The rings of truth

Researchers at Teagasc are looking at the basics of dendrochronology in forestry research – using tree ring analysis to explore the impact of climatic stress on tree growth performance and physiological responses.

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Projections of increased temperature coupled with decreasing precipitation during the growing season have the potential to cause reductions in the growth of certain tree species if water becomes a limiting factor.

The DAFM-funded Fit Forests project aims to assess the response of key species in Ireland to the uncertainties of climate change. Researchers at Teagasc and University College Dublin are using dendrochronology – a tree-dating technique – to understand past responses to drought events to predict future responses of trees to climate change.

These quantifications of past performance data can be modelled within future climate change scenarios under different warming levels and rainfall patterns. Therefore, we can forecast the growth trend of forest tree species based on future climate change predictions and assess their climate resilience, and then use this information for better management of species and more sustainable timber production.

The formation of tree rings

Tree rings are well-defined increments encircling the entire stem, resulting from wood formation with seasonal dynamics driven by genetic and environmental factors.

PhD Walsh Scholar Hui Xing says: "The annual rhythm of growing and dormant seasons drives the formation of annual tree rings. But external environmental forces, particularly climatic variations at both inter-annual and intra-annual levels, give us different ring characteristics and chemical properties. It is these annual growth increments and the science of identifying them – assigning them to an exact year – that form the basis for dendrochronology."

The yearly resolution of tree-ring data makes it possible to detect the impact of climatic extremes on growth performance and the underlying physiological process of trees' responses to inter-annual climate variation.

"This characteristic comes from two peculiarities of trees that are rare in the living world," explains Hui. "They are both sessile (fixed in one place) and long living. Being sessile and rooted in the ground is an advantage for researchers, providing an absolute stability in the recording location, in addition to the wealth of environmental signals that trees record along their life span.

"Whenever there is a climatic extreme, such as a drought event, the physiological response of trees is ingrained directly in tree ring structures as a functional trade-off between carbon gain and water loss during photosynthesis. Therefore, tree rings are libraries, keeping a precise record of regional climatic information and environmental cues in long tree ring chronologies.

"In turn, the retrospective analysis of tree ring series, such as ring width, wood density and isotopic compositions in wood cellulose, offer us an insight of past climatic extremes, such as drought, and their impact on tree growth performance and physiological responses."

The growth performance can be quantified through indicators of the resistance, recovery and resilience of trees before, during and after drought events.

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Tree terms

Dendrochronology – a tree-dating technique pioneered by Andrew E. Douglass in the early 20th century. It evaluates the annual growth increments of trees by identifying the exact year a tree ring was formed and examining how its formation was affected by historical climatic events.

Wood formation – a complex process of cambium activity and differentiation of secondary xylem, which is a process of xylem cell formation called xylogenesis. Annual growth rings are the result of cambial activity following periodical changes during xylogenesis.

Dendrochronology in forestry research

Climate variability causes variability in tree ring width and density at inter-annual and intra-annual scales.

Variations may occur within a single tree ring, such as density fluctuations (or 'false rings'), and the transition from earlywood to latewood in conifers and ring-porous broad-leaved species (such as ash or oak). Variations in ring width may also occur between tree rings formed in different years. For example, the sequence of wider and narrower tree rings in a series reflect changes in climatic conditions, notably for trees growing in their natural ecological settings. Favourable conditions such as ample water supply and ambient temperature typically result in wider rings, whereas climatic stress such as drought and heat may result in narrower rings.

These anatomical variations in tree rings serve as temporal markers for researchers to assess inter-annual, intra-annual and intra-seasonal variations in tree-climate interactions.

Radial growth is a good indicator of regional climatic conditions if trees grow close to the limits of their natural geographical distribution and are not affected by competition. In forestry, however, trees are planted in close stands in moderate favourable environments. Under these conditions, radial growth is found to respond less strongly to changes in rainfall and temperature due to complex integrating factors.

Complementary measures, such as the oxygen and carbon isotopic signatures of wood cellulose, can provide an additional, nuanced environmental fingerprint that records subtle shifts in temperature, precipitation and drought conditions. As the isotopic ratio in tree rings acts as a passive monitor of environmental change and is not dependent on net growth, it can potentially provide past climate information for regions that are not close to an ecological limit, such as in a forestry plantation setting. T

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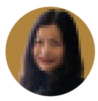

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