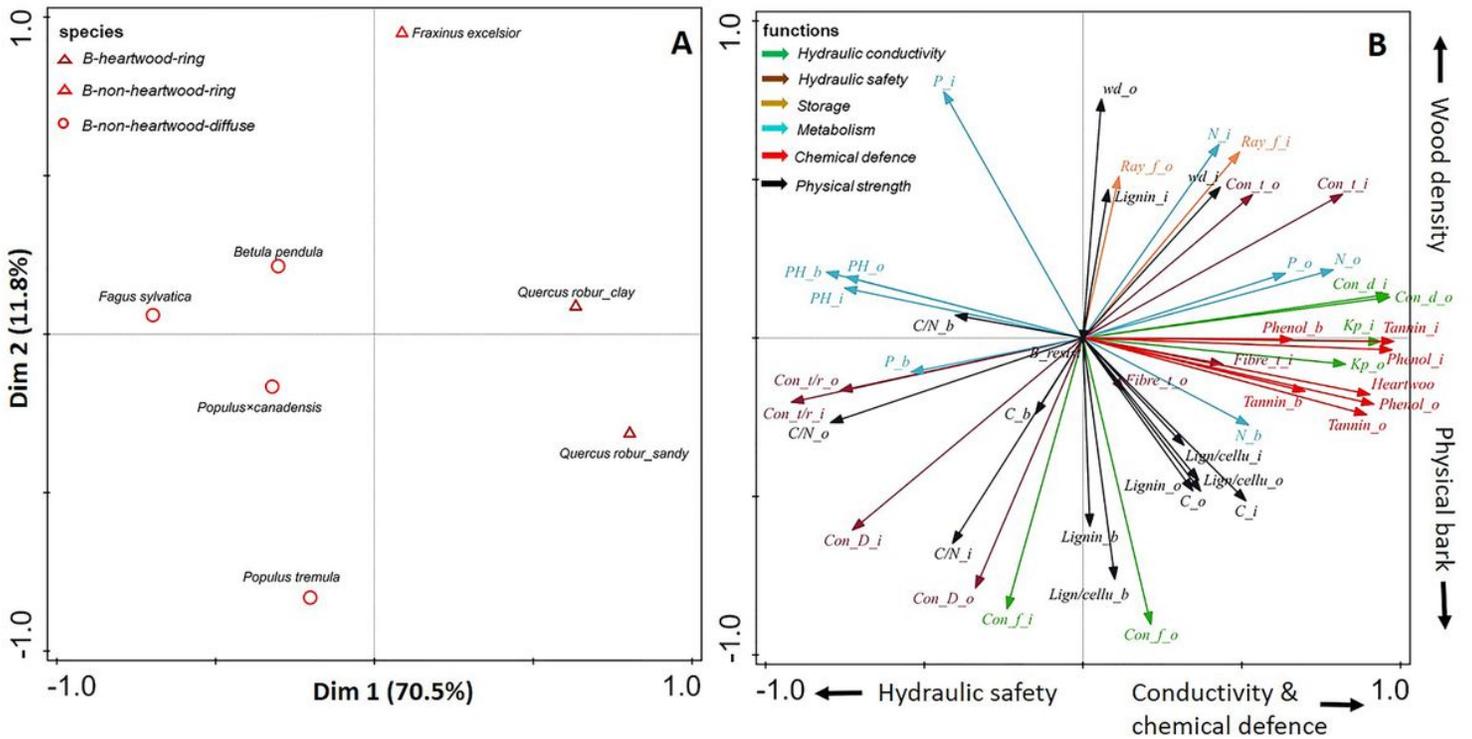


Figure 5

Principal-component analysis based on stem traits assessed in of three compartments (inner wood, outer wood, bark) for six angiosperms.

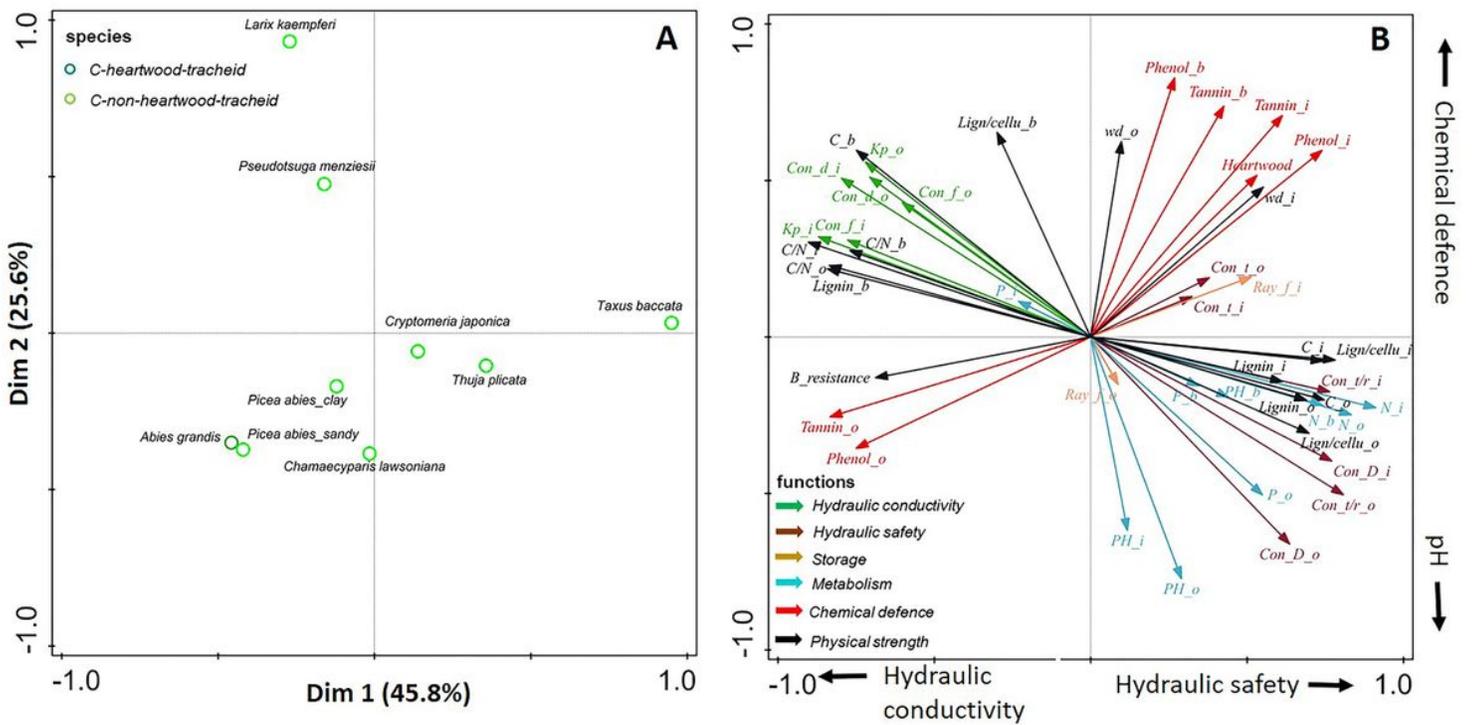


Figure 6

Principal-component analysis based on stem traits assessed in of three compartments (inner wood, outer wood, bark) for eight gymnosperms.

Supplementary Files

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- [Table2.docx](#)
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